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Yield evaluation of Potatoes under conservation agriculture based zero tillage Rice straw mulching in Assam

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Abstract

The majority of Agriculture in the State of Assam is primarily based on a rice-based cropping system. Any other crops that are grown in Assam is always followed by paddy harvesting. Due to recurring flood in Assam, paddy crop was delayed leaving a very short window for most of the Rabi crops. Among all crops, potato is affected due to this delay in paddy harvesting. This study evaluated the yield of potatoes under the Zero Tillage and Rice Straw Mulching (ZTRM) technique with varied irrigation scheduling. This was investigated using four different treatments in two locations of the Barpeta and Biswanath districts of Assam. Of which three treatments were using ZTRM and the fourth one was the farmer's conventional practice. A randomized block design was followed, where each treatment was replicated three times to understand the yield impact. The treatments involve ZTRM with no irrigation (Treatment 1), ZTRM with one irrigation (Treatment 2), ZTRM with two irrigations (Treatment 3), and the farmer's conventional practice (Treatment 4) where the entire decision-making was on the farmer's own choice. The crop cycle was considered for 90 days. The data shown here were recorded in the cropping season of 2021 and 2022 from November to March. The collected data were analysed with Two-Way ANOVA with Tukey's multiple comparison test to see the significance of the treatments at a 0.05 probability level. The analysis shows a significant difference in yield across the treatments. It was observed that the treatment of ZTRM with one irrigation gave the highest yield in both the places. It produces 13%, 15%, and 18% increased yield in Barpeta and 13%, 15%, and 24% higher yield in Biswanath district respectively when compared to Treatment 1, Treatment 3, and Treatment 4.

Key words : Potato, Zero Tillage, Mulching, Irrigation, Yield, Quality

Potato crop is grown in various agro-climatic zones in India. Northern part of India contributes about 82% of potatoes in India. The improvement of the potato sector in Assam needs quite a huge adoption of new technology and advanced knowledge among farmers specially to deal with low productivity, availability and access to inputs, irrigation practices, erratic floods, and emergence of new pests, and diseases (Assam State Action Plan on Climate Change, 2015). Farm mechanization in the state is not very advanced, which has an impact on the productivity of the state and an increased toll on farm operations eventually leads to a high cost of cultivation[7]. Adoption of new technology and management practices are some of the critical factors that need urgent attention for the upliftment of the agricultural sector in the state[5].

Assam, known for its fertile soil, faces frequent flooding, making crop diversification essential for farmers in flood-prone areas. This strategy helps manage the risks and limitations caused by recurring floods. The region's varied topography supports a range of crops, offering opportunities for diversification. Promoting crop diversification is therefore vital for building resilience in Assam's agricultural sector. However, the persistent flooding hinders the implementation of advanced crop management practices, which are crucial for adapting to challenging climatic conditions.

The state of Assam has quite a large area under potato cultivation. It ranks 5th in terms of potato farming area in the state. The state cultivates potatoes in an area of about 1 lakh hectares (Agriculture Statistics at a Glance, 2021). However, the productivity of the state is below the national average of 23 Metric Ton (MT) per Hectare (Ha.). Assam only produces 9-10 MT potatoes per hectare (Ha). The low productivity is largely attributed to the age-old practices among farmers and the unavailability of quality seeds in Assam. Ever-increasing emphasis on potato research and development has shown systematic progress in the overall improvement of potato productivity in the country[1,3].

Conservation Agricultural (CA) practices like Zero Tillage and Rice straw Mulching (ZTRM) have the advantage of growing potatoes quite early compared to the conventional system as most of the rice grown in Assam are long duration rice variety and affected by flood[13]. Hence, the harvesting of paddy is delayed as a result, showing that the second crop is usually delayed. In a conventional system, it takes at least 15 days to prepare the soil for the cultivation of potatoes. However, in CA-based practices it could be done early as zero tillage does not need soil preparation and rice straw mulching can retain moisture for better growth of the tubers[8]. It provides irrigation support to the crop with minimal investment in it. The practice eventually resonates with the current practice of farmers towards irrigating a crop. Farmers in Assam normally do not irrigate potato crops as a result it impacts productivity and return on investment. Practice like ZTRM effortlessly improves irrigation requirements of potato crops with less investment and contribute towards water conservation. This also improves soil quality by allowing the decomposition of the mulching material and utilizing this natural resource quite efficiently[9].

ZTRM in potatoes has been proven

to be useful basically for total environmental health with a high potential of return on investment, as a result, it has a positive impact on the environment[5]. This has also gained popularity in terms of getting good quality potato tubers and reduction in damaged tubers[13].

ZTRM has the potential to address much such stress by enhancing water use efficiency with the use of mulch[12,14]. It has the advantage of preponing the crop period and avoiding the heat regime due to normal delay in the sowing of potatoes in Assam. Moreover, this type of management practices which ensure high water retention in the crop fields can have enhanced yield even in comparatively higher heat regimes[5].

The present study evaluated the yield of potatoes under ZTRM technique with different treatments to recommend the practice to farmers for adoption in a potentially low land holding condition.

Study area :

The study was carried out in farmer's agriculture land in Gahiya village of Sarukhetri block in Barpeta district (26°5' and 26°51' North latitude and 90°38' East longitude) and in Gingia village of Baghmara block in undivided Sonitpur district (26.28-27° North latitude and 91.19-93.47 East longitude). Now a days it comes under Biswanath district. Data has been obtained from the year 2020-21 and 2021-22 from both the study sites between November and March. A 100 sqm plot area was taken for laying the plots. A randomize block design was followed for the experiment. Four different treatments were used for the experiment listed below. For each treatment 3 replications were taken. For the farmer's own practice *i.e.*, treatment 4, 3 different spots were earmarked for taking the observations from the farmer's field. A mulch cover of paddy straw was used up to a height of 6 inches for the ZTRM plots. For fertilization nitrogen, phosphorus, and potassium (NPK) dose of 60 kg N+50 kg P+50 kg K ha-1 was applied for the ZTRM treatments and for farmers' own practice dose of 60 kg N+100 kg P+100 kg K ha-1 was applied as per the PoP recommended by Assam Agriculture University.

Experiment design and management :

1. Treatment 1: ZTRM without irrigation
2. Treatment 2: ZTRM with one irrigation after 45 days of planting
3. Treatment 3: ZTRM with two irrigations after 45 and 60 days respectively
4. Farmer's conventional practice in traditional method (Treatment 4)

A definite planting geometry was maintained for all the plots where row-to-row distance was maintained at 60 cm and seed-to-seed distance was maintained at 30 cm for the treatments under Zero Tillage and Rice Straw Mulching. Whereas Treatment 4 was as per the farmer's conventional practice for all aspects where the farmers followed row-to-row distance at 40 cm and seed-to-seed at 15 cm in Barpeta and row-to-row distance at 45 cm and seed-to-seed distance at 20 cm in Biswanath. Whole seed was sown for the experiment with a seed rate of 51 seeds per block for the ZTRM plots. A mulch cover of 6 inches using rice straw was maintained for all the plots under ZTRM. The experiment was

carried out on paddy fields after the harvest of paddy. For farmers' own practice cut seed was sown. Potato variety Kufri Pukhraj was sown for the experiment.

Harvesting of all the plots were done after 90 days of planting. Yield estimation was done using 5 harvesting sites in each replication of the treatments using a "W" pattern (CIP, 2006). Individual plants were considered as harvesting spots. A total of 15 plants were evaluated from the three replicates of each treatment for yield and quality of tubers. Moreover, the number of tubers in each site with the weight of the potato was estimated for yield. The following formula was used to estimate yield (CIP, 2006)

$$Average\ weight\ of\ the\ tubers = \frac{W1 + w2 + \cdots\cdots\cdots\cdots + W15}{Number\ of\ sample}$$

W= individual weight of the tubers per plant The per hectare yield was then calculated by calculating plant population per hectare and multiplied by average yield per plot.

$$Plant\ population\ per\ hectare = \frac{Area\ of\ one\ hectare\ plot\ (m2)}{Row\ to\ Row\ spacing\ X\ Seed\ to\ Seed\ spacing\ (m)}$$

The unutilized space per plot was eliminated to arrive at actual acreage for calculating the yield.

The potato variety, Kufri Pukhraj was taken for the experiment. Whole seed was planted for the experiment in the treatments under ZTRM. For the Farmer's conventional practice, the crop geometry was followed as per the farmer's own choice.

Statistical Analysis :

The yield data was analysed using Two-Way ANOVA with Tukey's multiple comparison test by using GraphPad Prism (Version 10) to see whether the treatments had any significance on the yield of potatoes. Data of all 5 harvest sites from Barpeta and Biswanath district were taken for analysis. Statistical analysis were performed within and across year of cultivation among treatment groups.

The experiment provided a better understanding of the new conservation agriculture-based technique and its impact on yield considering factor like irrigation during the crop cycle. Carrera, *et al*.,[4] reported that the conservation tillage has the advantage of providing higher net return compared to conventional tillage which validate the strategy of conservation tillage for potato cultivation.

The results found in the experiment shows an influence of irrigation in the crop. Therefore, the results of all the treatments are different with difference in irrigation scheduling (Table-1). The results shows that treatment 2 of ZTRM with one irrigation is superior to the other two treatments viz. treatment 1: ZTRM without irrigation and treatment 3: ZTRM with two irrigations at 45 and 60 days after planting and finally the treatment 4 which is farmer's own choice (Figure 1). The mulch cover used in the technique retains water as a result the single irrigation helps optimum use of water by the crop to give optimum yield[8]. The treatment 2 shows 13% more yield over treatment 1 and 15% more yield over treatment 3 and 18% more yield over treatment 4 in Barpeta (Figure 1a). Similar result was also observed in Biswanath where yield in treatment 2 was 13% more over treatment 1,

18% more over treatment 3 and 24% more over Treatment 4 (Figure 1b). While the mulch cover retains quite a good amount of soil moisture, the increasing number of irrigations as in Treatment 3 perhaps creates an excess water condition for potato to grow. Whereas the Treatment 1 could not provide optimum water supply for potato to give maximum yield at the time of tuber bulking. Karam, *et al*.,[6] reported a similar study of potato yield under various irrigation treatment and the study found that a water deficit condition during tuber bulking produces 12% less yield. In case of Treatment 4 the entire crop operation was managed by the farmers with variations in crop geometry, agronomic practices, time of sowing and importantly irrigation (Figure 1, 2). The nutrient scheduling was quite different from the schedule used in ZTRM.

While calculated the average yield for treatment 2, the per hectare yield was arrived at 22.9 MT in Barpeta (Figure 2a) and 23.1 MT in Biswanath (Figure 2b) which is found to be more than the yield achieved in Treatment 1, Treatment 3, and Treatment 4.

The Two-Way ANOVA with Tukey's multiple comparison test analysis results found in respective treatments show significant difference among the treatment means (Figure 1, 2). However, the location means were

Table-1. Average yield (g/plant) in Barpeta and Biswanath or all the treatments in 2021 and 2022

Treatments	2021		2022	
Treatments	Barpeta	Biswanath	Barpeta	Biswanath
Treatment 1	368.52	372.14	267.26	370.28
Treatment 2	424.29	431.82	226.98	430.77
Treatment 3	359.35	366.00	363.89	365.01
Treatment 4	180.02	207.64	179.22	209.1

Treatment 1 = Zero Tillage and Rice Straw Mulching without irrigation; Treatment 2 = Zero Tillage and Rice Straw Mulching with one irrigation; Treatment 3 = Zero Tillage and Rice Straw Mulching with two irrigations; Treatment 4 = Farmer's conventional practice

Table-2. ANOVA: Treatment mean and location means for Barpeta in 2021 and 2022.

	Df	Sum Sq	Mean Sq	F value	Pr (>F)
Location	1	10.010	10.010	0.854	0.423
Treatment	3	204847.508	68282.503	5828.553	0.000
Replication within location	4	13.943	3.486	1.621	0.232
Location x Treatment	3	35.146	11.715	5.450	0.013
Error	12	25.797	2.150	NA	NA

*Based on P-value obtained from the experiment (alpha=0.05) the treatment means are significantly different showing difference at least between one pair of the treatments. There is not enough evidence of significant difference between location means.

Table-3: ANOVA: Treatment mean and location mean for Biswanath in 2021 and 2022.

	Df	Sum Sq	Mean Sq	F value	Pr (>F)
Location	1	2.233	2.233	0.722	0.458
Treatment	3	163313.678	54437.893	17603.136	0.000
Replication within location	4	0.884	0.221	0.453	0.769
Location x Treatment	3	9.278	3.093	6.329	0.008
Error	12	5.863	0.489	NA	NA

*Based on P-value obtained from the experiment (alpha=0.05) the treatment means are significantly different showing difference at least between one pair of the treatments. There is not enough evidence of significant difference between location means.

homogeneous with no significant difference among the means. It gives a clear indication that the irrigation treatments have an influence on the yield of potatoes as found in the experiment (Figure 2). Thus, the mulch alone is not sufficient for providing water requirement to potatoes under ZTRM. Moreover, ZTRM is more efficient than the Conventional Tillage practice as found in the study.

The F-ratio signifies that the factor considered has significance and the yield achieved in the experiment per treatment is dependent of irrigation scheduling. As it is evident from the results that a single irrigation can considerably enhance yield of potato under ZTRM technique.

Water plays a pivotal role in crop growth. Sood *et al*.,[10] reported that the estimated water requirement for potato to grow is in the range of 350-650 mm. Generally, farmers in Assam avoid irrigation or follow minimum irrigation in potato crop owing to cost involve in it and lack of accessibility of such irrigation facility. The experiment and the treatments used has shown quite a good result for potato to grow under ZTRM. The yield of potato was considerably high in the treatment where one irrigation of 10 mm water was used. It has eventually reduced amount of water used to irrigate a plot. In normal situation, farmers use flood irrigation where water loss is unprecedented. But the ZTRM is a great tool to conserve both soil moisture and saves a huge amount of irrigation water. Which eventually, help farmers to save money involved in irrigation. Moreover, the tubers obtained in this method of cultivation has low mechanical damage. Moreover, it has advantage of time if considered the conventional practice of cultivation. The technique does not need soil preparation hence the crop can be advanced by a considerable time. Also, it saves land preparation cost for farmers making the practice cost effective.

The result from the study shows a clear advantage of irrigation in ZTRM with judicial use of water. Hence, it creates a ground for farmers to opt for this method considering low land holding in the state. Water being one factor deciding yield of the crop does not conclude influence of other factors. It would need a comprehensive study to

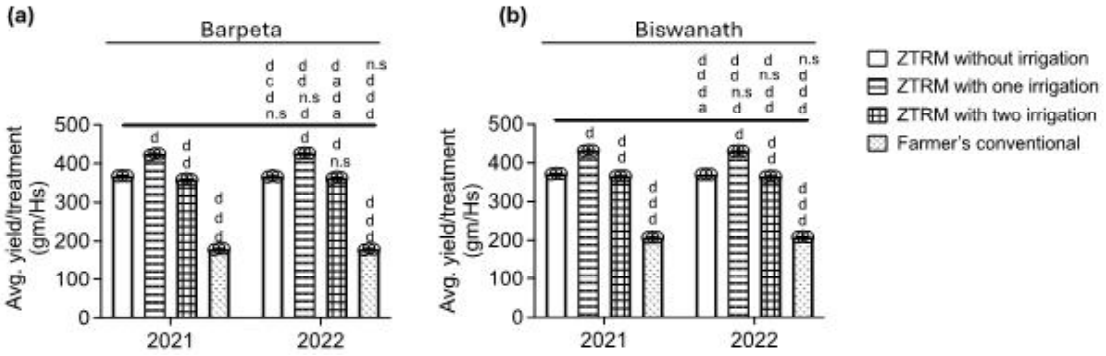

Figure 1: Effect of different irrigation treatment in potato yield under ZTRM of **(a)** Barpeta and **(b)** Biswanath districts. Data were analyzed by Two-Way ANOVA with Tukey's multiple comparison test. Average values of all 5 fields from **(a)** Barpeta and **(b)** Biswanath district were taken for analysis. a = p>0.05, c = p>0.001, d = p>0.0001. Statistical symbol in rows compared with lane 1, lane 2, lane 3 of same years. Statistical symbol above lane compared each lane of 2021 vs each lane of 2022.

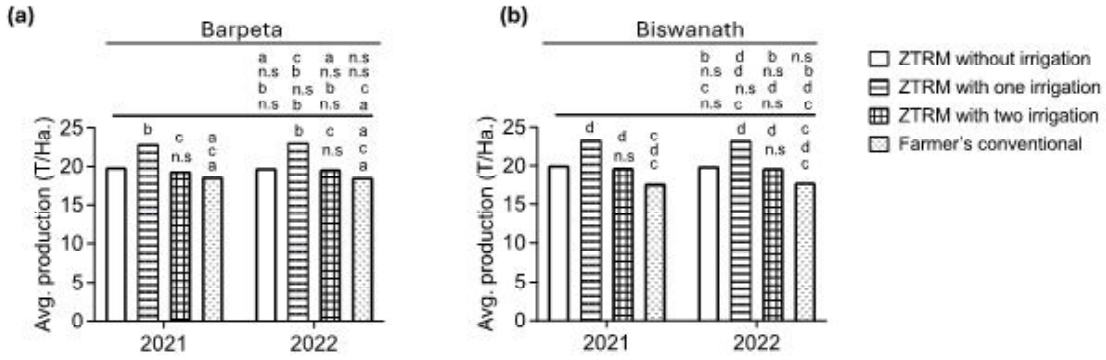

Figure 2: Potato yield under different treatment of ZTRM of **(a)** Barpeta and **(b)** Biswanath districts. Data were analyzed by Two-Way ANOVA with Tukey's multiple comparison test. Average yield values (T/Ha.) of all 5 fields from **(a)** Barpeta and **(b)** Biswanath district were taken for analysis. a = p>0.05, c = p>0.001, d = p>0.0001. Statistical symbol in rows compared with lane 1, lane 2, lane 3 of same years. Statistical symbol above lane compared each lane of 2021 vs each lane of 2022.

understand various other factors affecting yield potential of the crop under ZTRM technique.

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