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Effect of rice stubble management and planting density on establishment and productivity of forage oat under zero tillage conditions in rice fallows

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Abstract
India is a country where rice is the primary crop grown during the kharif season and there are vast amounts of crop residues produced 371 Mt annually. there is scope for planting rabi pulses or rabi fodder under zero-tillage systems. Therefore, an experiment was conducted to study the effect of rice stubble management and planting density on establishment and productivity of forage oat under zero tillage conditions at the experimental farm, CAU, Imphal during the *rabi* season of 2020, 2021 and 2022. The experiment was designed with a split-plot design replicated thrice. The treatment consists of four types of stubble cuts at different heights (10 cm, 25 cm, 40 cm), and no cutting of rice stubble as main plots, and three levels of seed rate (80, 100, and 120 kg/ha) as subplots. The plot treated with rice stubble bent without cutting recorded the highest number of tillers/m^2 (183). Among the main plots, maximum pooled green forage yield was obtained in the plot where bending of rice stubbles was performed (241.6 q/ha). Among the subplots, the seed rate of 120 kg/ha recorded the highest forage yield (184.96 g/ha). The dry matter yield was highest with bending of rice stubble without cutting (51.6 g/ha). The lowest was found in rice stubble cut at a height of 10 cm. The seed rate of 120 kg/ha recorded the maximum dry matter yield (39.42 g/ha). The highest pooled crude protein yield was found in the plot where rice straw was bent without cutting (4.25 q/ha).

Keywords: Rice stubble, zero tillage, fodder oats, productivity, quality

Introduction
India is a country where rice is the primary crop grown during the kharif season and also the main staple food consumed by approximately 65% of the total population. India is at the forefront in the largest rice-growing area, with 44.6 Million Hectares, and is second in rice production globally, after China. A considerable amount of crop residue is produced in India (371 Mt), contributing 51-57% annually, while wheat contributes 27-36% (Lohan *et al*., 2017; Venkatramanan *et al*., 2021) [16, 22]. India contributes 25% of the total rice straw produced in Asia (Bhuvaneshwari *et al*., 2019) [2], which reflects the significant role of rice and straw production in Asia and globally. After the harvest of kharif rice, the rice straw or stubbles are utilized minimally. Removal and processing should be completed within the 10-15 days available between the period of rice harvesting and sowing of the next succeeding crop (Thakur *et al*., 2018) [20]. Hence, the management of rice stubble and crop residue is a huge challenge for farmers (Gupta 2019) [8]. To overcome this issue, farmers often tend to burn the rice residue, resulting in a loss of biomass and contributing to environmental pollution (Thakur *et al*., 2018; Van Hung, 2020) [20, 21]. Straw burning emits particulate pollutants and greenhouse gases, substantially contributing to air pollution and posing a significant health hazard to humans, as well as environmental damage (Awasthi *et al*., 2010) [1]. After industrial and vehicular emissions, straw burning is the third most significant source of air pollution in many parts of the world (Gurjar *et al*., 2016) [9]. The residing population of Southeast Asia is exposed to excessive levels of air pollution as a result. Approximately 70-80% of crop residue is burnt in open fields due to a lack of alternative residue management practices, which cause greenhouse gas emissions and air pollution that are harmful to animal health and the environment (Lohan *et al*.,

2017; Chaudhary *et al*., 2019; Kumar *et al*., 2019) [16, 4, 15]. In India, rice straw burning typically occurs between October and November, coinciding with the onset of winter each year. The occurrence of dense fog and a significant amount of smoke generated from straw burning led to smog formation.

Methods and Materials

Sampling Location and Soil Properties

The present study was conducted at the CAU Experimental Farm, located in Andro, Manipur, India, at 24°45′ N latitude, 93°56′ E longitude, and an altitude of 790 m above mean sea level, during the Rabi seasons of 2020, 2021, and 2023. The site lies in the eastern Himalayan region (II) and sub-tropical (NEH-4) zone of Manipur, characterized by a sub-tropical climate with an average annual rainfall of 1212 mm. The soil order is Inceptisols, characterized by a clayey texture and an acidic pH (5.8), with medium available Nitrogen (270 N/kg), Phosphorus (18.8 P2O5 kg/ha), Potassium (226.3 K2O), and organic carbon (1.1%).

Fertilizer Treatment and Agriculture Management

The experiment was laid out in a split-plot design, replicated three times, and the treatments are as follows.

T1S1	Rice stubble at 10 cm above ground level + 80 kg/ha seed rate
T1S2	Rice stubble at 10 cm above ground level + 100 kg/ha seed rate
T1S3	Rice stubble at 10 cm above ground level + 120 kg/ha seed rate
T2S1	Rice stubble at 25 cm above ground level + 80 kg/ha seed rate
T2S2	Rice stubble at 25 cm above ground level + 100 kg/ha seed rate
T2S3	Rice stubble at 25 cm above ground level + 120 kg/ha seed rate
T3S1	Rice stubble at 40 cm above ground level + 80 kg/ha seed rate
T3S2	Rice stubble at 40 cm above ground level + 100 kg/ha seed rate
T3S3	Rice stubble at 40 cm above ground level + 120 kg/ha seed rate
T4S1	Bending of rice stubble (without cutting) + 80 kg/ha seed rate
T4S2	Bending of rice stubble (without cutting) + 100 kg/ha seed rate
T4S3	Bending of rice stubble (without cutting) + 120 kg/ha seed rate

Treatment imposition

During *the Kharif season*, the rice crop variety CAU R-4 (a tall variety) was grown with the recommended dose of fertilizer (60:40 N:P). The crop was harvested in the last week of November. During the harvesting time of rice, the treatment imposition for oat planting was done with four different levels of cutting of rice stubble at different heights, i.e., 10 cm, 25 cm, 40 cm, and bending of rice stubble without cutting. Later, during the first week of December, oat variety JHO-822 was sown by broadcasting in each plot at different seed rates (80, 100, and 120 kg/ha) with the recommended dose of fertilizer.

Plant sampling

Using a meter scale, the height of the randomly chosen plant samples was measured from ground level to the tip of the plant. The green fodder yield was calculated by weighing the green fodder harvested from the net plot and converting it to tons per hectare. At the same time, 500 g of randomly selected fodder was taken from each net plot, chopped thoroughly, and then dried in the sun and oven-dried at 65-70°C until a constant weight was reached. The yields of the green fodder were converted into dry matter yield, which was then expressed as t/ha. The crude protein content of the fodder was calculated by multiplying the nitrogen content (%) of the produce in each plot by a factor of 6.25.

Economic Analysis

The current market values of the produce during the experimental year were taken into account for calculating the treatment-wise gross monetary returns. The cultivation cost was deducted from the corresponding treatment's gross return to determine the net return. The benefit-cost ratio of each treatment was determined by dividing the gross return by the cultivation cost of the corresponding treatments. This is represented as the net returns in rupees per hectare.

Statistical Analysis

Fisher's method of analysis of variance (ANOVA) was employed to statistically evaluate and interpr*et al*l data related to the current inquiry, as described by Gomez and Gomez. However, 5% probability levels were used to analyze the results. Values for critical differences were computed in cases where the 'F' test was deemed significant. As recommended by Gomez and Gomez at a 5% probability level of significance, the treatment means were compared after critical differences (CD).

Principal Component Analysis and Correlation Analysis

The obtained experimental data were analyzed using the multivariate analysis software OriginPro (version 2021, OriginLab Corporation, Northampton, MA, USA). All of the datasets were standardized to unit variance (Kaiser, 1958) [12]. Pearson correlation analysis was also conducted to identify any relationship between parameters at a $p \leq 0.05$ significance level, and the results are represented graphically by a color-coded heat map correlation matrix (Friendly, 2002) [6]. PCA was performed using the covariance matrix approach, whereby eigenvalues greater than 1.0 were considered in determining the components to retain (Kaiser, 1960) [13]. Results were presented as a biplot that included treatment combinations (T1S1 to T4S3) using standard procedures in the agricultural data analysis (Jolliffe and Cadima, 2016; Gabriel, 1971) [11, 7].

Growth attributes

Plant height (cm)

The plant height was significantly influenced by rice stubble management during all experimental years and their pooled mean. The crop grown under T4 (complete stubble removal/burning + better seedbed conditions) attained the maximum pooled height, *i.e*., 122.7 cm, followed by T3 (119.2 cm). In contrast, the lowest plant height was observed under T1, which recorded 106.6 cm, where stubble was left unmanaged. Improved plant height under proper stubble management may be attributed to favorable soil tilth, enhanced nutrient availability, and application of crop residue (Dinesh *et al*., 2024) [5]. Similar findings were reported in previous studies on fodder oats and barley, where zero-tillage after residue management improved crop vigor. Seed rate levels showed slight effects. Taller plants were recorded under higher seed rates (S2 and S3 pooled 116-117 cm) compared to the lowest seed rate, S1 (113.4 cm) (Table 1). However, differences were not statistically significant in most years except in 2019. The higher plant height resulting from an increase in seed rate may be due to competition for light and nutrients among the plants. A similar finding was also reported by Sadig (2014) and Dawit and Teklu (2014). However, the interaction effects were non-significant.

No. of Tillers/m²

The no. of tillers/m² was strongly affected by stubble management. The highest tiller density was obtained with T4 (182.7 tillers/m² pooled), followed by T3 (177.8), while the lowest was under T1 (149.5). Seed rates significantly influenced tiller density, with more tillers recorded at moderate S2 and higher S3 (170 tillers/m² pooled), compared to S1 (Table 1). The improvement in tillering under T4 and higher seed rates can be attributed to better crop establishment, optimal nutrient mineralization from residues, and an adequate plant population due to the higher seed rate.

Table 1: Plant Height and Number of Tillers per Square Meter of Forage Oat Under Rice Stubble Management and Seed Rate Treatments Across Years (2019-2021) in Zero Tillage Rice Fallows

Treatment	Plant height (cm)				No. of tillers/m²			
	2019	2020	2021	Pooled	2019	2020	2021	Pooled
A. Rice Stubble Management								
T1	110.8	108.6	100.6	106.6	141.5	164.0	143.0	149.5
T2	110.4	116.6	113.8	113.6	164.8	175.2	169.2	169.7
T3	114.4	123.4	120.0	119.2	175.2	179.2	179.0	177.8
T4	115.2	129.0	124.0	122.7	188.1	181.2	179.0	182.7
S.Em(±)	1.71	2.22	2.35	1.35	0.64	1.74	0.63	0.63
CD 5%	5.91	7.70	8.15	4.66	2.22	6.01	2.19	2.19
B. Seed rate								
S1	110.25	117.37	112.71	113.44	169.67	168.17	170	169
S2	112.75	119.32	116.06	116.05	167.59	176.25	167	170
S3	114.78	121.53	115.11	117.14	165	180.33	165	170
S.Em(±)	1.56	1.69	1.74	1.21	0.64	2.29	0.64	0.86
CD 5%	4.68	NS	NS	NS	1.92	6.88	1.93	3.58
C. Interaction								
Rice Stubble Management at the Seed Rate Level								
S.Em(±)	3.07	3.54	3.69	2.4	1.23	4.13	1.23	1.54
CD 5%	9.64	NS	NS	NS	3.84	NS	NS	NS
Seed rate at Rice Stubble Management								
S.Em(±)	3.12	3.38	3.48	2.43	1.28	4.59	1.29	1.72
CD 5%	9.37	NS	NS	NS	NS	NS	NS	NS

Yield Attributes

Green Forage Yield (q/ha)

The rice stubble management had a profound impact on fodder yield. The highest pooled green forage yield was observed under T4 (241.6 q/ha), which was 2.1 times higher than that of T1 (115.2 q/ha). T3 (191.1 q/ha) and T2 (147.7 q/ha) were intermediate (Table 2). In the case of seed rate, the green fodder yield was significantly influenced. The pooled yield increased from S1 (162.6 q/ha) to S2 (174.1 q/ha) and was highest in S3 (185 q/ha). This signified that a higher seed rate resulted in a higher plant density, indicating a close relationship between forage yield and seed rate. A similar finding was reported by Budakli *et al.* (2010) [3]. The interaction between stubble management and seed rate was significant in some years.

Dry Matter Yield (q/ha)

The trend was similar to green forage yield, with T4 recording the maximum pooled dry matter yield (51.6 q/ha), while T1 produced the lowest (23.4 q/ha) (Table 2). The improvement in dry matter yield with the retention of crop residue was reported by Mohammad *et al.* (2014) [17]. The seed rate effect showed that S2 and S3 significantly outperformed S1, although the differences between S2 and S3 were marginal. The higher green forage and dry matter yield under T4 may be explained by enhanced growth (plant height, tillers) and biomass contribution under favorable soil conditions. In contrast, higher seed rates increased ground cover and forage accumulation. The higher dry matter yield with an increase in seed rate of maize was also reported by Iqbal *et al.* (2009) [10].

Table 2: Green Forage Yield and Dry Matter Yield of Forage Oat Under Rice Stubble Management and Seed Rate Treatments Across Years (2019-2021) in Zero Tillage Rice Fallows

Treatment	Green forage yield (q/ha)				Dry matter yield (q/ha)			
	2019	2020	2021	Pooled	2019	2020	2021	Pooled
A. Rice Stubble Management								
T1	120.19	116.71	108.6	115.17	23.85	24.08	22.12	23.35
T2	164.35	147.63	131.08	147.69	34.65	33.45	32.35	33.48
T3	213.36	183.16	176.75	191.09	43.14	43.6	37.99	41.58
T4	262.93	238.5	223.37	241.6	53.08	51.91	49.72	51.57
S.Em(±)	1.72	2.02	0.66	0.69	0.48	2.32	0.28	0.82
CD 5%	5.95	6.99	2.28	2.37	1.66	8.03	0.97	2.83
B. Seed rate								
S1	179.22	163.41	145.14	162.59	35.58	34.58	32.25	34.14
S2	190.42	169.14	162.78	174.11	40.32	40.95	35.49	38.92
S3	200.98	181.96	171.93	184.96	40.14	39.24	38.89	39.42
S.Em(±)	1.15	2.28	0.49	0.94	0.54	1.7	0.55	0.7
CD 5%	3.45	6.84	1.46	2.82	1.61	5.1	1.66	2.09
C. Interaction								
Rice Stubble Management at the Seed Rate Level								
S.Em(±)	2.55	4.24	1.03	1.68	1	3.62	0.95	1.4
CD 5%	8.17	NS	3.29	5.17	3.11	NS	2.87	4.42
Seed rate at Rice Stubble Management								
S.Em(±)	2.3	4.56	0.97	1.88	1.08	3.41	1.11	1.4
CD 5%	6.9	NS	2.91	5.64	3.23	NS	3.32	4.19

Quality Parameters

Crude Protein Yield (q/ha)

Management of rice stubble cutting at different heights significantly increased crude protein yield. The pooled maximum was observed at T4 (4.25 q/ha), followed by T3 (3.36 q/ha), while the lowest was at T1 (1.86 q/ha) (Table 3). A positive effect on the crude protein yield of oats with residue retention of rice stubble was also reported by Sunita *et al*. (2024) [19]. Seed rates also showed significant influence, where S3 produced the highest crude protein yield (3.26 q/ha), compared to S1 (2.76). Murali *et al*. (2021) [18] reported a higher crude protein yield at a higher seed rate.

Crude Protein Content (%)

The crude protein percentage in oats ranged from 8.0 to 8.26% pooled and remained relatively stable across treatments. Though some yearly variation occurred in all three years of the experiment (significant in 2021), overall trends indicated that stubble management enhanced total protein yield more through biomass improvement than through changes in protein concentration. Cutting rice stubble at a higher height influences the soil organic matter and nutrient cycle, as well as the microclimate of the subsequent crops, thereby optimizing nutrient absorption and plant quality of the succeeding crops (Wenju *et al*., 2024) [23].

Table 3: Crude Protein Yield and Content of Forage Oat Under Rice Stubble Management and Seed Rate Treatments Across Years (2019-2021) in Zero Tillage Rice Fallows

Treatment	Crude protein yield (q/ha)				Crude protein content (%)			
	2019	2020	2021	Pooled	2019	2020	2021	Pooled
A. Rice Stubble Management								
T1	3.8	1.83	1.96	1.86	7.55	7.59	8.87	8
T2	2.63	2.53	2.89	2.68	7.6	7.56	8.95	8.03
T3	3.34	3.37	3.37	3.36	7.75	7.73	8.86	8.11
T4	4.16	4.02	4.57	4.25	7.81	7.78	9.18	8.26
S.Em(±)	0.07	0.18	0.03	0.07	0.08	0.25	0.04	0.09
CD 5%	0.23	0.62	0.1	0.26	NS	NS	0.14	NS
B. Seed rate								
S1	2.74	2.67	2.88	2.76	7.69	7.7	8.89	8.09
S2	3.03	3.06	3.22	3.1	7.47	7.46	9.03	7.99
S3	4.68	3.09	3.5	3.26	7.87	7.84	8.96	8.22
S.Em(±)	0.04	0.15	0.05	0.06	0.04	0.16	0.05	0.06
CD 5%	0.12	NS	0.14	0.18	0.13	NS	NS	NS
C. Interaction								
Rice Stubble Management at the Seed Rate Level								
S.Em(±)	0.09	0.3	0.08	0.12	0.1	0.36	0.09	0.13
CD 5%	0.3	NS	0.25	0.39	0.33	NS	NS	NS
Seed rate at Rice Stubble Management								
S.Em(±)	0.08	0.29	0.1	0.12	0.09	0.31	0.1	0.12
CD 5%	0.24	NS	0.29	0.36	0.26	NS	NS	NS

Economics

The Economic analysis highlighted the superiority of proper stubble management across pooled data. T4 recorded the highest gross return (₹48,320/ha) and net return (₹27,608/ha), along with a maximum B:C ratio of 1.62, followed by T3 (₹17,506 net return, B:C 1.07) and lowest profitability was in T1 (₹2,321 net return; B:C 0.25) (Table 4). The higher gross return, net return, and B:C ratio in T4 may be attributed to the higher yield production achieved through retention bending of rice stubble, rather than cutting. Among seed rates, S3 provided the highest pooled gross return (₹36,991/ha) and net return (₹15,213/ha), which S2 closely follows, while S1 recorded the least. The B:C ratio remained around 0.87-0.90 for higher seed rates, significantly better than S1. Interactions were mainly non-significant, indicating that the effect of stubble management dominated that of seed rate. The superior returns in T4 resulted directly from enhanced biomass and protein yields, which translated into marketable output. In contrast, poor stubble handling (T1) led to uneconomic production. Retention of rice stubble residue results in an increase in net return and B:C due to higher yields, as reported by Khankhane *et al*. (2009) [14].

Table 4: Economic Performance of Forage Oat Under Rice Stubble Management and Seed Rate Treatments Across Years (2019-2021) in Zero Tillage Rice Fallows

Treatment	Gross return (Rs./ha)				Net return (Rs./ha)				B:C ratio			
	2019	2020	2021	Pooled	2019	2020	2021	Pooled	2019	2020	2021	Pooled
A. Rice Stubble Management												
T1	24038	23342	21720	23033	5608	4912	3290	2321	0.3	0.27	0.18	0.25
T2	32870	29525	26216	29537	14440	11095	7786	8825	0.78	0.6	0.42	0.6
T3	42672	36632	35351	38218	24242	18202	16921	17506	1.32	0.99	0.91	1.07
T4	52586	47701	44673	48320	34156	29271	26243	27608	1.85	1.59	1.43	1.62
S.Em(±)	344	404	132	137	344	404	132	137	0.02	0.02	0.01	0.01
CD 5%	1191	1398	456	475	1191	1398	456	475	0.07	0.08	0.02	0.03
B. Seed rate												
S1	35844	32682	29028	32518	18414	15252	11598	12873	1.06	0.88	0.67	0.87
S2	38085	33827	32555	34822	19655	15397	14125	14110	1.07	0.84	0.77	0.89
S3	40195	36391	34387	36991	20765	16961	14957	15213	1.07	0.87	0.77	0.9
S.Em(±)	230	456	97	188	230	456	97	188	0.01	0.02	0.01	0.01
CD 5%	690	1367	291	564	690	NS	291	564	NS	NS	0.02	0.03

C. Interaction												
Rice Stubble Management at the Seed Rate Level												
S.Em(±)	510	847	206	336	510	847	206	336	0.03	0.05	0.01	0.02
CD 5%	1635	NS	657	1034	1635	NS	657	1034	0.09	NS	0.04	NS
Seed rate at Rice Stubble Management												
S.Em(±)	460	912	194	376	460	912	194	376	0.03	0.05	0.01	0.02
CD 5%	1380	NS	583	1127	1380	NS	583	1127	0.08	NS	0.03	NS

Correlation analysis and Principal Component Analysis

Based on the correlation matrix data, the research found strong positive correlations between most of the parameters related to productivity of forage oat grown under ZT conditions with rice stubble management (Fig. 1). These data provided a strong indication that plant stature had the exceptionally high correlations (r = 0.93-0.97) with the tillering capacity, the forage yields, and economic returns, so that taller oat plants were much more regularly the more productive and more profitable. Interestingly, tillers per square meter were significantly correlated with both green and dry matter yields (r = 0.90 for both), indicating that increased tillering directly correlates with improved productivity. All three economic parameters (gross and net returns, and benefit-cost ratio) correlated moderately to highly with all yield parameters (0.84-1.00), implying that practices that encourage greater forage production, specifically bending rice stubble without cutting it together with optimum seeding rates of 100-120 kg/ha, are more economically viable. There were moderate correlations between crude protein content and other parameters, however (r = 0.49-0.71), suggesting that although a significant yield increase can be achieved through appropriate stubble management, improving protein quality would need further consideration beyond the stubble management practices tested in this study.

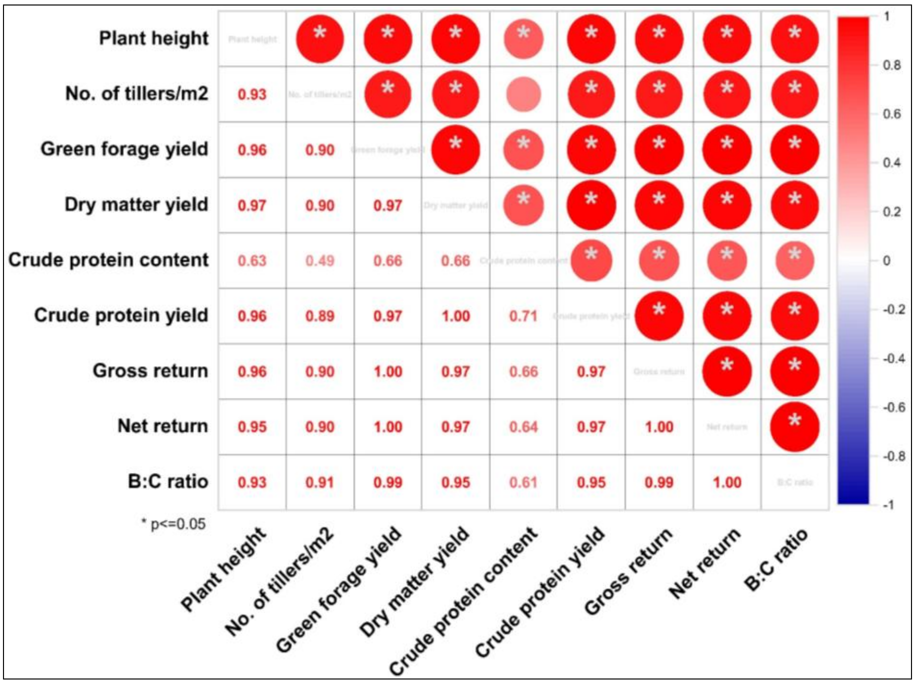

Fig 1: Correlation analysis between the plant growth parameters and economic attributes

The first two principal components of Principal Component Analysis (PCA) explained 97% of the total variation in the data (PC1- 90.4%, PC 2- 6.6%) (Table 5), which indicated good second dimension reduction and good differentiation of treatments in the performance of forage oat under the different rice stubble management practices (Fig. 2). PC1 distinguished treatments primarily based on overall productivity with most yield and growth parameters loading positively on the right, and PC2 separated treatments based on protein quality characteristics. Interestingly, T3S3, T3S1, and T4S3 treatments were clustering in the positive quadrant with crude protein content and crude protein yield, implying that moderate stubble cutting at 40cm height (T3) coupled with seeding rates and high seeding rate combined with a stubble bending (T4S3) technique is optimal to support protein quality parameters. The location of these combination regimens provides evidence that these combinations provided an excellent ratio of quantitative productivity to qualitative protein enrichment. The isolation of the crude protein content and the crude protein yield in relation to other productivity parameters, alongside PC2, shows that protein quality responds to different management variables compared to biomass production. The 40cm stubble height has a specific inclination towards optimizing protein quality. The PCA eloquently explains the trade off system of zero-tillage forage production, illustrating that stubble bending may maximize total output. However, moderate stubble cutting at a 40cm height may be beneficial in meeting protein quality objectives, suggesting that zero-tillage rice-fallow forage production system management decisions should consider both quantitative and quality yield objectives.

Table 5: Variance and Eigenvalue values through Principal Component Analysis

Principal Component Number	Eigenvalue	Percentage of Variance (%)	Cumulative (%)
1	8.13969	90.44102	90.44102
2	0.59077	6.56416	97.00518
3	0.14053	1.56142	98.5666
4	0.08675	0.96384	99.53044
5	0.03394	0.3771	99.90754
6	0.00789	0.08763	99.99516
7	4.09E-04	0.00454	99.99971
8	2.65E-05	2.94E-04	100
9	1.67E-09	1.86E-08	100

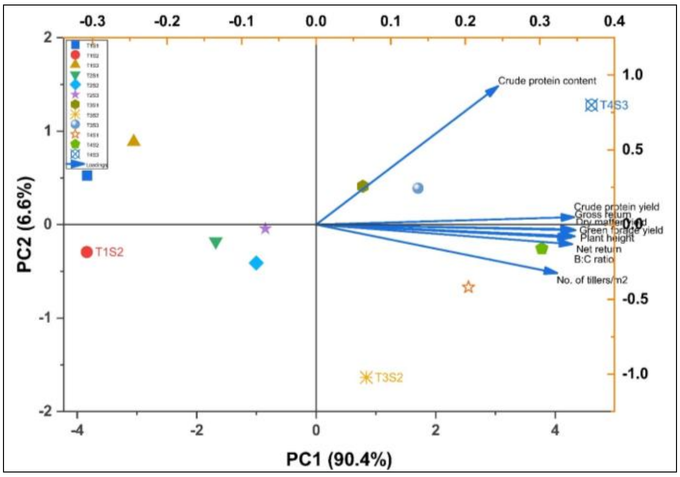

Fig 2: Principal Component analysis between the plant growth parameters and economic attributes

Summary and Conclusion

Rice is the major crop in India, which faces significant challenges in managing rice straw and stubble residue after harvest, primarily due to the short interval between harvesting and sowing of succeeding crops. The experimental findings indicate that retaining rice straw at a higher length of cutting or bending, without cutting, with a proper seed rate, can considerably improve the growth and performance of the succeeding crop, oat. Specifically, the plot treated with bending of rice stubble without cutting showed significant improvement in green fodder yield, dry matter content, and crude protein yield compared to lower cutting heights. Additionally, a higher seed rate also contributed to better plant growth and an increase in oat yield. However, the differences were not always statistically significant. Rice stubble management, especially bending without cutting followed by cutting at a higher length from above ground with a proper seed rate, leads to superior growth and economic returns for the subsequent oat cultivation. It also refers to the improved nutrient availability from managed residue, which promotes greater productivity and results in a rise in forage yield, dry matter accumulation, and crude protein yield. The optimum seed rate further enhances the benefits by increasing plant density and yield potential. This experiment highlights the importance of integrating effective stubble management and an appropriate seed rate to maximize the productivity and profitability of oats following rice cultivation.

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Author contributions

R. Joseph Koireng: Conception and Design, Supervision, Bidyapati Ngangom: Data Acquisition, Writing Publication, Critical Revision of Publication, Punabati Heisnam: Technical, Material Support, Yengkhom Linthoingambi: Data acquisition, Resources, G K Dinesh: Review, Editing, Analysis, Software and Writing, Tanu Oinam: Analysis and Interpretation of Data, Writing Publication

Conflict of Interest

The authors declare that they have no conflict of interest.

Ethics approval

Not applicable.

AI tool usage declaration

The authors did not use any AI and related tools to write this manuscript. For English language improvement, Grammarly software is used.

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