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# Effect of Straw Management Practices & Nitrogen Application on Straw Decomposition

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**Abstract**

An experiment was conducted on "Effect of Straw Management Practices & Nitrogen Application on Straw Decomposition" during rabi, 2023-23 in different blocks of Sultanpur district, U.P.. The experiment was laid out in randomized block design with factorial concept (FRBD) with three replications. Two paddy straw management options viz., paddy straw incorporation without phosphorous and paddy straw incorporation with phosphorous and four nitrogen levels viz., 100% RDN, 110% RDN, 115% RDN and 120% RDN were adopted, thus a total of 8 treatments were imposed. Nylon bag with 32 g of paddy straw was incorporated in paddy straw incorporation treatments at the time of transplanting and the rate of decomposition was recorded for every 15 days interval. Phosphorus showed a significant effect on decomposition. Incorporation of paddy straw with phosphorus resulted in decomposition of 42.4% paddy straw whereas incorporation without phosphorus resulted in the decomposition of 37.53% of paddy straw. The effect of nitrogen levels on paddy straw decomposition was found to be significant at 15 DAT, 30 DAT and at later stages no significant difference was observed.

**Keywords:** Decomposition, incorporation, paddy straw, nylon bag

## Introduction

Paddy straw, a byproduct of rice cultivation, is a crucial component of agricultural systems due to its high organic matter content and potential for nutrient recycling. Produced in significant quantities across rice-growing regions, paddy straw represents an abundant renewable resource with considerable importance in maintaining soil health and fertility. However, the management of paddy straw poses significant challenges, particularly in regions with intensive rice cultivation. Improper disposal practices, such as open-field burning (Bhuvaneshwari *et al*., 2019), are commonly employed for quick removal, but these contribute to severe environmental issues. The practice releases substantial amounts of greenhouse gases, such as carbon dioxide and methane, and harmful particulate matter, which exacerbate air pollution and impact public health Lohan *et al*. (2018). Furthermore, burning residues lead to the loss of valuable nutrients and organic matter, which are critical for sustaining soil productivity (Smitha *et al*., 2019).

Recognizing these challenges, researchers and practitioners are increasingly emphasizing sustainable alternatives for paddy straw management. Effective strategies include off-field utilization, such as the production of bioenergy, biochar, and animal feed, as well as in-situ approaches like mulching, composting, and soil incorporation for decomposition. Among these, the promotion of in-situ decomposition has gained significant attention due to its dual benefits: recycling nutrients back into the soil and reducing the environmental footprint of residue management. Proper decomposition of paddy straw enriches soil organic matter, enhances microbial activity, and supports the long-term sustainability of agricultural ecosystems.

To understand the decomposition process and its impact on nutrient cycling, the nylon mesh bag technique has emerged as a valuable tool in both research and practical applications. This method involves enclosing paddy straw in permeable nylon mesh bags that facilitate microbial activity, moisture retention, and nutrient exchange while preventing the loss of decomposing fragments. The controlled yet dynamic environment created by this technique allows researchers to systematically monitor the decomposition process over time. Key parameters, such as the rate of straw degradation, nutrient release patterns, and the influence of environmental factors like temperature, moisture, and microbial populations, can be effectively studied using this approach. Additionally, the technique ensures consistency and replicability across experiments, making it an indispensable tool for residue management research.

In this study, the nylon mesh bag technique was employed to investigate the decomposition of paddy straw under specific experimental conditions. By analyzing the rate of straw degradation and biomass loss, this study aims to provide insights into optimizing paddy straw management practices

## Material and Methods

The Crop Residue Management Scheme is a central government project in India that helps farmers manage farm stubble without burning it. CRM Project running from 2021 to till date at KVK, Hardoi-II.

**Key Project Details**

- **Goal:** Stop stubble burning, reduce air pollution, and turn waste into income.
- **Timeline:** Running actively through the 2026–2027 period.
- **Subsidies:** Individual farmers get a 50% subsidy on stubble machines. Custom Hiring Centers (CHCs) get an 80% subsidy to rent out tools cheaply.
- **Equipment:** Subsidies cover tools like Happy Seeders, Super Seeders, balers, and rakers.

**Management Techniques**

- **In-situ Management:** Mixing crop stubble back into the soil or using it as a mulch layer directly in the field using machines.
- **Ex-situ Management:** Collecting, baling, and transporting straw away from fields to power plants, bio-CNG units, and industrial ethanol plants.

**Benefits of the Project**

- **Better Soil:** Retaining organic residue adds vital nutrients like nitrogen and potassium back into the earth.
- **Moisture Control:** Residue layers trap soil water and prevent wind or water erosion.
- **Cleaner Air:** Prevents massive seasonal carbon emissions and toxic smog in northern regions.

The soil of the experimental site was clay loam, which is low in organic carbon (0.4%), low in soil available nitrogen 150.56 kg $ha^{-1}$, medium in soil available phosphorus (15.05kg $ha^{-1}$) and high in potassium (305.5kg $ha^{-1}$). The experiment was laid out in Factorial RBD, with 2 factors, factor 1 comprised of 2 levels and factor 2 comprised of 4 levels with a total of 8 treatments and replicated thrice. Paddy straw mulcher was run to chop it and is incorporated 10 days before transplanting. Paddy (variety- CSR 36) was transplanted with a spacing of 20x10cm. The recommended dose of fertilizer was 150:60:40 kg N, $P_2O_5$, $K_2O$ $ha^{-1}$. The entire recommended dose of phosphorus was applied to only those treatments with phosphorus application in the form of SSP and no phosphorus was applied to the treatments designated as without phosphorus and potassium was applied as basal dose as MOP. Nitrogen was applied in 3 splits and the excess of RDN was applied at basal in the form of urea.

**Table 1:** Treatment details

| | |
|---|---|
| $T_1$ | 100% RDN + Residue incorporation without phosphorus |
| $T_2$ | 10% excess N over RDN + Residue incorporation without phosphorus |
| $T_3$ | 15% excess N over RDN + Residue incorporation without phosphorus |
| $T_4$ | 20% excess N over RDN + Residue incorporation without phosphorus |
| $T_5$ | 100% RDN + Residue incorporation with P application through SSP |
| $T_6$ | 10% excess N over RDN + Residue incorporation with P application through SSP |
| $T_7$ | 15% excess N over RDN + Residue incorporation with P application through SSP |
| $T_8$ | 20% excess N over RDN + Residue incorporation with P application through SSP |

Nylon mesh bag technique Bocock and Gilbert (1957) [2] developed litter bag method to study decomposition processes of plant residues under field conditions. Paddy straw enclosed in a litter bag made from nylon mesh bags of size 11”×8” and mesh size about 2 mm constituting about 32 grams of straw was incorporated into soil at 15 cm depth in treatments with incorporation of paddy straw. About 6 such bags were buried in each paddy straw incorporated treatments. Single bag was removed from each such treatments for every 15 days interval and was washed properly, shade dried and oven dried for 5 days. Later weight of bags were taken to study the percent of decomposition.

$$\text{Percentage of decomposition} = \frac{\text{Initial weight-final weight}}{\text{Initial weight}} \times 100$$

**Results and Discussion**

The rate of decomposition of paddy straw was measured by loss of biomass is depicted in Table 2. The results showed that biomass of paddy straw decreased gradually as the decomposition rate increased over time. The straw mass decreased by 1.48 g, 3.63g, 9.88g, 10.2g, 10.46g and 12.01g after 15, 30, 45, 60, 75 days after transplanting and after harvest of *rabi* rice which corresponds to loss of 4.6%, 11.3%, 30.9%, 31.9%, 32.7% and 37.5% respectively in paddy straw incorporated treatments without phosphorus. While in paddy straw incorporated treatments with phosphorus the straw mass decreased by 2.43 g, 4.96 g, 11.08 g, 11.35 g, 11.56g and 13.57 g after 15, 30, 45, 60, 75 days after transplanting and after harvest of rabi rice respectively which corresponds to loss of 7.60%, 15.5%, 34.62%, 35.47%, 36.12% and 42.40% respectively in paddy straw incorporated treatments with phosphorus. The rate of decomposition was higher in paddy straw incorporation with phosphorus. Many researchers have reported that the rate of decomposition trend was faster during initial stage but it slowed down at later stages It is in consistent with the results of this study. Liu *et al*. (2006) reported that nitrogen addition alone or in combination with phosphorous triggered the rate of decomposition of *Allium bidentatum* and *Stipa krylovii*. The increase in rate of decomposition of paddy straw with increase in nitrogen levels and phosphorus is consistent with the reports of Thirukumaran and Paskinson, (2002), Rezig *et al*. (2014). This may be due to increased enzymatic activities of N- acetyl- glucosamidase and Leucine aminopeptidase by application of exogenous nitrogen fertilizer in the early stage of paddy straw decomposition (Guo *et al*., 2018). Chen *et al*. (2016) reported that addition of inorganic phosphorus stimulated residue decomposition suggesting that there exists a positive relationship between phosphorus input to soil and soil nutrient mineralization in phosphorus limited soils.

**Table 2:** Effect of different *kharif* paddy straw management options and fertilizer N levels on rate of decomposition (%) of paddy straw at different intervals of *rabi* rice

| Treatments | 15 DAT | 30 DAT | 45 DAT | 60 DAT | 75 DAT | After Harvest |
|---|---|---|---|---|---|---|
| Paddy straw management | | | | | | |
| I-P | 4.63 | 11.31 | 30.88 | 31.75 | 32.69 | 37.53 |
| I+P | 7.59 | 15.47 | 34.63 | 35.38 | 36.13 | 42.41 |
| SEm± | 0.29 | 0.48 | 0.85 | 0.98 | 0.82 | 0.98 |
| CD@5% | 0.90 | 1.15 | 2.57 | 2.96 | 2.50 | 2.97 |
| Nitrogen levels | | | | | | |
| 100% RDN | 5.22 | 11.97 | 30.84 | 31.84 | 32.97 | 38.31 |
| 110% RDN | 5.69 | 12.40 | 32.56 | 33.47 | 34.03 | 39.44 |
| 115% RDN | 6.13 | 14.16 | 33.22 | 33.88 | 34.75 | 40.69 |
| 120% RDN | 7.44 | 15.03 | 34.38 | 35.09 | 35.84 | 41.47 |
| SEm± | 0.42 | 0.67 | 1.19 | 1.38 | 1.16 | 1.38 |
| CD@5% | 1.28 | 2.04 | NS | NS | NS | NS |
| Interactions | | | | | | |
| SEm± | 0.59 | 0.95 | 1.69 | 1.95 | 1.65 | 1.96 |
| CD @5% | NS | NS | NS | NS | NS | NS |
| CV | 16.87 | 12.32 | 8.95 | 10.10 | 8.28 | 8.47 |

I-P- incorporation without phosphorus, I+P- incorporation with phosphorus, RDN- recommended dose of nitrogen

Paddy straw is a lignocellulosic biomass consists of 36-37% cellulose, 23-24% hemicelluloses and 15-16% lignin (Viji and Neelanarayanan, 2015) [24]. Yan *et al*. (2019) studied on paddy straw decomposition and observed that fastest rate of residue decomposition occurred during first 15 days which might be due to increased nitrogen supply increases the loss of cellulose (Talbot and Treseder, 2012) [20]. In a similar study done by Prasad *et al*. (2010) about 38% of straw was decomposed within 2 weeks of incorporation. Mishra *et al*. (2001) noted that the rate of decomposition during first five weeks relatively faster and about 38% of rice residue decomposed during first phase. In our study the maximum loss of paddy straw was observed between 30-45 DAT where nitrogen immobilization was completed and mineralization process started. By the day 45 after transplanting 30.9 % and 34.62% of paddy straw decomposed under incorporation without phosphorus and with phosphorus respectively. (Fig. 1) The rate of mass loss was slower after 45 DAT. Effect of nitrogen levels on mass loss of paddy straw during decomposition was found to be significant during 15 and 30 DAT, later stages of decomposition was found to be non significant (Table. 2 and Fig. 2). The increase in rate of paddy straw decomposition with nitrogen application was reported (Kalkhajeh *et al*. 2021) [8] and Zheng *et al*. 2023).

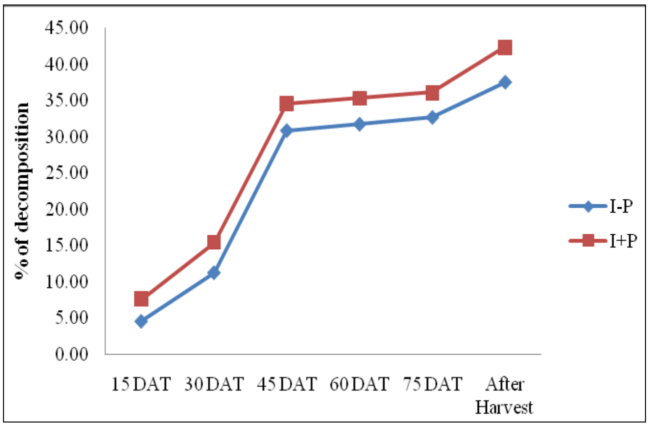


**Fig 1:** Percent of decomposition of paddy straw as influenced by paddy straw management

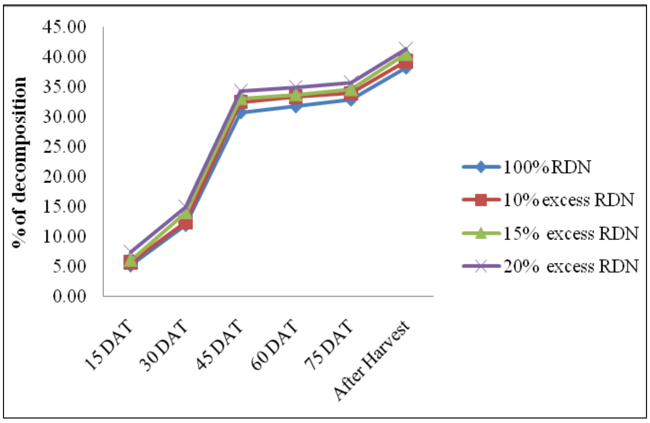


**Fig 2:** Percent of decomposition of paddy straw as influenced by different levels of nitrogen

Decomposition is a microbial mediated process and the activity of microorganisms is largely dependent on both climatic conditions and soil properties Sun *et al.* (2017) [19]. Decomposition of paddy straw in the field is affected by several factors. Chemical composition of paddy residue effects rate of decomposition of paddy straw. Rice straw with poor quality and with a high C:N ratio, results in slow decomposition and mineralization of nutrients, particularly during low availability of N (Thuy *et al*., 2008) [22]. Residue particle size is another physical factor – the smaller the particles size the more rapid the decomposition (Toenshoff 2014; Henriksen and Breland 1999) [7, 23]. Diminution of residues into smaller particles physically expose more surface area made available for the colonization of microorganisms and enhancing the process of decomposition. Under anaerobic condition, decomposition of organic matter is considerably low when compared with aerobic conditions. Decomposition of crop residue also depends on depth of incorporation of the residue. Straw incorporated within 5 cm of soil depth decomposed faster when compared to surface application of straw (Li *et al*. 2011, Kumar *et al*., 2024) [10]. Residue incorporation at a depth of 0-15 cm showed higher decomposition rate when compared to the residue incorporated at 10-20 cm depth and 20-30 cm depth which may facilitate higher nitrogen and carbon release (Latifmanesh *et al*. 2020) [11]. Rate of decomposition is also affected by environmental factors. Generally rate of decomposition is higher in tropical countries and decreases with decreases in temperature as most of the soil microorganisms are mesophilic and their activity is optimum between 25-35℃. Huang *et al*. (2021) [8] based on his studies on decomposition of maize residues by litter bag technique reported that decomposition of maize residue increased with increase in temperature. Soil moisture and temperature are the key environmental factors regulating straw decomposition (Devêvre and Horwáth, 2000) [4] and the effect of temperature is more pronounced on decomposition when compared to effect of soil properties on decomposition (Gregorich *et al*. 2017) [5].

The interactive effect of paddy straw management and nitrogen levels on mass loss of paddy straw was found to be non-significant.

**Conclusion**

Paddy straw decomposition increased progressively over time under both straw management options. Incorporation of paddy straw with phosphorus resulted in greater decomposition than incorporation without phosphorus, with 42.41% decomposition recorded at harvest compared with 37.53% without phosphorus. Nitrogen application significantly affected decomposition only during the early stages, particularly at 15 and 30 days after transplanting, while its effect was non-significant at later stages. The interaction between paddy straw management and nitrogen levels was also non-significant. Based on the results, in-situ paddy straw incorporation with phosphorus can improve straw decomposition and support residue recycling under the experimental conditions. Do not burned crop residues, decompose crop residues and to maintain soil health for better crop production.

5-days training on CRM (2021-2026)


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स्वास्थ्य एवं पर्यावरण दोनों के लिए हानिकारक है। उन्होंने
किसानों से फसल अवशेषों का खेत में ही वैज्ञानिक प्रबंधन

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**Declaration of AI Use**

This manuscript was prepared through the intellectual contributions of the author(s) to the study design, data analysis, interpretation of results, and scholarly content. Grammarly and ChatGPT were used solely to assist with grammatical refinement and reference formatting during manuscript revision. The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

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