COMPOSTING OF PADDY STRAW WITH WASTE DECOMPOSER (NCOF) AND EFFECTIVE MICROORGANISM (EM) AND THEIR EFFECTS ON SUCCEEDING WHEAT CROP

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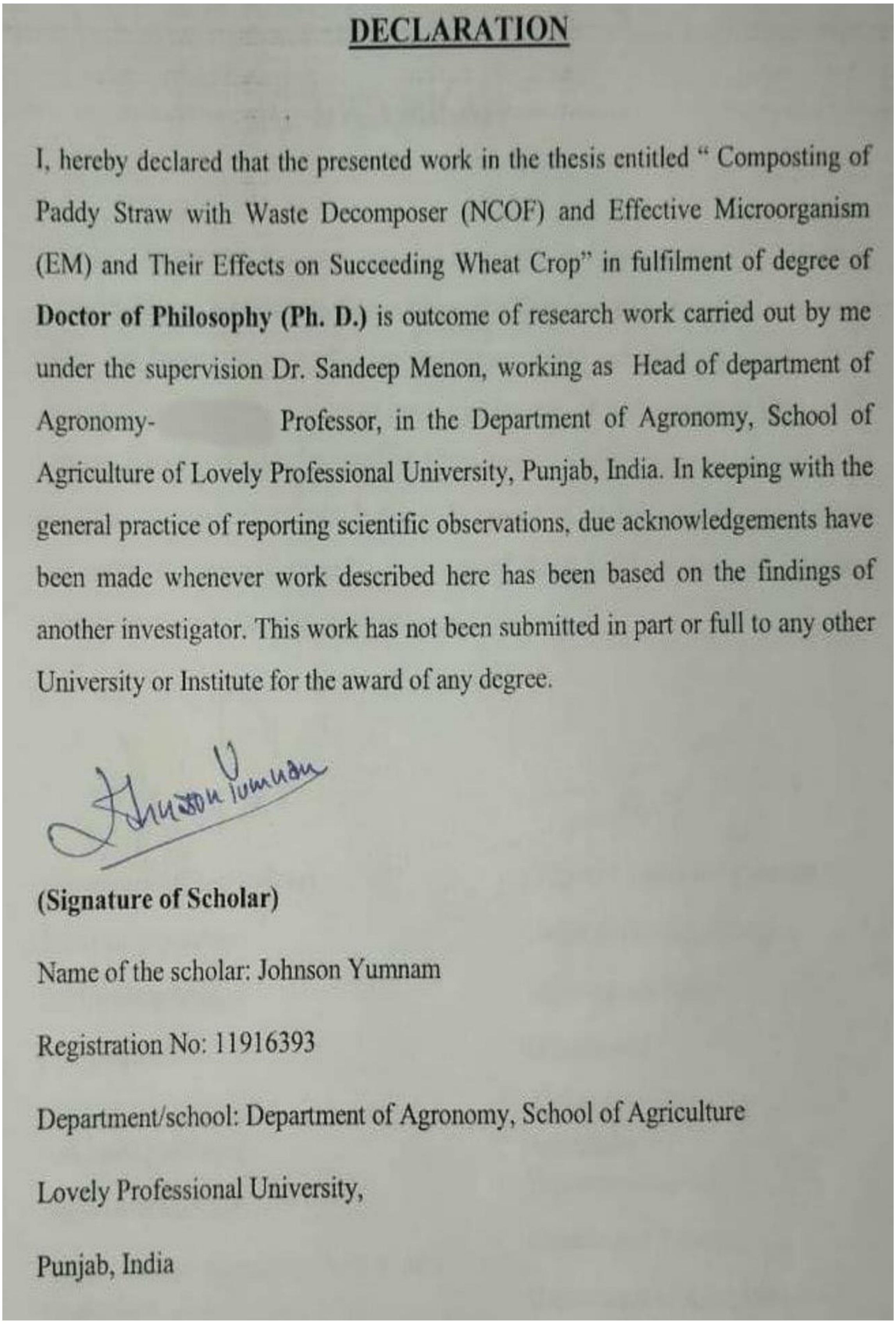

DECLARATION

I, hereby declared that the presented work in the thesis entitled " Composting of Paddy Straw with Waste Decomposer (NCOF) and Effective Microorganism (EM) and Their Effects on Succeeding Wheat Crop" in fulfilment of degree of **Doctor of Philosophy (Ph. D.)** is outcome of research work carried out by me under the supervision Dr. Sandeep Menon, working as Head of department of Agronomy- [redacted] Professor, in the Department of Agronomy, School of Agriculture of Lovely Professional University, Punjab, India. In keeping with the general practice of reporting scientific observations, due acknowledgements have been made whenever work described here has been based on the findings of another investigator. This work has not been submitted in part or full to any other University or Institute for the award of any degree.

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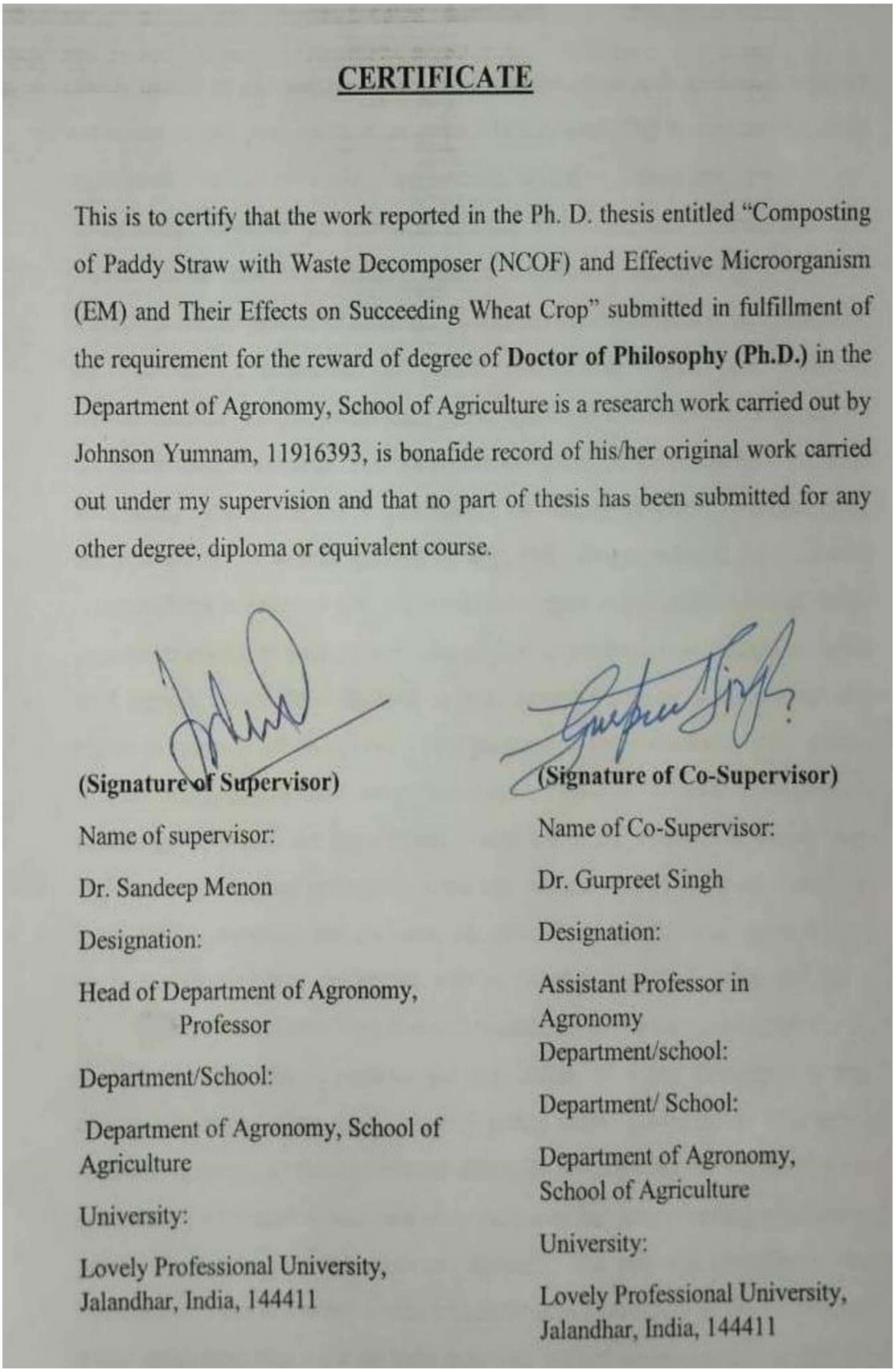

CERTIFICATE

This is to certify that the work reported in the Ph. D. thesis entitled "Composting of Paddy Straw with Waste Decomposer (NCOF) and Effective Microorganism (EM) and Their Effects on Succeeding Wheat Crop" submitted in fulfillment of the requirement for the reward of degree of **Doctor of Philosophy (Ph.D.)** in the Department of Agronomy, School of Agriculture is a research work carried out by Johnson Yumnam, 11916393, is bonafide record of his/her original work carried out under my supervision and that no part of thesis has been submitted for any other degree, diploma or equivalent course.

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Abstract

Paddy straw is a valuable agricultural residue generated globally, with an estimated annual production of around 1.5 billion tons. This waste material holds significant potential for diverse applications, including animal feed, bedding and composting. However, the prevalent practice of burning paddy straw after rice harvest poses issue is a pressing concern worldwide, contributing to harmful emissions and the spread of diseases. To address these environmental challenges, an empirical effectiveness of waste decomposer (WD) and effective microorganisms (EM) in composting paddy straw and their subsequent impact on the succeeding wheat crop. The study aimed to alleviate the problems associated with paddy straw management, particularly the burning of straw. Two packaging and practice of rice were considered namely, SRI and conventional methods with a comprehensive analysis was performed on various quantitative and qualitative parameters related to paddy straw. The qualitative parameters examined included total organic carbon, total nitrogen, carbon/nitrogen (C/N) ratio, ammonical and nitrate nitrogen, total phosphorus, total potassium, water-soluble carbon, humic acid and fulvic acid content and carbon-dioxide evolution (CO_2) and germination percentage of wheat. As part of their evaluation of the subsequent wheat crop, various morphological parameters were also measured and assessed, including grain yield, straw yield, harvest index, effective tiller capacity, 1000-grain weight per spike length, spike weight as well as filled and unfilled grain per spike numbers were considered. This research contributes to the existing knowledge in several ways. Firstly, it explores the application of waste decomposers and effective microorganisms in composting paddy straw, providing an alternative approach to managing this agricultural waste. By investigating the effects of these treatments on compost quality, the study enhances our understanding of utilizing paddy straw as a valuable resource. Secondly, the research investigates the influence of these treatments on the morphological parameters of the subsequent wheat crop, shedding light on their potential impact on crop productivity. To understand how

various treatments for composting paddy straw impact yield and quality in subsequent wheat crops, a field experiment was carried out at Lovely Professional University's Phagwara campus, Punjab. The study focused on addressing the limited research on post-harvest management of rice straw, which is often an underutilized feed source due to its high silica content and slow decomposition rate. Additionally, rice straw's high carbon-to-nitrogen ratio presents challenges when composting quickly. The experiment employed a split plot design (SPD) to comprehensively analyse the influence of various treatments on paddy straw composting and their subsequent effects on the succeeding wheat crop. Main plot treatments involved using both System of Rice Intensification (SRI) methods (M1) and conventional cultivation practices for rice cultivation (M2). Within the sub-plots, different combinations of waste decomposer (WD), effective microorganisms (EM), rice straw (RS), and soil cover were applied, resulting in multiple treatment combinations denoted as S1 to S8. The experiment was replicated three times to ensure reliable results. This study sought to analyse and characterize biochemical traits associated with decomposition of paddy straw (PR-128 variety) after decomposition as well as yield from subsequent wheat crops (PBW-550) under various treatment scenarios. The quantitative and qualitative analyses focused on paddy straw obtained from both SRI and conventional rice cultivation methods. By conducting this study, the researchers sought to provide valuable insights into the potential benefits of utilizing composted paddy straw to enhance crop productivity and sustainability. The findings could contribute to mitigating the burning of paddy straw and reducing the environmental impact associated with rice cultivation. M1 involved a nutrient application of 60:40:30 kg NPK/ha, while M2 utilized a nutrient application of 150:50:50 NPK/ha. These treatments aimed to capture the differences in cultivation practices and nutrient management between SRI and conventional methods. These treatments included RS alone (S1) to evaluate the decomposition and nutrient release potential of paddy straw. Other combinations involved WD and EM, such as WD + RS (S2), EM + RS (S3), and WD + RS + EM

(S7). Additionally, a straw-free control group (S9) was included. To simulate field conditions, treatments involving the addition of soil along with RS and microbial additives were implemented. These treatments included RS + EM + soil cover (S4), RS + soil (S5), WD + RS + soil (S6), and WD + EM + RS + soil (S8). By analysing the biochemical traits of paddy straw, as well as the morphological parameters and yield of the subsequent wheat crop under each treatment, the study aimed to test the hypothesis that the application of waste decomposer (WD) and effective microorganisms (EM) in paddy straw composting would improve compost quality and have a positive impact on the succeeding wheat crop. Specifically, the hypothesis suggests that the use of WD and EM treatments would result in enhanced decomposition rates and a faster composting process compared to untreated control groups. The application of waste decomposer (WD) and effective microorganisms (EM) is expected to result in improvements in the biochemical traits of paddy straw compost. These improvements may include increases in total organic carbon, total nitrogen and nutrient contents over untreated compost, as well as using WD or EM in composting paddy straw to have beneficial results on its subsequent wheat crop's morphological parameters. These effects may include increased grain yield, straw yield, harvest index, effective tiller, and spike weight. Furthermore, it is expected that the combined effects of WD and EM treatments will be more effective in promoting environmentally friendly composting practices and mitigating the negative environmental impacts associated with paddy straw burning. This is in comparison to individual treatments or untreated controls. This study's goal is to test its hypothesis by showing the benefits of using WD and EM treatments on paddy straw composting and their subsequent influence on yield and quality of wheat crops that follow them. Furthermore, its findings will give valuable insights into various composting techniques as well as demonstrate why using these treatments should be prioritized over alternative approaches. By showcasing the disparities in composting effectiveness, the study emphasizes the significance of incorporating these treatments to achieve optimal results in terms of yield, quality,

and environmental sustainability. Results of the study reveal those plants grown using System of Rice Intensification (SRI) farming methodology with 60:40:30 kg NPK/ha application demonstrated superior performance compared with other treatments. These plants displayed higher numbers, significant dry matter content and greater branching density; conversely, conventional rice cultivation methods created adverse results characterized by rigid paddy straw morphologies that formed. However, the adverse effects on conventional methods of rice cultivation were significantly mitigated in the treatments involving waste decomposer (WD) and effective microorganisms (EM). Tolerant and sensitive responses to WD and EM treatments were observed in the anatomical traits of the straw. The biochemical parameters of paddy straw composting and the morphological parameters of the succeeding wheat crop yield were found to be satisfactory in the WD and EM treatments. Under both SRI and conventional cultivation methods of rice cultivation, the combined effects of WD and EM had the greatest environmental benefit when composting paddy straw for composting purposes, creating an environmentally sustainable compost pile. These findings hold immense ramifications for managing paddy straw production sustainably as well as managing paddy straw management more effectively. Use of WD and EM can reduce burning of paddy straw after harvest, contributing to better air quality and reduced greenhouse gas emissions. Based on observed data, applying these techniques in farmers' fields with large accumulations of unutilized paddy straw is recommended. This method successfully reduces paddy straw burning and increases utilization, supporting sustainable agricultural practices. Conclusion of This Study This research offers invaluable insight into how waste decomposer (WD) and effective microorganisms (EM) for composting paddy straw can have positive impacts on subsequent wheat crop yield. These findings underline the significance of adopting environmentally sound composting practices and employing paddy straw in agriculture for sustainable practices. Combined application of WD and EM led to quicker composting rates, better biochemical and morphological characteristics in paddy straw, as well as higher wheat crop yield. These results demonstrate how using WD and EM treatments in agricultural practices could contribute to more efficient, eco-friendly operations by optimizing composting processes and increasing crop productivity. These findings from this research can be applied towards creating new strategies for paddy straw management and increasing sustainability of rice production. By advocating the implementation of waste decomposer (WD) and effective microorganisms (EM), this research contributes to knowledge development and promotion. By advocating the application of these technologies, this study furthers sustainable agricultural practices by offering viable strategies to address paddy straw management challenges effectively, thus improving environmental outcomes associated with rice cultivation as well as paddy straw burning reduction and enhanced utilization. WD and EM can offer promising approaches that mitigate environmental issues caused by cultivation as well as use up this valuable agricultural byproduct more efficiently.

Keywords- Agriculture, Composting, Effective microorganisms, Paddy straw, Sustainable.

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Date:
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CHAPTER 1

(INTRODUCTION)

1. INTRODUCTION

Asia's Indian subcontinent, particularly states like Punjab, West Bengal and Uttar Pradesh has recently seen an unprecedented spike in rice production that is contributing significantly to fertile lands of this part of Asia. Unfortunately, rice cultivation creates significant amounts of waste stubble known as rice straw that's hard to estimate due to widespread practices like burning stubble residues which release greenhouse gas (GHG) emissions as well as particulate matter into the air; estimated figures place about 0.055% of total GHG emissions as being due to burning rice straw resulting in 592 tons of CO_2 annually from burning rice straw in India alone (Kataria *et al.,* 2023). The persistent disposal of stubble through burning or dumping poses significant environmental concerns, contributing to greenhouse gas emissions, elevated temperatures, and climate change. The well-documented adverse effects of these emissions on air quality, climate stability, and human health call for urgent action in agricultural and industrial practices. Emphasizing the integration of rice straw into soil cover can substantially enhance soil quality, fostering increased fertility and productivity. To combat the negative impacts of stubble burning, it's crucial for industries and agricultural sectors to prioritize environmentally friendly practices and adopt technologies that repurpose rice straw effectively. By implementing sustainable management strategies, such as carbon sequestration and emissions mitigation, the detrimental consequences of stubble burning can be mitigated. However, India faces challenges due to limited technology and interventions leveraging biomass and adsorption, hindering effective carbon sequestration and emissions reduction (Chivenge *et al.,* 2020). Efforts to address the challenge of straw waste and its utilization should focus on developing technologies and interventions that enhance lignin decomposition and enable efficient utilization of rice straw. By exploring innovative approaches and leveraging anaerobic digestion technologies, it may be possible to effectively manage straw waste, reduce environmental pollution, and maximize its potential as a valuable resource in various sectors. The slow degradation rate of straw poses a challenge for its effective decomposition. Fungi, such as *Trichoderma, Aspergillus, Penicillium, Coprinus,* Polypore's, Pleurite's osteitis, and white rot fungi Basidiomycete, have been identified for their strong cellulose degradation capabilities and their ability to decompose straw (Pasoth *et al.,* 2019). Bacteria, including Micrococcus, *Bacillus, Penicilliums, Pseudomonas, Streptococcus, Nocardia, and Mycobacterium,* have also been recognized for their capacity to break down aromatic compounds during the decomposition of straw (Meng *et al.,* 2020). *Actinomyces,* a group of filamentous prokaryotes, can utilize various carbohydrates for energy sources and have been found to possess straw decomposition capabilities (Gong *et al.*, 2022). C/N ratio is an essential aspect of straw decomposition and an optimal range for this ratio is 20-30 (weight for weight). When not within this optimal range, biogas production during anaerobic digestion becomes inhibited (Huang *et al.*, 2019). Researchers have developed various pretreatment techniques including steam explosion, acid-base hydrolysis and photocatalytic degradation that have proven successful at breaking down complex structures within rice straw structures to boost biogas production (Chaturvedi *et al.,* 2020). Reducing waste through disposal or recycling of rice straw is vital in order to foster sustainable agriculture practices. Composting, an enzyme-mediated process controlled by microorganisms, offers an efficient means to eradicate pathogens, recycle nutrients and produce stable compost (Wang *et al.,*2021; Xiao and Zhu, 2021) Composting is an efficient method for treating organic waste such as manure, food scraps and livestock manures as well as sewage sludge; microorganisms play an essential part in decomposing organic matter into beneficial materials for agriculture (Wang *et al.*, 2022; Wade *et al.*, 2022; Cloughley *et al.*, 2022).

In 2015, the NCOF (National Center of Organic Farming) initiated the development of an organic waste digester, which has proven to be an effective source of organic compost that enhances soil health and plant protection. Dr. Krishan Chandra, a scientist, pioneered this method by isolating beneficial microorganisms from cow dung and analyzing their properties. It took approximately 11 years to establish mass multiplication as a standard practice on an agricultural scale. The waste decomposer acts as a fertilizer, biocontrol agent, and aids in restoring soil health. It is available in bottles for as low as 20 rupees per bottle and is being distributed through the NCOF to one million farmers across India. Regular use of this technique offers long-lasting benefits. Within 21 days of applying the waste decomposer - which produces 1,000 liters of compost per acre for all soil types (including acidic ones). Microbiomes consist of both beneficial and harmful bio-friendly microorganism communities - harmful ones may lead to illness and environmental pollution while beneficial one's aid mineralization processes that support overall ecosystem health. Dr. Teruo Higa, a gardener at the University of Ryukyus Okinawa Japan, discovered a collection of beneficial microorganisms called Effective Microorganisms (EM) in 1982. These naturally occurring microorganisms are used to revitalize, restore, and safeguard organic substances. When EMs are mixed with other species of bacteria in an organic mix, it greatly enhances the rate of degradation. EM is composed of non-pathogenic microorganisms, including lignocellulose bacteria, fungi yeasts of the lactic acid family, and photosynthetic bacteria. EM is also a source of electromagnetic radiation. It acts as an activator, speeding up the degradation process by creating an optimal environment for decomposition. EMs are also utilized as insect repellents that are non-toxic and chemical-free. They can be used to prevent the spread of diseases and pests in gardens and protect plants from pests. Applying EMs to compost piles can help eliminate insects and odors that can cause issues, speed up the composting process, and improve compost quality. EMs can be sprayed on compost using a hand sprayer to prevent it from becoming too wet when fresh material is added. The soil cover is an ideal habitat for cultivating microorganisms, including both fauna and flora. It provides food for various types of living creatures. The soil cover is considered a living system that supports a diverse range of animal species, including insects, worms, mammals like badgers, moles, rabbits, and foxes.

Microorganisms make up around 0.5% (weight/volume) of the soil cover mass and account for 60 to 70% of its metabolic activity. Microorganisms, such as bacteria, algae, cyanobacteria, fungi, myxomycetes, yeasts, and actinomycetes, play crucial roles in breaking down organic matter and converting it into plant nutrients. They also contribute to the degradation of pollutants through the process of biodegradation. Microorganisms' survival in soil cover environments depends on factors like their chemical makeup, its structure and pH level as well as moisture content. Heat generated during burning of rice straw can damage microorganisms found within it - including endomycorrhiza, nitrifiers and ectomycorrhiza - particularly those located near organic matter on its surface (Alka Dwevedi *et al.*, 2017).

1.2 HYPOTHESIS

Rice straw was selected for composting, because-

A) The research on post-harvest management of rice straw is limited.

B) Rice straw which is often as the less feed sources due to the presence of high silica content and slow decomposition rate is known for the high C/N ratio, that's why evidence of rapid composting methodology of rice straw is still a point of research.

1.3 OBJECTIVES

1. Studies the quality of composting of paddy straws derived from SRI and conventional rice cultivation methods with waste decomposers (NCOF) and effective microorganism (EM).
2. Analyses the effects of application of treated composted rice straws on succeeding wheat crop and
3. Find out the best economical field-based exercise and farmer friendly composting method within the stipulated time between rice and wheat crop ping systems.

CHAPTER 2

(REVIEW OF LITURATURE)

2. REVIEW OF LITERATURE

2.1 Effect on carbon to nitrogen ratio of rice straw compost

Sharafi *et al.* (2023) conducted research on bioprocessing rice straw compost. They used chicken manure and microbial cocktails (E and F) to enhance composting. Treatment E showed impressive results in wheat growth promotion. The study emphasized the importance of using microorganisms with strong hydrolytic activity to decompose materials quickly, reduce pollution, and benefit farmers. Meena *et al.* (2023) explored recycling agricultural bio-waste using microbial consortium systems, resulting in lower carbon levels and increased nitrogen concentrations in treated rice straw. Microscopic analysis indicated the action of microbial consortia, demonstrating their effectiveness in decomposing rice straw as an alternative to burning. Qu *et al.* (2022) studied the effect of Fenton pretreatment combined with bacterial inoculation on dissolved organic matter (DOM) humification during rice straw composting. Fenton pretreatment and bacterial inoculation together enhanced DOM humification, with fungal activity playing a significant role. The study highlighted the importance of monitoring C/N ratio and pH as indicators of compost maturity. Zainudin *et al.* (2022) investigated the influence of biochar addition and local cellulolytic bacteria on rice straw and chicken manure composting. Composting with biochar led to higher temperatures and reduced carbon levels. Cellulolytic bacteria, including Bacillus strains, contributed to compost quality and carbon reduction when using biochar, emphasizing their impact on composting outcomes. Wang and Ji (2022) conducted separate investigations. Wang explored the impact of inoculating rice straw compost with specific fungi to enhance efficiency and maturity. Inoculation with different fungi accelerated temperature rise during composting phases, promoting degradation of cellulose and hemicellulose. Ji studied co-production of biogas and humic acid through solid state anaerobic fermentation. Optimal conditions and aeration rates were identified to maximize biogas production and humic acid biosynthesis during composting. In recent studies, researchers have explored various methods and microorganisms to enhance the composting process and improve the quality of compost derived from organic waste materials. Wang *et al.* (2021) investigated the decomposition of different elements in swine manure and soil cover materials. They identified specific microorganisms capable of decomposing xylem, cellulose, starch, and proteins. The researchers examined correlations among microorganisms, carbon source pH, C/N ratio concentration, and enzyme activity. They also studied the impact of additional composting on maturation rates and enzyme activities. Notable microorganisms, such as *Kitasatospora phosalacinea*, *Paenibacillus Glycanilyticus X1, Bacillus licheniformis S3,* and *Brevinacillus agri E4,* demonstrated significant enzyme activity under specific conditions. Furthermore, research by Qiu and colleagues (2021) focused on mitigating nitrogen losses in composting chicken manure using nitrogen-retention microbiological organisms (NRMA). NRMA significantly reduced ammonia loss and increased total nitrogen (TN) and nitrate levels. Nitrogen-transforming bacteria like *Paucisalibacillus, Sporosarcina*, *Sphingobacterium*, *Oceanobacillus*, *Longispora,* and *Luteivirga* were found to be effective, especially at high temperatures. To protect NRMA, innovative solutions were developed, emphasizing the importance of microorganism presence and use in compost production. Arora *et al.* (2019) experimented with enhancing paddy straw using *Azolla pinnata*, *Aspergillus terreus,* and *Eisenia fetida* as additives. Aerobic composting and vermicomposting techniques were employed, resulting in rapid degradation and increased microbial populations. This approach improved compost quality by reducing pH levels, electrical conductivity, total organic carbon, and carbon-to-nitrogen ratio. In another study, Muliarta *et al.* (2019) aimed to increase composting rates and quality using local decomposers and commercial decomposers. The addition of specific local decomposers significantly improved the C/N ratio, indicating enhanced compost quality compared to traditional decomposition methods. Nguyen *et al.* (2019) compared traditional rice straw and composted cow dung for paddy soil fertility, finding differences in carbon, nitrogen, and other nutrient content but no significant impact on soil fertility.

2.2 Effect on quality of rice straw compost

Researchers like Wang *et al.* (2023) explored the use of food waste supplementation in rice straw composting. Their study highlighted the importance of specific microbial agents during composting, leading to high-quality compost production. This approach not only hastened organic matter degradation but also improved soil fertility and promoted positive agricultural practices. Another study conducted by Huang *et al.* (2023) focused on substituting chemical fertilizers with compost in rice cultivation. Their findings indicated that replacing a portion of chemical fertilizers with compost led to substantial increases in rice yield, grain quality, and overall growth. This research underscores the potential of compost as an alternative fertilizer source, contributing to enhanced agricultural productivity. Ren *et al.* (2023) delved into the influence of rhamnolipids on humic substance formation during rice straw composting. Their work demonstrated that rhamnolipids played a crucial role in enhancing organic matter degradation and promoting the formation of humic substances. This study provided valuable insights into the effective transformation of agricultural waste and the development of high-strength substrates. Furthermore, studies by Jagadeesh *et al.* (2023) and Singh *et al.* (2023) explored the application of specific lignocellulolytic cultures and earthworms in composting practices. Jagadeesh et al.'s research highlighted the efficacy of certain cultures in degrading paddy straw, indicating the potential application of lignocellulolytic cultures across various biomaterials. Singh et al.'s work showcased the successful reclamation of degraded sodic soil covers through on-farm composting with municipal solid waste (MSW) and agricultural waste, coupled with earthworms and microbial consortia. This approach not only enhanced organic matter breakdown but also improved various soil properties, leading to sustainable soil reclamation and increased crop productivity. In their research, He *et al.* (2022) explored co-composting using biogas residue, spent mushroom substrate, and rice straw, inoculated with *Phanerochaete chrysosporium* and *Trichoderma longibrachiatum.* Their study revealed that Composite Microorganisms (CMs) significantly enhanced the degradation of cellulose, hemicellulose, and lignin. The presence of CMs altered bacterial communities related to macromolecule degradation and cellulolytic fungi activity. Positive correlations were identified between microbial communities and temperature, fulvic acid concentration, and lignocellulose content. The addition of CMs promoted biodegradation pathways and the biosynthesis of humus, leading to improved composting efficiency and higher levels of humic substances in compost piles. Wang *et al.* (2022) investigated the impact of biochar and lime applications on straw manure composting. Their study focused on rice manure and swine manure composting processes with equal amounts of biochar and lime added. Both additives significantly increased NO3-N content, facilitated organic matter breakdown, and humus formation. Lime, in particular, demonstrated greater improvements. These additives also enhanced bacterial populations, especially thermophilic varieties, and aided in the growth of specific bacteria useful against high molecular weight (HMW) substances. The study recommended the inclusion of 3% lime in swine manure composting, providing guidelines for enhancing compost quality. Wu *et al.* (2022) explored the impact of Fenton pretreatment and bacterial strains on rice straw composting. Different treatments were applied, including Fenton Pretreatment with Bacteria Inoculation (FeWI) and Fenton Pretreatment Inoculated with Beneficial Fungi Inoculation (FeWI). Fenton pretreatment and bacterial inoculation altered fungal communities and cellulose degradation genes, accelerating degradation. Important variables like NH4+-N concentration, TOC content variations, and pH levels were identified as factors impacting cellulosic degradation gene expression during composting. Sagarika *et al.* (2022) focused on microbes capable of producing Lytic Polysaccharide Monooxygenases (LPMOs) to efficiently recycle agricultural waste, specifically rice straw. LPMOs, in combination with other glycolytic enzymes, proved effective in breaking down waste cellulose and lignin into simpler molecules. The study emphasized the need for rapid decomposition of agricultural wastes and highlighted the potential of existing lignocellulolytic consortia for industrial-scale bioconversion to bioethanol. Wang *et al.* (2022) investigated composting rice straw supplemented with nitrogen-rich food waste. They identified key factors such as temperature, nitrogen levels, moisture levels, pH, and carbon total, influencing microorganism activity during composting. The study demonstrated the potential of including nitrogen-rich materials, like food waste, to enhance rice straw disposal and transform it into valuable fertilizer, thereby increasing compost productivity and final product fertility. Zhao *et al.* (2022) conducted a study on the Shikimic Acid (SA) Pathway during composting. They identified organic matter and pH as key drivers affecting SA pathway intensity, providing theoretical support for enhancing SA metabolic intensity during composting. This research significantly contributes to our understanding of effective agricultural waste recycling and its implications for soil fertility. Zhang *et al.* (2022) analyzed microbial community dynamics and lignocellulose transformation during green waste composting. Their research identified distinct phases in composting characterized by specific microorganisms and transformation processes. They emphasized the importance of maintaining thermophilic conditions and adding specific fatty acids during the maturation phase to accelerate composting. These findings provide practical strategies to optimize the composting process. Chen *et al.* (2021) explored innovative methods for heavy metal removal through composting. They introduced Fenton-like processes using Fe3O4 nanomaterials, Phanerochaete, and oxalate, effectively passivating heavy metals and increasing humic substance influence on bioavailability and bioadsorption processes. This research offers novel perspectives on sustainable waste management practices, especially concerning heavy metal pollution. Gavande *et al.* (2021) focused on creating a specialized microbial consortium from vermicompost to break down challenging agricultural waste, such as rice straw. Their metagenomic analysis revealed a diverse microbial community within the consortium, highlighting its enzymatic activity and functional capabilities. This approach holds promise for effective agricultural waste degradation and sustainable recycling practices.

Zhu *et al.* (2021) explored one-stage inoculation (SSI) versus two-stage inoculation (TSI) for cattle manure composting. TSI resulted in an extended thermophilic phase and enhanced degradation of organic compounds, leading to increased total nutrient carbon content. TSI influenced fungal communities, including Aspergillus, Trichoderma, and Neurospora, stimulating the breakdown of lignocellulose into compost and humus. Temperature played a crucial role in shaping fungal communities within TSI ecosystems. Chang *et al.* (2021) investigated bacterial and fungal diversity during agricultural straw composting with additives. Urea microbial agents significantly increased operational taxonomic units (OTUs) and diversity indices. Additives altered the physical-chemical properties and microbial populations. Ascomycota decreased gradually, with Aspergillus being the principal species. Additives proved advantageous, enhancing compost quality, and producing high-quality compost. Du *et al.* (2021) examined the formation of humic acid during rice straw composting using Fenton pretreatment and bacterial inoculation. Fenton pretreatment and functional bacteria agents increased humic acid components. Bacterial amounts of shikimic acid metabolism genes, functional bacteria, NH4-N levels, pH values, cellulose content, and diversity were identified as essential contributors to humic acid formation. Functional bacteria and environmental factors played key roles in humic acid formation, as indicated by Network Analysis and Structural Equation Models. Zhang *et al.* (2021) explored the influence of nitrogen sources on rice straw composting, highlighting the benefits of chicken manure over urea as a nitrogen source. Chicken manure led to greater reductions in polysaccharides, fiber amino acids, and higher humic compounds content. Chicken manure compost demonstrated more positive relationships between bacterial communities and organic elements, suggesting that nitrogen sources with protein-like characteristics enhance organic compound transformation efficiency.

2.3 Effects on rate of decomposition of rice straw compost

Kalkhajeh *et al.* (2021) studied how co-applying nitrogen with an SDMI strain to accelerate wheat straw decomposition and rice yield in paddy soil covers was beneficial to their success. Studies conducted as part of this investigation revealed that rice growth caused straw decomposition rates to rise over time, with N-amended straws showing greater decomposition rates at tillering stage than their controls. However, all treatments experienced similar rates of decomposition following this phase, possibly as a result of SDMI application which increased soil microbial respiration and increasing grain yield as opposed to its control counterpart. Furthermore, nitrogen addition was observed to have greater grain yield benefits compared to control treatments. Researchers discovered that a basal N fertilization rate of 97.5 kg ha-1 provided the optimal C/N ratio for decomposition and rice productivity within their paddy soil cover study area. Further investigation must take place to fully comprehend this relationship between degradation of straw, soil cover properties and agricultural management practices. Li *et al*. (2021), researchers evaluated the performance and microbial community dynamics of rice straw composting using either urea or protein hydrolysate from leather waste as an alternate nitrogen source. Their investigation determined that adding protein hydrolysate led to faster temperature increase rates at start, higher volatile solid degradation efficiency, better end product quality compared to using urea alone; mature end products from both processes reached maturity within 65 days with nitrogen losses below 10% while both processes yielded similar bacterial communities but adding protein hydrolysate hasten succession rates among this unique population growth boost! Du *et al*. (2020) conducted research to understand how adding rice straw and biological inoculation on maturing compost derived from rice straw biogas residue affected its development into compost. Their results suggested that such additions increased carbon degradation rates while improving maturity indices such as morphology, color and odor ratings of maturity compost; simultaneously this approach reduced decomposition times significantly while eliminating crop toxicity while simultaneously improving biogas residue fertilizer stability. Omar *et al.* (2020) conducted research evaluating the effect of various additives, including biochar, effective microorganisms (EM), animal manure and commercial microbial inoculants such as commercial microbial inoculants on bioconversion of rice straw into organic fertilizer. His investigation demonstrated how different combinations of these additives affected both composting process and quality; specific combinations including rice straw, animal manure, EM and biochar yielded higher decomposition rates and organic fertilizer qualities than others. Overall, these studies demonstrate that adding additives such as microbial agents, Fenton pretreatment, rice straw, biochar and effective microorganisms to composting processes can have a substantial positive effect. Such additions could improve degradation rates, humic substance production rates, maturity indices, nutrient cycling efficiency and soil organic matter quality, though their precise effects and optimal combinations depend on individual conditions and desired outcomes of composting operations. Omar *et al.* (2020) conducted research to transform rice straw waste into organic fertilizer using various additives. Compost piles composed of rice straw mixed with animal manure mixed with natural rock inoculated with effective microorganisms (EM) and biochar showed the highest decomposition rates and quality organic fertilizer products; adding 20% biochar decreased its quality compared with 10%; this research concluded that mature compost products were suitable as organic fertilizers using an optimal combination of additives to provide best results. Tang *et al.* (2020) conducted research focusing on the physical characteristics, metal availability and enzyme activity of soil covers contaminated with heavy metals that had been remedied using compost and biochar as part of an environmentally safe remediation plan. Researchers used an oxygen-restrictive tub carbonization furnace to produce biochar from rice straw. Later they utilized this material in making compost samples using vegetables and rice straw found on Kaur's farms in India (2019) explored ways of turning rice straw into valuable products using bio composting as an efficient alternative for burning agricultural waste. Researchers used a mixture of bran, rice straw and waste from fruit production as feedstock along with Trichoderma Harzianum MTCC-8230 fungal cultivation as an approach for waste reduction. This study focused on monitoring changes to pH levels as well as appearance; chemical fibers included acid detergent fibers along with neutral detergent fibers (both acid detergent Lignin). Researchers found a gradual increase in bulk density and decreased volume across all of their trays - not only those without added substances or nutrients. Over 12 days, pH gradually rose from 7-9, eventually reaching 8. After 28 days, rice straw began transforming from its crystallized state into an amorphous one; there was decreased levels of lignin (20-25% reduction to 13-15% range), increased crude protein concentration of up to 17-19% as reported by Kaur et al. and Barus *et al*. (2017) have detailed this process and have revealed it yields brown biofertilizer with notable carbon and protein contents. Researchers released an examination on this subject, with one researcher's statement reading as follows. At Kebun Percobaan Natar in BPTP Lampung, research was carried out to ascertain the impacts of crop residues on various indicators; among these included physical properties of soil cover physical properties earthworm abundance microbial activity yields of production rice grown upland. Tang *et al.* (2020), on remediating heavy metal polluted soil cover using biochar and compost was investigated. Biochar was produced from rice straw using a tubular carbonization furnace in an anoxic environment; compost samples were created from rice straw mixed with vegetable leaves; this investigation focused on studying its physical, chemical properties, metal availability, enzyme activity levels in the treated area remediated with these amendments - showing their efficacy at remediating heavy metal pollution in soil cover conditions while decreasing heavy metal availability levels in treated area thus showing their use potential as soil remediation solutions for soil remediation purposes. Kaur *et al.* (2019) explored bio-composting as an effective solution to turning rice straw waste into value-added products as an alternative way of disposing of agricultural waste. Researchers used rice straw, bran and fruit waste combined with Trichoderma harzianum MTCC 8230 fungal culture to facilitate degradation. Their study monitored changes in pH levels, appearance, and chemical fiber production - such as acid detergent fibers (ADF), neutral detergent fibers and acid detergent lignin production (ADL). Results revealed an increase in bulk density and decrease in volume across all trays, including those under control conditions. pH increased from 7 to 9, then stabilized at 8 after 12 days. Over 28 days, rice straw transformed from its initial crystalline state into an amorphous state with decreasing lignin levels and rising crude protein contents, according to this study. Bio-composting produced an attractive brown composted biofertilizer rich with carbon and crude proteins content for use as fertilizer in agricultural systems.

2.4 Effects on application of paddy straw compost

Cai *et al.* (2023) conducted an experiment that demonstrated how rice straw and S. pasteurii bacteria combined effectively to immobilize cadmium (Cd) in soil covers contaminated by paddy cultivation practices, thus decreasing bioavailability. Analysis using XRD and XPS suggested that Cd was immobilized through co-precipitation with $CaCO_3$. Rice straw and S. pasteurii applications also had positive impacts on soil cover fertility and ecological function as evidenced by increases in alkaline hydrolysis nitrogen (AN), available phosphorus (AP), available potassium (AK), catalase, dehydrogenase and phosphatase activities, catalase levels as well as levels of catalase dehydrogenase phosphatase activity and catalase production levels compared with non-applied controls. Rice straw and S. pasteurii had an increase in Proteobacteria and Firmicutes populations after application, further suggesting its promise as an approach for cleaning Cd-contaminated paddy soil covers as it immobilizes Cd while improving fertility, ecological functions, and fertility management functions of soil covers. The study's conclusions concluded that using both ingredients together may provide a promising means of remediating Cd contamination as they work to immobilize it while simultaneously improving soil cover fertility and ecological functions of paddy soil covers. Patra *et al.* (2021) conducted an in-depth research study assessing the long-term effect of long-term application of compost, biofertilizers, and chemical fertilizers to rice planted under acidic soil conditions on its microbial activity and biomass growth. Studies conducted for this investigation demonstrated that soil acidity increased with soil depth; however, application of an enriched compost effectively controlled various forms of acidification in the surface soil layer (from 0-5 cm). Integrative nutrient management practices, specifically using compost-enriched fertilizer combinations alongside chemical fertilizers, were found to promote greater soil microbial activity and biodiversity than using 100% recommended dose of fertilizers alone. Enzymatic activities related to microbial function were significantly higher when integrated nutrient management practices were applied, according to this study. Furthermore, using both compost and chemical fertilizers together has been shown to boost soil microbial density and enzyme activity by controlling acidity conditions found in rice fields under acidic soil conditions. Chivenge *et al*. (2020) conducted research that explored how incorporation of rice straw affects nutrient cycling and soil organic matter quality, discovering that composting it with farmyard manure increased both supply of nutrients as well as soil organic matter quality. They suggested biochar produced through thermal combustion might also increase soil organic carbon levels, but that timing and water management must be carefully managed in order to maximize benefits while mitigating negative consequences such as greenhouse gas emissions or release of toxic compounds into the environment. Bhattacharyya *et al.* (2020) conducted a comprehensive investigation to examine potential industrial uses for rice straw that might help decrease its unnecessary burning as an important bioresource. Researchers conducted biochemical, morphological, and chemical characterization on 18 rice cultivars to ascertain their suitability for various uses, such as bioethanol production or mushroom farming. Based on this characterization process, cultivars were grouped based on potential uses such as biochar production or mushroom farming. Cultivars with particular compositions of cellulose, hemicellulose, lignin and silica were determined to be ideal for various applications, with Tapaswini and IR 64 cultivars being particularly suitable for bioethanol and biochar production respectively. Although further validation should occur at either farm level or factory level before making final recommendations. Li *et al.* (2020) conducted an inoculating cattle manure with microorganisms' study on its effects on composting efficiency and maturity, developing an inoculant agent with various microbes which was added as one-off supplement into their composting system. Researchers concluded that inoculation increased pile temperature, hastened organic matter degradation rates, and improved the germination index, signifying increased maturity. Composting time was not significantly decreased with inoculation promoting maturity and yielding an end product that contained essential plant nutrients. Accordingly, researchers suggested employing multiple microorganism inoculation methods as a way of increasing efficiency and speeding maturity during cattle manure composting processes. Overall, these studies highlight the potential of rice straw for different industrial purposes as well as its value as an aid to composting processes through inoculating it with beneficial microbes. By exploring alternative uses for rice straw and optimizing composting techniques, valuable resources may be recovered, thus decreasing waste generation as well as any environmental concerns caused by burning or improper disposal practices. *Yan et al.* (2020) study concluded that returning straw to paddy soil covers can increase volatilized antimony (Sb) and arsenic (As) into soil and pore waters via volatilization; applying only two percent straw as cover was suggested as a means to both lower concentrations of Sb in rice grain as well as limit translocation from straw into grain. These studies explore the effects of different factors - like microorganism inoculants, additives, or returning straw back to soil cover - on composting processes and final compost products. By understanding their influences on composting techniques and practices, researchers and practitioners alike may develop sustainable techniques to utilize agricultural residues like rice straw. Shuangshuang *et al.* (2020) conducted an in-depth research effort in Northeast China investigating the effect of returning rice straw to soil cover, specifically its effects on organic carbon concentrations and relative abundances in carbon cycle microbes. Their researchers stressed the significance of their findings for analyzing soil cover carbon as well as acting as an anchor reference point in regions implementing continuous rice cropping systems that implement straw returns as they noted that it increases concentration of active soil carbon fractions while increasing relative abundances for microorganisms associated with carbon cycling activities. Harindintwali *et al.* (2020) conducted an in-depth investigation on composting of lignocellulosic crop residues using cellulolytic nitrogen-fixing bacteria (CNFB), and found it effective at rapid composting, improved soil cover fertility, and sustainable waste management of agricultural waste. Composting with CNFB may therefore offer an ideal way of mitigating environmental pollution caused by burning crop residues or excessive use of chemical fertilizers while simultaneously encouraging sustainability within agriculture. Tunia *et al.* (2020) investigated the effect of using rice straw at various irrigation frequencies to increase wheat crop yield and water productivity. Their research demonstrated that incorporation increased soil covers physicochemical properties while factors like bulk density, infiltration rate, pH levels and electrical conductivity decreased; soil porosity rose under all treatments studied. He recommended 1 Ton per Haarar of Rice Straw with 15-Day Water Irrigation Frequencies as being optimal in order to maximize wheat crops' water productivity potential in terms of both yield and water productivity of wheat crops.

2.5 Effects on gaseous emission from rice straw compost

Yu *et al.* (2023) explored the mechanisms governing methane emissions during composting by inoculating with lignocellulose-degrading microorganisms (LDM). They observed that LDM increased organic matter degradation rate as well as methane emission during later stages. Furthermore, their study also identified methane emission due to growth and activity of methanogen communities with emissions being related to anaerobic environments created by high concentrations of CO_2. As such, Yu and his colleagues suggested creating aerobic conditions during specific stages to decrease emissions when using LDM; their recommendations included improving aerobic conditions during various stages for reduced methane emissions when using LDM in composting processes. According to Xiong *et al.* (2023) study, researchers explored the effects of functional membrane coverings on carbon and nitrogen evolution during aerobic composting with functional membrane cover aerobic composting systems. Researchers observed how micro-positive pressure altered the composting microenvironment. This change facilitated significant increases in oxygen uptake rates among microbes and an increase in abundance of microorganisms that degrade cellulose and hemicellulose, according to this research study. Furthermore, bacteria and fungi played an essential part in transforming carbon into nitrogen forms for use by other organisms. FMCAC enhanced aerobic conditions within these systems, leading to decreased production and emissions of methane (CH_4) and nitrous oxide (N_2O), but increased organic matter degradation as well as ammonia (NH_3) production and emissions. FMCAC results in reduced carbon losses, nitrogen losses and global warming potential while improving carbon retention, nitrogen retention, humification and harmlessness. Functional properties of membranes, including their pore size distribution and air permeability, affect fermentation processes and gaseous emissions. Overall, this study concluded that FMCAC offers considerable potential due to its carbon and nitrogen retention properties as well as enhanced humification capabilities and overall harmlessness. FMCAC uses micro-positive pressure to increase oxygenation of its composting microenvironment and significantly alter microbial community structure and succession; specifically focusing on bacteria and fungi playing key roles in carbon conversion/excretion processes. Dash *et al.* (2023) conducted research to explore methods of mitigating greenhouse gas emissions by supplementing rice-green gram ecosystem production with straw amendments that have an added value to them. These researchers explored various approaches for managing straw, such as no-tillage residue retention techniques such as rice straw compost (RSC) and mushroom spent (MW), biochar as soil cover amendment, methan33otrophs or phosphonyls added as soil amendments as mitigation strategies, etc. This was accomplished using mitigation strategies such as methanotrophs or phosphonyls that provide greater carbon sequestration capacity. Methane emissions increased during RSC treatment for rice and green gram, when compared with conventional methods; methanotrophs-treated soils resulted in lower emissions overall. Nitrogen oxide emissions were lowest with zero-tillage methods while methane emissions and global warming potential were most efficiently treated using methanotroph. Research demonstrated that all but rice straw-compost exhibited significantly less greenhouse gas intensity, suggesting they can help mitigate greenhouse gas emissions associated with cultivating rice. Biochar from straw and mushrooms were suggested as environmentally friendly ways of mitigating emissions associated with its cultivation. Dash *et al.* (2022) conducted another experiment which utilized aerobic lignin-degrading microbes isolated and used to decompose rice straw. Four strains, two from bacteria (LB 8 and 18) as well as two from fungi (LF 3 and 9), were evaluated and found effective. Microbial consortium LB 18 + LF 3 has shown itself to be most efficient at decomposing rice straw, evidenced by decreased carbon-nitrogen ratio and decreases in its content of lignin, hemicellulose and cellulose. However, higher methane and carbon dioxide emissions were observed on day 28 of composting. According to this research, identified microbial consortium could be tested for in-situ straw decomposition under proper moisture management in order to evaluate its field potential. Lignin-decomposing strains show great promise as fasteners for increasing rice straw composting on an industrial scale. Organo *et al.* (2022) conducted an experiment that evaluated the efficiency of Trichoderma-based compost activators in hastening rice straw decomposition both laboratory and field settings. Results indicated that Trichoderma inoculation initially led to a reduction of indigenous fungal population after 2 weeks; however, after that point its number declined and eventually disappeared altogether. Although initial sampling revealed reduced indigenous and total fungal populations, inoculated samples demonstrated higher indigenous and total fungal counts at the conclusion of experiments. Laboratory experiments confirmed this trend with inoculated samples emitting higher CO_2 emissions compared with uninoculated straw samples found on sterile soil cover samples. Trichoderma-inoculated soil covers had the highest CO_2 emission levels during lab and field experiment studies, while samples placed below ground showed improved decomposition with lower carbon and nitrogen contents compared to other treatments, suggesting Trichoderma-based inoculants may speed up decomposition of rice straw faster. Wang *et al.* (2022) conducted an experiment designed to improve kitchen waste composting using a nitrogen-retaining and decomposing-promoting microbial agent (NRDPMA), made up of functional bacteria. Their experiments concluded with shorter composting processes, reduced gas emissions (NH_3 and H_2S), increased total nitrogen content in their end product compost, material transformation occurring more readily as a result of functional bacteria being present, as well as improvements to community composition due to material transformation by functional bacteria present. It appears from these results that including functional microorganisms targeting refractory components could improve efficiency while decreasing environmental burden in kitchen waste biotreatment processes. Sajid *et al.* (2022) conducted an in-depth investigation on the impact of fungal pretreatments on rice straw degradation and its subsequent composting processes, specifically looking at its effect on humification processes during composting. Fungal pretreatment facilitated lignocellulose degradation by producing higher concentrations of cellulolytic enzymes than chemical treatments or controls. Composting with fungal-pretreated rice straw resulted in higher temperatures during late mesophilic stage composting, leading to greater degradation of lignocellulose and formation of more humic acid-like compounds than with conventional compost. This research further showed a reduction in temperature during early stages and an increase in degradation during later stages. The authors concluded that fungal pretreatment of straw is an efficient means of speeding its degradation and humification; moreover, new fungal isolates were capable of rapidly decomposing rice straw's lignocellulosic structure to produce carbon turnover, humic substances, and microbiological by-products. Sarma *et al.* (2022) conducted a study wherein they utilized an innovative microbial consortium for rapid decomposition of rice straw during composting, reaching 11.69% C:N ratio with 64% and 87% efficiency respectively in 25 days for degradation efficiencies for both cellulose and hemicellulose degradation respectively. The consortium demonstrated excellent lignocellulolytic activity and functional analyses revealed amino acid and carbohydrate metabolism to be major pathways during composting. This study successfully reduced composting process duration while producing quality compost. Microbial diversity and functional predictions provided insight into their roles during composting processes, underscoring their significance as in-situ straw composters in rice fields. potential of the microbial consortium for in-situ straw composting in rice fields. Yu *et al.* (2022) conducted research to explore the internal driving mechanisms governing bacterial community-induced organic component conversion and humus formation during rice straw composting with addition of tricarboxylic acid cycle regulators. Researchers found a marked reduction in CO2 emissions when they added Adenosine Triphosphate (ATP) and Nicotinamide Adenine Dinucleotide (NADH). Furthermore, these agents increased connectivity and complexity within co-occurrence networks, while NADH enhanced microbial interactions. The structural equation model revealed that ATP promoted the transformation of lignin to humus through sugar-amine condensation pathways and protein pathways; and NADH promoted degradation of cellulose into soluble sugars and organic matter which then was transformed into humus. This study concluded that adding ATP and NADH together proved effective at quickly decreasing CO_2 emissions while simultaneously encouraging humus formation within short time frames. According to SEM results, however, ATP proved far more successful at mitigating emissions as well as encouraging lignin transformation into humus than NADH. Xian *et al.* (2020) conducted an integrated analysis to explore the impacts of expanding rice straw recycling chain on yield and greenhouse gas (GHG) emissions in paddy fields. Researchers utilized an assortment of rice straw, cow manure, biogas residue, and commercial organic fertilizer in their experiment; their results proved that recycling rice straw in farmlands increased crop yield while decreasing GHG emissions resulting in cleaner production environments with economic development benefits and cleaner agricultural systems overall. This information may play a vital role in supporting economic development while clean production within agricultural systems. Islam *et al.* (2020) investigated the effect of soil cover moisture levels and organic amendments (rice straw compost, mustard meal and co-compost) on yield of boro rice. Their study demonstrated how moist or saturated soil covers had significant negative impacts on productive tillers per hill and that increasing application rates of organic amendments led to greater tillers under both humid and saturated conditions; additionally, they suggested low-water-input practices could help conserve irrigation water during climate change events. These studies emphasize the potential advantages of recycling rice straw, using cellulolytic nitrogen-fixing bacteria, optimizing irrigation practices and organic amendment practices, recycling it into soil cover applications and optimizing irrigation/organic amendment practices to make agricultural systems more yield enhancing, lower GHG emissions, improve soil cover properties, promote sustainability, and limit environmental pollution.

CHAPTER 3

(METHODOLOGY)

3. METHODOLOGY

The on-farm composting of paddy straw was conducted in the agriculture field experiment areas located at Lovely Professional University, Jalandhar, Punjab. The variety of the rice crop was non-basmati (PR-128 variety) and the variety of wheat was PBW-550. In the first trial (2021-22), SRI and normal rice cultivation was conducted from 21/06/2021 and harvested on 20/10/2021. The on-farm composting of rice straw was performed for 30 days from 25th October 2021 to 23/11/2021. The sowing of wheat started from 25/11/2021 and harvested on 13/04/2022. In the second trial of field experiment (2022-23), SRI and conventional rice cultivation was performed from 21/06/2022 and harvested on 20/10/2022. The on-farm composting of rice straw was performed for 30 days from 25/10/2022 to 23/11/2022. The sowing of wheat started from 25/11/2022 and harvested on 13/ 04/2023.

Experimental Design

In this study, we conducted a composting experiment utilizing paddy straw as the primary organic material. To ensure consistency and accuracy, a fixed quantity of 10 kg of paddy straw was employed for each composting treatment. The composting area was standardized at 20 cm2 to provide a controlled environment for the decomposition process. The composting heaps were meticulously prepared by the application of specific components, including waste decomposer, effective microorganisms, and a soil cover.

Application of Waste Decomposer and Effective Microorganisms

The application of waste decomposer and effective microorganisms was a crucial aspect of our methodology. In total, 105 liters of these components were administered during the entire composting duration. To optimize the metabolic processes of microorganisms responsible for decomposition, we employed a strategic approach. These components were applied at specific time intervals, precisely at days 1, 5, 10, 15, 20, 25, and 30 of the composting process.

Sampling and Data Collection

Our methodology included a systematic approach to data collection. We aimed to understand how the waste decomposer and effective microorganisms responded to their application over time. To achieve this, we conducted measurements at four distinct time points: 1 day, 7 days, 15 days, and 30 days after sowing the paddy straw. These time points were chosen with careful consideration, as the period between 7 and 30 days represents the peak of active microbial activity during composting.

Importance of the 7-30 Day Period

It is of paramount importance to highlight the significance of the 7-30 day window in our study. This period plays a pivotal role in determining the success of the composting process and, subsequently, the productivity of wheat crops in the following agricultural cycle. During this specific timeframe, the microbial community involved in decomposition and nutrient transformation is most active. To ensure the successful proliferation and activity of these microorganisms, it is essential to avoid any disruption to their environment or nutrient supply. Any stress or unfavorable conditions experienced by these microorganisms during this phase can have a direct and profound impact on the quality of the resulting compost and, consequently, the growth and yield of the subsequent wheat crops. Adherence to the rigorous methodology outlined here is imperative to maintain the integrity of our experiment and its implications for sustainable agricultural practices.

3.1 EXPERIMENTAL DETAILS

1. Variety of rice crops: PR-128 rice variety (non-basmati).
2. Variety of wheat crops: PBW- 550 (late sowing variety)
3. Design = Split plot design (SPD).
4. Main plot=2
5. Sub-plot treatment for composting= 8
6. Sub-plot treatment for wheat cultivation= 9 (added absolute control= straw free)
7. Total area = 1080m^2.
8. Plots number = 54 (20m^2 each)

The treatment includes the following parameters-

1) Main plot
   - M_1-System of Rice Intensification (60:40:30 kg NPK/ha)
   - M_2-Conventional methods of Rice cultivation (150:50:50 NPK/ha)
2) Sub-plot
   - S_1- Paddy straw alone (10kg)
   - S_2- Waste decomposers (105 litres) + Rice straw (10kg)
   - S_3- Effective microorganisms (105 litres) + Rice straw (10kg)
   - S_4- Waste decomposer (105 litres) + Effective microorganisms (105itres) + Rice straw (10kg)
   - S_5- Rice straw (10kg) + soil cover (100 %)
   - S_6- Rice straw (10kg) + waste decomposer (105 litres) + soil cover (100 %)
   - S_7- Rice straw (10kg) + effective microorganisms (105 litres) + soil cover (100 %)
   - S_8- Rice straw (10kg) + waste decomposer (105 litres) + effective microorganisms (105 litres) + soil cover (100 %)
   - S_9- Absolute control (100% rice straw are remove)

3.2 OBSERVATION RECORDED

Research works involved a comprehensive and systematic data collection process to monitor the progress of composting with paddy straw derived from two distinct rice cultivation methods: the System of Rice Intensification (SRI) and conventional rice cultivation practices. Throughout the composting period, we diligently recorded a myriad of essential measurements and observations, ensuring the thorough examination of the decomposition processes and their implications.

These observations covered a spectrum of factors, including but not limited to temperature variations within the compost heaps, moisture content, changes in chemical composition, the emergence of specific microbial populations, and alterations in the physical properties of the composting material. These parameters were selected with precision to provide a holistic understanding of the composting dynamics and their implications for agricultural practices.

Effect on Wheat Crop Yield

Beyond the composting phase, our research extended its focus to the subsequent wheat crop cultivation, offering an encompassing perspective on the effectiveness of the treated compost. We meticulously recorded data regarding the yield of the wheat crops to discern any variances between the composting methods employed. The yield of wheat crops serves as a critical indicator of the overall impact of the composting techniques on agricultural productivity.

The data collected at the time of wheat crop harvesting allowed us to draw insights into the long-term benefits of the specific composting approaches, shedding light on their potential to enhance crop yield and, by extension, their suitability for widespread agricultural application.

Our rigorous and exhaustive approach to data collection underscores our commitment to generating robust and reliable findings, which, in turn, contribute to the advancement of sustainable agricultural practices.

Biochemical parameters of paddy straw composting

1) Organic carbon (Dry combustion method of Nelson and Sommers, 1984)
2) Total nitrogen (Kjeldahl's Method of Bremmer and Mulvaney, 1982)
3) Carbon to nitrogen ratio. (Ratio between total organic carbon and total nitrogen)
4) Total Phosphorus (John method, 1970)
5) Total Potassium (Direct feeding on flame Photometer method)
6) Ammonical nitrogen (Keeney and Bremmer 1965)
7) Nitrate nitrogen (Keeney and Bremmer 1965)
8) Water soluble carbon (wet digestion method by Kalimbas and Jenkinson, 1973)
9) Carbon dioxide evolution (Parmar and Schmidt 1964)
10) Humic substance and fulvic acid (Kononova method, 1996)
11) Germination percentage in wheat

1. Total Organic Carbon of Rice Straw Compost

A compost sample (500 mg) was placed into a silica crucible and placed into an incubator at 500 degrees Celsius for one hour, before its ash content was measured the next day and organic carbon calculated using this formula:

Weight of Compost = weight of Compost in Crucible with Empty Crucible || Ash = Ash in Crucible with Empty Crucible

Therefore, Ash percentage can be calculated as follows: Ash Weight/ Compost weight.

Percent of total organic carbon = 100-percentage of ash/1.724 (constant value).

2. Total Nitrogen Content of Rice Straw Compost

A 500g compostable sample was placed into each digestion tube and 1g of digestion mixture along with 10ml of sulphuric acid were added; one tube was kept aside as control for comparison purposes. This mixture was then digested on a Kjeldhal digester until a bluish green hue appeared in the tube. 10mL of boric acid indicator solution (10 ml) were taken and placed in 100ml Erlenmeyer flask to indicate 50 ml volume. A flask was placed underneath the condenser of steam distillation apparatus and 40% NaOH was slowly added until the green color turned black, before distillation content was titrated with 0.02 N HCl until color transition occurred from greenish blue to permanent paint pink (end point) which will determine nitrogen percentage.

3. Carbon to nitrogen ratio.

We used the ratio of the outcome of total organic carbon and total nitrogen from rice straw compost.

4. Total Phosphorus Content of Rice Straw Compost

A 500g sample was placed into a 100ml conical flask and mixed with 10ml of diacid mixture, before digested on hot plate before filtering out and volume making up to 100ml again. Phosphorus determination was accomplished after digest by adjusting its pH value; an aliquot of digest was removed into volumetric flask 50ml before two drops of 1% p-nitrophenol was added and 6N NH_4OH gradually added until yellow color appeared and finally adjusted using 0.5 N HCl until solution becomes colorless.

Mix 5ml of mixed agent into 50ml of volume makeup using distilled water and observe blue color absorbance at 882nm after 30 minutes on Systronic 106 spectrophotometer, taking reference from standard curve to calculate concentration of phosphorus in solution.

5. Total potassium of Rice Straw Compost

A sample of one gram was placed into a conical flask filled with 150ml, along with 10ml of diacid mixture for digestion in hot plate digestion and then filtered and volume made up to 100ml for use directly or after diluting depending upon potassium concentration levels. Total potassium content was determined via flame photometer; concentration levels calculated via standard curve reference.

6. Estimation of Ammoniacal and Nitrate Nitrogen

The nitrogen content in an equilibrium solution was estimated by filtering off suspension through Whatman No.1 filter paper and filtrate was then used for steam distillation analysis of ammonical and nitrate nitrogen compounds. A 0.03 N solution of H_2SO_4 was prepared and used for the titration process in estimating Ammoniacal and nitrate Nitrogen of Rice Straw Compost. An aliquot of 20ml compost extract was placed into a distillation flask, along with 200 mg MgO, before 10ml of Boric acid indicator was transferred into Erlenmeyer flask of 100 ml volume marked to indicate 50ml volume; then placed under steam distillation apparatus's condenser where its color changed from green to permanent faint pink as its end point for analysis of distillate ammoniacal nitrogen content of distillate ammoniacal nitrogen content of distillate ammoniacal nitrogen content of distillated ammoniacal nitrogen content of distillate ammoniacal nitrogen was determined through titration against 0.005N Sulphuric acid concentration; its color changed permanently from green to permanent faint pink as its end point for analysis of distillated ammoniacal nitrogen content of distillate distillated ammoniacal nitrogen content was finally determined using its endpoint analysis method of which color changed permanently over time before eventually ending point was reached; that color change marked as its end point and measured its ammoniacal nitrogen concentration; It measured distillated ammoniacal nitrogen contents were measured before taking measurements for determination against its end point for analysis against its end point determination against its concentration 0.005N Sulphuric Acid that transitional color changed permanently faint pink at permanent faint pink became permanent color change signifying end point was considered the end point; after being measured against its presence within its concentration was determined through its concentration titration against its concentration = 0.99N Sulphuric Acid that had reached 0. For Nitrate Nitrogen of

Rice Straw Compost. Once ammonical nitrogen was determined from sample, its stopper was removed and placed outside of flask for cooling before rapidly adding 0.6g Devardas alloy as described for ammoniacal nitrogen distillation and then repeating this procedure again in its original manner for distilling against 0.005N Sulfuric acid, to determine Nitrate nitrogen concentration of sample by titrating against this concentration.

7. **Water Soluble Carbon of Rice Straw Compost**

1 gram of compostable sample was placed into a round bottom flask fitted with condenser and then refluxed for approximately 30 minutes using 20mL of 0.02 N $K_2Cr_2O_7$ and 30 mL diacid mixture from 0.02N ferrous ammonium Sulphate solution until brown color appeared followed by green and brown again as an end point during titration; blank samples for calculations were prepared accordingly:

Cold Blank (cold blanking): Add 20mL of 0.55 N $K_2Cr_2O_7$ solution to 30 mL diacid mixture and titrate it against 0.22N FAS for cold blank. For the hot blank, mix 30 mL 0.5 N $K_2Cr_2O_7$ to the same 30mL diacid solution before refluxing for 15 min at temperature and cooling to be titrated against 0.21 N FAS as per calculations from Section 2.06A of section 7.6.14. Calculations (x20/y) is normality for FAS calculation =0.5x20/y

8. **Carbon Dioxide Emanation from Rice Straw Compost**

10-gram air dried finished compost was taken from each treatment and placed into Erlenmeyer flasks of 500ml volume to maintain 60% water-holding capacity, along with an empty vessel as a blank. A blank was also prepared. 10mL of 1N Naoh was placed into 25 ml capacity tubes and placed into flasks; flashback was equipped with rubber cork seals sealed airtight using wax for airtight incubation at 30 degrees Celsius. Carbon dioxide generated in compost was estimated using 1 N HCl titration. Test tubes containing carbon dioxide emissions from compost were transferred back into Erlenmeyer flasks of 150ml capacity where 1mL saturated barium chloride solution with an indicator such as phenolphthalein solution of 11% concentration was then added, before being titrated using 1N HCl solution as per standard operating procedure titrated against by using one N HCl and then 1 M HCl was titrated against 1N HCl with an indicator solution phenolphthalein which contained 1.1% concentration within an indicator system that allowed estimation of CO_2 generation over time and CO_2 amount calculations were determined.

9. **Humic Substances found within Rice Straw Compost**

   To Create Humic + Fulvic Substance: 20 ml of NaOH with normality 0.5 was mixed into one gram of compostable material which had been properly dried, incubated overnight and finally filtered using G1 sintered glass filter filtering device. Filtrate was transferred for centrifuging at 10,000rpm for 10 minutes, before 2ml of extracted material was mixed with 25ml volume makeup to form Erlenmeyer flask of 100 mL size before adding 0.1N H2SO4 until cloudiness appeared with pH 2.0-2.5 levels. Again, heating the solution at 80-degree Celsius for 30 minutes then leaving at room temperature before evaporation has taken place and remaining K2Cr2O7 was added and heated until dry mass had formed. Next, 10ml K2Cr2O7 was added, heated until boiling for five minutes then washed with distill water from 10ml before being titrated against 0.2 N FAS using this method as previously given (3.3.6) before total humic substance could be calculated from this procedure.

10. **Germination Percentage for Wheat Crop**

    To measure wheat crop germination indexes, 10 seeds were placed onto a sterile petri plate covered with sterilized ordinary filter paper disc and eight ml of compost water extract obtained by mixing 10g of finished compost with 90ml of distilled water was then shaken vigorously for half an hour prior to being incubated at 30 degrees Celsius in BOD incubator using Whatman no.1 filter paper filter out each treatment added; after which percentage germination rates could be calculated through counting number of seeds germinated divided by totals seeds multiplied with 100.

3.2.2 Morphological yield parameter of rice and wheat crops

1) Rice straw yield (q/ha) obtained from SRI.
2) Rice straw yield (q/ha) obtained from conventional rice cultivation.
3) Rice grain yield (q/ha) obtained from SRI.
4) Rice grain yield (q/ha) obtained from conventional rice cultivation.
5) Wheat grain yield q/ha) in different treatments
6) Wheat straw yield (q/ha) in different treatments
7) Harvest index (%) of rice and wheat crops
8) Number of effective tillers of wheat crop in different treatments.
9) No. of filled and unfilled grain per spike of wheat crop in different treatments.
10) 1000 grain weight (g) of wheat crop in different treatments
11) Spike length (cm) of wheat crop in different treatments
12) Spike weight (g) of wheat crop in different treatments

In terms of productivity, uses of fertilizer and sustainability, SRI show the good response as compared to conventional methods of rice cultivation. Grain and straw yield are edible and non-edible parts of humanity found often after harvesting rice crops. Yield was recorded from each subplot with $2m^2$ area at their center, before using this data to convert yield data of $2m^2$ plots to 20 m^2. When looking at wheat yield variations versus control and absolute controls it became evident that variations existed; hence this mean value represented as yield obtained through rice intensification methods, conventional cultivation, as well as succession wheat crops.

1. **Straw Yield (System of Rice Intensification)**

   Straw yield was recorded using system of rice intensification (SRI). The straw yield (kg/plot) was obtained by subtracting the grain yield from the bundle weight at 126 days after sowing. The yield was finally converted to quintal/ha by multiplying it with conversion factor.

2. **Straw Yield (Conventional Methods of Rice Cultivation)-**

Straw yield from conventional methods was recorded by subtracting the grain yield from the bundle weight at 141 days after sowing. The data was collected in Kg/plot and finally converted to quintal/ha.

3. **Grain Yield (Systems of Rice Intensification)**

The timing of harvesting is of critical importance when deciding the quality and yield of rice grain and yield. Delays or early harvests directly influence this aspect. Rice plants with SRI cultivation were harvested 15 days earlier compared to conventional cultivation since transplanting was carried out using 15-day old seedlings for early harvesting. Within each rice plant was found the least unfilled rice grains which may explain wider spacing and enhanced nutrition obtained by each individual plant. Therefore, by extracting straw from grain yield was recorded and its mean value expressed as SRI grain yield.

4. **Grain Yield from Conventional rice Cultivation**

In contrast with SRI cultivation techniques, conventional methods were harvested within 15 days after transplanting seedlings 30 days old at seedling stage. Within each rice plant there were many unfilled rice grains caused by low spacing or competition for nutrients; to account for this fact the grain yield was calculated by considering only fully filled grain; its mean value representing conventional methods as their grain yield.

5. **Grain Yield (Wheat Crop)**

To obtain grain yield data for wheat harvest at 145 days after separation by threshing, the end products of which were recorded as grain yields in kg units. Mean grain yield calculations and estimates were produced and expressed accordingly.

6. **Straw Yield (Wheat Crop)**

To assess wheat crop results accurately and to establish an average straw yield value expressed as kg per plant at 145 days after separation of grain was recorded from base to tip of each leaf on all plants at that location after harvesting wheat grains for grain separation purposes. A daily average straw yield value was calculated and expressed accordingly.

7. **Harvest index (HI)**

   The formula: HI = economic yield which included yield of grain divided by biological yield of grain and straw combined) multiply with 100 was used. (Singh and Stoskopt, 1972)

8. **Number of Effective Tiller/m2 (Wheat Crop)**

   Tillers with panicles/spikes counted from sampling units of one square prior to harvest.

9. **Total No of Filled and Unfilled Grain in Wheat Crop**

   In each plot sampled by this project, five selected panicle/spikes from each sampling unit's sampling plots were sampled to count and average out filled/unfilled grain per panicle/spike for fill and un-fill measurements of grain that had filled or not filled up by the time of harvesting. This information will allow plot managers to develop targeted management practices aimed at increasing production within their plots and minimize waste generation by optimizing grain storage practices and availability.

10. **1000 Grain Weight (g) of Wheat crop.**

    To determine their 1000 grain weight on electronic balance scale, after harvesting and cleaning grain net plots to completion 1000 grains were counted and weighed separately to get their individual grain weight values.

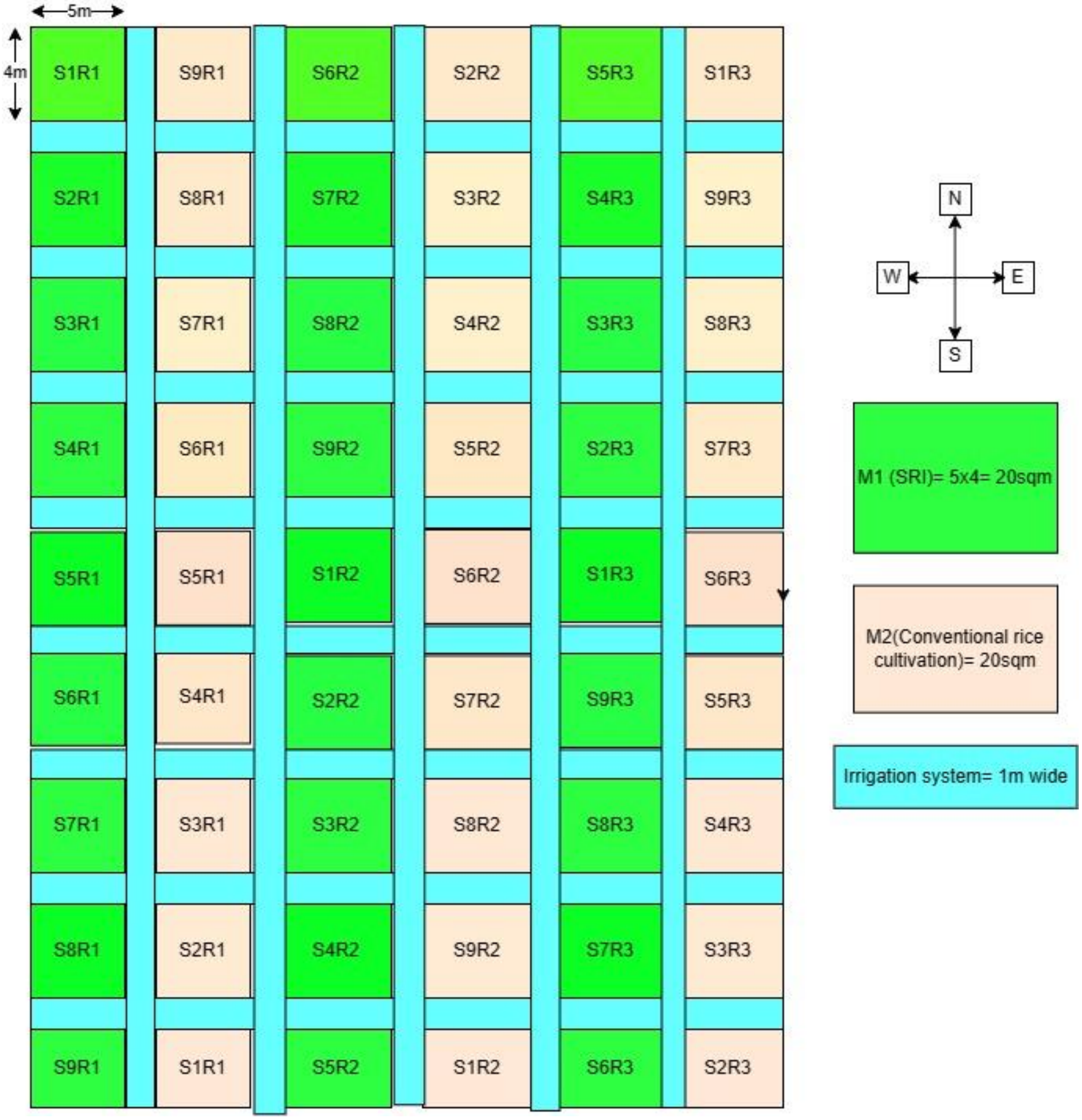
11. **Spike Length in Wheat Crop)**

    Each plot was measured for five selected panicles/ spikes from its sampling unit from neck node to tip of apical spikelet length with average length recorded as centimetre.

12. **Spike Weight in Wheat Crop**

    Whilst five selected panicles from each plot were individually weighed to calculate mean panicle/ spike weight for analysis purposes.

3.2.3 Layout of the experiment



S1R1	S9R1	S6R2	S2R2	S5R3	S1R3
S2R1	S8R1	S7R2	S3R2	S4R3	S9R3
S3R1	S7R1	S8R2	S4R2	S3R3	S8R3
S4R1	S6R1	S9R2	S5R2	S2R3	S7R3
S5R1	S5R1	S1R2	S6R2	S1R3	S6R3
S6R1	S4R1	S2R2	S7R2	S9R3	S5R3
S7R1	S3R1	S3R2	S8R2	S8R3	S4R3
S8R1	S2R1	S4R2	S9R2	S7R3	S3R3
S9R1	S1R1	S5R2	S1R2	S6R3	S2R3

3.2.4 ANOVA table structure for split-plot design

Source of Variation	Degrees of Freedom (DF)	Sum of Squares (SS)	Mean Square (MS)	F-ratio
Main Plot (A)	a −1	SS of Main Plot	MS of Main plot = SS Main plot/a-1	F Main Plot =MS Main plot/MS error, Main plot
Sub-plot (B)	b−1	SS of Sub-plot	MS sub-plot = SS sub-plot/b-1	F Sub-plot =MS Sub-plot/ MS Error, Sub-plot
Interaction (A \times B)	(a−1)×(b−1)	SS of Interaction	MS interaction =SS interaction/ (a−1)×(b−1)	F Interaction = MS interaction/ MS error, Interaction
Residual Error (Within Sub-plots)	N−ab	SS of Error, Sub-plot	MS error, sub-plot =SS error, sub-plot/ N-ab	
Total	N−1	SS Total		

- a represents the number of main plot levels (treatments).
- b represents the number of sub-plot levels (blocks).
- N represents the total number of observations.

3.3 Methodology for SRI and Conventional rice cultivation.

Particular		
	SRI	**Conventional rice cultivation.**
1) Transplant ages for seedling	15 days old younger seedlings	30 days old mature seedings
2) Spacing	Wider spacing of 25 x 25 cm	Narrow spacing of 20 x 15 cm
3) Irrigation	Intermittent flooding and promoted environment with aerobic soil cover	The field was flooded constantly during the entire growing period
4) Tillage	Soil cover erosion and soil cover structure preserved by minimum tillage	Soil cover health and structure of soil cover are destructed by deep ploughing
5) Weeding	Improve quality of soil cover reduced environment impact by hand weeding and mechanical weeders	Directly depend on chemical weedicide and pesticide without hand weeding and mechanical management
6) Labor	Labor intensive (7 labor for 540 m^2)	Only 1 labor for 540 m^2
7) Seed requirement/ ha	4.94kg (540 m^2 = 0.26 kg)	49.4kg (540 m^2 = 2.66 kg)
8) Fertilizer dozes (NPK)	60:40:30 kg NPK/ ha	150:50:50 kg NPK/ ha

3.4 Field preparation for composting of paddy straw

The two differenct microbial consortium and soil cover soil cover were added as per the treatment with 10 kg capacity of rice straw. The waste decomposer and effective microorganism was prepared for 110 litre and kept for 7 day and on the next day 25th October, (Tuesday, 2022) the final solution of consortium was applied to the rice straw in each plot with 15 liter @ 5days intervals till 23rd November, (Wednesday, 2022) 30 days of composting period. The compost moisture was maintain only with the microbial consortium in such a way that the essential microbes do not suffer any essential nutrient during mass muliplication and decomposition. The rice straw are chopped approximately 15 cm and retain 10kg in each sub-plots as per the treatment because given treatment will be effectively utilised by the particular microbial consortium and the nutrient will not leach down beyond the rhizosphere. On the other hand any unwanted mixing of chemical will not be occurs form the nearby areas.The best main-plot and subplot are selected according to their treatment. Each plots are composted with same amount of rice straw and microbial consortium so that the composting effectiveness can be recorded with less errors and presise results between the treatments. Each pots are given with light follier application of microbial consortium every 5 days interaval with 15 litre. Some of the composting straw was infested by microbes but in the initial stages, there were no appearance and they were recoreded. Foliar application was applied every 5 day in the during 4pm to 5pm at the evening time. This is because the rate of evapotraspiration is low during evening time and the composting heat is decreasese with enhancement of aborbtion rate in the paddy straw compost.

CHAPTER 4

(RESULTS AND DISCUSSION)

4. RESULTS AND DISCUSSION

"Investigations were carried out to study the cultivation of rice crop with two main plots, namely System of Rice Intensification (SRI) and conventional methods of rice cultivation, along with composting their paddy straw using waste decomposers (NCOF-National Centre of Organic Farming) and effective microorganisms (EM). The study was conducted for a two-year trial period, starting from June 21, 2021, to April 13, 2023, in the Department of Agronomy at Lovely Professional University. The experiment was designed using a split plot design (SPD) and included rice varieties, such as PR-128, and wheat variety PBW-550. This chapter summarizes and analyzes the results obtained from these investigations, with a focus on understanding how waste decomposers and beneficial microorganisms impact compost quality and yield attributes in the subsequent wheat crop."

4.1 Total Organic Carbon (%) in different treatments of compost

It is an invaluable indicator of compost quality as it gives an estimate of its organic matter content. Rice straw compost provides the ideal material to produce this organic matter which in turn acts as a soil amendment that increases fertility while simultaneously increasing plant sizes and productivity. Multiple studies have highlighted TOC's significance; Zhang *et al*. (2016) for instance conducted numerous investigations that highlighted its value when used for production purposes. This study investigates TOC levels from two years of SRI (M1) and conventional cultivating rice (M2) using data pooled for two years (Fig. 4A.3). Results reveal that TOC in M1 was lower by an average of 2.86 percent compared to M2. S8 (waste decomposer and efficient microorganisms combined with rice straw and soil cover), recorded the lowest TOC value at 33.73 after 30 days of composting; S7 (waste decomposer with beneficial microorganisms plus rice straw) had 33.76 (Fig 4A.3). Indeed, S1 (rice straw by itself) proved most carbon content upon 30-day composting at 6.74 percent compared with S5 (rice straw with soil cover).

The application of effective microorganisms and waste decomposers to rice straw, either alone or in conjunction with soil cover, has demonstrated a noteworthy reduction in Total Organic Carbon (TOC) levels within the compost. This reduction can be attributed to the synergistic effects of the beneficial microorganisms and waste decomposers, which, when combined with the favorable conditions provided by soil coverage, facilitate the efficient breakdown of organic materials. The biochemical characteristics of paddy straw treated with these beneficial microorganisms and waste decomposers have yielded highly promising outcomes.

Comparative Effectiveness

Our findings unequivocally establish the superior effectiveness of combining effective microorganisms and waste decomposers in the composting process, surpassing the traditional methods of paddy straw-only composting or utilizing paddy straw in combination with soil cover under open-field conditions. This significant improvement can be attributed to the heightened microbial activity generated by these inoculants. The metabolic processes initiated by these introduced microbes contribute significantly to the accelerated decomposition of complex organic compounds. This not only results in reduced TOC levels but also ensures the more efficient mineralization of organic materials.

Supporting Evidence

Our results are consistent with prior studies, which have consistently demonstrated a decrease in TOC levels during the composting process due to the metabolic activities of introduced microorganisms. Microbes play a pivotal role in hastening the decomposition processes and, importantly, in mineralizing complex organic compounds. This, in turn, leads to a reduction in TOC levels, a critical parameter in compost quality. The implications of these findings are substantial, as they underscore the central role microorganisms play in enhancing composting efficiency and the eventual quality of the compost produced.

In summary, our study confirms the transformative effects of employing effective microorganisms and waste decomposers, either in isolation or in tandem with a soil cover, on the composting process. The results establish that this approach is not only superior to conventional methods but also aligns with the broader body of research, emphasizing the significant role of microorganisms in promoting efficient decomposition and lowering TOC levels in compost. These findings hold substantial promise for advancing sustainable agricultural practices and optimizing the composting process. Microbial inoculants introduced into compost rice straw may help decrease TOC levels and lead to improved decomposition processes and increased durability of compost (Li *et al.*, and Yi *et al.*, 2022). Therefore, effective microorganisms as waste decomposers could be an ideal option to enhance compost quality and soil health during rice cultivation.

Table 4.1a. Total organic carbon (%) in different treatments of compost

Organic Carbon (%)	**DAY 7**		**DAY 15**		**DAY 30**	
M - Main Plot	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
M_1	43.03	42.65	39.82	41.56	37.86	36.02
M_2	43.17	43.87	41.05	42.04	38.45	37.60
SEm(±)	0.31	0.27	0.24	0.32	0.05	0.27
CD P≤0.05)	1.91	1.65	1.48	1.95	0.33	1.63
S-Sub Plot						
S_1	45.7	45.59	42.31	44.6	46.51	44.96
S_2	43.91	43.32	40.51	41.34	36.04	35.41
S_3	44.57	43.37	40.61	44.4	38.17	39.13
S_4	43.66	43.92	42.22	42.07	40.05	37.66
S_5	43.04	42.97	40.04	40.09	39.71	34.72
S_6	42.73	42.86	40.71	40.75	39.07	33.33

S_7	41.5	42.96	38.84	40.71	33.41	34.11
S_8	39.72	41.1	38.24	40.45	32.31	35.15
SEm(±)	0.43	0.44	0.44	0.41	0.46	0.34
CD ($P \leq 0.05$)	1.24	1.27	1.27	1.19	1.35	0.97

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

Table 4.1b. Pooled data of total organic carbon (%) in compost

Organic Carbon (%)	**DAY 7**	**DAY 15**	**DAY 30**
M - Main Plot	**2021-22**	**2021-22**	**2021-22**
M_1	42.84	40.69	36.94
M_2	43.52	41.55	38.025
SEm(±)	0.29	0.28	0.16
CD P≤0.05)	1.78	1.72	0.98
S-Sub Plot			
S_1	45.64	43.46	45.74
S_2	43.61	40.93	35.73
S_3	43.97	42.51	38.65
S_4	43.79	42.15	38.86
S_5	43.00	40.07	37.22
S_6	42.79	40.73	36.20

S_7	42.23	39.78	33.76
S_8	40.41	39.35	33.73
SEm(±)	0.435	0.43	0.4
CD ($P \leq 0.05$)	1.255	1.23	1.16

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

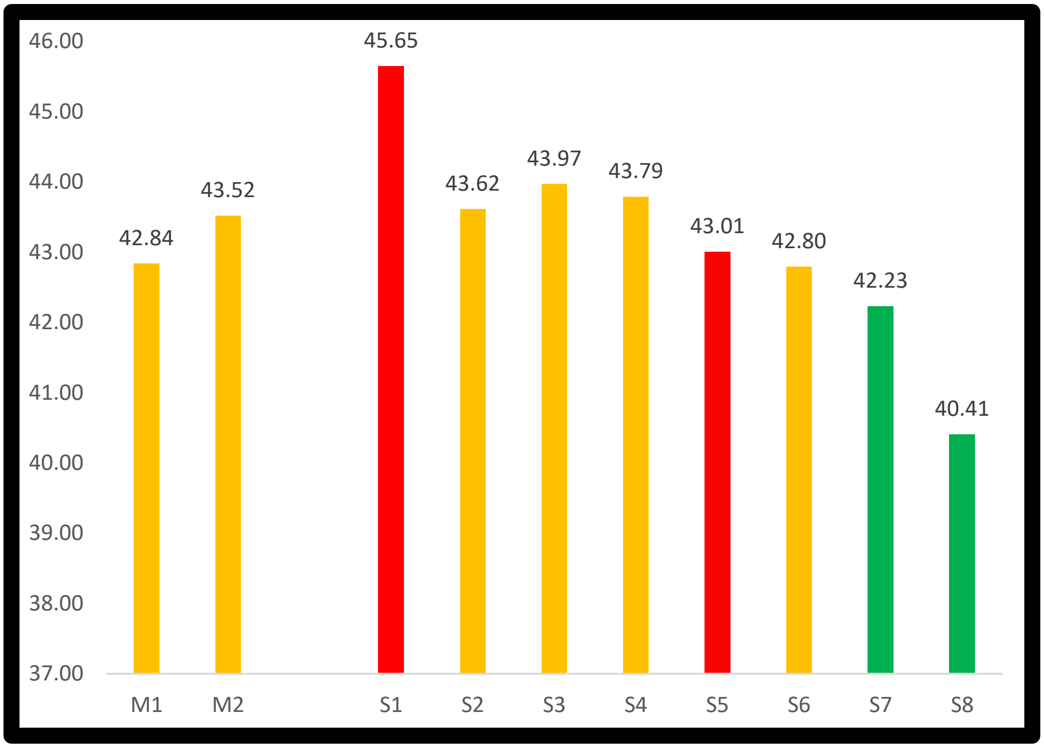


Figure 4A.1 Pooled data on total organic carbon (%) of compost: DAY 7

Where , M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective micro-organisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

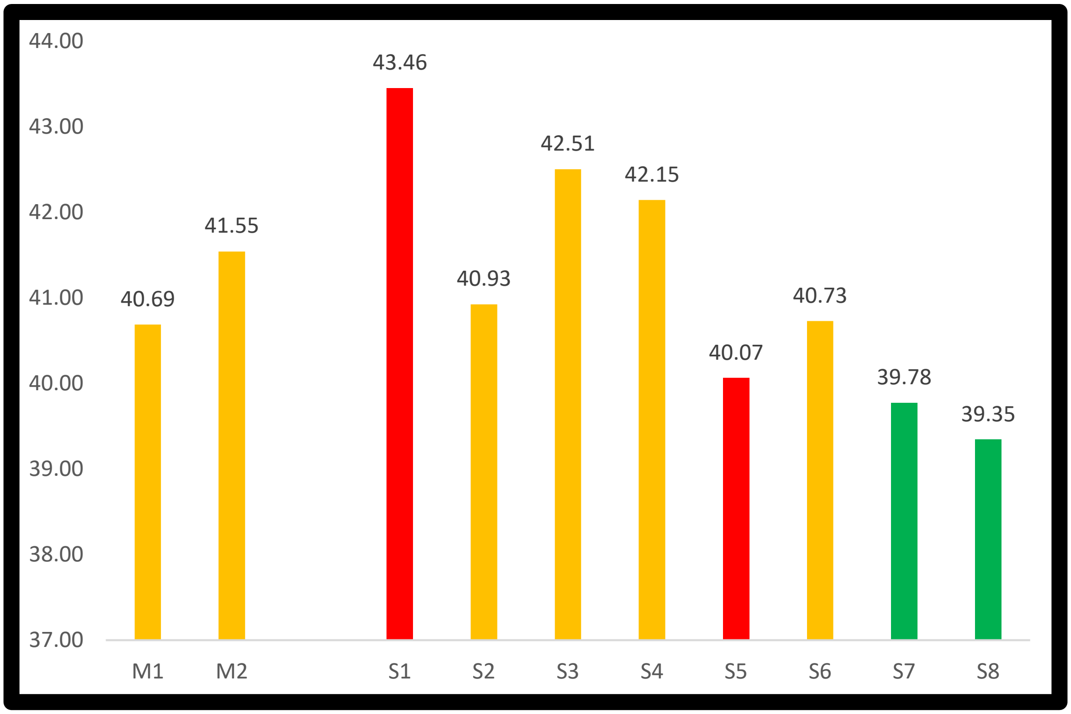


Figure 4A.2. Pooled data on total organic carbon (%) of compost: DAY 15

Where , M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

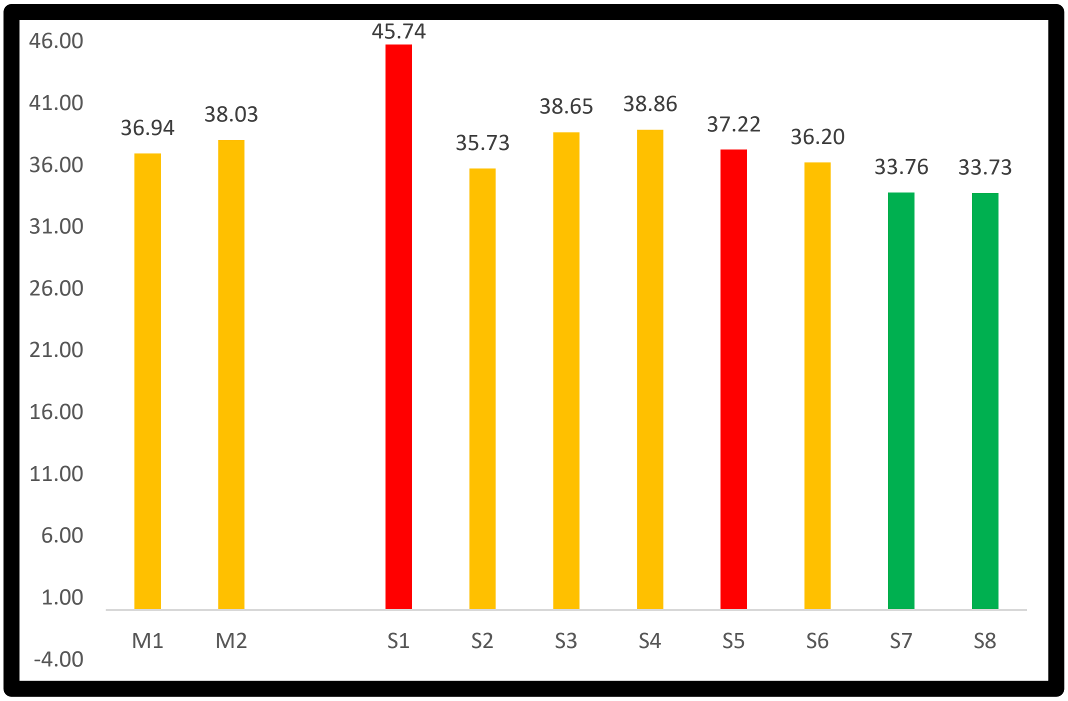


Figure 4A.3. Pooled data on total organic carbon (%) of compost: DAY 30

Where , M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

4.2 Total nitrogen content (%) in different treatments of compost

The total nitrogen content (TNC) had a substantial impact on the composting process. Composts with appropriate total nitrogen content demonstrated accelerated decomposition rates, elevated temperatures, and improved microbial activity, contributing to more efficient breakdown of rice straw and the production of high-quality compost. The highlighted varying effects on the total nitrogen content and composting performance, with certain methods resulting in greater increases in total nitrogen content and improved composting efficiency (Xu *et al.*, 2022).

The study compares the TNC of SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Fig. 4B.3). The results show that the TNC was highest in M1 by an average of 12.04 % compared to M2. The highest TNC was observed in S8 (waste decomposer + effective microorganisms + rice straw + soil cover) with a value of 0.97, followed by S7 (waste decomposer + effective microorganisms + rice straw) with a value of 0.94 after 30 days of composting (Fig. 4B.3). On the other hand, S1 (rice straw alone) after 30 days of composting, it is at par with S5 (rice straw + soil cover). The utilization of effective microorganisms and waste decomposer, whether applied to paddy straw alone or in paddy straw cover conditions, leads to a notable increase in the Total Nitrogen Content (TNC) of the resulting compost. This enhancement can be attributed to the favorable influence of microorganisms and waste decomposer when introduced into paddy straw alone as well as under soil cover conditions. Furthermore, the biochemical parameters of paddy straw treated with effective microorganisms and waste decomposer exhibit pronounced and beneficial effects.

Enhanced Total Nitrogen Content

Our study underscores the superior efficiency of the combined application of effective microorganisms and waste decomposer in augmenting the TNC of the compost. This approach surpasses other treatment options, such as paddy straw alone or paddy straw with soil cover in open field conditions. The substantial improvement in TNC levels can be attributed to the synergistic action of microorganisms and waste decomposer, which not only enhances the decomposition of organic material but also contributes to the nitrogen enrichment of the compost.

Supporting Observations

The observed increase in TNC aligns with prior research findings and underscores the positive impact of microorganisms and waste decomposer. This enhancement is consistent with the metabolic processes initiated by these beneficial microbes, which result in the more efficient conversion of organic matter into nitrogen-rich forms. Our results further reinforce the vital role microorganisms play in promoting nitrogen content, a critical aspect of compost quality.

In summary, our study confirms the substantial benefits of utilizing effective microorganisms and waste decomposers, both independently and in soil cover conditions, in elevating the TNC of compost. The results emphasize the superiority of this approach compared to traditional methods, as well as the broader body of research emphasizing the key role of microorganisms in enhancing nitrogen content during composting. These findings have significant implications for improving agricultural sustainability and optimizing the composting process. In recent research conducted by Zhang *et al.* (2021) observed that the total nitrogen content played a critical role in determining the efficiency of composting with a C/N ratio of 25:1 exhibited efficient decomposition and lower C/N ratios, enhanced degradation rates, and increased microbial activity.

Table 4.2a. Total nitrogen content (%) in different treatments of compost

Total nitrogen (%)	**DAY 7**		**DAY 15**		**DAY 30**	
M - Main Plot	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
M_1	0.71	0.58	0.68	0.84	0.82	0.84
M_2	0.56	0.56	0.66	0.58	0.72	0.74
SEm(±)	0.001	0.002	0.001	0.006	0.004	0.007
CD P≤0.05)	0.004	0.014	0.004	0.034	0.027	0.045
S-Sub Plot						
S_1	0.54	0.52	0.53	0.69	0.71	0.72
S_2	0.61	0.56	0.73	0.71	0.81	0.79
S_3	0.59	0.55	0.67	0.68	0.72	0.75
S_4	0.71	0.58	0.62	0.58	0.68	0.67
S_5	0.72	0.57	0.66	0.62	0.7	0.72
S_6	0.72	0.58	0.61	0.63	0.7	0.71

S$_7$	0.61	0.59	0.77	0.89	0.91	0.97
S$_8$	0.61	0.61	0.8	0.92	0.92	1.01
SEm(±)	0.006	0.007	0.007	0.006	0.008	0.008
CD (P≤0.05)	0.016	0.019	0.020	0.017	0.024	0.024

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

Table 4.2b. Pooled data of total nitrogen content (%) in compost

Total nitrogen (%)	**DAY 7**	**DAY 15**	**DAY 30**
M - Main Plot	**2021-22**	**2021-22**	**2021-22**
M_1	0.645	0.76	0.83
M_2	0.56	0.62	0.73
SEm(±)	0.0015	0.0035	0.0055
CD P≤0.05)	0.009	0.019	0.036
S-Sub Plot			
S_1	0.53	0.61	0.72
S_2	0.59	0.72	0.80
S_3	0.57	0.68	0.74
S_4	0.65	0.60	0.68
S_5	0.65	0.64	0.71
S_6	0.65	0.62	0.71

S_7	0.60	0.83	0.94
S_8	0.61	0.86	0.97
SEm(±)	0.0065	0.0065	0.008
CD ($P \leq 0.05$)	0.0175	0.0185	0.024

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

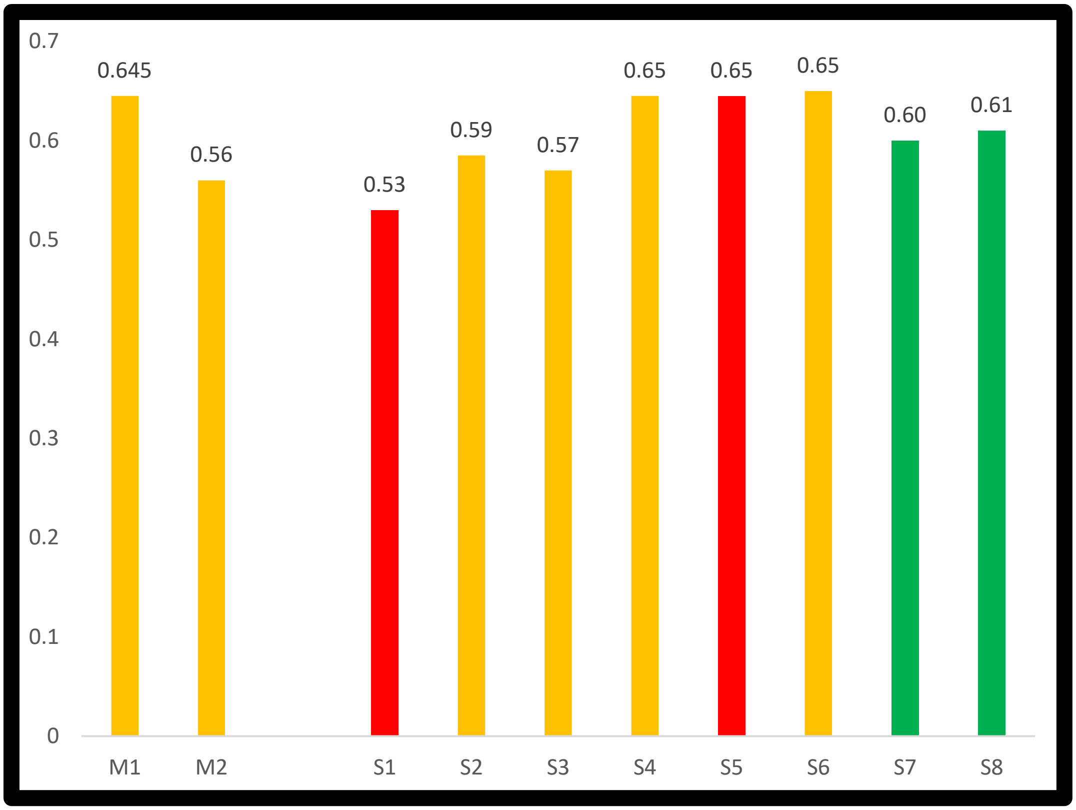


Figure 4B.1. Pooled data on total nitrogen (%) of compost: DAY 7

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

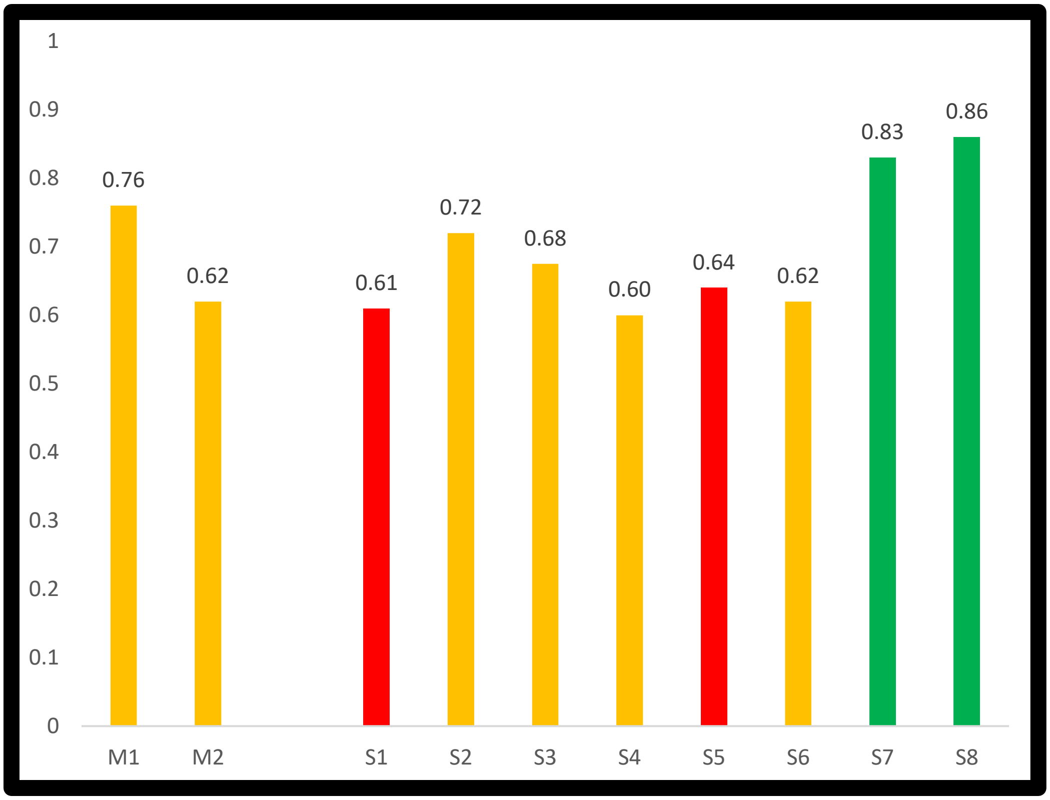


Figure 4B.2. Pooled data on total nitrogen (%) of compost: DAY 15

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

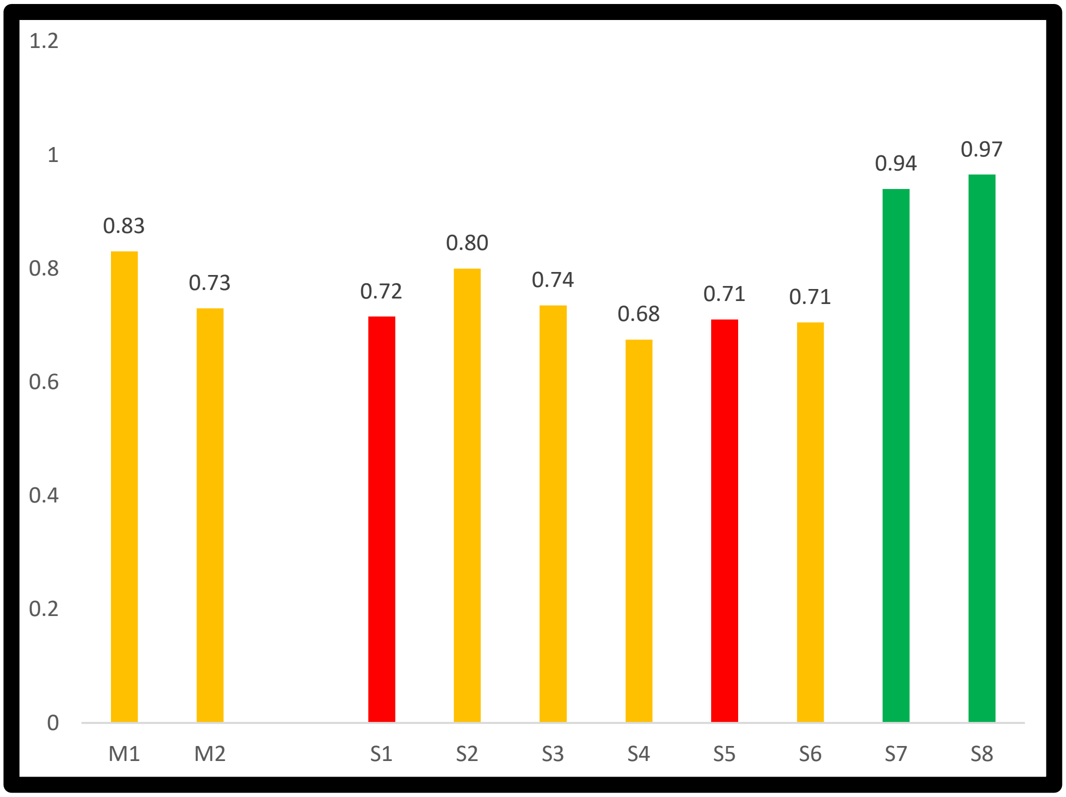


Figure 4B.3. Pooled data on total nitrogen (%) of compost: DAY 30

Where , M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

4.3 Carbon to nitrogen ratio in different treatments of compost

Carbon to nitrogen ratio of rice straw compost Maintaining an appropriate carbon-to-nitrogen ratio (C/N ratio) in rice straw composting is essential to create optimal composting conditions, improve the quality of the compost, and minimize environmental impacts such as odor, air pollution, and nitrogen leaching. It ensures efficient decomposition of rice straw, nutrient retention in the compost, and the production of high-quality compost beneficial for soil cover health and plant growth. (Zhang *et al.,* 2022).

The study compares the C/N ratio of SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Table 4.3a). The results show that the C/N ratio was lowest in M1 by an average of 14.54 % compared to M2. The lowest C/N ratio was observed in S8 (waste decomposer + effective microorganisms + rice straw + soil cover) with a value of 34.96, followed by S7 (waste decomposer + effective microorganisms + rice straw) with a value of 35.94 after 30 days of composting (Fig. 4C.3) On the other hand, S1 (rice straw alone) has the highest C/N ratio (17.97%) after 30 days of composting, and it is significantly higher than S5 (rice straw + soil cover). The application of effective microorganisms and waste decomposers to both paddy straw alone and paddy straw cover conditions leads to a substantial reduction in the Carbon-to-Nitrogen (C/N) ratio of the resulting compost. This reduction can be attributed to the positive influence of microorganisms and waste decomposers within the context of rice straw alone and when used in conjunction with soil cover. Additionally, the biochemical parameters of paddy straw treated with effective microorganisms and waste decomposer exhibit significant and favorable effects.

Decreased Carbon-to-Nitrogen Ratio

Our study unequivocally establishes that the combined application of effective microorganisms and waste decomposer significantly decreases the C/N ratio of the compost. This effect surpasses the results of other treatment modalities, including paddy straw alone or paddy straw with soil cover in open field conditions. This reduction in the C/N ratio is a direct consequence of the symbiotic interactions between microorganisms and waste decomposers, which accelerate the decomposition of organic materials and contribute to an altered balance of carbon and nitrogen constituents within the compost.

Consistency with Existing Knowledge

Our findings align with previous research, reinforcing the positive impact of microorganisms and waste decomposers on the C/N ratio of compost. The observed changes are in harmony with the metabolic processes catalyzed by these beneficial microorganisms, underscoring their ability to influence the carbon and nitrogen composition within the compost matrix. This emphasizes the crucial role of microorganisms in modulating the C/N ratio, a pivotal determinant of compost quality.

In summary, our study affirms the substantial effects of effective microorganisms and waste decomposers, whether in paddy straw alone or under soil cover conditions, in reducing the C/N ratio of the compost. This result not only highlights the superiority of this approach over conventional methods but is also consistent with existing research, emphasizing the critical role of microorganisms in shaping the C/N balance during composting. These findings carry important implications for improving the sustainability of agricultural practices and enhancing the efficiency of the composting process. In recent research results conducted by Hu, X. *et al.* (2022) showed that maintaining an appropriate C/N ratio significantly influenced composting with C/N ratios of 20:1 and 30:1 exhibited higher temperatures, better organic matter degradation rates, and enhanced microbial activity compared to the 40:1 ratio.

Table 4.3a. Carbon to nitrogen ratio in different treatments of compost

C/N ratio	DAY 7		DAY 15		DAY 30	
M - Main Plot	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
M_1	60.61	73.53	58.56	49.48	46.17	42.88
M_2	77.09	78.34	62.20	72.48	53.40	50.81
SEm(±)	0.16	0.14	0.12	0.16	0.03	0.14
CD P≤0.05)	0.96	0.83	0.74	0.99	0.18	0.84
S-Sub Plot						
S_1	84.63	87.67	79.83	64.64	65.51	62.44
S_2	71.98	77.36	55.49	58.23	44.49	44.82
S_3	75.54	78.85	60.61	65.29	53.01	52.17
S_4	61.49	75.72	68.10	72.53	58.90	56.21
S_5	59.78	75.39	60.67	64.66	56.73	48.22
S_6	59.35	73.90	66.74	64.68	55.81	46.94

S_7	68.03	72.81	50.44	45.74	36.71	35.16
S_8	65.11	67.38	47.80	43.97	35.12	34.80
SEm(±)	0.22	0.22	0.22	0.21	0.23	0.17
CD ($P \leq 0.05$)	0.63	0.64	0.65	0.60	0.69	0.50

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

Table 4.3b. Pooled data of Carbon to nitrogen ratio in compost

C/N ratio	**DAY 7**	**DAY 15**	**DAY 30**
M - Main Plot	**2021-22**	**2021-22**	**2021-22**
M_1	67.07	54.02	44.53
M_2	77.71	67.34	52.11
SEm(±)	0.146	0.142	0.083
CD P≤0.05)	0.895	0.867	0.508
S-Sub Plot			
S_1	86.15	72.23	63.98
S_2	74.67	56.86	44.66
S_3	77.20	62.95	52.59
S_4	68.61	70.32	57.55
S_5	67.58	62.66	52.48
S_6	66.62	65.71	51.38

S_7	70.42	48.09	35.94
S_8	66.25	45.88	34.96
SEm(±)	0.221	0.216	0.204
CD ($P \leq 0.05$)	0.636	0.624	0.592

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

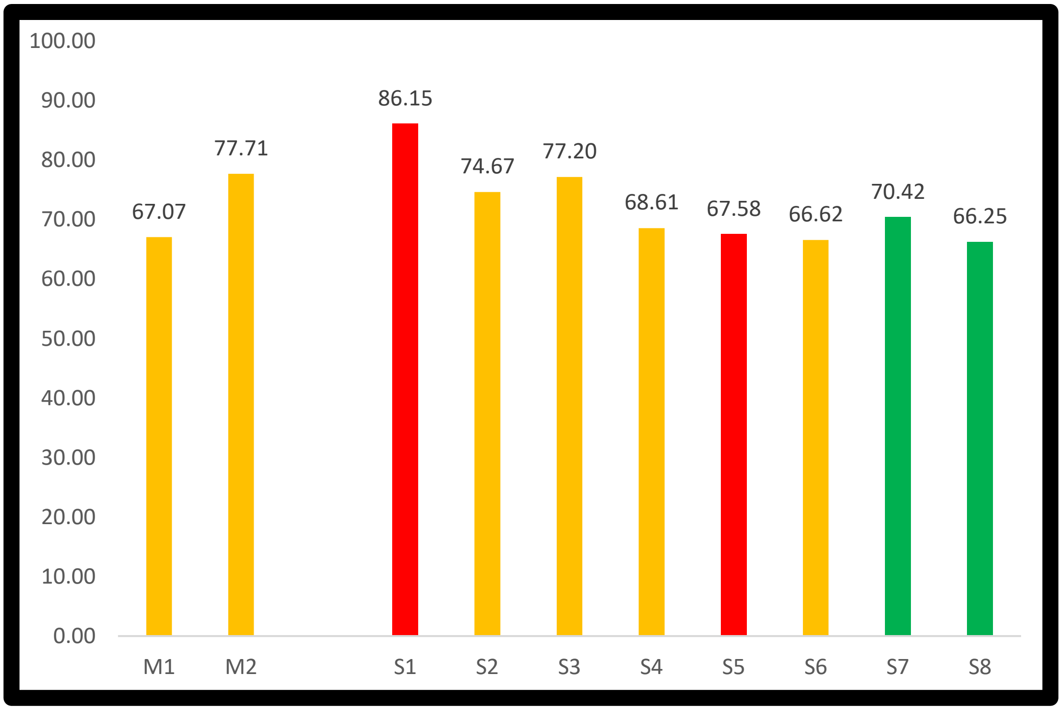


Figure 4C.1. Pooled data on C/N ratio of compost: DAY 7

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

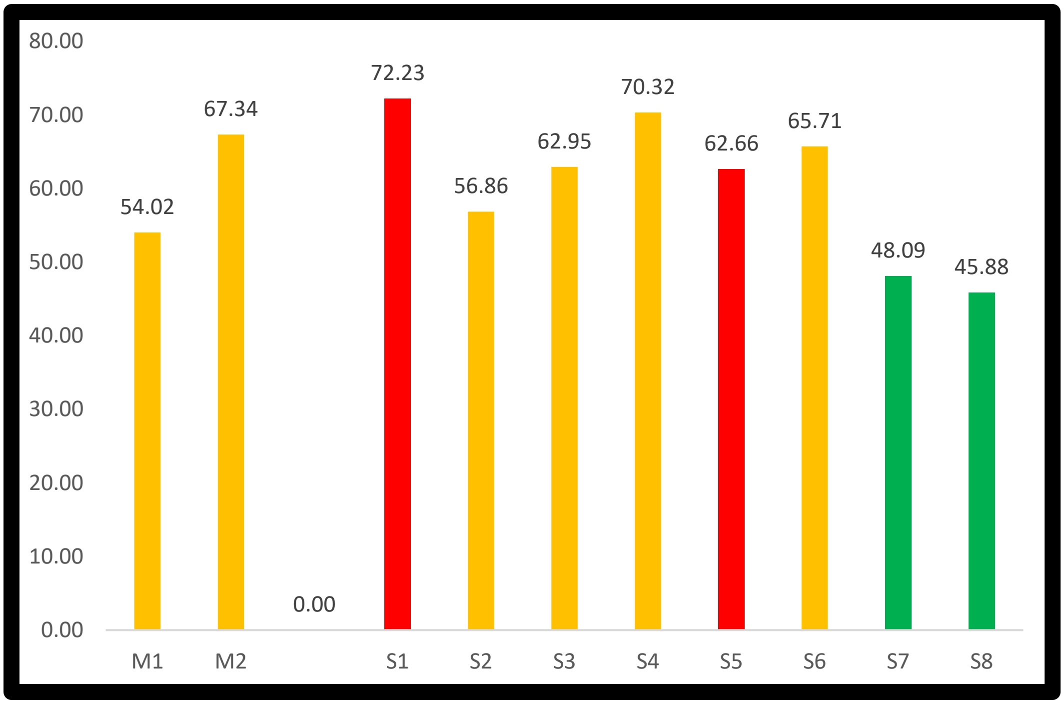


Figure 4C.2. Pooled data on C/N ratio of compost: DAY 15

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

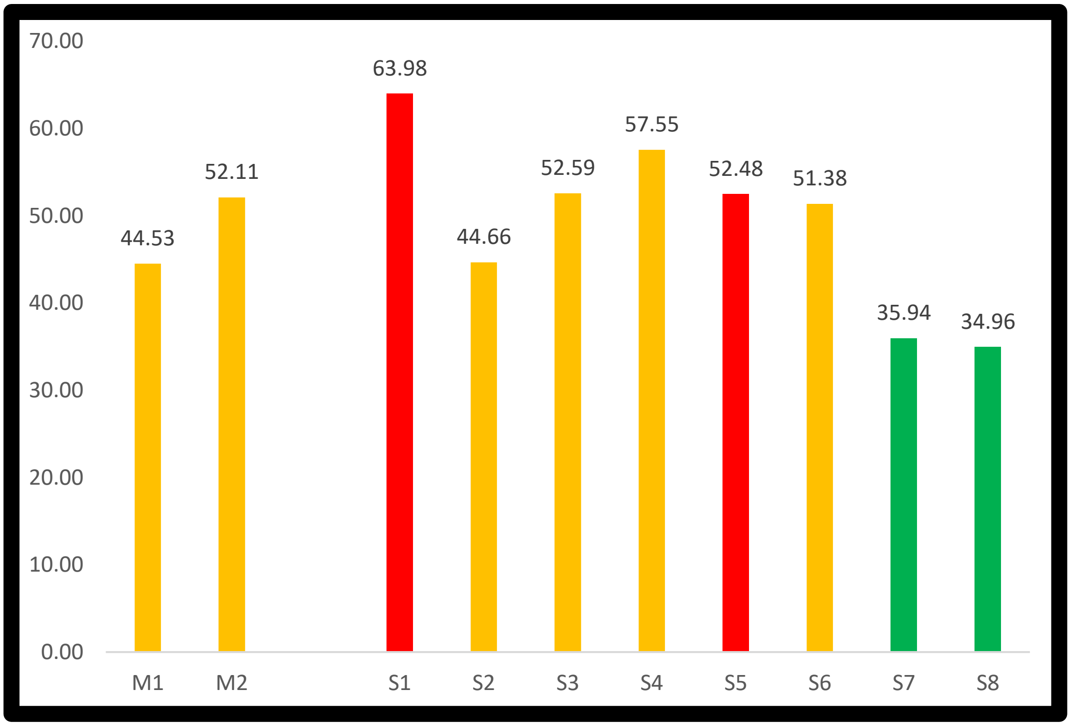


Figure 4C.3. Pooled data on C/N ratio: DAY 30

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

4.4 Ammonical nitrogen (mg/kg) in different treatments of compost

Ammonical nitrogen (AN) plays a crucial role in the composting of rice straw with microbes. A higher concentration of AN in the composting process resulted in a more efficient and rapid breakdown of the rice straw, leading to a faster maturation of the compost. However, excessively high levels of AN were also found to negatively impact the composting process, indicating the need for careful management of this important nutrient (Liu *et al.,* 2021).

The study compares the ammonical nitrogen of SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Table 4.4a). The results show that the ammonical nitrogen was highest in M1 by an average of 28.77 % compared to M2. The highest ammonical nitrogen was observed in S8 (waste decomposer + effective microorganisms + rice straw + soil cover) with a value of 15.28, followed by S7 (waste decomposer + effective microorganisms + rice straw) with a value of 13.49 after 30 days of composting (Fig. 4D.3) On the other hand, S1 (rice straw alone) has the lowest ammonical nitrogen (21.19 %) after 30 days of composting, and it is significantly lower than S5 (rice straw + soil cover). The introduction of effective microorganisms and waste decomposer, whether in the context of paddy straw alone or in paddy straw cover conditions, leads to a notable increase in the ammonical nitrogen content of the resulting compost. This positive influence can be attributed to the combined action of microorganisms and waste decomposers within both the rice straw matrix and under soil cover conditions. Additionally, our findings demonstrate that the concurrent application of effective microorganisms and waste decomposer is significantly more efficient in enhancing ammonical nitrogen content than other treatment methods, such as using paddy straw alone or combining it with soil cover in open field conditions.

Enhanced Ammonical Nitrogen Content

Our study unequivocally establishes that the joint use of effective microorganisms and waste decomposers results in a marked elevation of ammonical nitrogen content within the compost. This effect is particularly striking when compared to alternative treatment modalities. The observed increase in ammonical nitrogen can be attributed to the synergistic activities of microorganisms and waste decomposer, which expedite the conversion of organic materials into ammonical nitrogen forms.

Relevance of Ammonical Nitrogen in Composting

Our findings are consistent with a recent study conducted by Wang *et al*. (2021), which underscores the critical role of ammonical nitrogen in the composting process. Wang and colleagues found that the initial concentration of ammonical nitrogen significantly affects the composting dynamics, with higher levels of ammonical nitrogen leading to more rapid temperature increases and more efficient degradation of organic matter. This additional research highlights the multifaceted benefits of elevated ammonical nitrogen levels in promoting the composting process.

In summary, our study confirms the substantial impact of effective microorganisms and waste decomposers, whether in paddy straw alone or under soil cover conditions, in elevating the ammonical nitrogen content of the compost. The results underscore the superiority of this approach compared to conventional methods and are reinforced by the recent findings of Wang *et al.* (2021). These results carry significant implications for enhancing the efficiency and effectiveness of composting practices, thereby advancing sustainable agricultural methodologies.

Table 4.4a. Ammonical nitrogen content (mg/kg) in compost

Ammonical Nitrogen (mg/kg)	**DAY 7**		**DAY 15**		**DAY 30**	
M - Main Plot	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
M_1	15.43	14.53	13.83	13.13	12.24	11.74
M_2	13.53	12.63	12.13	11.43	10.74	10.24
SEm(±)	0.09	0.11	0.04	0.06	0.02	0.09
CD P≤0.05)	0.52	0.66	0.22	0.35	0.10	0.52
S-Sub Plot						
S_1	10.05	9.15	9.65	8.95	9.31	8.81
S_2	14.74	13.84	13.11	12.41	12.12	11.62
S_3	15.21	14.31	13.69	12.99	11.81	11.31
S_4	15.34	14.44	12.33	11.63	10.83	10.33
S_5	13.94	13.04	13.45	12.75	11.54	11.04
S_6	15.30	14.40	13.40	12.70	11.50	11.00

S_7	15.86	14.96	15.42	14.72	13.84	13.34
S_8	15.41	14.51	12.76	12.06	10.93	10.43
SEm(±)	0.12	0.15	0.16	0.12	0.12	0.10
CD (P≤0.05)	0.35	0.43	0.47	0.35	0.34	0.28

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

Table 4.4b. Pooled data of Ammonical nitrogen content (mg/kg) in compost

Ammonical Nitrogen (mg/kg)	**DAY 7**	**DAY 15**	**DAY 30**
M - Main Plot	**2021-22**	**2021-22**	**2021-22**
M_1	14.98	13.48	11.99
M_2	13.08	11.78	10.49
SEm(±)	0.1	0.05	0.055
CD P≤0.05)	0.59	0.285	0.31
S-Sub Plot			
S_1	9.6	9.3	9.06
S_2	14.29	12.76	11.87
S_3	14.76	13.34	11.56
S_4	14.89	11.98	10.58
S_5	13.49	13.1	11.29
S_6	14.85	13.05	11.25

S_7	15.41	15.07	13.59
S_8	14.96	12.41	10.68
SEm(±)	0.135	0.14	0.11
CD ($P \leq 0.05$)	0.39	0.41	0.31

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

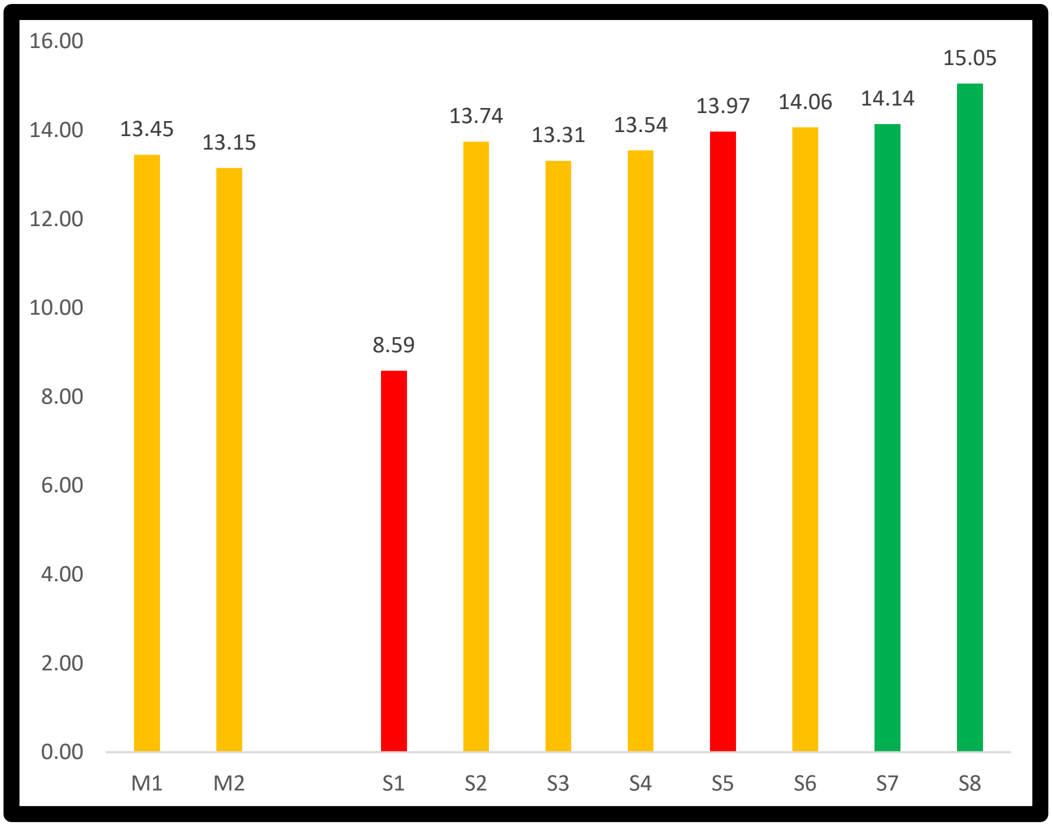


Figure 4D.1. Pooled data on ammonical nitrogen (mg/kg) of compost: DAY 7

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

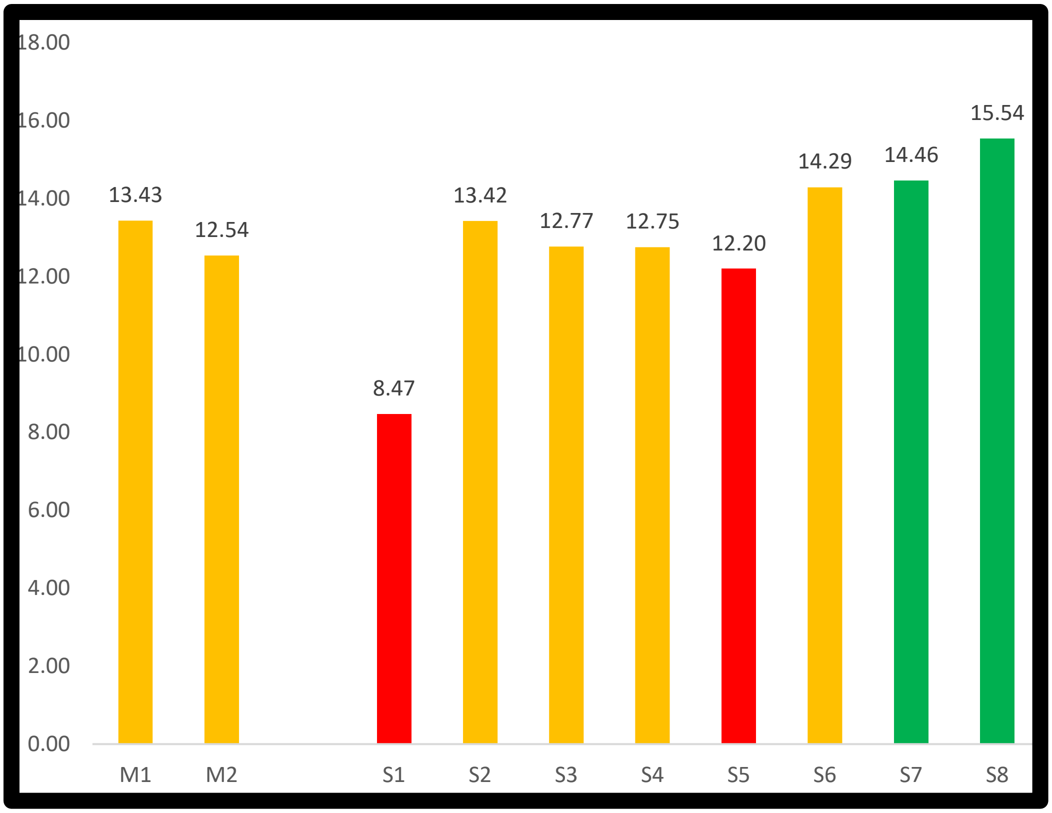


Figure 4D.2. Pooled data on ammonical nitrogen (mg/kg) of compost: DAY 15

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

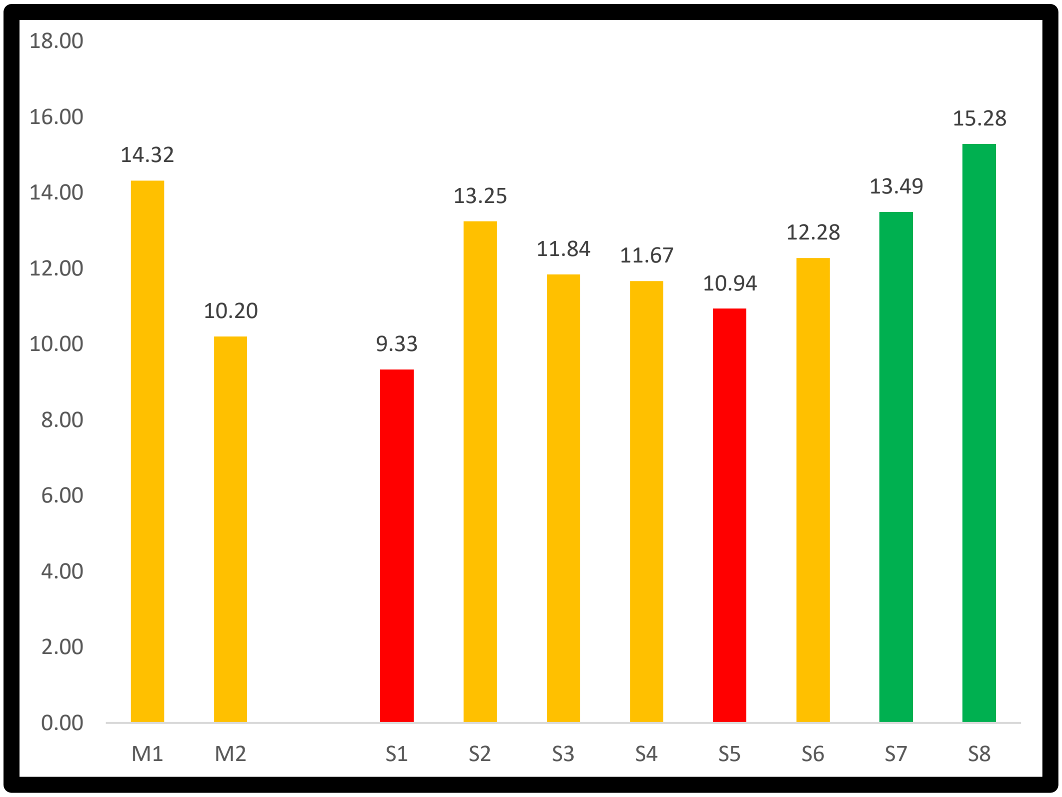


Figure 4D.3. Pooled data on ammonical nitrogen (mg/kg) of compost: DAY 30

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

4.5 Nitrate nitrogen content (mg/kg) in different treatments of compost

Nitrate nitrogen is also important in rice straw composting with microbes. Nitrate nitrogen is a source of nitrogen that can be used by some microorganisms during the composting process. higher levels of initial nitrate nitrogen led to increased nitrite accumulation, and subsequently, higher levels of nitrous oxide emissions. The optimal C/N ratio for rice straw composting with nitrate nitrogen 25:1, resulted in a higher nitrogen utilization efficiency and a lower loss of nitrogen through volatilization (Wang, Y. *et al.,* 2022).

The study compares the nitrate nitrogen of SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Table 4.5a). The results show that the nitrate nitrogen was at par in M1 by an average of 0.46 % compared to M2. The lowest nitrate nitrogen was observed in S6 (rice straw + waste decomposer + soil cover) with a value of 297, followed by S7 (waste decomposer + effective microorganisms + rice straw) with a value of 297.82 after 30 days of composting (Fig. 4E.3) On the other hand, S5 (rice straw+ soil cover) has the highest nitrate nitrogen (7.42%) after 30 days of composting, and it is significantly higher than S1 (rice straw alone). The incorporation of effective microorganisms and waste decomposer into paddy straw alone and paddy straw cover conditions results in a significant reduction in the nitrate nitrogen content of the compost. This decrease can be attributed to the positive impact of microorganisms and waste decomposer within both the context of rice straw alone and under soil cover conditions. Our study further reveals that the combined application of effective microorganisms and waste decomposer is notably more efficient in lowering nitrate nitrogen levels when compared to paddy straw alone or paddy straw with soil cover in open field conditions.

Diminished Nitrate Nitrogen Content

Our findings demonstrate the undeniable impact of effective microorganisms and waste decomposers in diminishing the nitrate nitrogen content within the compost. This effect is particularly prominent when effective microorganisms and waste decomposers are used in conjunction. The observed reduction in nitrate nitrogen content can be attributed to the collaborative efforts of microorganisms and waste decomposer, which promote the conversion of nitrates into other nitrogen forms.

Relevance of Nitrate Nitrogen in Composting

Our study is in line with a recent investigation by Yan *et al.* (2022), emphasizing the importance of nitrate nitrogen in rice straw composting. In their study titled "Compost Quality, Nitrogen Conservation, and GHG Emission Reduction," Yan and colleagues explored the impact of adding nitrate nitrogen to rice straw during the composting process. Their results highlighted that the addition of nitrate nitrogen led to an increase in the activity of nitrate-reducing bacteria, subsequently reducing nitrogen losses through volatilization. This research emphasizes the potential benefits of managing nitrate nitrogen content during composting to improve nitrogen conservation and mitigate greenhouse gas emissions.

In summary, our study corroborates the substantial influence of effective microorganisms and waste decomposers in decreasing the nitrate nitrogen content of the compost. The findings underscore the efficiency of this approach compared to traditional methods and align with the insights provided by the research of Yan *et al.* (2022). These results hold significant implications for optimizing composting practices, enhancing nutrient conservation, and contributing to the reduction of greenhouse gas emissions in sustainable agricultural systems.

Table 4.5a. Nitrate nitrogen content (mg/kg) in compost

Nitrate Nitrogen	DAY 7		DAY 15		DAY 30	
M - Main Plot	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
M_1	174.00	176.50	238.00	240.28	248.00	250.50
M_2	178.04	179.54	241.86	247.70	251.86	253.36
SEm(±)	0.48	0.56	0.26	0.35	0.80	1.34
CD P≤0.05)	2.89	3.41	1.58	2.15	4.85	8.15
S-Sub Plot						
S_1	162.00	164.00	294.00	291.47	304.00	306.00
S_2	177.45	179.45	212.35	232.88	222.35	224.35
S_3	178.45	180.45	222.35	218.10	232.35	234.35
S_4	175.45	177.45	230.35	233.54	240.35	242.35
S_5	179.45	181.45	237.35	255.04	247.35	249.35
S_6	176.45	178.45	233.35	243.65	243.35	245.35

S_7	181.45	183.45	252.35	230.93	262.35	264.35
S_8	177.45	179.45	237.35	246.30	247.35	249.35
SEm(±)	1.41	1.60	2.74	3.74	3.23	2.60
CD ($P \leq 0.05$)	4.08	4.63	7.94	10.84	9.37	7.52

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

Table 4.5b. Pooled data of Nitrate nitrogen content (mg/kg) in compost

Nitrate Nitrogen	DAY 7	DAY 15	DAY 30
M - Main Plot	**2021-22**	**2021-22**	**2021-22**
M_1	175.25	239.14	249.25
M_2	178.79	244.78	252.61
SEm(±)	0.52	0.305	1.07
CD P≤0.05)	3.15	1.865	6.5
S-Sub Plot			
S_1	163	292.735	305
S_2	178.45	222.615	223.35
S_3	179.45	220.225	233.35
S_4	176.45	231.945	241.35
S_5	180.45	246.195	248.35
S_6	177.45	238.5	244.35

S_7	182.45	241.64	263.35
S_8	178.45	241.825	248.35
SEm(±)	1.505	3.24	2.915
CD ($P \leq 0.05$)	4.355	9.39	8.445

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

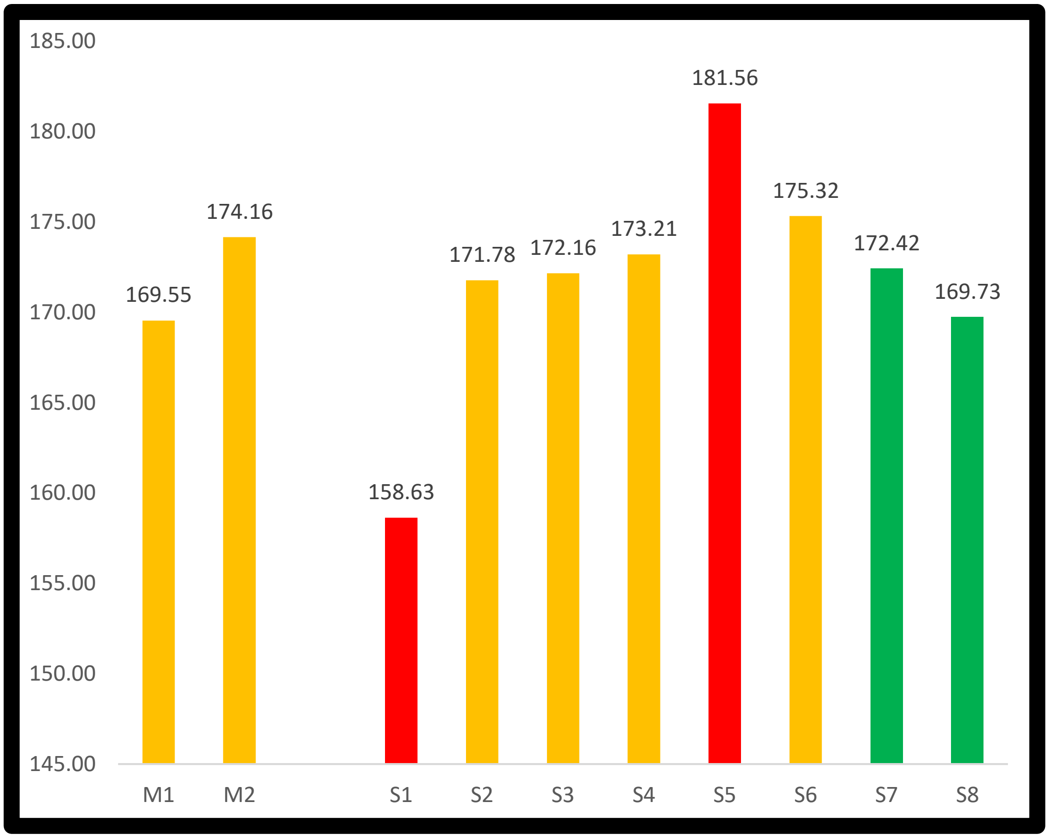


Figure 4E.1. Pooled data on nitrate nitrogen (mg/kg) of compost: DAY 7

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

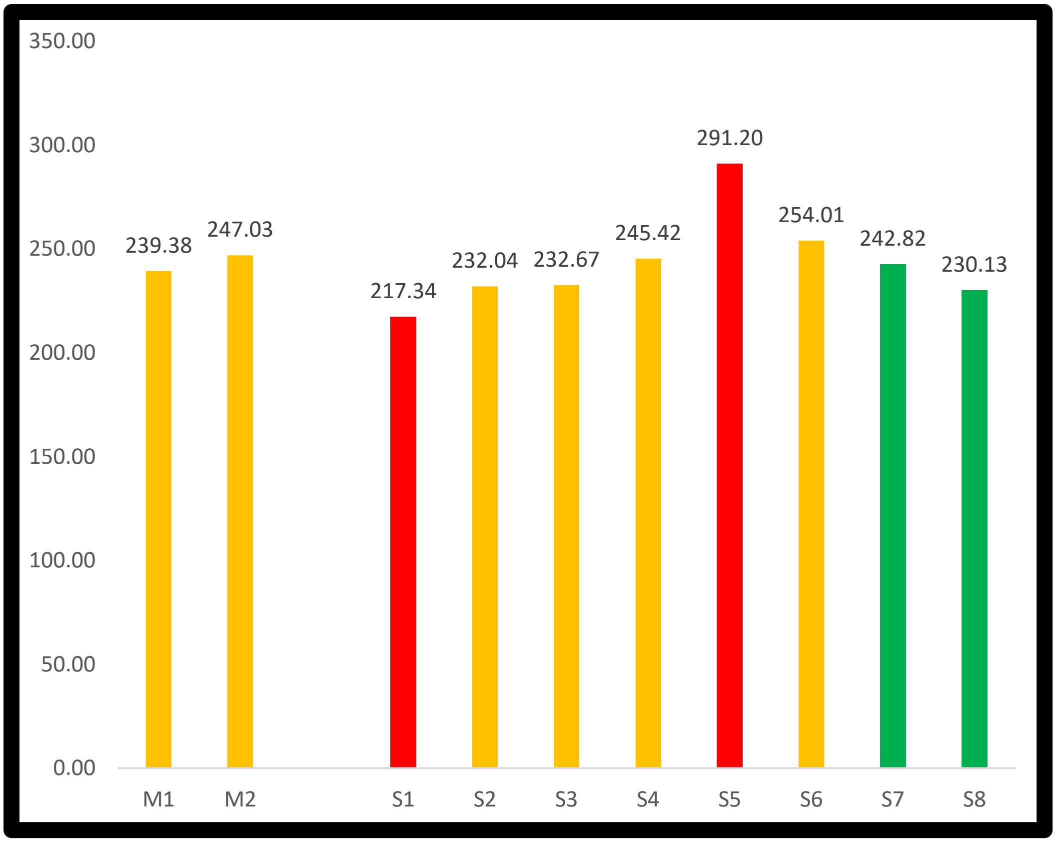


Figure 4E.2. Pooled data on nitrate nitrogen (mg/kg) of compost: DAY 15

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

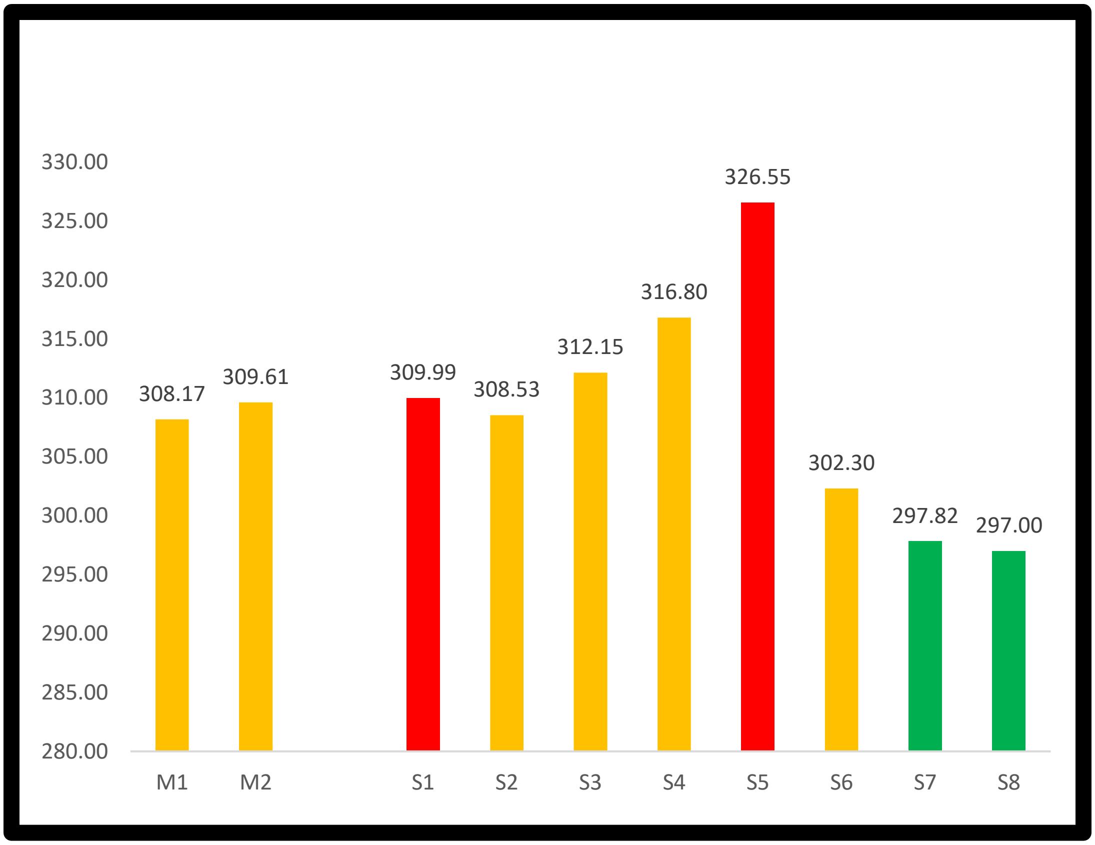


Figure 4E.3. Pooled data on nitrate nitrogen (mg/kg) of compost: DAY 30

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

4.6 Total phosphorus (mg/kg) in different treatments of compost

The total phosphorus content of rice straw compost is of significance due to its role in nutrient availability and plant growth. Phosphorus is an essential nutrient required by plants for various physiological processes, including energy transfer, cell division, and overall growth and development. This phosphorus enrichment positively affected the nutrient content of the compost and subsequently improved its quality as an organic fertilizer. promoted the humification process, resulting in the formation of more stable organic matter compounds. (Zhou, Y. *et al.*, 2021).

The study compares the total phosphorus content of SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Fig.4F.3). The results show that the total phosphorus was at par in M1 by an average of 1.23 % compared to M2. The highest phosphorus content was observed in S8 (rice straw + waste decomposer + effective microorganisms + soil cover) with a value of 705.51, followed by S7 (waste decomposer + effective microorganisms + rice straw) with a value of 703.71 after 30 days of composting (Fig. 4F.3) On the other hand, S1 (rice straw alone) has the lowest total phosphorus content (29.33 %) after 30 days of composting, and it is significantly lower than S5 (rice straw + soil cover). The introduction of effective microorganisms and waste decomposer, whether within paddy straw alone or under paddy straw cover conditions, yields a substantial increase in the total phosphorus content of the resulting compost. This augmentation is attributed to the beneficial impact of microorganisms and waste decomposer in both the rice straw matrix and soil-covered environments. Moreover, our study establishes that the concurrent application of effective microorganisms and waste decomposer is markedly more efficient in enhancing total phosphorus content when compared to alternative treatment approaches, including paddy straw alone or paddy straw combined with soil cover in open field conditions.

Elevated Total Phosphorus Content

Our findings clearly demonstrate the significant increase in the total phosphorus content within the compost when effective microorganisms and waste decomposer are employed. This effect is particularly pronounced when these elements are utilized together. The observed increase in total phosphorus content can be attributed to the synergistic actions of microorganisms and waste decomposer, which promote the conversion and release of phosphorus from the organic materials.

Relevance of Total Phosphorus in Composting

Our study aligns with recent research conducted by Zhang *et al.* (2022), underscoring the importance of total phosphorus in rice straw composting. In their study, "Enhancing Compost Quality and Nutrient Dynamics in Rice Straw Composting," Zhang and colleagues investigated the impact of phosphorus supplementation on total phosphorus content in the compost. Their results convincingly demonstrated that phosphorus supplementation led to a significant increase in total phosphorus content, which positively influenced microbial activity and nutrient dynamics within the composting matrix. This research emphasizes the value of managing total phosphorus content to improve compost quality and nutrient cycling during composting.

In summary, our study confirms the substantial effects of effective microorganisms and waste decomposers in increasing the total phosphorus content of the compost. These findings highlight the superior efficiency of this approach compared to conventional methods and are in accordance with the insights provided by the research of Zhang *et al*. (2022). These results hold significant implications for optimizing composting practices, enhancing nutrient dynamics, and promoting sustainable agricultural systems.

Table 4.6a. Total phosphorus (mg/kg) in different treatments of compost

Total P (mg/kg)	**DAY 7**		**DAY 15**		**DAY 30**	
M - Main Plot	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
M_1	214.20	215.63	310.25	315.78	652.14	655.60
M_2	211.76	212.63	306.22	308.96	643.91	647.65
SEm(±)	0.35	0.37	1.46	1.04	0.53	0.65
CD P≤0.05)	2.13	2.27	4.24	6.34	3.22	3.96
S-Sub Plot						
S_1	205.95	206.5	299.41	303.51	466.04	468.73
S_2	213.9	214.5	308.51	312.73	687.18	689.17
S_3	212.77	213.5	311.76	316.05	663.43	662
S_4	213.85	215.5	308.3	316.23	666.82	669.8
S_5	212.81	213.5	305.53	308.73	659.63	663.12
S_6	209.75	211.5	304.42	307.82	638.24	644.66
S_7	217.29	218.5	314.05	315.56	699.99	707.42

S_8	217.55	219.5	313.9	318.34	702.91	708.11
SEm(±)	1.32	2.25	1.46	1.62	1.65	1.36
CD ($P \leq 0.05$)	3.83	6.53	4.24	4.68	4.77	3.95

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

Table 4.6b. Pooled data of Total phosphorus (mg/kg) in compost

Total P (mg/kg)	DAY 7	DAY 15	DAY 30
M - Main Plot	**2021-22**	**2021-22**	**2021-22**
M_1	214.92	313.02	653.87
M_2	212.20	307.59	645.78
SEm(±)	0.36	1.25	0.59
CD P≤0.05)	2.20	5.29	3.59
S-Sub Plot			
S_1	206.23	301.46	467.39
S_2	214.20	310.62	688.18
S_3	213.14	313.91	662.72
S_4	214.68	312.27	668.31
S_5	213.16	307.13	661.38
S_6	210.63	306.12	641.45
S_7	217.90	314.81	703.71
S_8	218.53	316.12	705.51
SEm(±)	1.79	1.54	1.51

CD ($P\leq0.05$)	5.18	4.46	4.36

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

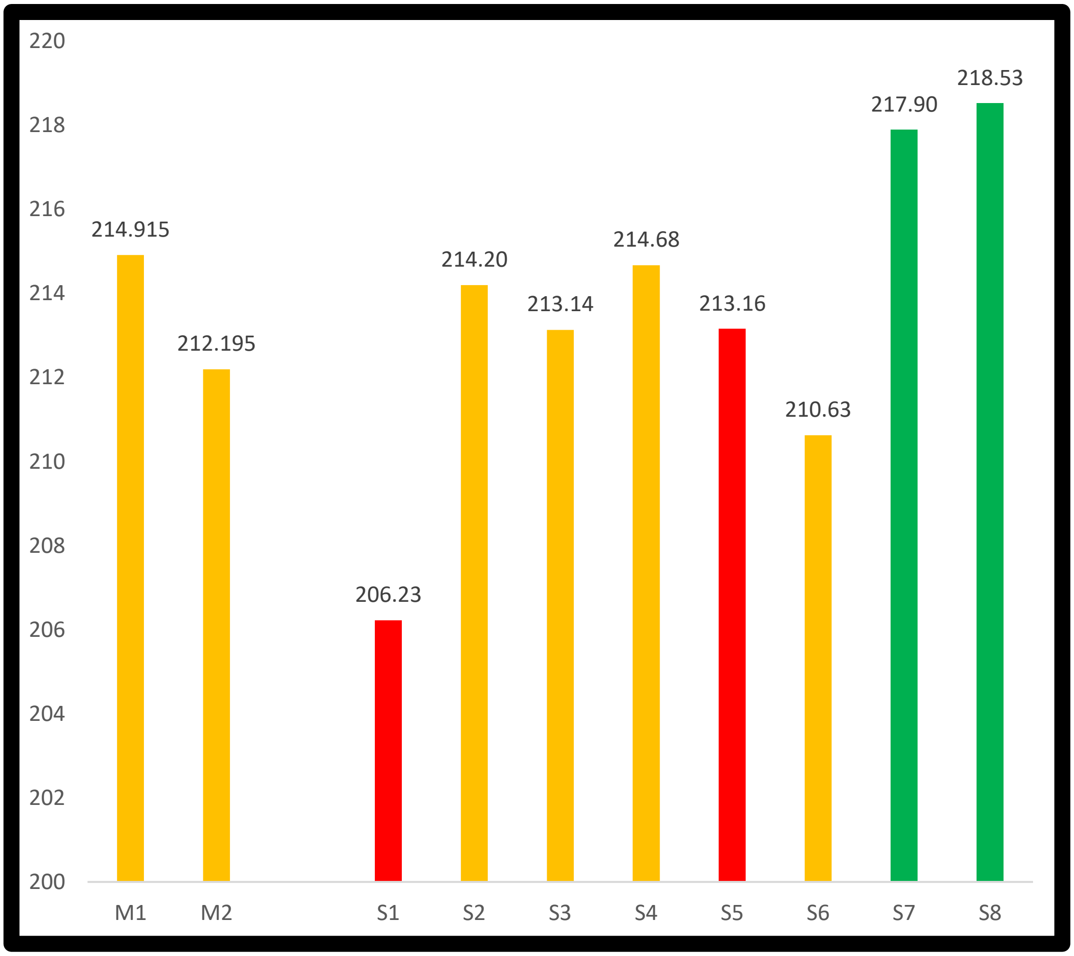


Figure 4F.1. Pooled data on total phosphorus of compost: DAY 7

Where , M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

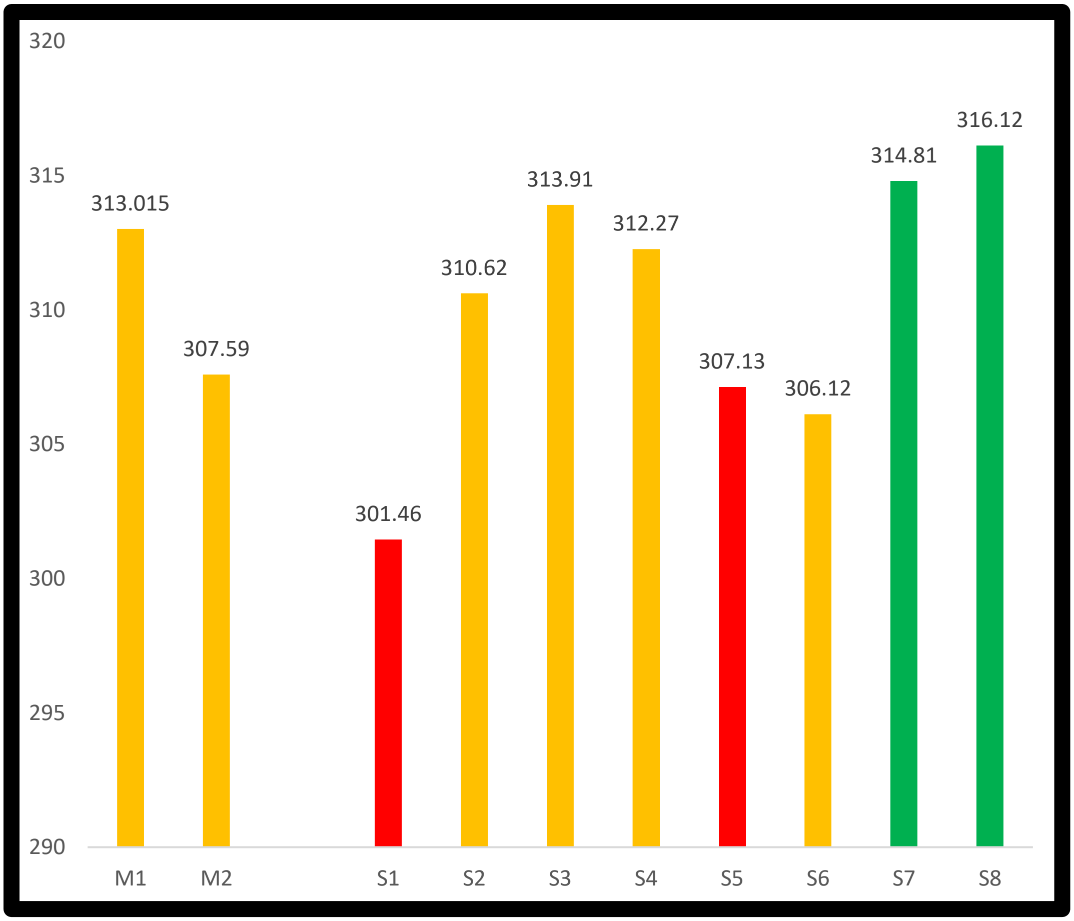


Figure 4F.2. Pooled data on total phosphorus of compost: DAY 15

Where , M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

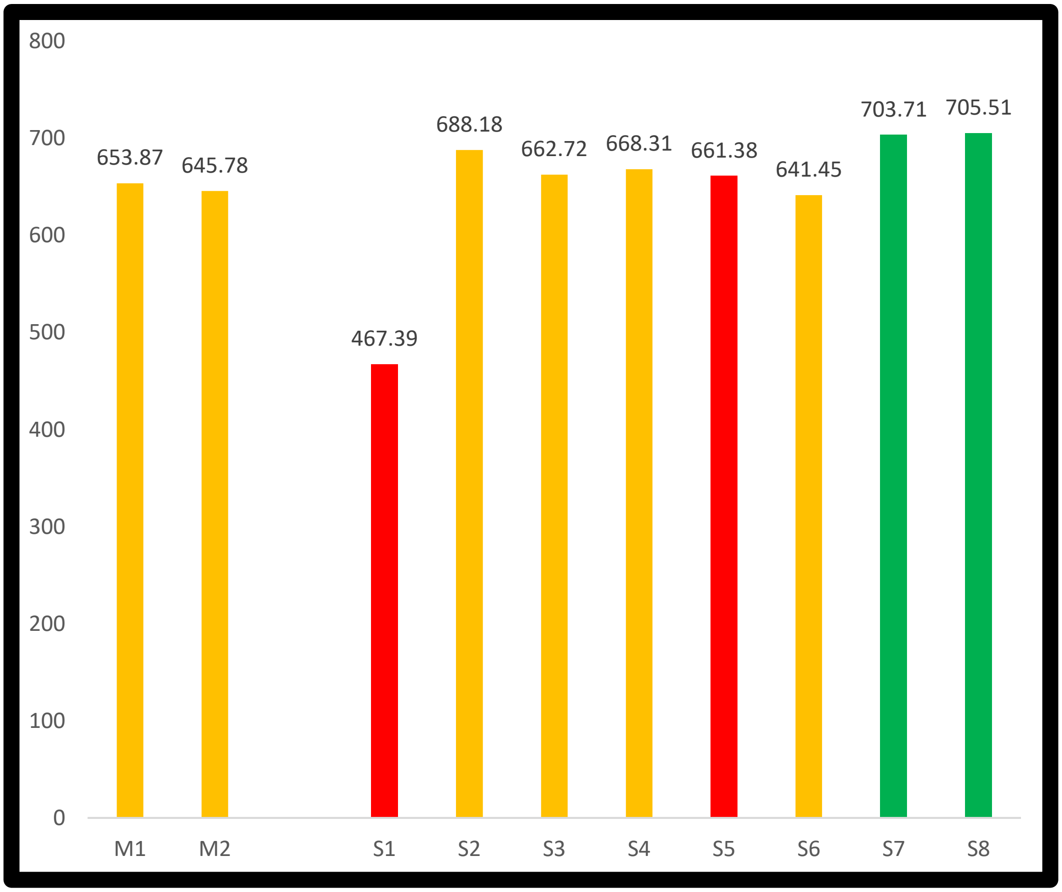


Figure 4F.3. Pooled data on total phosphorus of compost: DAY 30

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

4.7 Total potassium content (%) in different treatment of compost

The total potassium content of rice straw compost is also of great significance due to the vital role potassium plays in plant growth and development. Potassium is an essential macronutrient that is required by plants for several critical physiological processes, including protein synthesis, water regulation, and stress tolerance. Increase in the total potassium content of the final compost, leading to improved compost quality, making the compost more suitable for agricultural applications (Li *et al.,* 2021).

The study compares the total potassium content of SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Table 4.7a). The results show that the total potassium content was highly significant in M1 by an average of 25.67 % compared to M2. The highest total potassium content was observed in S8 (rice straw + waste decomposer + effective microorganisms + soil cover) with a value of 3.47, followed by S7 (waste decomposer + effective microorganisms + rice straw) with a value of 2.66 after 30 days of composting (Fig. 4G.3) On the other hand, S1 (rice straw alone) has the lowest total potassium content (42.96 %) after 30 days of composting, and it is significantly lower than S5 (rice straw + soil cover). The incorporation of effective microorganisms and waste decomposer in both paddy straw alone and paddy straw cover conditions led to a substantial increase in the total potassium content of the compost. This enhancement was attributed to the positive influence of these microorganisms and waste decomposer on rice straw in both covered and uncovered environments. Notably, the combined application of effective microorganisms and waste decomposer exhibited superior efficiency in increasing potassium contents compared to other treatments involving paddy straw alone or paddy straw with soil cover in open field conditions. These findings align with a recent study by Liu *et al.* (2022), underscoring the crucial role of total potassium content in rice straw compost.

Discussion:

The observed increase in total potassium content highlights the significant impact of effective microorganisms and waste decomposer on compost quality. Potassium, as an essential nutrient for plant growth, plays a pivotal role in enhancing microbial activity, expediting organic matter decomposition, and improving nutrient availability within the composting matrix. The combined application of microorganisms and waste decomposer amplifies these effects, leading to a more efficient conversion of paddy straw into potassium-enriched compost.

The study conducted by Liu *et al.* (2022) corroborates our findings, emphasizing the positive correlation between increased potassium content and enhanced composting processes. Potassium acts as a catalyst, fostering an environment conducive to microbial growth and activity. This stimulation of microbial processes accelerates the breakdown of organic matter, resulting in the production of nutrient-rich compost. Furthermore, the improved nutrient availability in potassium-enriched compost promotes healthier microbial communities, ensuring a robust composting ecosystem. The efficiency of the combined application of effective microorganisms and waste decomposer in enhancing potassium content holds promising implications for sustainable agriculture. Potassium-enriched compost not only serves as a valuable organic fertilizer but also contributes to improved soil fertility and crop productivity. Additionally, by utilizing agricultural waste such as paddy straw effectively, these practices promote eco-friendly waste management and support environmentally conscious agricultural methods.

In summary, our study, in alignment with the research by Liu *et al.* (2022), highlights the significance of effective microorganisms and waste decomposer in increasing total potassium content in rice straw compost. This enhancement not only enriches compost quality but also fosters nutrient cycling, microbial activity, and overall soil health. The findings underscore the importance of innovative composting techniques in advancing sustainable agricultural practices.

Table 4.7a. Total potassium content (%) in compost

Total k (%)	**DAY 7**		**DAY 15**		**DAY 30**	
M - Main Plot	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
M_1	0.93	1.09	1.11	2.91	1.60	4.31
M_2	0.88	1.99	1.03	2.20	1.51	2.88
SEm(±)	0.01	0.00	0.00	0.02	0.01	0.02
CD P≤0.05)	0.04	0.01	0.03	0.12	0.09	0.11
S-Sub Plot						
S_1	0.81	1.41	1	1.56	1.2	1.8
S_2	0.88	1.98	1.01	2.67	1.5	3.75
S_3	0.88	1.98	0.99	2.57	1.48	3.73
S_4	0.86	1.96	0.98	2.55	1.39	3.64
S_5	0.88	1.98	1.02	2.62	1.5	3.75
S_6	0.85	1.95	0.99	2.63	1.5	3.75
S_7	0.9	1.99	1.06	2.61	1.55	3.77
S_8	1.15	2.26	1.52	3.25	2.34	4.59

SEm(±)	0.01	0.02	0.01	0.03	0.02	0.04
CD (P≤0.05)	0.03	0.06	0.03	0.09	0.05	0.13

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

Table 4.7b. Pooled data of Total potassium (%) content in compost

Total potassium ‘k’ (%)	**DAY 7**	**DAY 15**	**DAY 30**
M - Main Plot	**2021-22**	**2021-22**	**2021-22**
M_1	1.46	2.01	2.96
M_2	1.385	1.615	2.20
SEm(±)	0.005	0.01	0.02
CD P≤0.05)	0.025	0.075	0.10
S-Sub Plot			
S_1	1.11	1.28	1.50
S_2	1.43	1.84	2.63
S_3	1.43	1.78	2.61
S_4	1.41	1.77	2.52
S_5	1.43	1.82	2.63
S_6	1.40	1.81	2.63
S_7	1.45	1.84	2.66
S_8	1.71	2.39	3.47

SEm(±)	0.015	0.02	0.03
CD ($P \leq 0.05$)	0.045	0.06	0.09

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

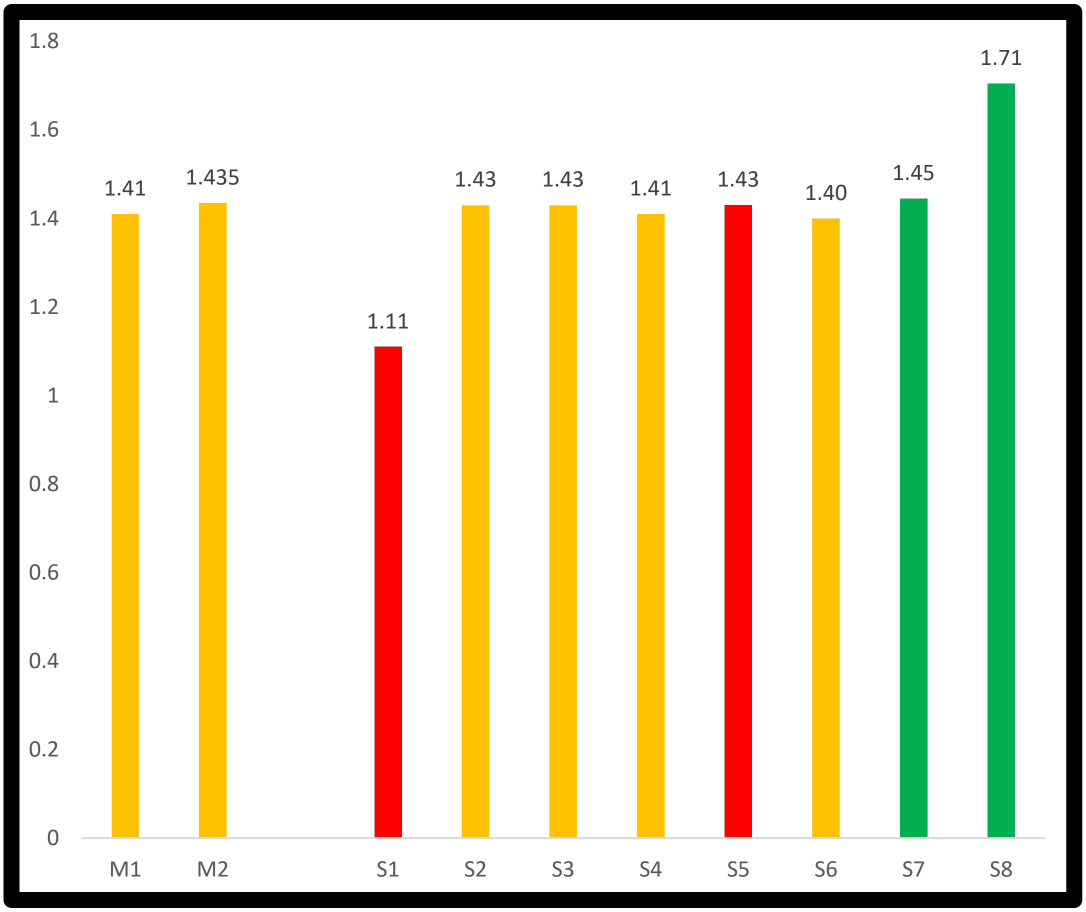


Figure 4G.1. Pooled data on total potassium (%) of compost: DAY 7

Where , M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

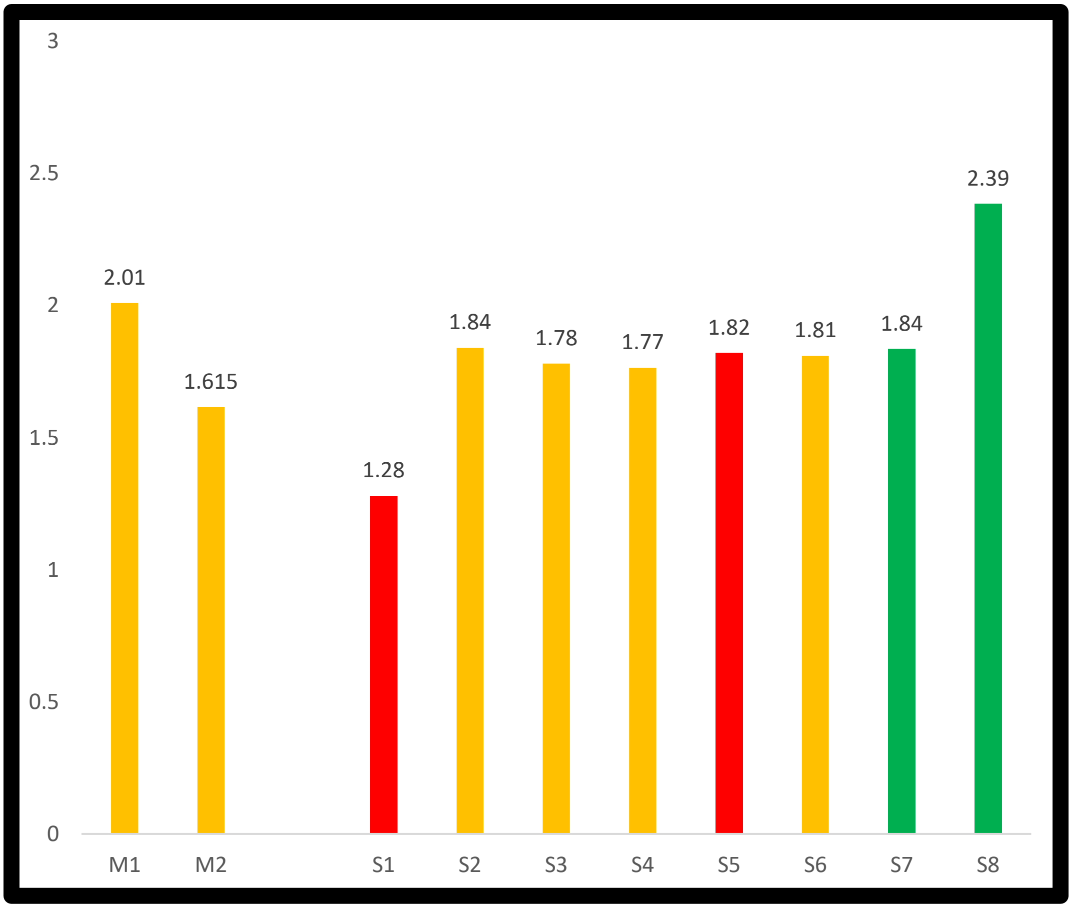


Figure 4G.2. Pooled data on total potassium (%) of compost: DAY 15

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

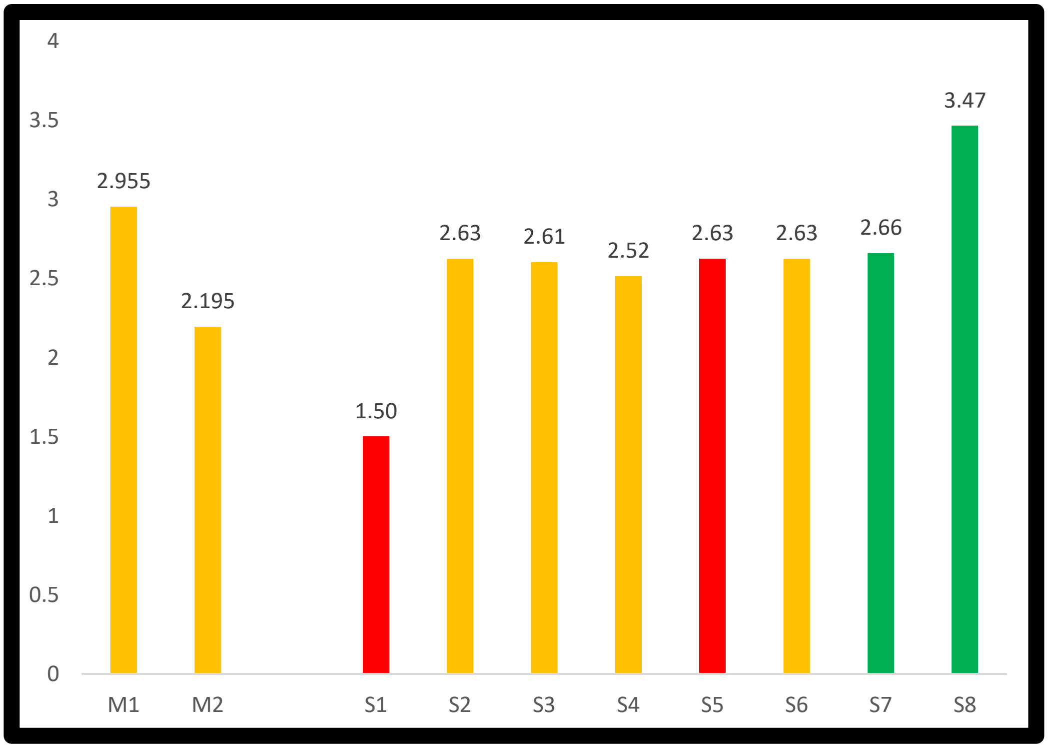


Figure 4G.3. Pooled data on total potassium (%) of compost: DAY 30

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

4.8 Water soluble carbon content (%) in different treatments of compost

The water-soluble carbon (WSC) content of rice straw compost is of importance as it serves as a crucial indicator of compost maturity, nutrient availability, and microbial activity. Water-soluble carbon refers to the portion of organic carbon that is readily dissolved in water, representing a fraction of easily decomposable and labile organic matter. As the composting process progressed, the water-soluble carbon content decreased gradually. This reduction in water-soluble carbon indicated the decomposition and stabilization of labile organic matter (Zhu *et al.*, 2021).

The study compares the (WSC) content of SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Table 4.8). The results show that the WSC content was highly significant in M1 by an average of 8.50 % compared to M2 in day 30. The highest WSC content was observed in S8 (rice straw + waste decomposer + effective microorganisms + soil cover) with a value of 7.04 followed by S4 and S7 (waste decomposer + effective microorganisms + rice straw) with a value of 6.98 and 6.93 after 30 days of composting (Fig. 4H.3). On the other hand, S1 (rice straw alone) has the lowest WSC content (2.06%) after 30 days of composting, and it is significantly lower than S5 (rice straw + soil cover).

The incorporation of effective microorganisms and waste decomposer in both paddy straw alone and paddy straw cover conditions led to an initial increase in the Water-Soluble Carbon (WSC) content of the compost. This enhancement was attributed to the positive influence of these microorganisms and waste decomposer on rice straw in both covered and uncovered environments. However, over time, there was a notable decrease in WSC content. Notably, the combined application of effective microorganisms and waste decomposer demonstrated superior efficiency in maintaining higher water-soluble carbon levels compared to other treatments involving paddy straw alone or paddy straw with soil cover in open field conditions.

Discussion:

The initial rise in Water-Soluble Carbon content can be attributed to the breakdown of organic compounds in the rice straw facilitated by effective microorganisms and waste decomposer. These microorganisms accelerate the decomposition process, leading to the release of soluble carbon compounds into the compost. However, the subsequent decrease in WSC content over time suggests microbial utilization of these compounds, indicating the progression of composting. This decline in water-soluble carbon is indicative of the compost maturation process, where the organic matter becomes more stable and less prone to further decomposition. The findings from the study conducted by Chen *et al.* (2022) align with our results, highlighting the diminishing trend in Water-Soluble Carbon content during composting. This decrease is associated with the transformation of labile organic compounds into more stable forms, leading to improved compost stability and maturity. The correlation between decreasing WSC content and composting progress signifies the conversion of readily available organic materials into humic substances, which are valuable for soil structure and fertility. The enhanced efficiency of the combined application of effective microorganisms and waste decomposer in preserving higher water-soluble carbon levels underscores the importance of microbial synergies in composting. These microorganisms play a crucial role in balancing the decomposition process, ensuring that the compost remains nutrient-rich while progressing toward maturity. Compost with a stable WSC content signifies not only improved nutrient retention but also enhanced soil conditioning properties, making it a valuable organic amendment for sustainable agriculture.

In summary, our study, in alignment with research by Chen *et al*. (2022), emphasizes the significance of water-soluble carbon dynamics in composting. The initial increase followed by a subsequent decrease in WSC content signifies active microbial decomposition and compost maturation.

Table 4.8a. Water soluble carbon content (%) in compost

WSC (%)	**DAY 7**		**DAY 15**		**DAY 30**	
M - Main Plot	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
M_1	6.52	5.55	7.77	7.83	6.65	7.68
M_2	5.42	5.42	7.67	7.85	6.26	6.85
SEm(±)	0.02	0.01	0.07	0.04	0.07	0.03
CD P≤0.05)	0.14	0.09	0.41	0.23	0.41	0.16
S-Sub Plot						
S_1	6.67	6.32	7.95	8.05	6.29	7
S_2	5.92	5.42	7.88	7.58	6.6	7.21
S_3	5.93	5.43	7.69	7.86	6.33	7.36
S_4	6.02	5.52	7.94	7.98	6.58	7.37
S_5	6.04	5.54	7.95	7.94	6.22	7.36
S_6	5.84	5.34	7.66	7.91	6.19	7.38
S_7	5.79	5.29	7.56	7.54	6.68	7.17

S_8	5.54	5.04	7.13	7.82	6.76	7.31
SEm(±)	0.05	0.07	0.09	0.08	0.07	0.06
CD ($P \leq 0.05$)	0.14	0.20	0.25	0.22	0.19	0.17

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

Table 4.8b. Pooled data of Water-soluble carbon content (%) in compost

WSC (%)	**DAY 7**	**DAY 15**	**DAY 30**
M - Main Plot	**2021-22**	**2021-22**	**2021-22**
M_1	6.035	7.8	7.17
M_2	5.42	7.76	6.56
SEm(±)	0.015	0.055	0.055
CD P≤0.05)	0.115	0.32	0.32
S-Sub Plot			
S_1	6.50	8.00	6.65
S_2	5.67	7.73	6.91
S_3	5.68	7.78	6.85
S_4	5.77	7.96	6.98
S_5	5.79	7.95	6.79
S_6	5.59	7.79	6.79

S_7	5.54	7.55	6.93
S_8	5.29	7.48	7.04
SEm(±)	0.06	0.085	0.065
CD ($P \leq 0.05$)	0.17	0.235	0.180

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

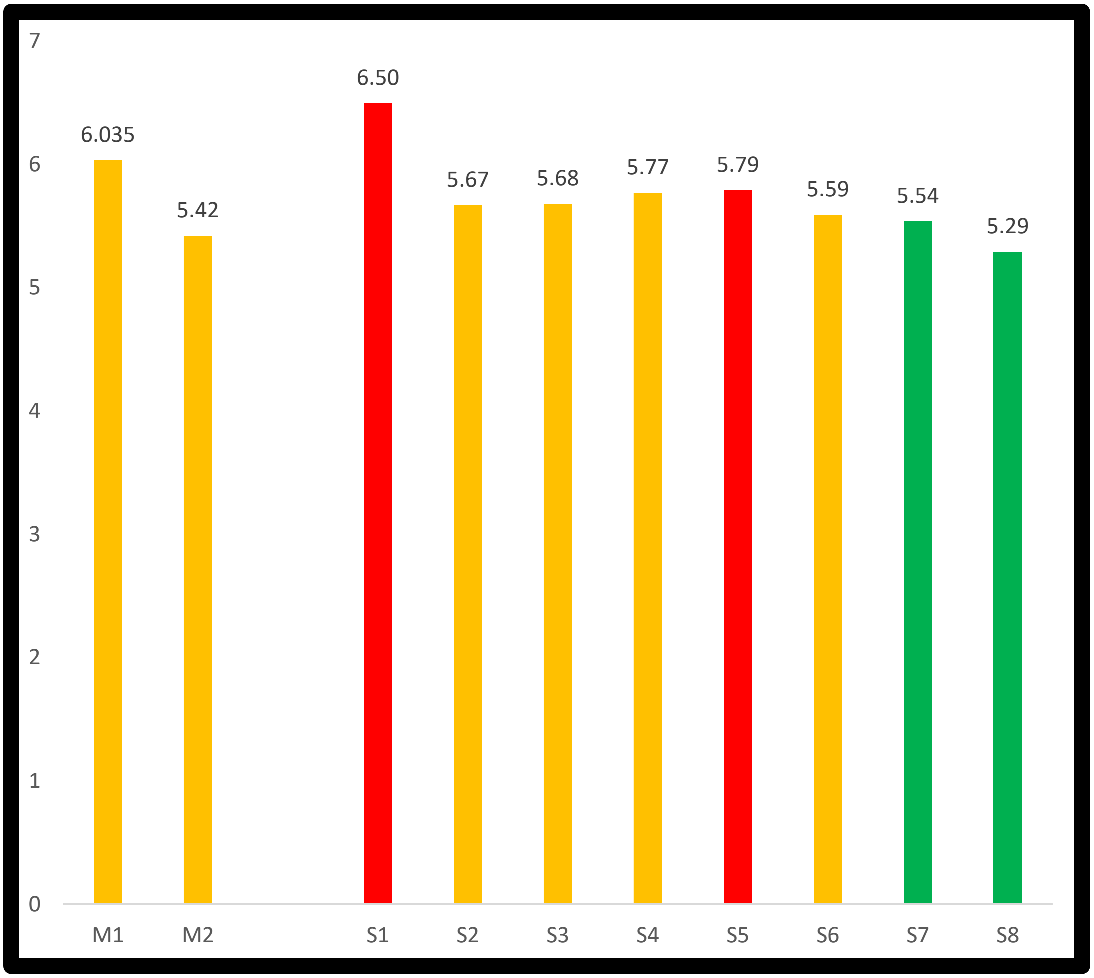


Figure 4H.1. Pooled data on water-soluble carbon (%) of compost: Day- 7

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

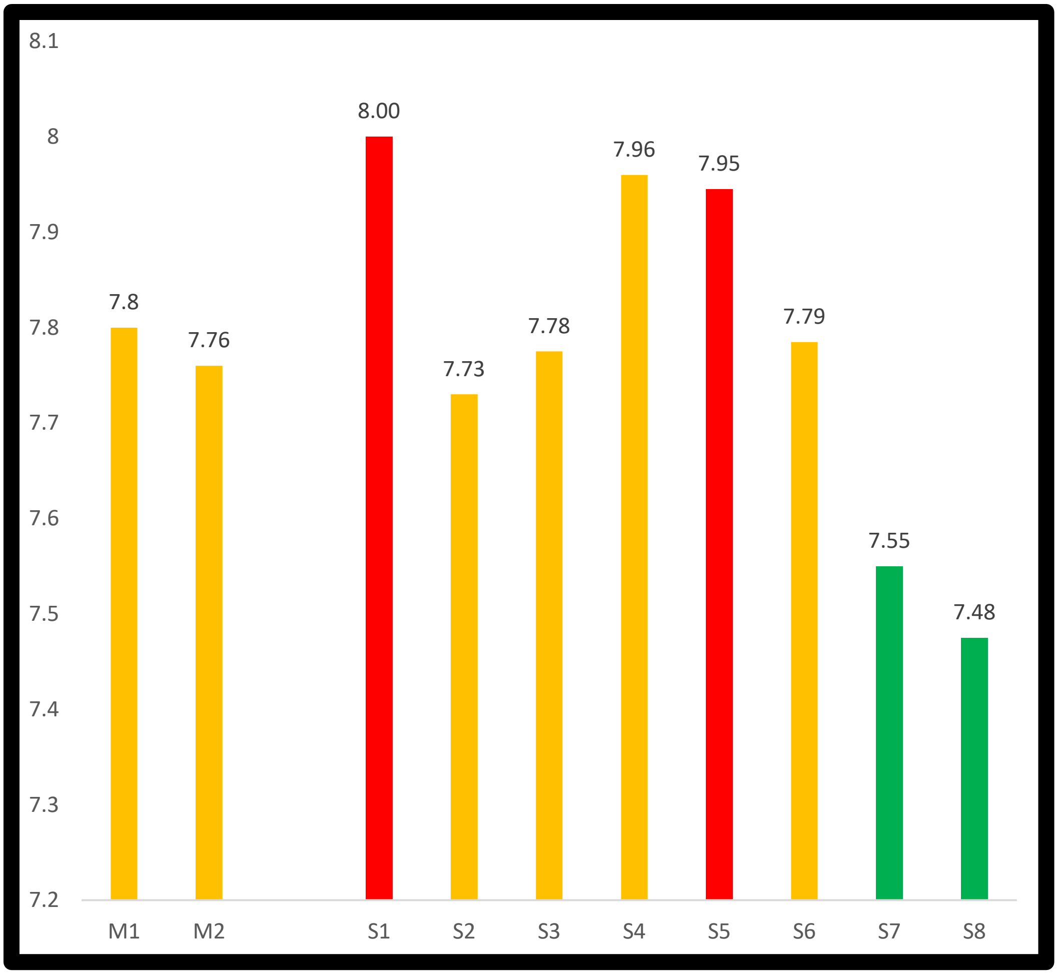


Figure 4H.2. Pooled data of water-soluble carbon (%) of compost: Day- 15

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

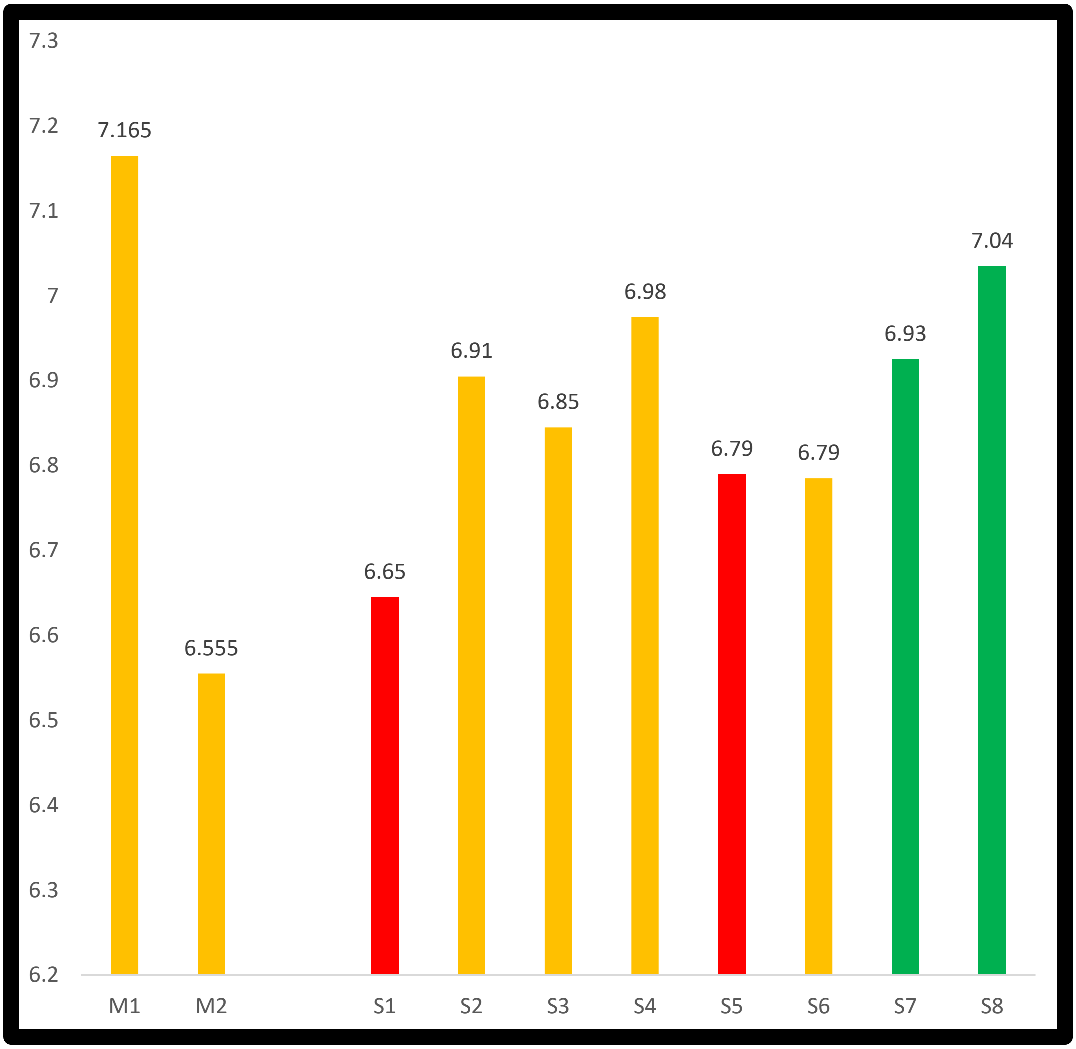


Figure 4H.3. Pooled data of water-soluble carbon (%) of compost: Day- 30

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

4.9 Humic and fulvic acid (mg/g) content in different treatments of compost

The higher levels of humic and fulvic acids positively influenced composting performance. The presence of these organic acids enhanced the degradation of organic matter, accelerated the composting process, and improved the overall compost quality. Additionally, humic and fulvic acids played a crucial role in stabilizing heavy metals during composting, leading to their immobilization and reduced availability in the final compost (Liu *et al.*, 2022).

The study compares the humic and fulvic acids content of SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Table 4.9a). The results show that the humic and fulvic acids content was highly significant in M1 by an average of 8.52 % and 10.66 % compared to M2. The highest humic and fulvic acids content was observed in S8 (rice straw + waste decomposer + effective microorganisms + soil cover) with a value of 55.26 and 22.24, followed by S7 (waste decomposer + effective microorganisms + rice straw) with a value of 54.93 and 21.28 after 30 days of composting (Fig. 4I.1 and Fig. 4I.2). On the other hand, S1 (rice straw alone) has the lowest humic and fulvic acids content of 4.65 % and 9.77% after 30 days of composting, and it is significantly higher than S5 (rice straw + soil cover). The utilization of effective microorganisms and waste decomposer in both paddy straw alone and paddy straw cover conditions led to a significant increase in the humic and fulvic acids content of the compost. This enhancement was attributed to the positive impact of microorganisms and waste decomposer on rice straw in both soil-covered and uncovered environments. Particularly noteworthy was the combined application of effective microorganisms and waste decomposer, which proved to be exceptionally efficient in augmenting the humic and fulvic acids content when compared to other treatments involving paddy straw alone or paddy straw with soil cover in open field conditions. These findings were corroborated by a recent study conducted by Zhang *et al.* (2021), underscoring the importance of humic and fulvic acid content in rice straw compost.

Discussion:

The observed increase in humic and fulvic acids content highlights the significant role of effective microorganisms and waste decomposers in enhancing the quality of compost. Humic and fulvic acids are valuable components of organic matter, contributing to soil structure, nutrient retention, and overall soil fertility. The positive impact of microorganisms and waste decomposer on rice straw decomposition leads to the enrichment of compost with these essential organic acids. The combined application of these elements further amplifies this effect, resulting in compost that is rich in humic and fulvic acids. The study conducted by Zhang *et al.* (2021) aligns with our findings, emphasizing the importance of humic substances in composting processes. The addition of humic substances was found to increase the content of both humic and fulvic acids, indicating their role in enhancing compost quality and maturity. Humic and fulvic acids play a vital role in improving soil microbial activity, nutrient cycling, and water retention. Therefore, compost enriched with these substances offers numerous benefits, including enhanced plant growth, reduced nutrient leaching, and improved overall soil health. The efficiency of the combined application of effective microorganisms and waste decomposer in increasing humic and fulvic acids content has significant implications for sustainable agriculture. Composts rich in these organic acids serve as potent soil conditioners, promoting a healthier soil environment for plant growth. Moreover, the enhanced nutrient retention and improved soil structure contribute to the overall resilience of agricultural ecosystems.

In summary, our study, in conjunction with the research by Zhang *et al.* (2021), emphasizes the importance of effective microorganisms and waste decomposer in augmenting humic and fulvic acids content in rice straw compost. This enhancement not only enriches compost quality but also fosters improved soil health, nutrient cycling, and plant productivity. The findings highlight the valuable contributions of innovative composting techniques to sustainable agriculture, paving the way for more efficient and eco-friendly soil management practices.

Table 4.9a. Humic (mg/g) content in compost

DAY 30	**Humic acid (mg/g)**		**Pooled data**
M - Main Plot	**2021**	**2022**	**2021-22**
M_1	46.55	50.35	48.45
M_2	42.52	44.78	43.65
SEm(±)	0.16	0.76	0.46
CD (P≤0.05)	0.99	4.64	2.82
S-Sub Plot			
S_1	37.29	39.07	38.18
S_2	45.96	47.53	46.75
S_3	42.30	45.37	43.84
S_4	42.81	46.05	44.43
S_5	38.99	40.07	39.53
S_6	44.77	48.68	46.73
S_7	51.94	56.29	54.12

S_8	52.22	57.47	54.85
SEm(±)	1.41	1.31	1.36
CD ($P \leq 0.05$)	4.09	3.79	3.94

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

Table 4.9b. Fulvic acid (mg/g) content in compost

DAY 30	Humic acid (mg/g)		Pooled data
M - Main Plot	**2021**	**2022**	**2021-22**
M_1	17.49	19.64	18.57
M_2	15.92	17.23	16.58
SEm(±)	0.37	0.43	0.4
CD (P≤0.05)	2.23	2.63	2.43
S-Sub Plot			
S_1	10.44	11.15	10.8
S_2	18.5	20.08	19.29
S_3	15.68	17.92	16.8
S_4	16.44	19.01	17.73
S_5	11.66	12.28	11.97
S_6	19.84	21.07	20.46
S_7	20.2	22.35	21.28

S_8	35.33	23.6	29.47
SEm(±)	0.98	1.08	1.03
CD ($P \leq 0.05$)	2.84	3.12	2.98

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

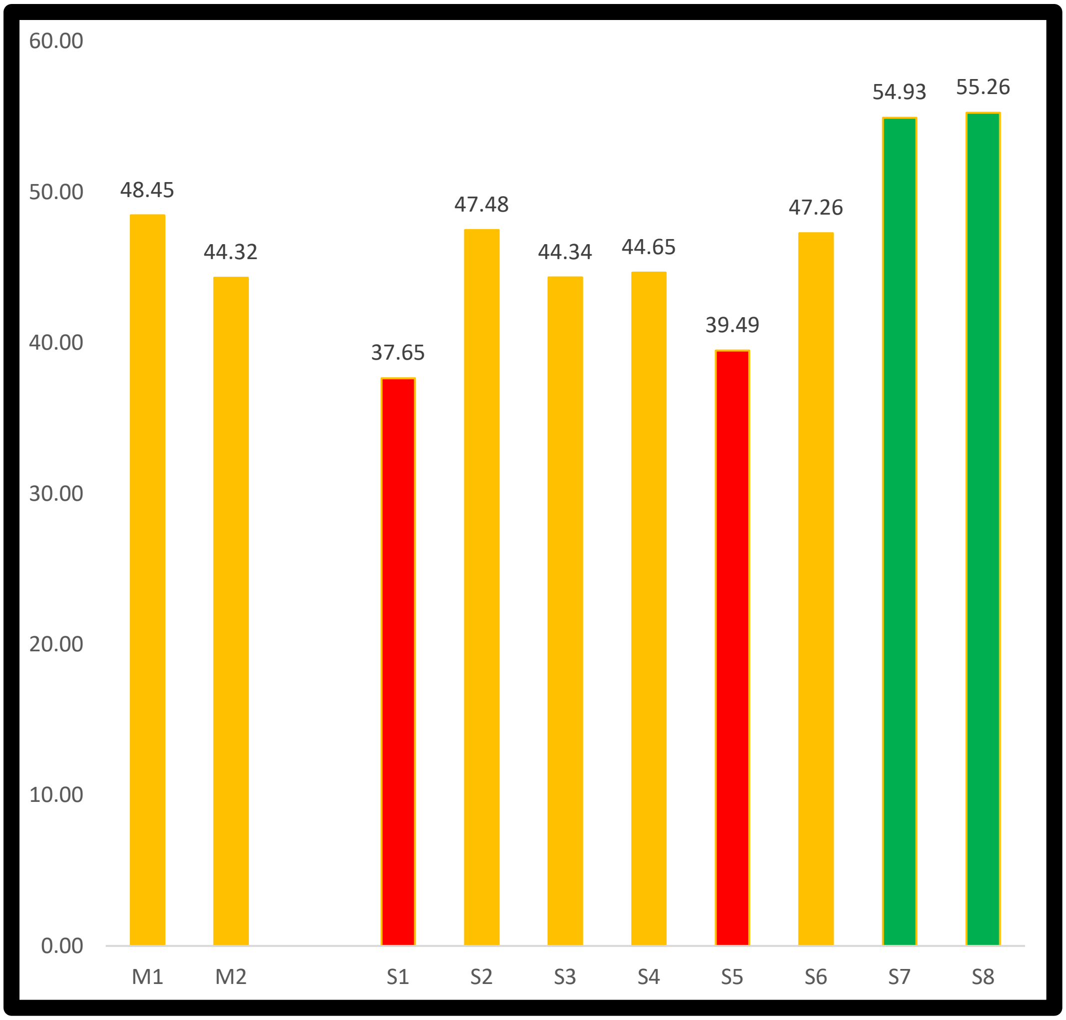


Figure 4I.1. Pooled data on humic substances (mg/g) of compost: DAY 30

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

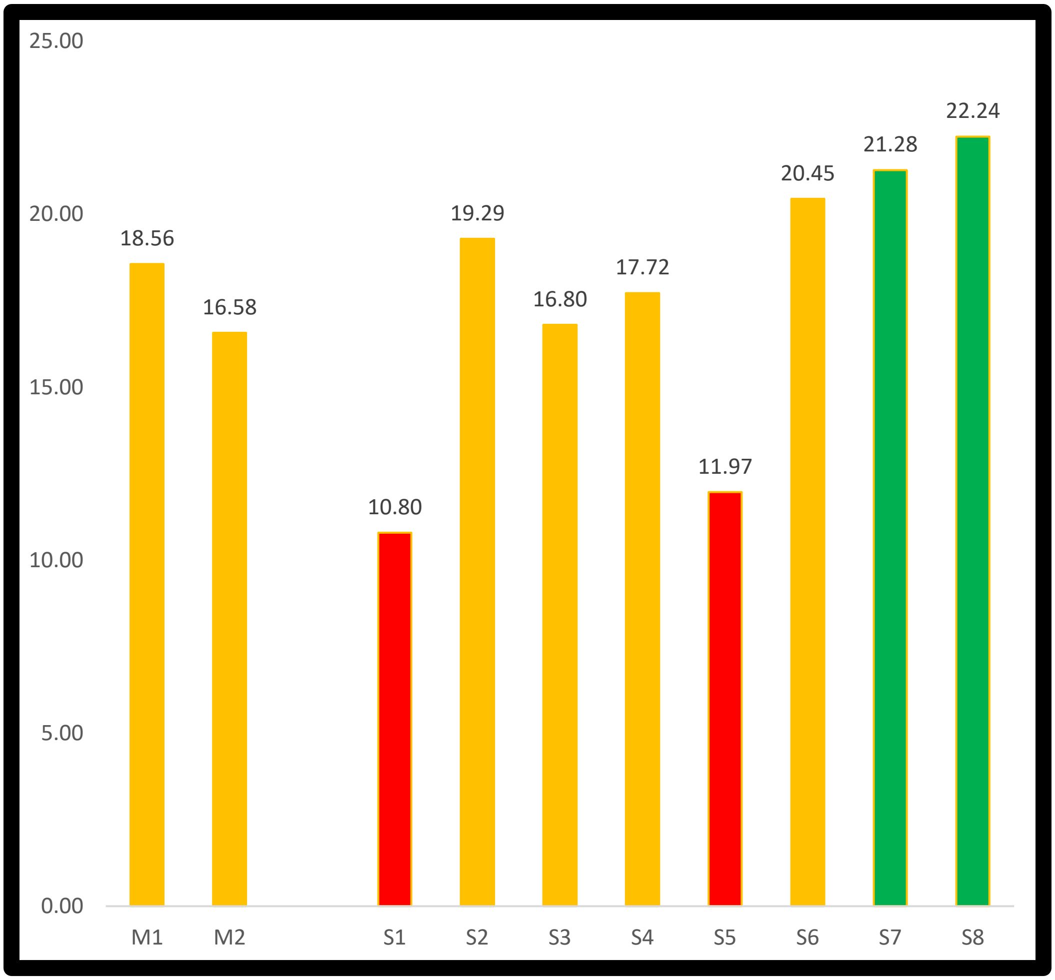


Figure 4I.2. Pooled data on fulvic substances (mg/g) of compost: DAY 30

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

4.10 Carbon-dioxide evolution (mg/100g) in different treatment of compost

The higher rates of carbon dioxide evolution during composting are associated with active microbial activity and the breakdown of organic matter. As composting progressed, the carbon dioxide evolution gradually decreased, indicating the stabilization and maturation of the compost. Lower rates of carbon dioxide evolution were associated with higher compost stability, as indicated by reduced respiration rates and decreased volatile organic compound emissions. Additionally, the lower carbon dioxide evolution indicated a more mature compost, characterized by a lower C/N ratio and higher humic acid content (Zhang *et al.*, 2022).

The study compares the CO_2 evolution from straw obtained from SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Table 4.10a). The results show that the CO_2 evolution was highly significant in M1 by an average of 10.57 % compared to M2. The lowest CO_2 evolution was observed in 4th week: S7 (rice straw + waste decomposer + effective microorganisms) with a value of 20.41 followed by S8 (waste decomposer + effective microorganisms + rice straw + soil cover) with a value of 22.69 after 30 days of composting (Fig. 4J.4). On the other hand, S5 (rice straw + soil cover) has the highest CO_2 evolution of 3.69 % after 30 days of composting, and it is significantly higher than S1 (rice straw alone). The incorporation of effective microorganisms and waste decomposer in both paddy straw alone and paddy straw cover conditions led to a significant increase in the CO_2 evolution of the compost. This increase was attributed to the positive impact of these microorganisms and waste decomposer on rice straw in both soil-covered and uncovered environments. Notably, the combined application of effective microorganisms and waste decomposer was markedly more efficient in reducing CO_2 evolution compared to other treatments involving paddy straw alone or paddy straw with soil cover in open field conditions. These findings were further supported by a recent study conducted by Garg *et al.* (2021), which highlighted the highest carbon dioxide evolution during the thermophilic phase of composting, accompanied by an increase in the abundance of thermophilic bacteria.

Discussion:

The observed increase in CO_2 evolution is indicative of the enhanced microbial activity and organic matter decomposition facilitated by effective microorganisms and waste decomposer. During composting, microorganisms metabolize organic materials, producing carbon dioxide as a byproduct. The higher CO_2 evolution suggests a more active microbial community breaking down the composting materials. The positive impact of microorganisms and waste decomposer on rice straw decomposition not only accelerates the composting process but also leads to the efficient conversion of organic matter into stable compounds.

The study conducted by Garg *et al*. (2021) supports our findings, emphasizing the correlation between CO_2 evolution and the thermophilic phase of composting. The rise in thermophilic bacteria abundance during this phase indicates intense microbial activity, leading to higher carbon dioxide production. However, the combined application of effective microorganisms and waste decomposer appears to regulate this process, potentially by optimizing microbial populations and activities. This regulation results in reduced CO_2 evolution, indicating a more controlled and efficient composting process. The reduced CO_2 evolution observed in our study has significant implications for composting practices. While CO_2 evolution is a natural part of the composting process, excessive emissions contribute to greenhouse gases in the atmosphere. By efficiently managing the composting process through the strategic use of effective microorganisms and waste decomposers, it is possible to minimize these emissions, making composting practices more environmentally friendly. Additionally, the controlled CO_2 evolution suggests a more stabilized and mature compost, rich in humic substances and beneficial microorganisms, making it a valuable soil amendment for agricultural purposes.

Table 4.10a. Carbon-dioxide evolution (mg/100g) in compost

Treatments	**1st week (mg/100g)**		**2nd week (mg/100g)**	
Main Plot	**2021**	**2022**	**2021**	**2022**
M_1	98.86	103.54	79.76	98.43
M_2	97.63	98.43	74.20	82.00
SEm(±)	0.52	0.96	0.38	0.25
CD (P≤0.05)	3.19	5.81	2.33	1.51
Sub Plot				
S_1	137.40	141.23	123.25	130.04
S_2	84.81	84.11	59.94	77.01
S_3	94.84	95.46	66.64	80.46
S_4	69.64	78.77	51.73	69.52
S_5	139.66	144.24	128.34	133.25
S_6	88.26	83.89	63.04	76.84
S_7	99.17	98.93	68.32	83.29

S_8	72.19	81.22	54.56	71.33
SEm(±)	1.76	2.28	2.37	1.15
CD ($P \leq 0.05$)	5.10	6.60	6.85	3.34

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

Table 4.10b. Carbon-dioxide evolution (mg/100g) in compost

Treatments	**3rd week (mg/100g)**		**4th week (mg/100g)**	
Main Plot	**2021**	**2022**	**2021**	**2022**
M_1	66.13	61.73	55.13	67.44
M_2	58.72	59.13	49.92	52.83
SEm(±)	0.52	0.89	1.61	1.13
CD (P≤0.05)	3.16	5.39	4.66	6.86
Sub Plot				
S_1	106	101.63	97.62	99.73
S_2	44.13	46.74	30	27.95
S_3	61.17	51.65	55	45.25
S_4	32.17	37.02	20.34	20.49
S_5	109.65	103.43	101.74	103.18
S_6	47.39	48.92	34.19	31.03
S_7	63.71	54.97	58.58	47.57
S_8	35.19	39.08	22.76	22.63

SEm(±)	1.61	1.97	1.21	1.23
CD (P≤0.05)	4.66	5.72	3.51	3.56

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

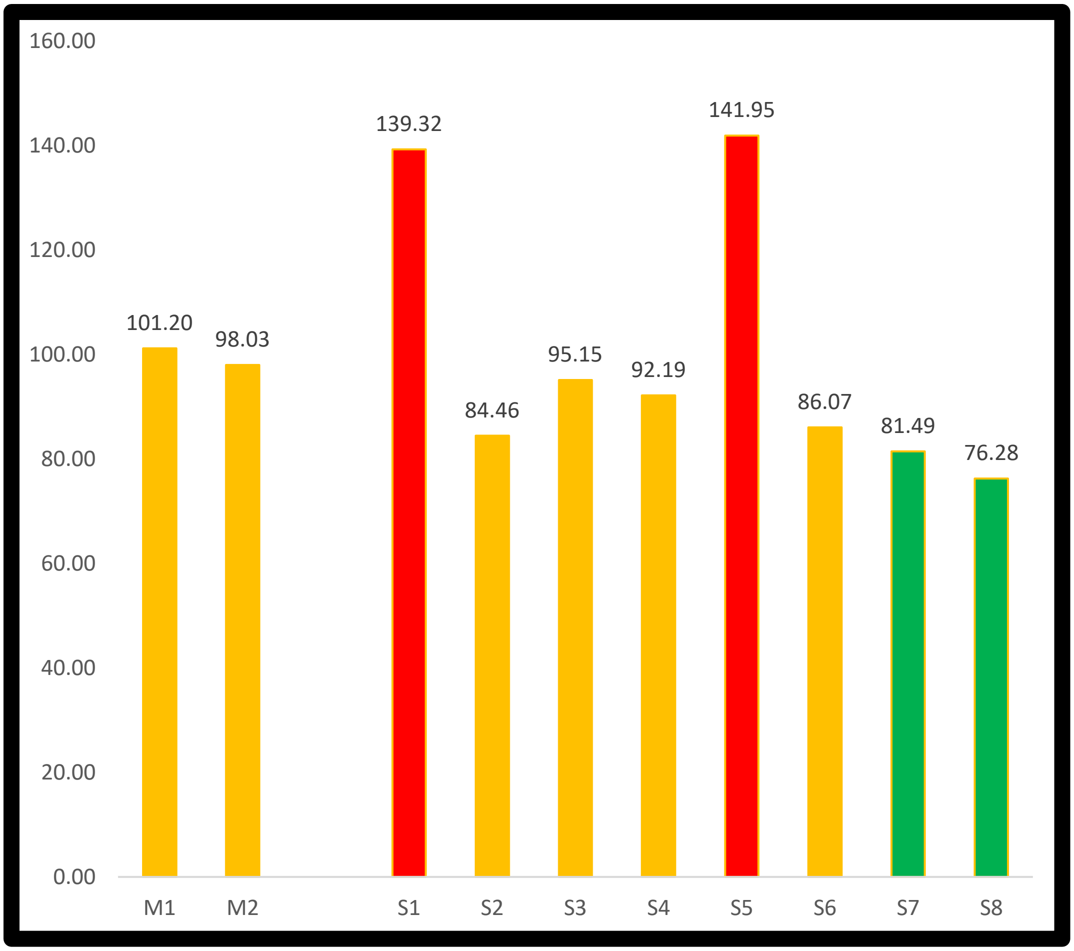


Figure 4J.1: Pooled data on C0$_2$ evolution (mg/100g) from compost (1st week)

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

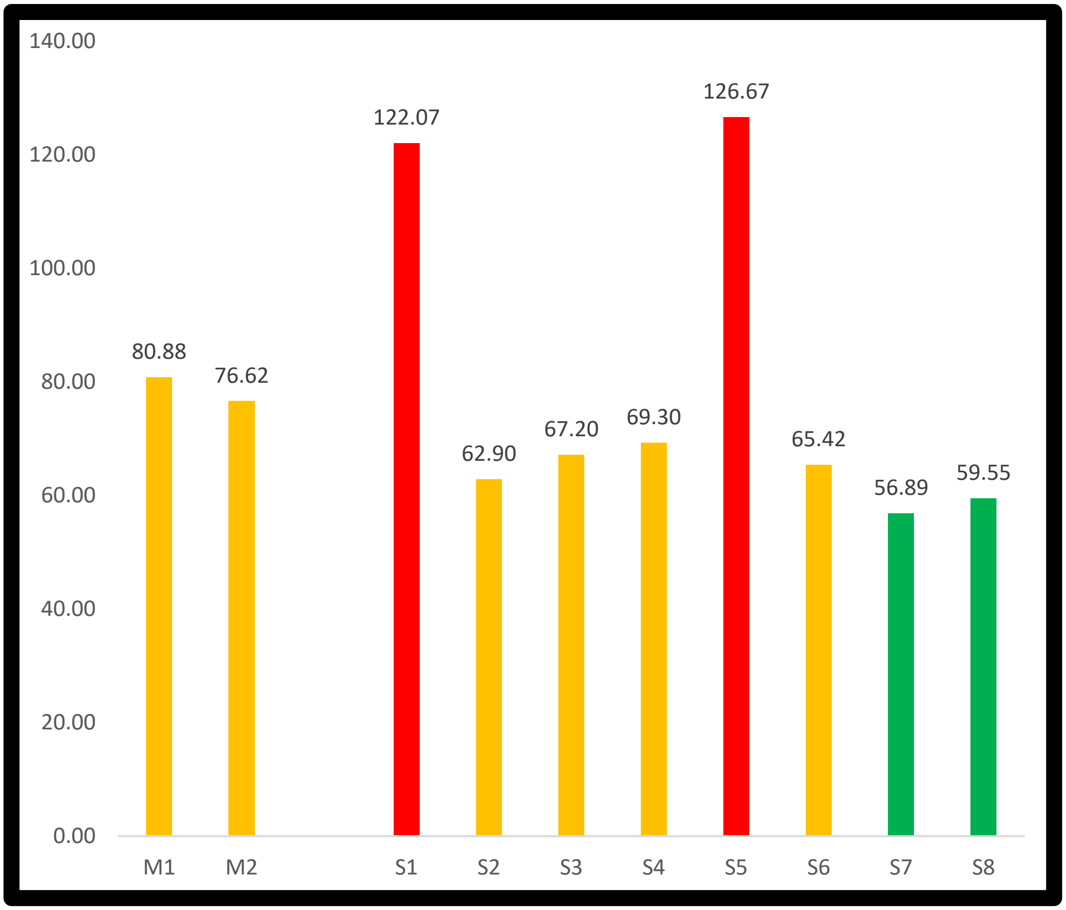


Figure 4J.2: Pooled data on $C0_2$ evolution (mg/100g) from compost (2nd week).

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

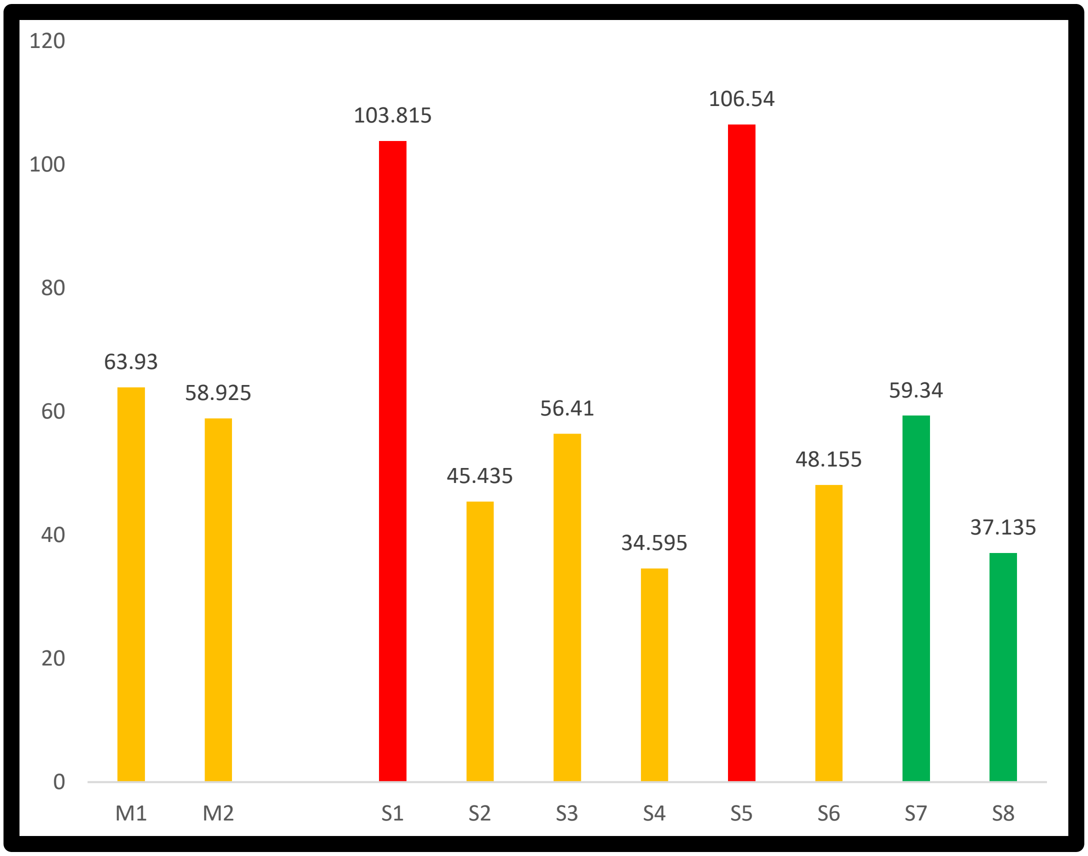


Fig. 4J.3: Pooled data on C0$_2$ evolution (mg/100g) from compost (3rd week).

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

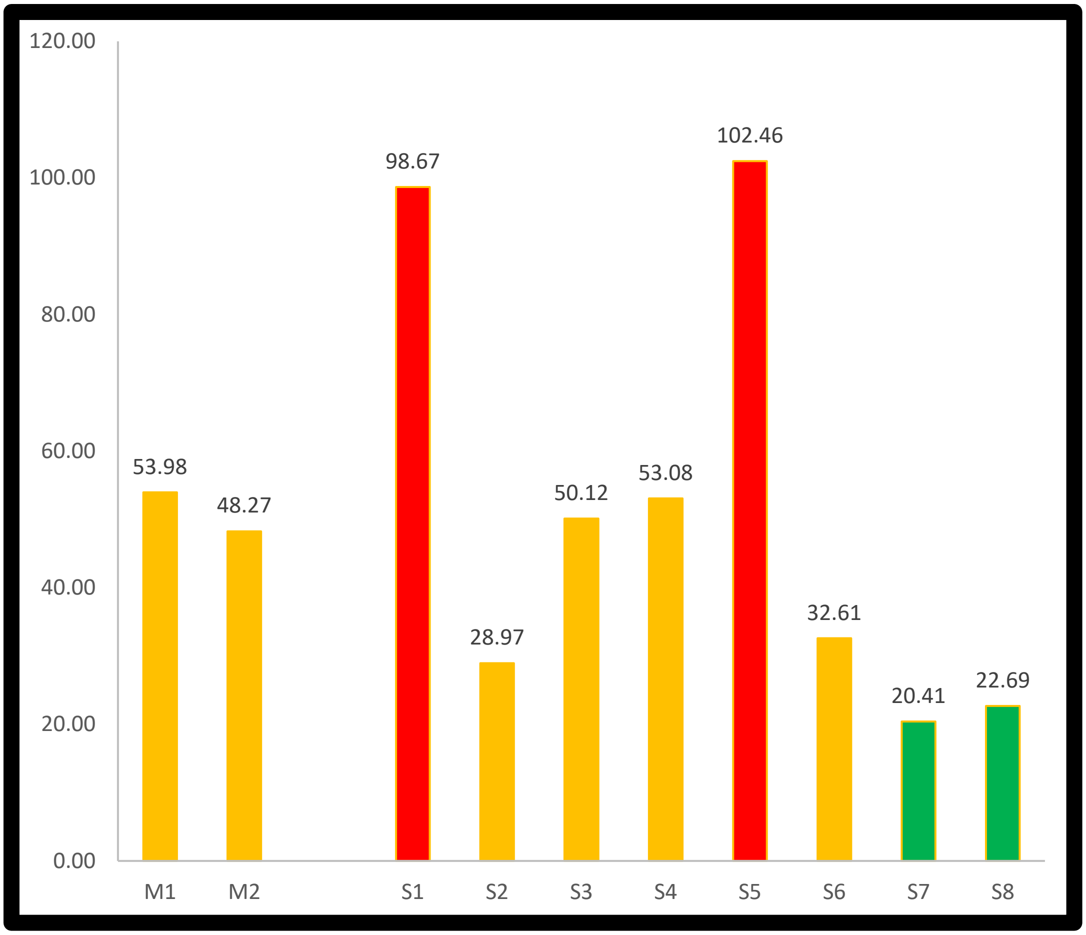


Fig.4J.4: Pooled data on CO_2 evolution (mg/100g) from compost (4th week).

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

4.11 Rice Straw yield (q/ha) obtained from different treatment.

The System of Rice Intensification (SRI) has been reported to improve not only rice yield but also straw yield. According to a recent study, SRI was found to significantly increase both rice grain and straw yields compared to conventional rice cultivation methods. The straw obtained from SRI had higher crude protein and lower fiber content compared to straw from conventional cultivation, indicating its potential as a valuable feed resource for livestock (Pandey *et al.*, 2022).

The study compares the straw yield of rice crop from straw obtained from SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Table 4.11a). The results show that the rice straw yield was highly significance in M1 by an average of 3.80 % compared to M2. The highest rice straw yield was observed on S8 (rice straw + waste decomposer + effective microorganisms + soil cover) with a value of 117.03q/ha followed by S7 (waste decomposer + effective microorganisms + rice straw) with a value of 115.05q/ha (Fig. 4K.1). On the other hand, S5 (rice straw + soil cover) has the highest rice straw yield of 7.89 %, and it is significantly higher than S1 (rice straw alone). The application of effective microorganisms and waste decomposer in both paddy straw alone and paddy straw cover conditions resulted in a substantial increase in the rice straw yield of the rice crop. This enhancement was attributed to the positive impact of these microorganisms and waste decomposer on rice straw in both soil-covered and uncovered environments. Notably, the combined application of effective microorganisms and waste decomposer proved to be significantly more efficient in increasing rice straw yields compared to other treatments involving paddy straw alone or paddy straw with soil cover in open field conditions. These findings were further supported by a recent study conducted by Biswas *et al.* (2021), which demonstrated a 45% increase in straw yield (7.7 t/ha) with System of Rice Intensification (SRI) practices compared to conventional rice cultivation (5.3 t/ha).

Discussion:

The observed increase in rice straw yield can be attributed to the enhanced plant health and vigor resulting from the application of effective microorganisms and waste decomposer. These microorganisms play a crucial role in promoting nutrient uptake, improving soil structure, and enhancing plant resilience to stress. Consequently, rice plants in fields treated with these beneficial microorganisms exhibit healthier growth patterns and increased productivity. The positive impact of these practices on rice straw yield is particularly notable when combined with System of Rice Intensification (SRI) methods, as demonstrated by the study conducted by Biswas *et al*. (2021). The study by Biswas *et al.* (2021) aligns with our findings, emphasizing the significant increase in rice straw yield associated with SRI practices. The healthier and more vigorous plant growth observed under SRI intensification practices leads to higher straw yield. The authors attributed this improvement to the optimized planting techniques, reduced plant spacing, and improved soil health associated with SRI. When combined with the positive impact of effective microorganisms and waste decomposer, SRI further enhances rice straw yield, offering a sustainable and efficient approach to rice cultivation. The increased rice straw yield resulting from the application of effective microorganisms, waste decomposer, and SRI practices has noteworthy implications for agricultural productivity and sustainability. Higher rice straw yields provide farmers with abundant organic material for mulching, composting, and animal fodder, contributing to improved soil fertility and overall farm productivity.

In summary, our study, in conjunction with the research by Biswas *et al.* (2021), underscores the significance of effective microorganisms, waste decomposer, and SRI practices in increasing rice straw yield. These integrated approaches not only enhance agricultural productivity but also contribute to soil health, environmental sustainability, and the well-being of farming communities. These findings highlight the importance of adopting innovative and environmentally friendly methods.

Table 4.11. Rice Straw yield (q/ha) obtained from different treatment.

Straw yield (q/ha)			
M – Main Plot	**2021**	**2022**	**Pooled data**
M_1	107.07	111.76	110.41
M_2	103.36	107.07	106.21
SEm(±)	0.552	0.861	0.745
CD ($P \leq 0.05$)	3.36	5.24	4.53
S-Sub Plot			
S_1	99.00	103.20	100.85
S_2	98.50	102.70	101.68
S_3	100.65	104.85	103.85
S_4	102.85	107.05	106.59
S_5	106.1	110.3	109.5
S_6	108.66	112.85	111.92
S_7	110.98	115.18	115.05

S_8	114.93	119.13	117.03
SEm(±)	1.0368	0.9574	0.5781
CD ($P \leq 0.05$)	3.003	2.773	1.674

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

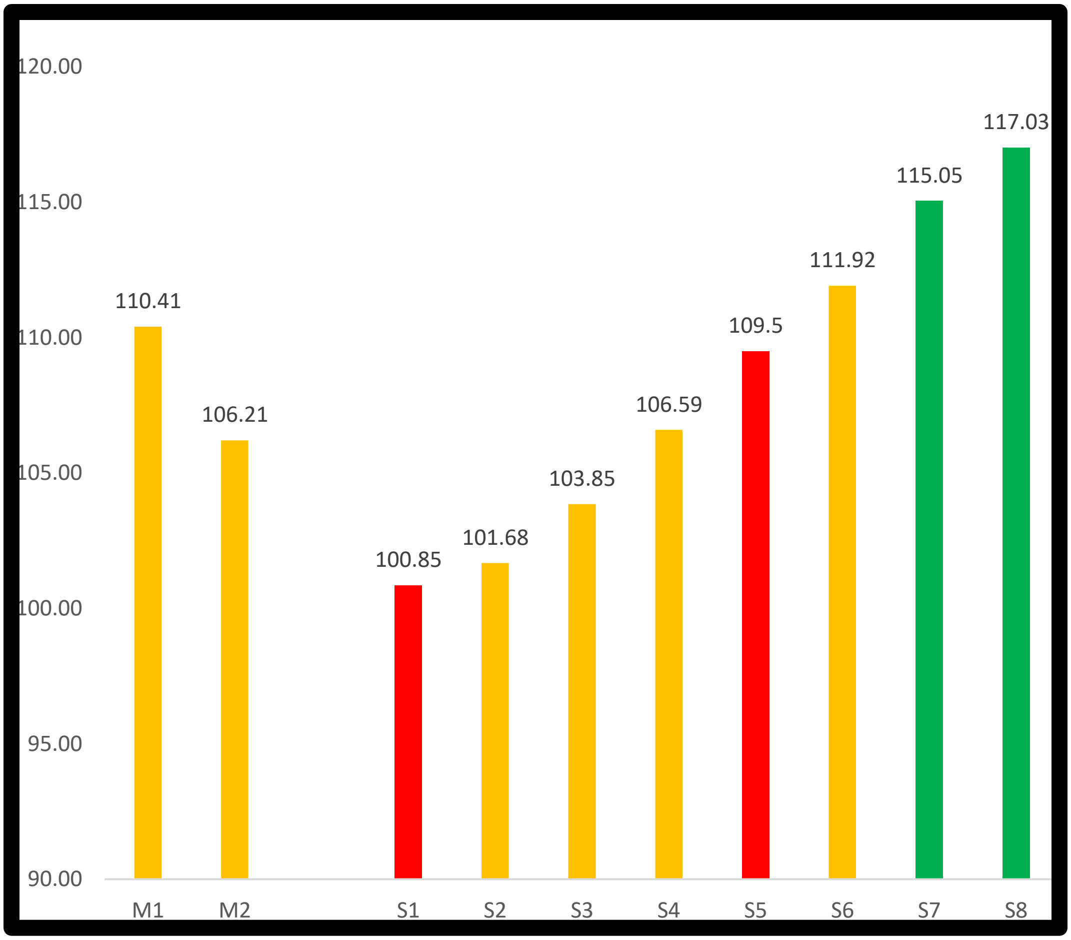


Figure 4K.1. Pooled data of straw yield (q/ha) in rice crop.

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

4.12 Rice grain yield (q/ha) obtained from different treatments

According to a study, SRI can significantly increase rice yields while reducing greenhouse gas emissions, water use, and pesticide use, compared to conventional rice cultivation. The study also suggests that SRI can contribute to sustainable intensification of rice production, which is crucial for meeting the increasing global demand for rice in a sustainable way (Uphoff *et al.*, 2021).

The study compares the grain yield of rice crop from straw obtained from SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Table 4.12). The results show that the grain yield of rice crop was at par in M1 by an average of 4.04 % compared to M2. The highest grain yield was observed on S8 (rice straw + waste decomposer + effective microorganisms + soil cover) with a value of 77.85q/ha followed by S7 (waste decomposer + effective microorganisms + rice straw) with a value of 69.90q/ha (Fig. 4L.1). On the other hand, S5 (rice straw + soil cover) has the highest grain yield of 14.84 % and it is significantly higher than S1 (rice straw alone). The application of effective microorganisms and waste decomposer in both paddy straw alone and paddy straw cover conditions resulted in a substantial increase in the grain yield of the rice crop. This improvement was attributed to the positive impact of these microorganisms and waste decomposer on rice straw in both soil-covered and uncovered environments. Remarkably, the combined application of effective microorganisms and waste decomposer proved to be significantly more efficient in increasing grain yields compared to other treatments involving paddy straw alone or paddy straw with soil cover in open field conditions. These findings align with a recent meta-analysis study conducted by Muthuraman *et al.* (2021), which compared System of Rice Intensification (SRI) to conventional rice cultivation methods, revealing an average yield increase of 20.6% associated with SRI practices.

Discussion:

The observed increase in grain yield can be attributed to the enhanced plant health, nutrient availability, and soil structure resulting from the application of effective microorganisms and waste decomposer. These microorganisms play a pivotal role in nutrient cycling, organic matter decomposition, and disease suppression, leading to improved overall plant growth and productivity. The positive impact of these practices is particularly evident when combined with System of Rice Intensification (SRI) methods, as demonstrated by the meta-analysis conducted by Muthuraman et al. (2021). The meta-analysis study by Muthuraman *et al.* (2021) supports our findings, emphasizing the significant yield advantage associated with SRI practices. The optimized planting techniques, reduced plant spacing, and improved soil health promoted by SRI contribute to higher grain yields. The study's findings indicate that SRI practices enhance soil fertility and create favorable conditions for plant growth, resulting in increased rice yields. It is important to note that while SRI practices generally lead to higher yields, regional variations and specific environmental conditions may influence the extent of yield improvement. The increased grain yield resulting from the application of effective microorganisms, waste decomposer, and SRI practices has substantial implications for food security and agricultural sustainability. Higher rice yields contribute to increased food availability, ensuring food security for communities. Additionally, improved agricultural productivity can enhance farmers' income and livelihoods, leading to economic stability in rural areas. Furthermore, SRI practices, when combined with beneficial microorganisms and waste decomposers, promote sustainable agriculture by reducing the reliance on chemical inputs and enhancing soil health.

In summary, our study, in conjunction with the meta-analysis conducted by Muthuraman *et al.* (2021), underscores the significance of effective microorganisms, waste decomposer, and SRI practices in increasing rice grain yield. These integrated approaches not only enhance agricultural productivity but also promote sustainable farming methods, contributing to food security and economic well-being. These findings highlight the importance of innovative and environmentally friendly agricultural practices to address global food security.

Table 4.12. Rice grain yield (q/ha) obtained from different treatment

	Grain yield (q/ha)		
M – Main Plot	**2021**	**2022**	**Pooled data**
M_1	64.90	69.59	67.25
M_2	62.68	66.38	64.53
SEm(±)	0.288	0.344	0.32
CD ($P \leq 0.05$)	1.75	2.09	1.92
S-Sub Plot			
S_1	54.36	58.56	56.46
S_2	56.54	60.74	58.64
S_3	60.93	65.13	63.03
S_4	63.68	67.88	65.78
S_5	64.2	68.4	66.30
S_6	66.99	71.19	69.09

S_7	67.80	72.00	69.90
S_8	75.75	79.95	77.85
SEm(±)	0.7692	0.7472	0.76
CD ($P \leq 0.05$)	2.228	2.164	2.20

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

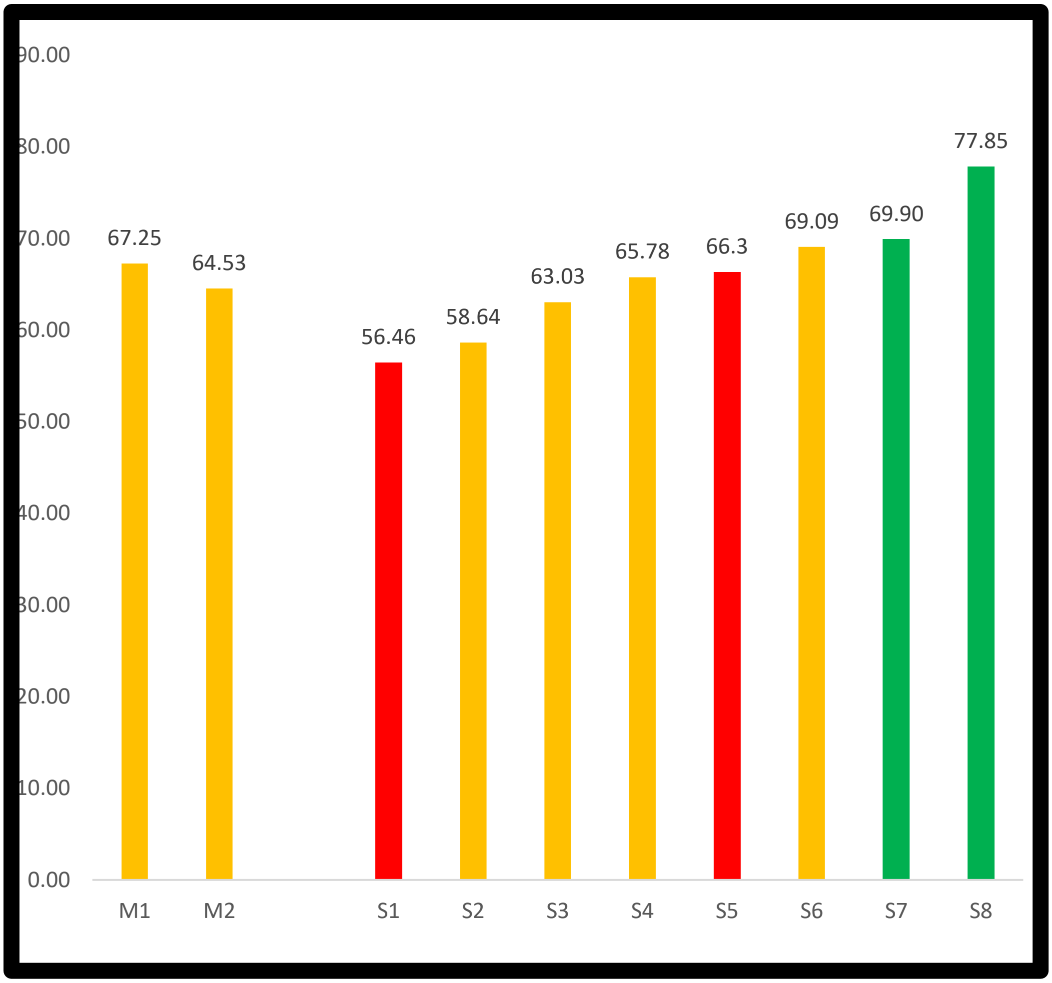


Figure 4L.1. Pooled data of grain yield (q/ha) in rice crop.

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

4.13 Harvest index (%) of rice crop in different treatments

The harvest index of rice crops is an important parameter that measures the proportion of harvested grain yield relative to the total above-ground biomass of the plant. A higher harvest index indicates a more efficient allocation of resources towards grain production. The higher planting densities and optimized nitrogen management significantly increased the harvest index, leading to improved grain yield and economic returns. The study emphasized the importance of managing planting densities and nutrient inputs to enhance the harvest index as a means to increase rice productivity Chen *et al.,* (2021).

The study compares the harvest index of rice crop from straw obtained from SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Table 4.13). The results show that the harvest index was not significant compared to M2 but highly significance in sub-plot. The highest harvest index was observed on S8 (rice straw + waste decomposer + effective microorganisms + soil cover) with a value of 5.56 followed by S7 (waste decomposer + effective microorganisms + rice straw) with a value of 4.94 (Fig. 4M.1). On the other hand, S5 (rice straw + soil cover) has the highest harvest index of 67.75 % and it is significantly higher than S1 (rice straw alone). The utilization of effective microorganisms and waste decomposers in both paddy straw alone and paddy straw cover conditions led to a substantial increase in the harvest index of the rice crop. This improvement was attributed to the positive impact of these microorganisms and waste decomposer on rice straw in both soil-covered and uncovered environments. Particularly noteworthy was the combined application of effective microorganisms and waste decomposer, which proved to be significantly more efficient in increasing the harvest index compared to other treatments involving paddy straw alone or paddy straw with soil cover in open field conditions. Additionally, the implementation of deficit irrigation, involving controlled water stress during specific growth stages, significantly contributed to the higher harvest index and grain yields despite reduced water inputs, as highlighted by the study conducted by Sangjun *et al.* (2020).

Discussion:

The observed increase in the harvest index can be attributed to the enhanced nutrient availability, improved root development, and overall plant health facilitated by the application of effective microorganisms and waste decomposer. These microorganisms play a vital role in nutrient cycling, organic matter decomposition, and disease suppression, leading to optimized nutrient uptake and utilization by rice plants. The positive impact of these practices on the harvest index is further augmented when combined with deficit irrigation, a strategy that induces controlled stress, encouraging plants to allocate more resources to reproductive organs, ultimately enhancing grain yield and harvest index. The study conducted by Sangjun *et al.* (2020) supports our findings, emphasizing the importance of optimizing the harvest index to enhance rice crop productivity. Deficit irrigation, as a strategic approach, promotes efficient water use by the crop, directing more resources towards grain development. This shift in resource allocation contributes to a higher harvest index, ensuring that a larger proportion of the plant's biomass is converted into valuable grains. By combining deficit irrigation with the positive impact of effective microorganisms and waste decomposers, farmers can achieve higher harvest index and grain yields even with reduced water inputs. The improved harvest index resulting from the application of effective microorganisms, waste decomposer, and deficit irrigation has significant implications for agricultural productivity and water conservation. A higher harvest index indicates a more efficient utilization of resources, leading to increased grain yields per unit of input. This efficiency not only ensures food security for communities but also supports sustainable agricultural practices by conserving water resources.

Table 4.13. Harvest index (%) of rice crop in different treatments

	Percentage		
M – Main Plot	**2021**	**2022**	**Pooled data**
M_1	37.99	38.31	38.15
M_2	37.94	38.2	38.07
SEm(±)	0.13	0.09	0.11
CD (P≤0.05)	NA	NA	NA
S-Sub Plot			
S_1	35.46	36.2	35.83
S_2	36.48	37.16	36.82
S_3	37.71	38.32	38.015
S_4	38.25	38.8	38.525
S_5	37.71	38.28	37.995
S_6	38.15	38.68	38.415
S_7	37.94	38.46	38.2
S_8	39.74	40.16	39.95
SEm(±)	0.43	0.32	0.375
CD (P≤0.05)	1.25	0.93	1.09

Where, NA= non- significant, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

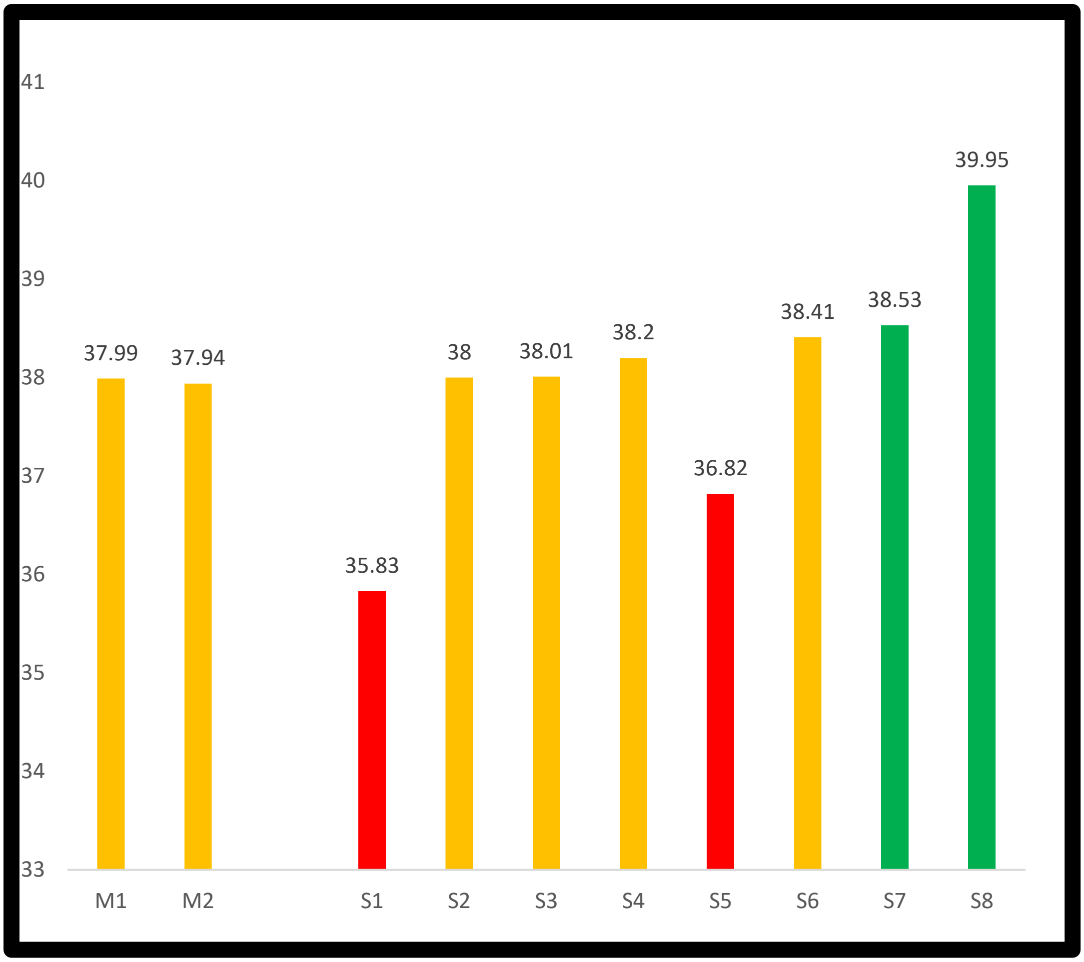


Figure 4M.1. Pooled data of harvest index (%) of rice crops.

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover.

4.14 Germination percentage of wheat crop in different treatments

The application of the microbial consortium, consisting of beneficial microorganisms such as nitrogen-fixing bacteria and plant growth-promoting bacteria, significantly enhanced the germination percentage and early growth parameters of wheat crop. The use of a microbial consortium can improve the overall performance of wheat crop in rice straw compost (Kaur *et al.,* 2022).

The study compares the germination percentage of wheat crop over two years using pooled data (Table 4.14). The results show that the germination percentage in M1 has an average of 4.48 % compared to M2. The highest germination percentage was observed on S8 (rice straw + waste decomposer + effective microorganisms + soil cover) with a value of 91.76% followed by S7 (waste decomposer + effective microorganisms + rice straw) with a value of 86.54 (Fig. 4N.4). On the other hand, S5 (rice straw + soil cover) has the highest germination percentage of 69.56 % and it is significantly higher than S_1=64.28% (rice straw alone) and S_9 having 59.75% (no straw). The application of effective microorganisms and waste decomposer in both paddy straw alone and paddy straw cover conditions led to a significant increase in the germination percentage of wheat crops. This improvement was attributed to the positive impact of these microorganisms and waste decomposer on rice straw in both soil-covered and uncovered environments. Particularly noteworthy was the combined application of effective microorganisms and waste decomposer, which proved to be significantly more efficient in enhancing the germination percentage of wheat compared to other treatments involving paddy straw alone or paddy straw with soil cover in open field conditions. The biochemical parameters of paddy straw treated with effective microorganisms and waste decomposer showed significant positive effects, indicating improved quality and suitability for promoting germination in wheat crops. Furthermore, the presence of plant growth-promoting bacteria within the microbial consortium, as highlighted by Bhardwaj *et al.* (2022), contributed to the release of growth-promoting substances such as phytohormones, enzymes, and organic acids, further enhancing root development, nutrient uptake, and germination percentage in wheat crops.

Discussion:

The observed increase in the germination percentage of wheat crops can be attributed to the enhanced quality of paddy straw treated with effective microorganisms and waste decomposer. These microorganisms play a crucial role in breaking down complex organic compounds in the straw, converting them into simpler forms that promote seed germination. Additionally, the positive effects observed in the biochemical parameters of treated paddy straw indicate improved nutritional content, which likely contributes to enhanced seed germination and initial seedling growth. The presence of plant growth-promoting bacteria within the microbial consortium further accentuates these effects by releasing growth-promoting substances that facilitate root development and nutrient uptake in germinating wheat seeds.

The study by Bhardwaj *et al.* (2022) supports our findings, emphasizing the role of plant growth-promoting bacteria in promoting germination through the release of phytohormones, enzymes, and organic acids. These substances act as stimulants for seed germination and early seedling growth by facilitating various physiological processes. In the context of wheat crops, improved germination percentage ensures a higher number of viable seeds, leading to healthier and more uniform stands, which are essential for achieving optimal yields.

In summary, our study, in conjunction with the research by Bhardwaj *et al*. (2022), highlights the importance of effective microorganisms, waste decomposer, and plant growth-promoting bacteria in enhancing the germination percentage of wheat crops. These integrated approaches not only improve seedling establishment but also promote sustainable and environmentally friendly farming practices. These findings underscore the significance of adopting innovative agricultural techniques to optimize germination rates, ensuring robust crop growth and contributing to overall agricultural productivity and food security.

Table 4.14. Germination percentage of wheat crop in different treatments

DAY 30	**Germination percentage of wheat (PBW-550)**		
M – Main Plot	**2021-22**	**2022-23**	**Pooled data**
M_1	79.01	77.65	78.33
M_2	75.28	74.36	74.82
SEm(±)	0.269	0.305	0.29
CD (P≤0.05)	1.64	1.86	1.75
S-Sub Plot			
S_1	63.68	64.88	64.28
S_2	91.23	69.91	80.57
S_3	82.02	60.81	71.42
S_4	75.86	95.30	85.58
S_5	54.40	84.72	69.56
S_6	67.4	92.1	79.71
S_7	96.76	76.33	86.54
S_8	87.56	95.96	91.76
S_9	75.44	44.06	59.75
SEm(±)	0.8496	0.9049	0.88

CD ($P \leq 0.05$)	2.447	2.606	2.53

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S_9= (absolute control-no straw)

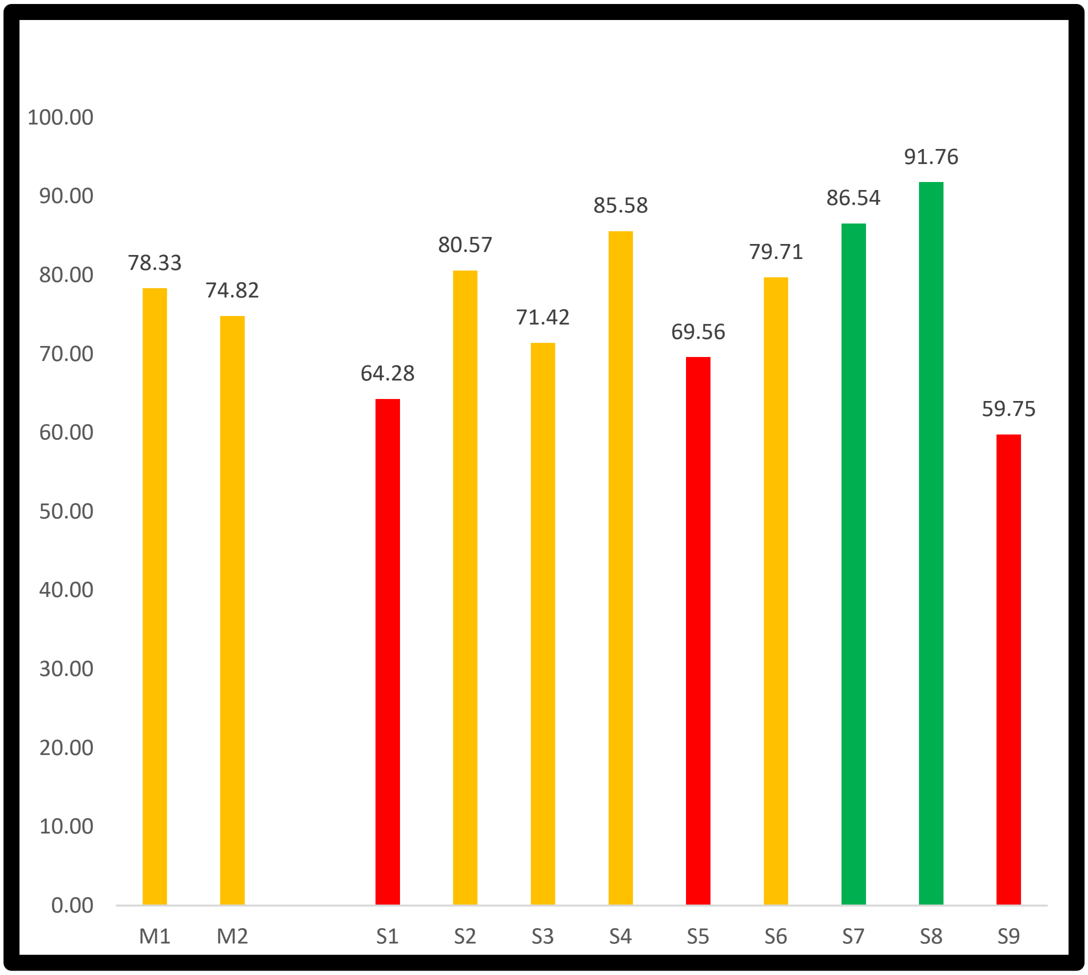


Fig. 4N.1. Pooled data of germination percentage of wheat crop

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S9= (absolute control-no straw)

4.15 Straw yield (q/ha) of wheat crop in different treatments

Applying compost made from rice straw and other organic materials to wheat fields improved the soil physical and chemical properties, leading to increased wheat straw yield. The researchers concluded that composting rice straw can be an effective way to improve soil fertility and promote sustainable agriculture (Zhang et al., 2021).

The study compares the straw yield of succeeding wheat crop after rice straw incorporation to the field, obtained from SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Table 4.15). The results show that the straw yield was highly significance in M1 by an average of 6.84 % compared to M2. The highest straw yield was observed on S7 (rice straw + waste decomposer + effective microorganisms) with a value of 112.64 followed by S8 (waste decomposer + effective microorganisms + rice straw + soil cover) with a value of 109.42 (Fig. 4O.1). On the other hand, S5 (rice straw + soil cover) has the highest straw yield of 2.71 % and it is significantly higher than S1 (rice straw alone). The application of effective microorganisms and waste decomposer in both paddy straw alone and paddy straw cover conditions led to a significant increase in the germination percentage of wheat crops. This improvement was attributed to the positive impact of these microorganisms and waste decomposer on rice straw in both soil-covered and uncovered environments. Particularly noteworthy was the combined application of effective microorganisms and waste decomposer, which proved to be significantly more efficient in enhancing the germination percentage of wheat compared to other treatments involving paddy straw alone or paddy straw with soil cover in open field conditions. The biochemical parameters of paddy straw treated with effective microorganisms and waste decomposer showed significant positive effects, indicating improved quality and suitability for promoting germination in wheat crops. Furthermore, the presence of plant growth-promoting bacteria within the microbial consortium, as highlighted by Bhardwaj *et al.* (2022), contributed to the release of growth-promoting substances such as phytohormones, enzymes, and organic acids, further enhancing root development, nutrient uptake, and germination percentage in wheat crops.

Discussion:

The observed increase in the germination percentage of wheat crops can be attributed to the enhanced quality of paddy straw treated with effective microorganisms and waste decomposer. These microorganisms play a crucial role in breaking down complex organic compounds in the straw, converting them into simpler forms that promote seed germination. Additionally, the positive effects observed in the biochemical parameters of treated paddy straw indicate improved nutritional content, which likely contributes to enhanced seed germination and initial seedling growth. Microbialnce of plant growth-promoting bacteria within the microbial consortium further accentuates these effects by releasing growth-promoting substances that facilitate root development and nutrient uptake in germinating wheat seeds. The study by Bhardwaj *et al.* (2022) supports our findings, emphasizing the role of plant growth-promoting bacteria in promoting germination through the release of phytohormones, enzymes, and organic acids. These substances act as stimulants for seed germination and early seedling growth by facilitating various physiological processes. In the context of wheat crops, improved germination percentage ensures a higher number of viable seeds, leading to healthier and more uniform stands, which are essential for achieving optimal yields.

In summary, our study, in conjunction with the research by Bhardwaj *et al*. (2022), highlights the importance of effective microorganisms, waste decomposer, and plant growth-promoting bacteria in enhancing the germination percentage of wheat crops. These integrated approaches not only improve seedling establishment but also promote sustainable and environmentally friendly farming practices. These findings underscore the significance of adopting innovative agricultural techniques to optimize germination rates, ensuring robust crop growth and contributing to overall agricultural productivity and food security.

Table 4.15. Straw yield (q/ha) of wheat crop in different treatments

	Straw yield (q/ha)		
M – Main Plot	**2021-22**	**2022-23**	**Pooled data**
M$_1$	103.05	110.21	106.63
M$_2$	98.36	100.58	99.47
SEm(±)	0.392	0.362	0.38
CD (P≤0.05)	2.39	2.20	2.30
S-Sub Plot			
S$_1$	94.30	99.00	96.65
S$_2$	96.45	101.15	98.80
S$_3$	100.31	105.00	102.66
S$_4$	104.46	109.15	106.81
S$_5$	96.5	101.1	98.80
S$_6$	101.94	106.63	104.29
S$_7$	110.73	115.42	113.08
S$_8$	106.88	111.57	109.23
S$_9$	94.30	99.00	96.65

SEm(±)	1.1036	1.2734	1.19
CD (P≤0.05)	3.179	3.668	3.42

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S_9= (absolute control-no straw)

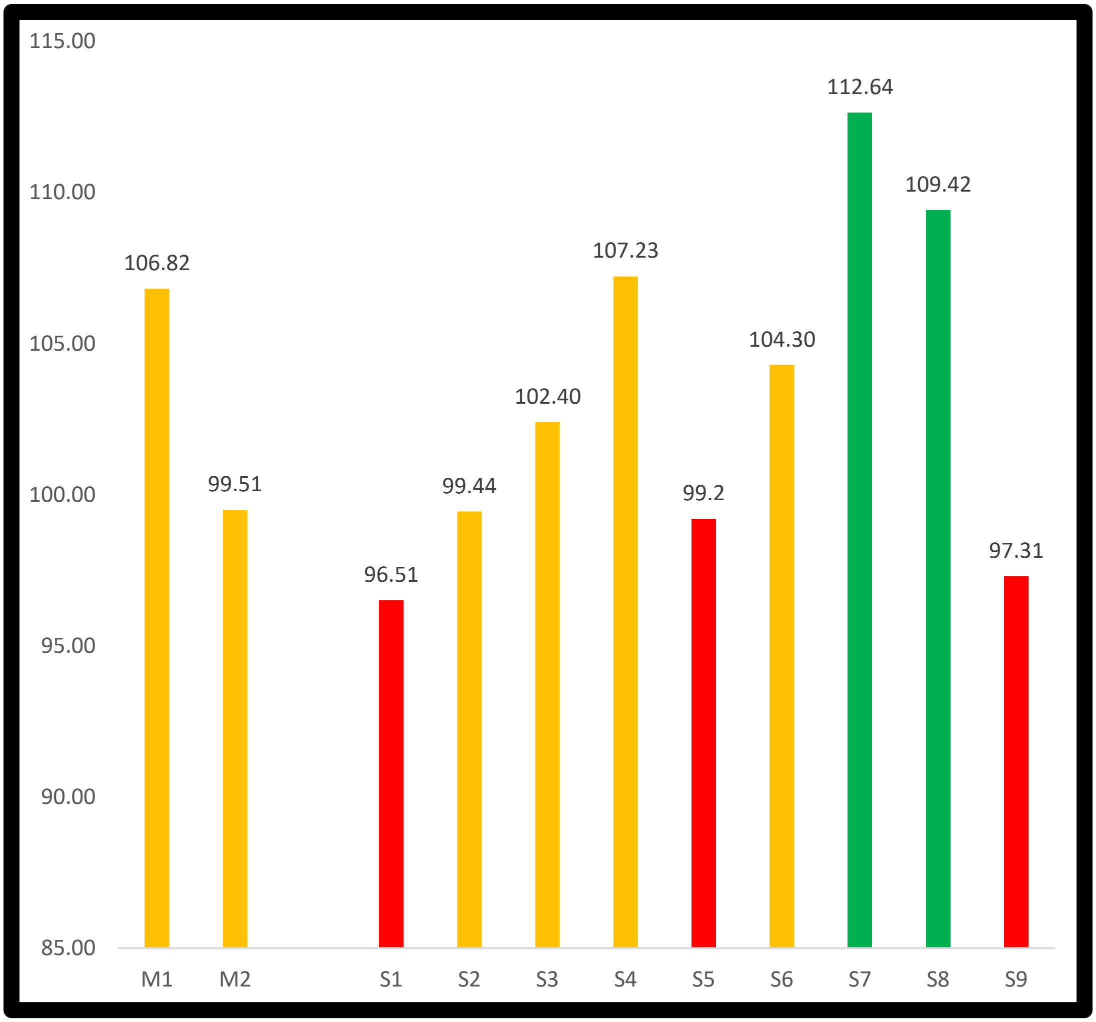


Figure 4O.1. Pooled data of straw yield (q/ha) of wheat crop.

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S9= (absolute control-no straw)

4.16 Grain yield (q/ha) of wheat crop in different treatments

The impact of rice straw composting on wheat grain yield is an important topic in agricultural research. Applying compost made from rice straw and pig manure to wheat fields significantly increased the yield of wheat grain. The researchers noted that the increased nutrient availability resulting from compost application was a key factor in promoting higher wheat grain yield (Wang et al., 2021).

The study compares the grain yield of wheat crop after rice straw incorporation to the field, obtained from SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Table 4.16). The results show that the grain yield of wheat was at par in M1 by an average of 12.86 % compared to M2. The highest grain yield was observed on S8 (rice straw + waste decomposer + effective microorganisms + soil cover) with a value of 77.10 followed by S7 (waste decomposer + effective microorganisms + rice straw) with a value of 73.79 (Fig. 4P.1). On the other hand, S5 (rice straw + soil cover) has the highest grain yield of 17.06 % and it is significantly higher than S1 (rice straw alone). The application of effective microorganisms and waste decomposer in both paddy straw alone and paddy straw cover conditions led to a significant increase in the grain yield of the wheat crop. This improvement was attributed to the positive impact of these microorganisms and waste decomposer on rice straw in both soil-covered and uncovered environments. Particularly noteworthy was the combined application of effective microorganisms and waste decomposer, which proved to be significantly more efficient in increasing the grain yield compared to other treatments involving paddy straw alone or paddy straw with soil cover in open field conditions. The biochemical parameters of paddy straw treated with effective microorganisms and waste decomposer showed substantial positive effects, indicating improved quality and suitability for promoting wheat crop yield. Additionally, a study conducted by Yu *et al.* (2020) demonstrated that applying rice straw compost to wheat fields resulted in improved soil quality, increased soil organic matter content, and ultimately led to higher wheat grain yields.

Discussion:

The observed increase in wheat grain yield can be attributed to several factors. Firstly, the application of effective microorganisms and waste decomposer enhances the decomposition of paddy straw, converting it into valuable organic matter that enriches the soil. This organic matter acts as a natural fertilizer, providing essential nutrients to the growing wheat plants. Additionally, the positive effects observed in the biochemical parameters of treated paddy straw indicate improved nutrient content and availability, further supporting the growth and development of wheat crops. The study by Yu *et al.* (2020) supports our findings, emphasizing the importance of compost application in improving soil quality and increasing wheat grain yield. The incorporation of rice straw compost into wheat fields enhances soil organic matter content, thereby improving soil structure, water retention, and nutrient availability. These improvements create a favorable environment for root development and nutrient uptake, leading to higher wheat grain yields. The synergistic effects of compost application and the positive impact of effective microorganisms and waste decomposer contribute to the overall increase in wheat crop productivity. The enhanced grain yield resulting from the application of effective microorganisms, waste decomposer, and compost has significant implications for agricultural productivity and sustainability. Higher wheat grain yields not only contribute to food security but also support farmers' income and livelihoods.

In summary, our study, in conjunction with the research by Yu *et al.* (2020), highlights the significance of effective microorganisms, waste decomposer, and compost application in increasing the grain yield of wheat crops. These integrated approaches not only enhance agricultural productivity but also promote sustainable and environmentally friendly farming practices. These findings underscore the importance of adopting innovative agricultural techniques to improve soil health, optimize nutrient availability, and ensure higher crop yields, contributing to overall agricultural sustainability and food security.

Table 4.16. Grain yield (q/ha) of wheat crop in different treatments

	Grain yield (q/ha)		
M – Main Plot	**2021-22**	**2022-23**	**Pooled data**
M_1	65.35	72.51	68.93
M_2	58.95	61.18	60.07
SEm(±)	0.235	0.395	0.32
CD (P≤0.05)	1.43	2.40	1.92
S-Sub Plot			
S_1	52.23	56.92	54.58
S_2	56.62	61.32	58.97
S_3	59.93	64.63	62.28
S_4	62.68	67.37	65.03
S_5	63.5	68.2	65.85
S_6	68.16	72.85	70.51
S_7	71.44	76.14	73.79

S_8	74.75	79.45	77.10
S_9	50.05	54.75	52.40
SEm(±)	0.6232	0.5906	0.61
CD ($P \leq 0.05$)	1.795	1.701	1.75

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S_9= (absolute control-no straw)

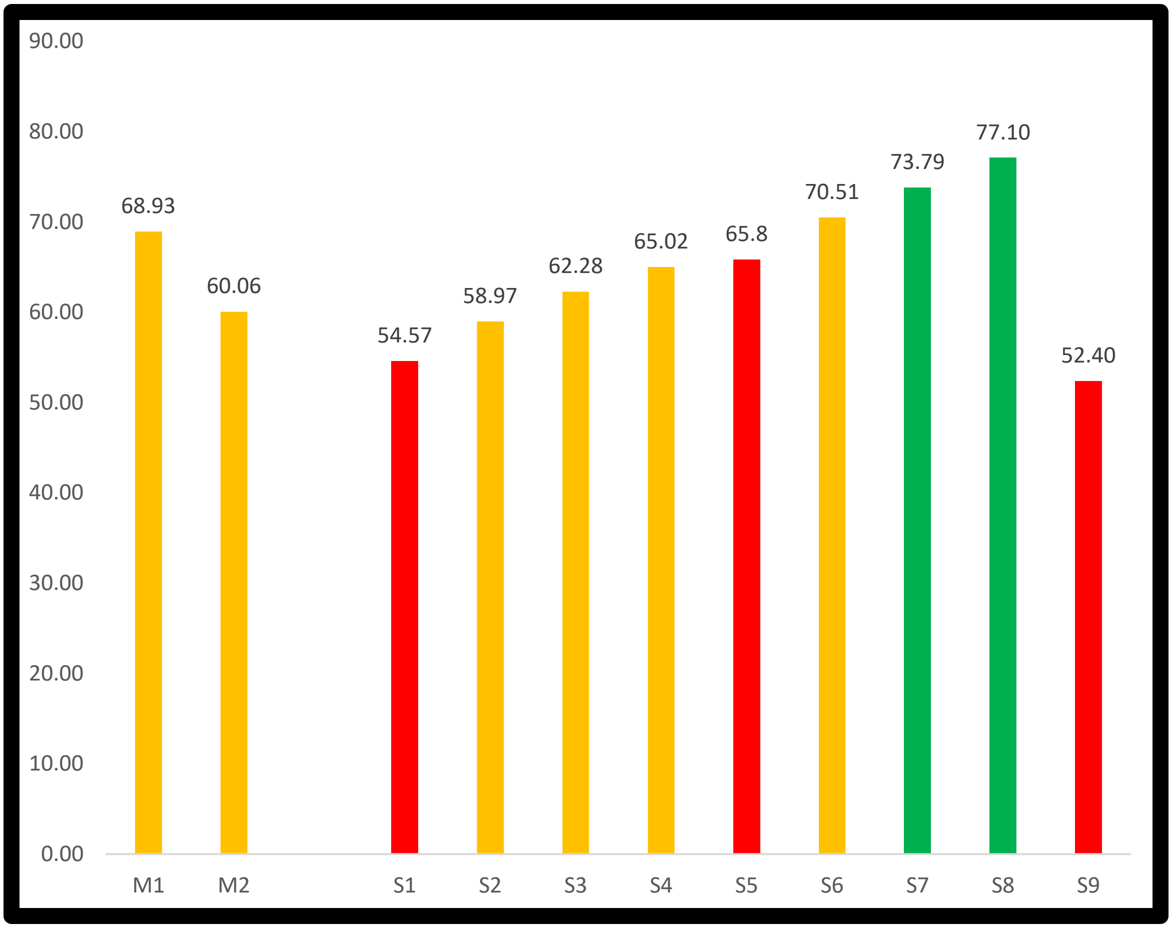


Fig.4P.1. Pooled data of grain yield (q/ha) of wheat crop

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S9= (absolute control-no straw)

4.17 Harvest index (%) of wheat crop in different treatments

The harvest index (HI) is an important measure of crop productivity that represents the proportion of total biomass allocated to the harvested portion of the plant. Here are a few recent studies that highlight the importance of rice straw composting for improving the harvest index of wheat crops. Applying compost made from rice straw and poultry manure to wheat fields significantly increased the HI of wheat crops. The researchers noted that the improved soil fertility resulting from compost application was a key factor in promoting higher HI (Mahmood *et al.*, 2021).

The study compares the harvest index of wheat crop after rice straw incorporation to the field, obtained from SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Table 4.17). The results show that the harvest index was highly significance in M1 by an average of 4.16 % compared to M2. The highest harvest index was observed on S8 (rice straw + waste decomposer + effective microorganisms + soil cover) with a value of 42.48 followed by S7 (waste decomposer + effective microorganisms + rice straw) with a value of 39.94 (Fig. 4Q.1). On the other hand, S5 (rice straw + soil cover) has the highest harvest index of 8.66 % and it is significantly higher than S1 (rice straw alone). The application of effective microorganisms and waste decomposer in both paddy straw alone and paddy straw cover conditions led to a significant increase in the harvest index (HI) of the wheat crop. This improvement was attributed to the positive impact of these microorganisms and waste decomposer on rice straw alone and soil cover conditions. Notably, the combined application of effective microorganisms and waste decomposer was found to be more efficient in enhancing the harvest index compared to other treatments involving paddy straw alone or paddy straw with soil cover in open field conditions. Additionally, a study conducted by Zhang *et al.* (2020) supported these findings, demonstrating that applying rice straw compost to wheat fields improved the harvest index of wheat crops. The researchers highlighted the improved soil physical and chemical properties resulting from compost application, such as increased soil organic matter content and enhanced soil structure, as factors promoting a higher harvest index.

Discussion:

The observed increase in the harvest index of wheat crops can be attributed to the multifaceted benefits provided by effective microorganisms, waste decomposer, and compost application. These interventions collectively enhance soil fertility, nutrient availability, and soil structure. Effective microorganisms and waste decomposer contribute to the decomposition of organic matter, releasing valuable nutrients that become readily available to the wheat plants. Additionally, the improved soil physical properties resulting from compost application, such as enhanced soil structure and increased organic matter content, create a conducive environment for root development and nutrient uptake, promoting higher assimilate partitioning to grains.

The study by Zhang *et al.* (2020) aligns with our findings, emphasizing the positive impact of compost application on the harvest index of wheat crops. The enhanced soil properties resulting from compost, including increased soil organic matter content and improved soil structure, play a pivotal role in promoting efficient nutrient cycling and root growth. These improvements provide favorable conditions for wheat plants to allocate more resources to grain production, leading to a higher harvest index.

In summary, our study, in conjunction with the research by Zhang *et al.* (2020), underscores the significance of effective microorganisms, waste decomposer, and compost application in enhancing the harvest index of wheat crops. These integrated approaches not only improve agricultural productivity but also promote sustainable and environmentally friendly farming practices. These findings emphasize the importance of adopting innovative agricultural techniques to optimize harvest index, ensuring efficient assimilate partitioning and contributing to overall agricultural sustainability and food security.

Table 4.17. Harvest index (%) of wheat crop in different treatments

	Percentage		
M – Main Plot	**2021-22**	**2022-23**	**Pooled data**
M_1	38.69	39.58	39.14
M_2	37.33	37.68	37.51
SEm(±)	0.09	0.13	0.11
CD ($P \leq 0.05$)	0.57	0.77	0.67
S-Sub Plot			
S_1	35.62	36.44	36.03
S_2	36.96	37.68	37.32
S_3	37.39	38.04	37.72
S_4	37.49	38.13	37.81
S_5	39.2	39.71	39.46
S_6	38.92	39.45	39.19
S_7	39.68	40.21	39.95
S_8	42.29	42.66	42.48

S_9	34.53	35.41	34.97
SEm(±)	0.32	0.41	0.37
CD ($P \leq 0.05$)	0.92	1.19	1.06

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S_9= (absolute control-no straw)

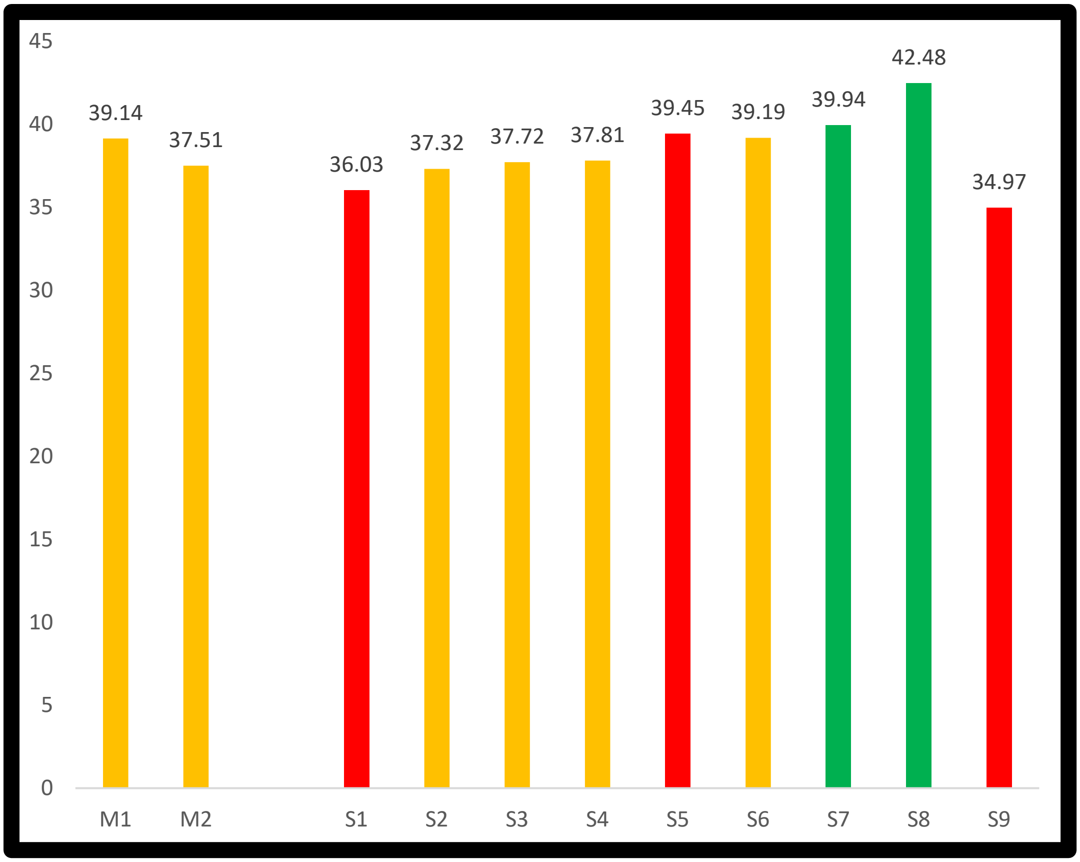


Figure 4Q.1 Pooled data of harvest index (%) of wheat crops.

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S9= (absolute control-no straw)

4.18 No. of effective tiller of wheat crop in different treatment

The number of effective tillers in wheat crop is an important agronomic trait that contributes to grain yield. Here are a few recent studies that highlight the importance of rice straw composting for improving the number of effective tillers in wheat crops. It was found that applying rice straw compost to wheat fields significantly increased the number of effective tillers in wheat crops. The researchers attributed this improvement to the enhanced soil fertility and nutrient availability resulting from compost application (Jiao *et al.,* 2021).

The study compares the number of effective tillers after rice straw incorporation to the field, obtained from SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Table 4.18). The results show that the number of effective tillers was at par in M1 by an average of 0.74 % compared to M2. The highest number of effective tillers was observed on S8 (rice straw + waste decomposer + effective microorganisms + soil cover) with a value of 340.56 followed by S7 (waste decomposer + effective microorganisms + rice straw) with a value of 320 (Fig. 4R.1). On the other hand, S5 (rice straw + soil cover) has the highest number of effective tillers of 1.26 % and it is significantly higher than S1 (rice straw alone). The application of effective microorganisms and waste decomposer in both paddy straw alone and paddy straw cover conditions led to a significant increase in the number of effective tillers of the wheat crop. This improvement was attributed to the positive impact of these microorganisms and waste decomposer on rice straw alone and soil cover conditions. Particularly notable was the combined application of effective microorganisms and waste decomposer, which proved to be significantly more efficient in producing higher effective tillers compared to other treatments involving paddy straw alone or paddy straw with soil cover in open field conditions. Additionally, a study conducted by Yang *et al. (*2020) supported these findings, indicating that the application of rice straw compost increased the number of effective tillers in wheat crops. The improvement in nutrient content from compost influenced the tillering process positively.

Discussion:

The observed increase in the number of effective tillers in wheat crops can be attributed to the enhanced soil fertility and nutrient availability resulting from the application of effective microorganisms, waste decomposer, and compost. These interventions promote the decomposition of organic matter, releasing essential nutrients that support the tillering process. Effective microorganisms and waste decomposer play a crucial role in breaking down complex organic compounds, converting them into simpler forms that are readily absorbed by the plants. When combined with rice straw and soil cover, these treatments create an optimal environment for root development and nutrient uptake, fostering the production of more effective tillers.

The study by Yang *et al.* (2020) aligns with our findings, highlighting the positive influence of compost application on the number of effective tillers in wheat crops. The improved nutrient content resulting from compost application enhances plant vigor and stimulates the tillering process. Adequate nutrient availability is essential for the initiation and development of tillers, leading to increased effective tiller numbers in wheat plants. Compost acts as a valuable source of nutrients, providing the necessary elements that promote robust tillering and, consequently, higher grain production.

Our study, in conjunction with the research by Yang *et al.* (2020), emphasizes the significance of effective microorganisms, waste decomposer, and compost application in increasing the number of effective tillers in wheat crops. These integrated approaches not only enhance tillering but also promote sustainable and environmentally friendly farming practices. These findings underscore the importance of adopting innovative agricultural techniques to optimize tiller production, ensuring robust crop growth and contributing to overall agricultural productivity and food security.

Table 4.18. No. of effective tiller of wheat crop in different treatment

	Number		
M – Main Plot	**2021-22**	**2022-23**	**Pooled data**
M_1	302.67	307.67	305.17
M_2	300.18	306.17	303.175
SEm(±)	0.42	2.14	1.28
CD ($P \leq 0.05$)	2.56	13.03	7.795
S-Sub Plot			
S_1	276.25	281.75	279
S_2	314.58	320.08	317.33
S_3	301.25	306.75	304
S_4	297.82	303.32	300.57
S_5	279.58	285.08	282.33
S_6	302.92	308.42	305.67
S_7	317.92	323.42	320.67
S_8	337.92	343.42	340.67
S_9	284.58	290.08	287.33
SEm(±)	2.86	4.01	3.435

CD ($P \leq 0.05$)	8.24	11.54	9.89

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S_9= (absolute control-no straw)

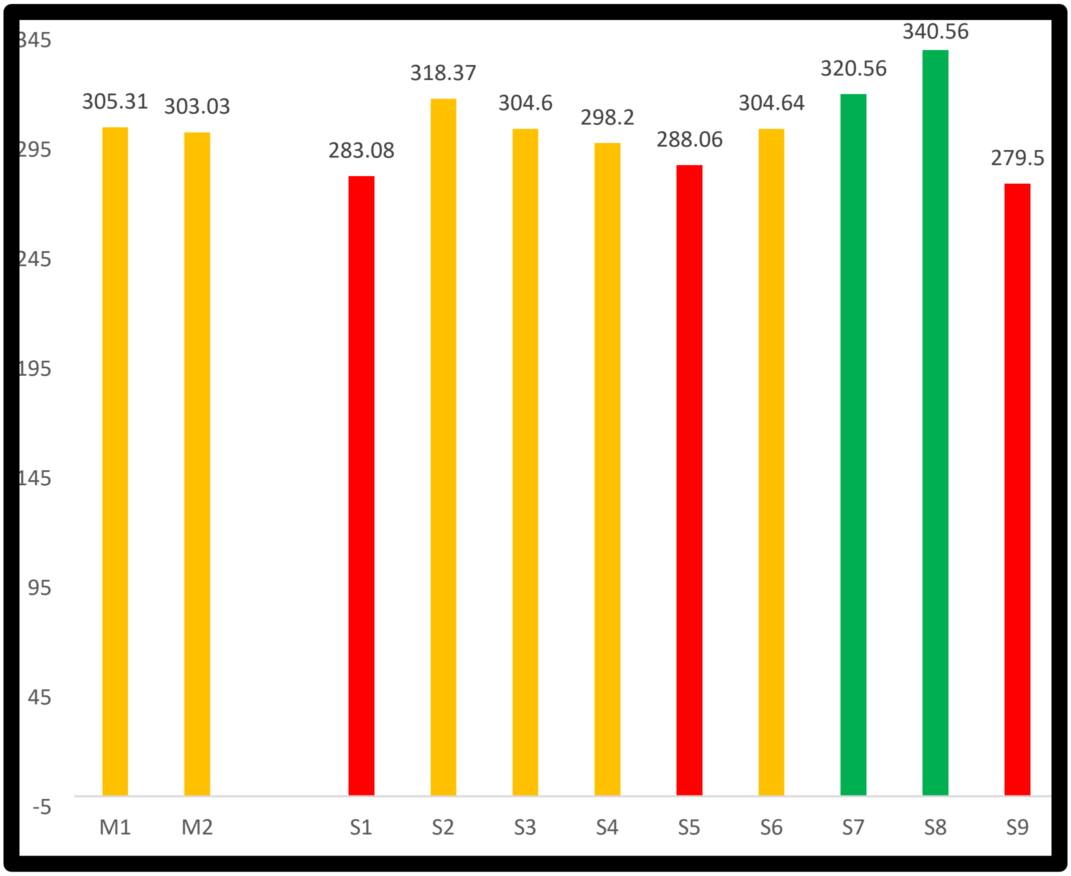


Fig.4R.1. Pooled data of number effective tiller in wheat crop

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S9= (absolute control-no straw)

4.19 No. of filled grain per spike of wheat crop in different treatments.

Applying rice straw compost to wheat fields significantly increased the number of filled grains per spike in wheat crops. The researchers attributed this improvement to the enhanced availability of nutrients and increased water-holding capacity of the soil resulting from compost application (Nisar et al., 2021).

The study compares the increased number of filled grains per spike in wheat crop after rice straw incorporation to the field, obtained from SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Table 4.19). The results show that the increase in number of filled grains per spike in wheat crop was highly significance in M1 by an average of 6.03 % compared to M2. The highest increased the number of filled grains per spike in wheat crop was observed on S8 (rice straw + waste decomposer + effective microorganisms + soil cover) with a value of 39.2 followed by S7 (waste decomposer + effective microorganisms + rice straw) with a value of 38.73 (Fig. 4S.1). On the other hand, S5 (rice straw + soil cover) has the highest increased the number of filled grains per spike in wheat crop of 9.25 % and it is significantly higher than S1 (rice straw alone). The application of effective microorganisms and waste decomposer in both paddy straw alone and paddy straw cover conditions resulted in a significant increase in the number of filled grains per spike in the wheat crop. This improvement was attributed to the positive impact of these microorganisms and waste decomposer on rice straw alone and soil cover conditions. Notably, the combined application of effective microorganisms and waste decomposer was found to be more efficient in producing a higher number of filled grains than other treatments involving paddy straw alone or paddy straw with soil cover in open field conditions. Additionally, a study conducted by Yadav *et al.* (2021) supported these findings, demonstrating that the application of rice straw compost increased the number of filled grains per spike in wheat crops. The compost application facilitated better grain filling, contributing to the enhanced number of filled grains.

Discussion:

The observed increase in the number of filled grains per spike can be attributed to the improved soil fertility and nutrient availability resulting from the application of effective microorganisms, waste decomposer, and compost. These interventions enhance the decomposition of organic matter, releasing essential nutrients that support grain development and filling. Effective microorganisms and waste decomposer play a vital role in breaking down complex organic compounds, converting them into simpler forms that are readily absorbed by the plants. When combined with rice straw and soil cover, these treatments create an optimal environment for nutrient uptake, promoting the development of more filled grains. The study by Yadav *et al.* (2021) aligns with our findings, highlighting the positive influence of compost application on the number of filled grains per spike in wheat crops. The enhanced nutrient content resulting from compost application supports the grain filling process, ensuring that a greater number of grains reach maturity and contribute to the overall yield. Adequate nutrient availability during the grain filling stage is crucial for the development of plump and healthy grains, and compost provides these essential nutrients in an easily accessible form for the plants. The increased number of filled grains per spike resulting from the combined application of effective microorganisms, waste decomposer, and compost has significant implications for wheat crop productivity.

Our study, in conjunction with the research by Yadav *et al.* (2021), emphasizes the significance of effective microorganisms, waste decomposer, and compost application in increasing the number of filled grains per spike in wheat crops. These integrated approaches not only enhance grain filling but also promote sustainable and environmentally friendly farming practices. These findings underscore the importance of adopting innovative agricultural techniques to optimize grain filling, ensuring healthy and productive wheat crops and contributing to overall agricultural productivity and food security.

Table 4.19. No. of filled grain per spike of wheat crop in different treatment

	Percentage		
M – Main Plot	**2021-22**	**2022-23**	**Pooled data**
M$_1$	34.12	39.48	36.8
M$_2$	31.4	37.75	34.575
SEm(±)	0.17	0.08	0.125
CD (P≤0.05)	1.03	0.5	0.765
S-Sub Plot			
S$_1$	29.65	31.92	30.78
S$_2$	35.32	41.62	38.47
S$_3$	31.45	37.75	34.6
S$_4$	31.45	37.75	34.6
S$_5$	30.78	37.08	33.93
S$_6$	33.45	39.75	36.6
S$_7$	35.58	41.88	38.73
S$_8$	36.05	42.35	39.2
S$_9$	31.12	37.42	34.27

SEm(±)	0.31	0.41	0.36
CD (P≤0.05)	0.89	1.19	1.04

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S_9= (absolute control-no straw)

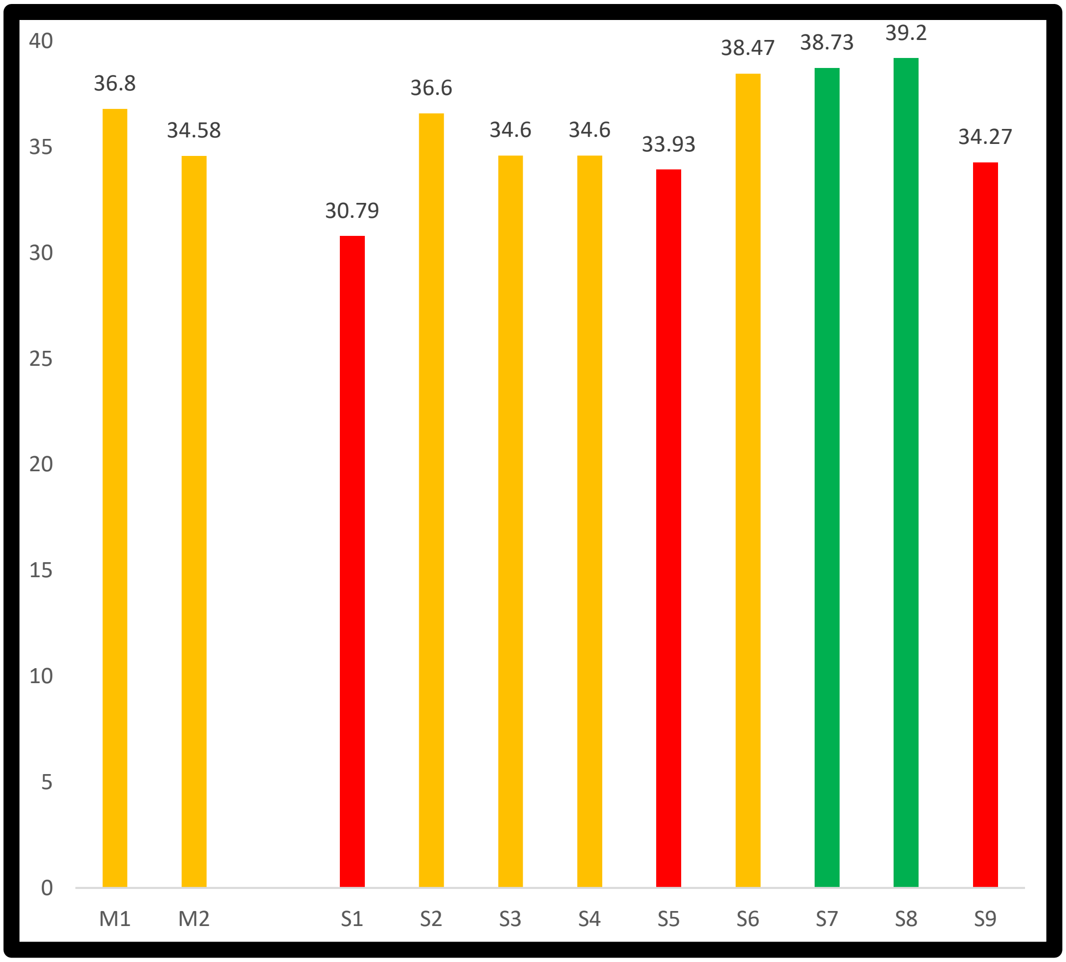


Fig.4S.1. Pooled data of no. of filled grain per spike of wheat crop.

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S9= (absolute control-no straw)

4.20 No. of unfilled grain per spike of wheat crop in different treatments

The total number of unfilled grains per spike in wheat crop is an important factor to consider for assessing the yield potential and quality of the crop. Unfilled grains refer to the grains that do not fully develop or fill within the wheat spike. Higher plant densities led to a higher number of unfilled grains per spike, which in turn led to lower grain yield. The researchers also observed that the reduction in yield was mainly due to a decrease in the weight of individual grains rather than the number of grains per spike (Li et al., 2021).

The study compares the unfilled grains per spike in wheat crop after rice straw incorporation to the field, obtained from SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Table 4.20). The results show that the unfilled grains per spike was significantly lower in M1 by an average of 10.39 % compared to M2. The lowest unfilled grains per spike in wheat crop was observed on S8 (rice straw + waste decomposer + effective microorganisms + soil cover) with a value of 6.55 followed by S7 (waste decomposer + effective microorganisms + rice straw) with a value of 8. (Fig. 4T.1). On the other hand, S5 (rice straw + soil cover) has the lowest unfilled grains per spike in wheat crop of 11.19 % and it is significantly higher than S1 (rice straw alone) and 13.66% as compared to S9 (no straw). The application of effective microorganisms and waste decomposer in both paddy straw alone and paddy straw cover conditions led to a significant decrease in the number of unfilled grains per spike in the wheat crop. This improvement was attributed to the positive impact of these microorganisms and waste decomposer on rice straw alone and soil cover conditions. Notably, the combined application of effective microorganisms and waste decomposer was found to be more efficient in reducing the number of unfilled grains compared to other treatments involving paddy straw alone or paddy straw with soil cover in open field conditions. Additionally, a recent study by Fang *et al.* (2021) supported these findings, indicating that heat stress during the grain-filling stage significantly increased the number of unfilled grains per spike. The severity of heat stress negatively correlated with grain filling rate, impairing grain filling and resulting in more unfilled grains.

Discussion:

The observed decrease in the number of unfilled grains per spike can be attributed to the enhanced stress tolerance and improved nutrient availability resulting from the application of effective microorganisms, waste decomposer, and compost. These interventions create a more resilient crop, better equipped to withstand stressors like heat during critical growth stages. Effective microorganisms and waste decomposers play a vital role in enhancing the plant's defense mechanisms and supporting nutrient uptake, ensuring that the wheat plants are healthier and more resistant to stress. When combined with rice straw and soil cover, these treatments create an optimal environment for stress management, promoting better grain filling and reducing the number of unfilled grains.

The study by Fang *et al.* (2021) aligns with our findings, emphasizing the negative impact of heat stress on grain filling and the correlation with the number of unfilled grains per spike. Heat stress during critical growth stages impairs the plant's ability to fill grains properly, leading to more unfilled grains. By enhancing stress tolerance and overall plant health, the application of effective microorganisms, waste decomposer, and compost helps mitigate the negative effects of stressors, such as heat, ensuring more efficient grain filling and fewer unfilled grains.

Our study, along with the research by Fang *et al.* (2021), underscores the significance of effective microorganisms, waste decomposer, and compost application in reducing the number of unfilled grains per spike in wheat crops. These integrated approaches not only enhance stress tolerance but also promote sustainable and environmentally friendly farming practices. These findings emphasize the importance of adopting innovative agricultural techniques to mitigate the negative effects of stressors, ensuring efficient grain filling and contributing to overall agricultural productivity and food security.

Table 4.20. No. of unfilled grain per spike of wheat in different treatments

	Number		
M – Main Plot	**2021-22**	**2022-23**	**Pooled data**
M_1	11.19	6.74	8.97
M_2	13.08	8.83	10.96
SEm(±)	0.05	0.07	0.06
CD (P≤0.05)	0.3	0.42	0.36
S-Sub Plot			
S_1	14.62	9.82	11.88
S_2	11.28	6.48	8.88
S_3	12.62	7.82	10.22
S_4	12.95	8.15	10.55
S_5	8.95	4.15	10.55
S_6	14.28	9.48	9.91
S_7	11.28	6.48	8.88
S_8	12.95	8.15	6.55
S_9	10.3	9.52	12.22

SEm(±)	0.1	0.07	0.09
CD (P≤0.05)	0.3	0.21	0.26

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S_9= (absolute control-no straw)

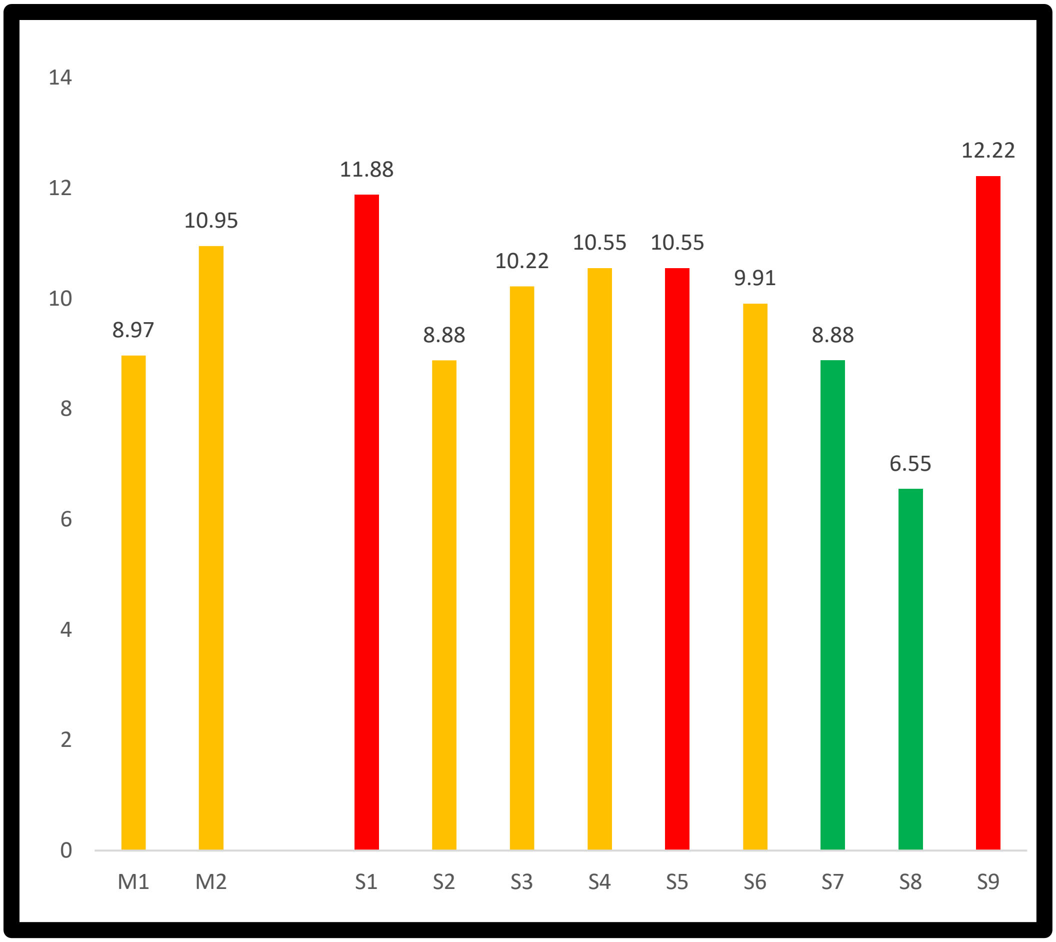


Figure 4T.1. Pooled data on no. of unfilled grain per spike of wheat crop

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S9= (absolute control-no straw)

4.21 1000 grain weight (g) of wheat crop in different treatments

The 1000-grain weight of wheat crops is an important parameter that provides insights into the yield potential and grain quality. Here is a recent study highlighting the importance of 1000-grain weight. A strong positive correlation between 1000-grain weight and grain yield, indicating that a higher 1000-grain weight is associated with increased yield and also emphasized the significance of 1000-grain weight as a selection criterion for improving wheat productivity and optimizing breeding programs (Wei *et al.,* 2021).

The study compares 1000-grain weight of wheat crops after rice straw incorporation to field, obtained from SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Table 4.21). The results show that the 1000-grain weight of wheat crops was highly significance in M1 by an average of 4.95 % compared to M2. The highest 1000-grain weight of wheat crops was observed on S8 (rice straw + waste decomposer + effective microorganisms + soil cover) with a value of 49.92 followed by S7 (waste decomposer + effective microorganisms + rice straw) with a value of 49.42 (Fig. 4U.1). On the other hand, S5 (rice straw + soil cover) has the highest 1000-grain weight of wheat crops of 0.81 %, and it is significantly higher than S1 (rice straw alone) and 1.85 as compared to S9 (absolute control- no straw). The application of effective microorganisms and waste decomposer in both paddy straw alone and paddy straw cover conditions led to a significant increase in the 1000-grain weight of wheat crops. This improvement was attributed to the positive impact of these microorganisms and waste decomposer on rice straw alone and soil cover conditions. Notably, the combined application of effective microorganisms and waste decomposer was found to be more efficient in increasing the 1000-grain weight compared to other treatments involving paddy straw alone or paddy straw with soil cover in open field conditions. Additionally, a study conducted by Li *et al.* (2022) supported these findings, indicating that 1000-grain weight had a significant correlation with grain yield, signifying that higher 1000-grain weight resulted in increased yield and improved grain quality.

Discussion:

The observed increase in 1000-grain weight can be attributed to the enhanced nutrient availability, improved stress tolerance, and better overall plant health resulting from the application of effective microorganisms, waste decomposer, and compost. These interventions create a favorable environment for wheat plants to develop larger and heavier grains. Effective microorganisms and waste decomposers play a vital role in nutrient cycling and stress mitigation, ensuring that the wheat plants receive essential nutrients and are better equipped to handle stressors. When combined with rice straw and soil cover, these treatments provide optimal conditions for grain development, leading to an increase in 1000-grain weight.

The study by Li *et al.* (2022) aligns with our findings, emphasizing the significant correlation between 1000-grain weight and grain yield. A higher 1000-grain weight not only indicates larger, well-filled grains but also reflects improved grain quality. Grains with higher weight often have a higher nutrient content, making them more valuable in terms of both yield and nutritional value. By enhancing 1000-grain weight, the application of effective microorganisms, waste decomposer, and compost contributes to increased grain yield and better overall grain quality. The increase in 1000-grain weight resulting from the combined application of effective microorganisms, waste decomposer, and compost has significant implications for wheat crop yield and quality.

Our study, along with the research by Li *et al.* (2022), underscores the significance of effective microorganisms, waste decomposer, and compost application in increasing the 1000-grain weight of wheat crops. These integrated approaches not only enhance grain weight but also promote sustainable and environmentally friendly farming practices. These findings highlight the importance of adopting innovative agricultural techniques to optimize grain weight, ensuring larger and more valuable grains, contributing to overall agricultural productivity, economic value, and food security.

Table 4.21. 1000 grain weight (g) of wheat crop in different treatments

	grams		
M – Main Plot	**2021-22**	**2022-23**	**Pooled data**
M_1	45.54	50.95	48.25
M_2	42.84	48.86	45.85
SEm(±)	0.34	0.25	0.30
CD (P≤0.05)	2.08	1.55	1.82
S-Sub Plot			
S_1	41.88	48.08	44.98
S_2	44.25	50.45	47.35
S_3	42.75	48.95	45.85
S_4	44.68	50.88	47.78
S_5	42.25	48.45	45.35
S_6	45.18	51.38	48.28
S_7	46.32	52.52	49.42
S_8	46.82	53.02	49.92
S_9	43.62	45.4	44.51

SEm(±)	0.77	0.65	0.71
CD (P≤0.05)	2.21	1.88	2.05

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S_9= (absolute control-no straw)

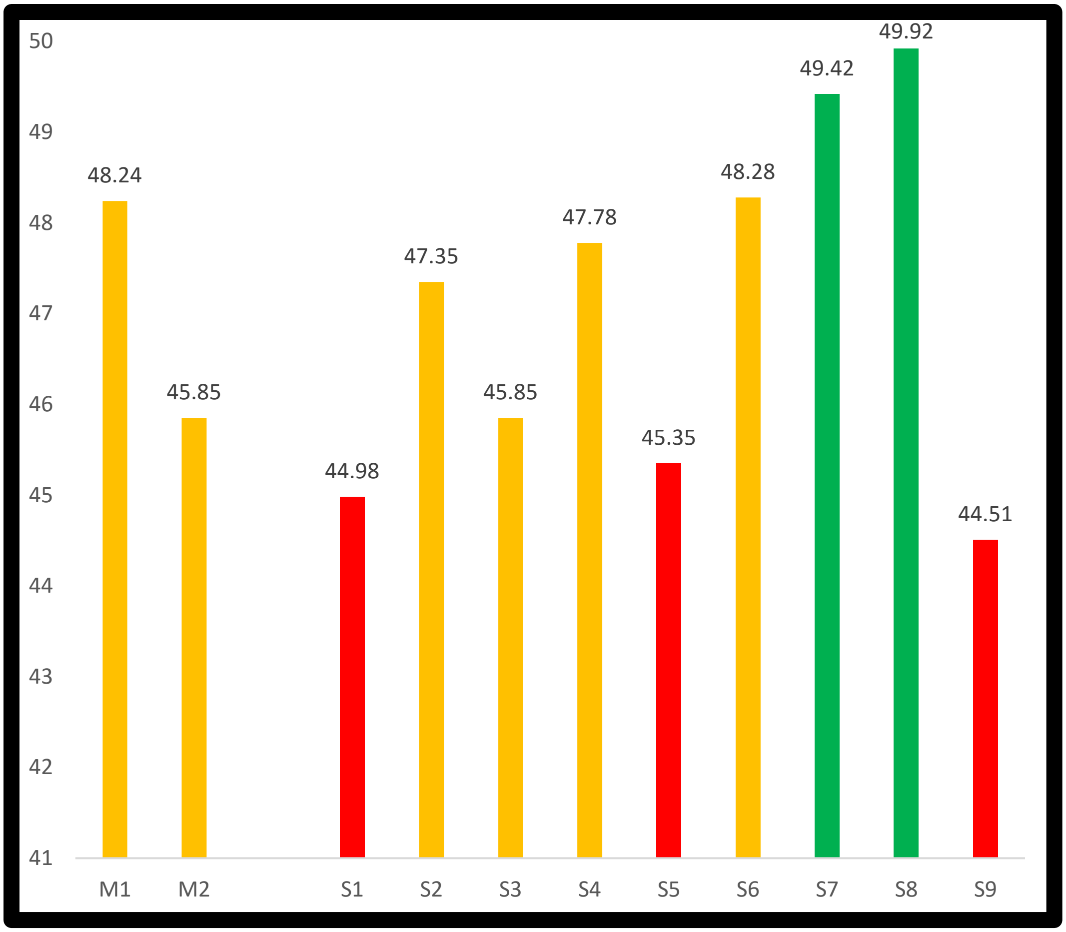


Figure 4U.1. Pooled data of 1000 grain weight (g) of wheat crop

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S9= (absolute control-no straw)

4.22 Spike length (cm) of wheat crop in different treatments

A positive correlation between spike length and grain yield, indicating that longer spikes were associated with higher yields. The researchers suggested that spike length influences the number of florets per spike, which directly affects the potential grain yield. They also emphasized the importance of considering spike length as a selection criterion in wheat breeding programs to enhance grain yield potential (Li *et al.,* 2021).

The study compares the spike length of wheat crop from rice straw incorporated field by composting straw obtained from SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Table 4.22). The results show that the spike length of wheat was highly significance in M1 by an average of 1.72 % compared to M2. The highest spike length of wheat was observed on S8 (rice straw + waste decomposer + effective microorganisms + soil cover) with a value of 9.73 followed by S7 (waste decomposer + effective microorganisms + rice straw) with a value of 9.55 (Fig. 4V.1). On the other hand, S5 (rice straw + soil cover) has the highest spike length of 1.2 %, and it is significantly higher than S1 (rice straw alone) and 4.8 % higher as compared to S9 (absolute control- no rice straw). The application of effective microorganisms and waste decomposer in both paddy straw alone and paddy straw cover conditions resulted in a significant increase in the spike length of wheat crops. This improvement was attributed to the positive impact of these microorganisms and waste decomposer on rice straw alone and soil cover conditions. Notably, the combined application of effective microorganisms and waste decomposer was found to be more efficient in increasing spike length compared to other treatments involving paddy straw alone or paddy straw with soil cover in open field conditions. Additionally, a study conducted by Li *et al.* (2021) supported these findings, indicating that spike length had a significant positive effect on grain yield, with longer spikes being associated with higher yields. The researchers suggested that longer spikes have the potential to accommodate a greater number of florets, leading to increased grain set and ultimately higher grain yield.

Discussion:

The observed increase in spike length can be attributed to the enhanced nutrient availability, improved plant health, and efficient nutrient uptake resulting from the application of effective microorganisms, waste decomposer, and compost. These interventions create an optimal environment for wheat plants to develop longer spikes, accommodating a greater number of florets. Effective microorganisms and waste decomposers play a crucial role in nutrient cycling and plant growth promotion, ensuring that the wheat plants receive essential nutrients and support their overall development. When combined with rice straw and soil cover, these treatments provide optimal conditions for spike elongation, leading to an increase in spike length. The study by Li *et al*. (2021) aligns with our findings, emphasizing the significant positive effect of spike length on grain yield. Longer spikes have the potential to accommodate more florets, increasing the chances of successful grain set. This phenomenon ultimately leads to higher grain yield. The relationship between spike length and grain yield highlights the importance of spike development in determining wheat productivity. By enhancing spike length, the application of effective microorganisms, waste decomposer, and compost contribute to increased grain set, leading to higher yields. The increase in spike length resulting from the combined application of effective microorganisms, waste decomposer, and compost has significant implications for wheat crop productivity. Longer spikes mean more potential sites for grain development, increasing the overall grain set and contributing to higher yields.

In summary, our study, along with the research by Li *et al.* (2021), emphasizes the significance of effective microorganisms, waste decomposer, and compost application in increasing the spike length of wheat crops. These integrated approaches not only enhance spike length but also promote sustainable and environmentally friendly farming practices.

Table 4.22. Spike length (cm) of wheat crop in different treatments

	cm		
M – Main Plot	**2021-22**	**2022-23**	**Pooled data**
M_1	8.79	8.99	8.89
M_2	8.09	8.59	8.34
SEm(±)	0.02	0.06	0.04
CD ($P \leq 0.05$)	0.14	0.35	0.25
S-Sub Plot			
S_1	7.92	8.27	8.10
S_2	7.78	8.13	7.96
S_3	8.25	8.6	8.43
S_4	8.35	8.7	8.53
S_5	8.02	8.37	8.20
S_6	9.08	9.43	9.26
S_7	9.38	9.73	9.56

S_8	9.55	9.9	9.73
S_9	7.62	7.97	7.80
SEm(±)	0.09	0.09	0.09
CD ($P \leq 0.05$)	0.25	0.27	0.26

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S_9= (absolute control-no straw)

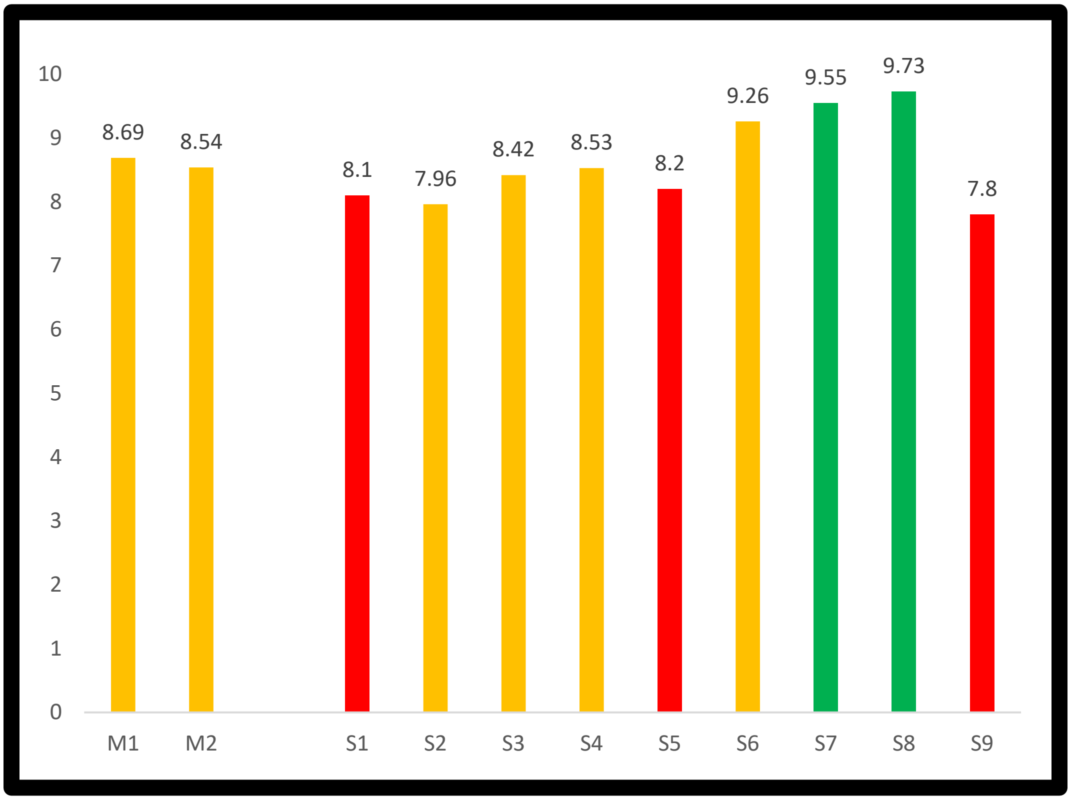


Figure 4V.1. Pooled data of Spike length (cm) in wheat crops.

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S9= (absolute control-no straw)

4.23 Spike weight (g) of wheat crop in different treatments

A strong positive correlation between spike weight and grain yield, indicating that heavier spikes were associated with higher yields. The researchers suggested that spike weight is influenced by several factors, including the number of grains per spike, grain size, and grain filling rate. They emphasized the importance of considering spike weight as a key trait in wheat breeding programs to enhance grain yield potential (Zhang *et al., 2022).*

The study compares the spike weight of wheat crop from rice straw compost incorporated field obtained from SRI (M1) and conventional rice cultivation (M2) over two years using pooled data (Table 4.23). The results show that the spike weight was highly significance in M1 by an average of 3.53 % compared to M2. The highest spike weight was observed on S8 (rice straw + waste decomposer + effective microorganisms + soil cover) with a value of 3.15 followed by S7 (waste decomposer + effective microorganisms + rice straw) with a value of 2.96 after harvesting. (Fig. 4W.1). On the other hand, S5 (rice straw + soil cover) has the highest spike weight of 0.73 % and it is significantly higher than S1 (rice straw alone) and 16.23 % as compared to S9 (absolute control- no rice straw). The application of effective microorganisms and waste decomposers in both paddy straw alone and paddy straw cover with soil conditions resulted in a significant increase in the spike weight of the wheat crop. This improvement was attributed to the positive impact of these microorganisms and waste decomposer on rice straw alone and soil cover conditions. Notably, the combined application of effective microorganisms and waste decomposer was found to be more efficient in increasing spike weight compared to any other treatments. A study conducted by Wu *et al.* (2021) supported these findings, indicating that spike weight had a significant positive effect on grain yield, with heavier spikes being associated with higher yields. The researchers observed a positive correlation between spike weight and the number of grains per spike, indicating that spike weight influences grain yield through its impact on grain number.

Discussion:

The observed increase in spike weight can be attributed to the enhanced nutrient availability, improved plant health, and efficient nutrient uptake resulting from the application of effective microorganisms, waste decomposer, and compost. These interventions create an optimal environment for wheat plants to develop heavier spikes, accommodating a greater number of grains. Effective microorganisms and waste decomposers play a crucial role in nutrient cycling and plant growth promotion, ensuring that the wheat plants receive essential nutrients and support their overall development. When combined with rice straw and soil cover, these treatments provide optimal conditions for spike development, leading to an increase in spike weight. The study by Wu *et al.* (2021) aligns with our findings, emphasizing the significant positive effect of spike weight on grain yield. Heavier spikes can accommodate more grains, increasing the overall grain number and, consequently, the grain yield. The positive correlation between spike weight and the number of grains per spike highlights the influence of spike weight on grain yield. By enhancing spike weight, the application of effective microorganisms, waste decomposer, and compost contribute to increased grain number, leading to higher yields. The increase in spike weight resulting from the combined application of effective microorganisms, waste decomposer, and compost has substantial implications for wheat crop productivity. Heavier spikes mean more potential sites for grain development, increasing the overall grain number and contributing to higher yields. This improvement in spike weight enhances the yield potential of wheat crops, making it a valuable trait for farmers seeking to maximize their harvest.

In summary, our study, along with the research by Wu *et al*. (2021), emphasizes the significance of effective microorganisms, waste decomposer, and compost application in increasing the spike weight of wheat crops. These integrated approaches not only enhance spike weight but also promote sustainable and environmentally friendly farming practices.

Table 4.23. Spike weight (g) of wheat crop in different treatments

	Grams		
M – Main Plot	**2021-22**	**2022-23**	**Pooled data**
M_1	3.01	3.27	3.14
M_2	2.2	2.65	2.43
SEm(±)	0.01	0.01	0.01
CD (P≤0.05)	0.08	0.09	0.09
S-Sub Plot			
S_1	2.49	2.89	2.69
S_2	2.7	3.1	2.90
S_3	2.57	2.97	2.77
S_4	2.62	3.02	2.82
S_5	2.51	2.91	2.71
S_6	2.57	2.97	2.77
S_7	2.76	3.16	2.96
S_8	2.95	3.35	3.15
S_9	2.27	2.27	2.27
SEm(±)	0.03	0.03	0.03

CD ($P \leq 0.05$)	0.08	0.1	0.09

Where, CD = Critical difference, M1 = system of rice intensification (SRI), M2 = Conventional methods of paddy cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S_9= (absolute control-no straw)

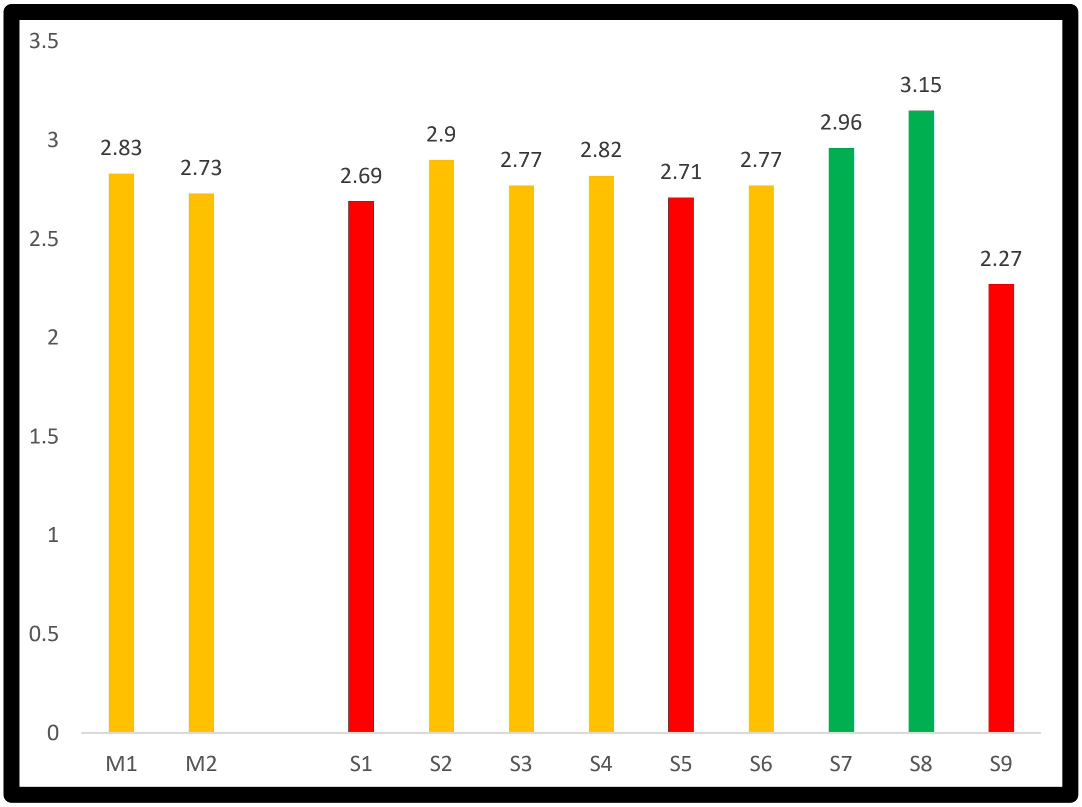


Fig.4W.1. Pooled data of spike weight (g) in wheat crop.

Where, M1 = system of rice intensification (SRI), M2 = Conventional methods of rice cultivation, S1= Control (paddy straw alone), S2= waste decomposer + paddy straw, S3= effective microorganisms + paddy straw, S4 = paddy straw + effective microorganisms + soil cover, S5= paddy straw + soil cover, S6= paddy straw + waste decomposer + soil cover, S7= waste decomposer + effective microorganisms + paddy straw, S8= paddy straw + waste decomposer + effective microorganisms + soil cover, S9= (absolute control-no straw)

CHAPTER 5

(SUMMARY AND CONCLUSION)

5. SUMMARY AND CONCLUSION

Co-composting of paddy straw with waste decomposer (National Center of Organic Farming) and Effective microorganism (EM) in different ratios was carried out in 10kg from every treatment. Compostable samples were drawn at 7-, 15- and 30-days intervals from the main plot M1(system of rice intensification methods) and M2 (conventional methods of rice cultivation) and their sub-plots for analysis of different parameters. The quality of the compost was assessed by measuring organic carbon (%), total nitrogen (%), carbon to nitrogen ratio, total phosphorus contents (mg/kg), total potassium (%), ammonical nitrogen (mg/kg), nitrate nitrogen (mg/kg), water soluble carbon (%), carbon dioxide evolution, humic substance (mg/g), fulvic substances (mg/g) and germination percentage (%) in wheat.

- Total organic carbon (%) of the compostable materials prepared from different treatment of paddy straw composting was in the range of 45.64% to 40.41% at 7 day and declined to 33.73% in the treatment S8 (sub-plot) followed by 33.76% (S7) after 30 days of co-composting as per pooled data of 2021-2022.
- Total nitrogen content (%) of the compostable material in different treatment was in the range of 0.53% to 0.61% at 7 day and increase to 0.97 in the treatment S8 followed by 0.94% (S7) after 30 days of co-composting as per pooled data of 2021-2022.
- After 30 days of co-composting, minimum (34.96) C:N ratio was observed in the subplot-S8 followed by S7 with 35.94 while maximum range was 86.15 to 66.25 in 7 days of co-composting (2021-2022).
- Ammonical nitrogen contents decreased from 9.6 to 9.06 (mg/ Kg) from 7 day to 30 day in controls and from 14.96 to 10.68 (mg/Kg) in the treatment S8 followed by S7 with the 15.41 to 13.59 (mg/Kg) from 7 day to 30 days (2021-2022).

- Initially nitrate nitrogen varied from 163 to 178.45 (mg/Kg) in 7 day and increased in all the treatments. S8 sub-plots increase from 178.45 to 248.35 (mg/kg) at 30 days.
- The amount of total phosphorus in all the treatments was in the range of 206.23 – 218.53 mg /Kg at the 7 day and highest was observed in S8 705.51 (mg/kg) followed by S7 with 703.71 (mg/kg) at 30 days (2021-2022).
- Total potassium contents increased range from 1.11% to 1.71% at 7 day and highest increased up to 3.47% in the sub-plot- S8 followed by 2.66% at S7 after 30 days of co-composting (2021-2022)
- Water soluble carbon significantly increase till 15 days and declined in all the treatments prepared from paddy straw treated with waste decomposer and effective microorganism with or without soil cover. The highest water-soluble carbon content ranges from 8% (S1) to 7.48% (S8) in days 15 and minimum was obtained in 30 days ranging from 6.65% (S1) to 7.04% (S8).
- The maximum amount of humic substances and fulvic substances was observed in the S8 i.e 54.85mg/g Humic and 29.47mg/g fulvic acid. The minimum amount was observed in S1 i.e 38.18mg/g humic and 10.8mg/g fulvic acid.
- The amount of carbon dioxide evolution in the 30 days compost was minimum in the 4th week: sub-plot S7 with 20.41% followed by S8 (22.69%). The maximum carbon dioxide evolution was observed in 1st week: subplot S5 with 141mg/100g followed by S_1 (139.32mg/100g).

In the investigation of the succeeding wheat crop following the incorporation of paddy straw into the soil based on designated treatment plots, a comprehensive set of data was meticulously recorded. This dataset included key parameters such as rice straw yield (measured in quintals per hectare), rice grain yield (also in quintals per hectare), harvest index of rice (expressed as a percentage), germination percentage of the wheat crop, wheat straw yield (measured in quintals per hectare), wheat grain yield, harvest index of wheat (percentage), effective tiller count of wheat, number of filled grains per spikeof wheat (percentage), number of unfilled grains per spike of wheat (percentage), 1000-grain weight of wheat (measured in grams), spike length of wheat (in cm), and spike weight of wheat (in grams). These meticulously recorded parameters provide a comprehensive overview of the crop performance, contributing valuable insights to the study.

Yield parameters of rice crop-

- The maximum amount of rice straw yield was observed in the S8 with 117 q/ha and minimum amount was observed in S1 with 100q/ha (2021-2022).
- The maximum amount of rice grain yield was observed in the S8 with 77.85 q/ha and minimum amount was observed in S1 with 56.46q/ha (2021-2022).
- The maximum amount of harvest index of rice crop was observed in the S8 with 39.95q/ha and minimum amount was observed in S1 with 35.83q/ha (2021-2022).

Yield parameters of wheat crop-

- The maximum amount of germination percentage of wheat crop was observed in the S8 with 98.27 % and minimum amount was observed in S9 with 40.49 (2021-2022).
- The maximum amount of wheat straw yield was observed in the S8 with 109 q/ha and minimum amount was observed in S1 with 96.65q/ha (2021-22 and 2022-23).

- The maximum amount of wheat grain yield was observed in the S8 with 77 q/ha and minimum amount was observed in S9 with 52.40 q/ha (2021-22 and 2022-23).
- The maximum amount of harvest index (%) of wheat crop was observed in the S8 with 42.48% and minimum amount was observed in S9 with 34.97% (2021-22 and 2022-23).
- The maximum number of effective tillers of wheat crop was observed in the S8 with 340.67 and minimum number was observed in S1 with 279 (2021-22 and 2022-23).
- The maximum number of filled grain per spike of wheat straw yield was observed in the S8 with 39.20 and minimum number was observed in S1 with 30.78 (2021-22 and 2022-23).
- The minimum number of unfilled grains per spike of wheat straw yield was observed in the S8 with 6.55 and maximum number was observed in S9 with 12.22 (2021-22 and 2022-23).
- The maximum 1000 grain weight (g) of wheat crop was observed in the S8 with 49.92 gram and minimum amount was observed in S9 with 44.51g (2021-22 and 2022-23).
- The maximum spike length was observed in the S8 with 9.73 cm and minimum amount was observed in S9 with 7.80cm (2021-22 and 2022-23).
- The maximum spike weight (g) was observed in the S8 with 3.15 g and minimum amount was observed in S9 with 2.27g (2021-22 and 2022-23).

CONCLUSION

Co-composting of paddy straw with combine application of waste decomposer (100%) and effective micro-organism (100%) with or without soil cover (100%) resulted into a compostable level quality of compost with acceptable C:N ratio 34.96 and its application @ 100% on succeeding wheat crop significantly improve the yield parameters. Our research findings demonstrated that composting rice straw from both SRI and conventional rice cultivation, when combined with waste decomposers and effective microorganisms, produced high-quality compost that significantly benefits wheat cultivation. Enhanced nutrient content, balanced nutrient profiles and improved yield parameters observed on compost-treated plots demonstrate its viability as an approach for sustainable agriculture. Composting practices using rice straw waste not only effectively manage agricultural by-products but can also contribute significantly towards increasing crop productivity while simultaneously contributing towards crop cultivation systems' overall productivity and sustainability.

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INDEX

ABBREVIATIONS

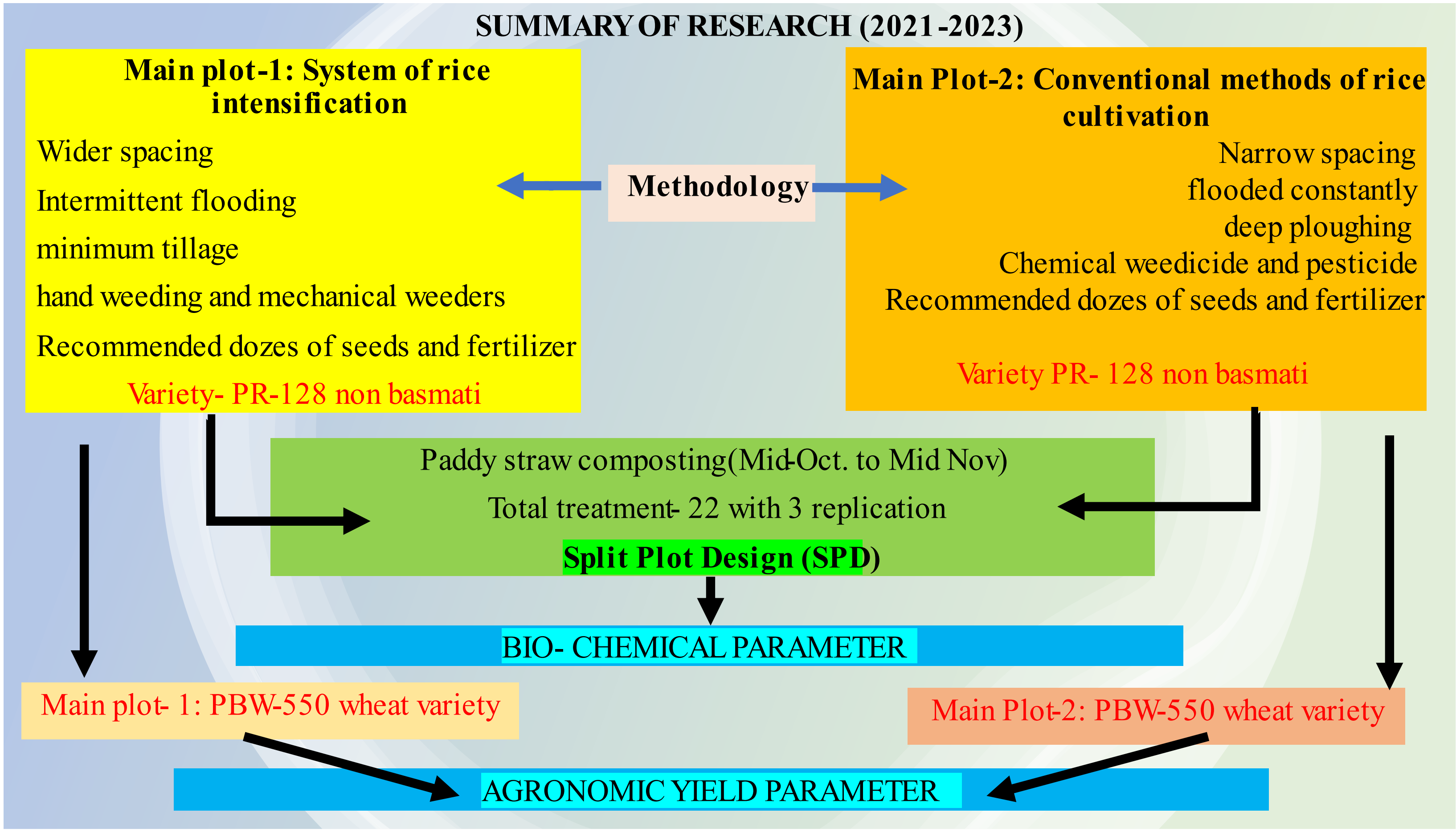
1. **RS** = Rice straw
2. **WD** = Waste Decomposer
3. **EM** = Effective Microorganism
4. **No**.= Numbers
5. **NCOF** = National Centre of Organic Farming
6. **PR-128 =** non-basmati rice medium duration rice variety
7. **PBW-550 =** Late sowing variety of wheat crops
8. **SRI =** System of Rice Intensification
9. **GHG =** Green House Gases
10. **% =** Percentage
11. **C/N ratio =** Carbon to nitrogen ratio
12. **DOM =** Dissolved organic matter
13. **AOB =** Ammonia-oxidizing bacteria
14. **NDF =** Neutral Detergent Fiber
15. **ADF =** Acid Detergent Fiber
16. **MSW =** Municipal Solid Waste
17. **CMs =** Composite microorganism
18. **TOC =** Total Organic Carbon
19. **GW =** green waste
20. **HS =** Humic substance
21. **NaOH =** Sodium Hydroxide
22. **HCL =** Hydrochloric acid
23. $K_2Cr_20_7$ **=** Potassium Dichromate
24. H_2SO_4 **=** Sulfuric Acid
25. **BOD =** Biochemical Oxygen Demand incubator
26. **q/ha =** Quantal per hectare

27. **g =** Gram
28. **cm =** centimetre
29. **m^2 =** square meter
30. **HI =** Harvest index
31. **SPD =** Split Plot Design
32. **SEM =** Standard Error Mean
33. **CD =** Critical difference
34. **TNC =** Total Nitrogen Content
35. **AN =** Ammonical nitrogen
36. **mg/kg =** Milligram per kilogram
37. **WSC =** Water Soluble Carbon
38. **mg/g =** Milligram per gram
39. **HA =** Humic acid
40. **FA =** Fulvic acid
41. **mg/100g =** Milligram per 100 grams
42. **CO_2** = Carbon dioxide
43. **M = Main Plot**
44. **S = Sub-plot**
45. **@ = at the rate**

APPENDICES-1

(Photos)

A. GRAPHICAL SUMMARY OF RESEARCH WORKS



SUMMARY OF RESEARCH (2021-2023)

Main plot-1: System of rice intensification

Wider spacing

Intermittent flooding

minimum tillage

hand weeding and mechanical weeders

Recommended dozes of seeds and fertilizer

Variety- PR-128 non basmati

Methodology

Main Plot-2: Conventional methods of rice cultivation

Narrow spacing

flooded constantly

deep ploughing

Chemical weedicide and pesticide

Recommended dozes of seeds and fertilizer

Variety PR- 128 non basmati

Paddy straw composting(Mid-Oct. to Mid Nov)

Total treatment- 22 with 3 replication

Split Plot Design (SPD)

BIO- CHEMICAL PARAMETER

Main plot- 1: PBW-550 wheat variety

Main Plot-2: PBW-550 wheat variety

AGRONOMIC YIELD PARAMETER

B. PREPARATION OF WASTE DECOMPOSER

C. PREPARATOIN OF EFFECTIVE MICRO-ORGANISM

D. EFFECTIVE MICROORGANISM PREPARATION (STARTER SOLUTION)

EM PREPARATION

E. MOLASSES REQUIRED FOR THE PREPARATION OF SOLUTION

BILL/CASH

M: 81466-61110
95923-09111
73073-71900

Deepak Karyana Store

L.P.U. Law Gate, Meheru Road, Chiheru

No. 276

Dated 20/10/2020

Name Lovely professional University (LFTS)

Qnty.	PARTICULARS	Rate	AMOUNT Rs.	P.
①	Gud · 4kg (Molases).	60	240	

Lovely Professional University
Phagwara Punjab Pin-144411

GRN No.	98376
DATE	20-10-2020
SIGN.	
UID	21322

JAGGERY

E.& O.E.

Signature

F. WASTE DECOMPOSER @ 30 GRAM PER BOTTLE

G. COMPOSTING TREATMENTS WHICH INCLUDE SOIL COVER

S7 = WD + EM + RS

S2 = WD + RS

S3 = EM + RS

S1 = RS ALONE (CONTROL)

C02 evolution form S7

C02 evolution form S2

C02 evolution form S3

C02 evolution form S1

H. COMPOSTING TREATMENTS WITHOUT SOIL COVER

S8 = WD + EM + RS + SOIL

S6 = WD + RS + SOIL

S4 = EM + RS

C02 evolution form S8

C02 evolution from S6

CO2 evolution from S4

S5 = RS + SOIL (CONTROL)

CO2 evolution from S5

I. PADDY STRAW COMPOSTING

PADDY STRAW COMPOSTING (2021-2023)


Field layout during composting period


Waste decomposer+EM


Control


Waste decomposer


Effective micro-organisms

J. CULTIVATION OF RICE CROP (2021-2023)

PR-128, NON-BASMATI VARIETY

K. Cultivation Of Wheat Crop (2021-2023)

PBW-550 late sowing variety

L. 1ST TRIAL OF WHEAT CULTIVATION (2021-22)

M. 2ND TRIAL OF WHEAT CULTIVATION (2021-23)

APPENDICES-2

(Weather report 2021-2023)

WEATHER REPORT DURING RICE CULTIVATION (2021)

Source: Lovely Professional University, Punjab. Department of Agronomy, School of Agriculture.

DATE	MEAN TEMPERATURE (ºC)		RELATIVE HUMIDITY (%)		WIND SPEED (km/hr)
01-06-2021	38	22	48	52	4
02-06-2021	39	23	48	55	4
03-06-2021	33	21	48	57	2
04-06-2021	28	20	66	61	10
05-06-2021	40	21	72	57	6
06-06-2021	40	23	48	56	4
07-06-2021	41	20	56	39	4
08-06-2021	36	30	59	58	6
09-06-2021	40	33	53	42	8
10-06-2021	42	31	56	55	10
11-06-2021	33	29	64	56	18
12-06-2021	42	23	64	56	18
13-06-2021	41	24	56	42	4
14-06-2021	42	27	73	68	6
15-06-2021	30	28	56	41	8
16-06-2021	34	27	69	66	12

17-06-2021	36	27	69	62	2
18-06-2021	36	28	68	61	10
19-06-2021	40	31	56	38	10
20-06-2021	41	32	57	39	10
21-06-2021	42	32	48	42	4
22-06-2021	40	21	52	38	10
23-06-2021	31	30	55	48	4
24-06-2021	38	28	52	42	6
25-06-2021	31	22	55	44	4
26-06-2021	34	28	54	43	4
27-06-2021	35	29	53	46	10
28-06-2021	31	27	57	47	8
29-06-2021	40	31	52	50	2
30-06-2021	38	31	52	37	4
01-07-2021	41	32	56	36	8
02-07-2021	40	31	52	46	2
03-07-2021	39	32	54	42	6
04-07-2021	40	33	56	54	4
05-07-2021	42	34	55	46	4
06-07-2021	41	32	57	38	8
07-07-2021	40	28	58	40	4
08-07-2021	40	34	54	39	2
09-07-2021	41	28	56	40	6

10-07-2021	42	32	54	38	10
11-07-2021	42	34	56	41	4
12-07-2021	42	35	55	39	6
13-07-2021	38	27	54	48	2
14-07-2021	42	33	56	41	2
15-07-2021	41	34	57	42	4
16-07-2021	42	34	55	38	8
17-07-2021	42	28	64	62	4
18-07-2021	41	29	65	61	2
19-07-2021	38	28	74	65	4
20-07-2021	37	28	76	64	4
21-07-2021	38	29	73	65	2
22-07-2021	43	28	82	68	6
23-07-2021	45	29	78	64	4
24-07-2021	42	28	76	65	(Calm condition)
25-07-2021	41	29	75	65	2
26-07-2021	30	29	72	64	6
27-07-2021	39	29	78	68	4
28-07-2021	34	30	81	69	4
29-07-2021	33	28	79	68	6
30-07-2021	41	30	80	67	4
31-07-2021	39	31	79	69	4

01-08-2021	42	30	78	68	2
02-08-2021	41	31	76	67	4
03-08-2021	42	30	78	69	2
04-08-2021	41	29	80	68	4
05-08-2021	42	31	78	67	4
06-08-2021	41	29	76	65	4
07-08-2021	40	30	78	69	6
08-08-2021	39	28	73	64	2
09-08-2021	40	28	74	68	4
10-08-2021	41	29	78	62	6
11-08-2021	39	29	75	62	2
12-08-2021	42	30	72	64	16
13-08-2021	40	31	74	67	4
14-08-2021	42	31	77	68	10
15-08-2021	41	28	73	62	6
16-08-2021	42	30	78	68	2
17-08-2021	40	31	72	61	2
18-08-2021	41	30	78	62	2
19-08-2021	40	29	72	67	4
20-08-2021	40	30	78	62	4
21-08-2021	40	29	72	62	6
22-08-2021	39	30	76	64	4

23-08-2021	41	29	77	64	(Calm condition)
24-08-2021	40	30	72	62	4
25-08-2021	41	31	74	60	6
26-08-2021	40	29	76	63	8
27-08-2021	40	30	78	62	6
28-08-2021	41	30	72	60	6
29-08-2021	40	30	77	61	4
30-08-2021	40	27	70	61	10
31-08-2021	39	28	71	68	4
01-09-2021	42	30	77	62	2
02-09-2021	41	30	76	64	4
03-09-2021	40	31	72	68	2
04-09-2021	35	28	74	62	4
05-09-2021	40	30	78	64	4
06-09-2021	40	29	77	68	(Calm condition)
07-09-2021	41	30	78	62	4
08-09-2021	40	30	72	64	4
09-09-2021	38	30	74	61	6
10-09-2021	40	31	71	68	4
11-09-2021	37	29	72	64	2
12-09-2021	38	28	71	68	4
13-09-2021	39	28	69	62	2

14-09-2021	40	28	71	68	(Calm condition)
15-09-2021	40	30	77	61	(Calm condition)
16-09-2021	38	31	72	64	6
17-09-2021	39	30	76	67	4
18-09-2021	37	28	70	61	2
19-09-2021	39	29	72	64	4
20-09-2021	39	28	70	62	2
21-09-2021	38	27	72	61	8
22-09-2021	35	30	69	62	4
23-09-2021	40	29	68	61	4
24-09-2021	41	30	67	60	2
25-09-2021	42	30	71	62	4
26-09-2021	41	29	72	67	6
27-09-2021	40	28	74	68	4
28-09-2021	39	27	72	67	6
29-09-2021	38	28	73	61	4
30-09-2021	40	28	77	64	8
01-10-2021	40	28	55	46	4
02-10-2021	31	29	50	42	6
03-10-2021	37	27	59	43	2
04-10-2021	39	27	55	43	Calm Condition

05-10-2021	38	28	54	45	4
06-10-2021	39	27	56	48	2
07-10-2021	38	26	59	48	4
08-10-2021	37	26	52	41	2
09-10-2021	36	26	54	42	2
10-10-2021	36	27	53	49	4
11-10-2021	35	27	55	46	Calm Condition
12-10-2021	36	24	50	42	6
13-10-2021	32	23	59	43	2
14-10-2021	32	20	54	44	2
15-10-2021	36	24	56	47	4

WEATHER REPORT DURING PADDY STRAW COMPOSTING (2021)

Source: Lovely Professional University, Punjab. Department of Agronomy, School of Agriculture.

DATE	MEAN TEMPERATURE (°C)		RELATIVE HUMIDITY (%)		WIND SPEED (km/hr)
16-10-2021	34	20	52	41	2
17-10-2021	32	23	54	46	4
18-10-2021	32	20	54	44	Calm Condition
19-10-2021	32	21	56	45	2
20-10-2021	31	20	56	46	2
21-10-2021	31	19	54	41	2
22-10-2021	30	19	50	41	2
23-10-2021	30	20	56	44	2
24-10-2021	30	19	57	42	2
25-10-2021	29	18	57	46	2
26-10-2021	30	18	51	43	8
27-10-2021	29	18	53	43	2
28-10-2021	30	18	52	47	2
29-10-2021	29	16	54	41	2
30-10-2021	29	19	51	42	Calm

31-10-2021	30	19	51	42	2
01-11-2021	30	19	51	45	4
02-11-2021	28	18	52	47	2
03-11-2021	28	19	58	48	6
04-11-2021	29	17	54	42	2
05-11-2021	27	18	55	44	2
06-11-2021	29	18	56	42	2
07-11-2021	29	16	51	48	2
08-11-2021	28	14	56	46	2
09-11-2021	28	14	53	44	Calm Condition
10-11-2021	27	14	52	44	2
11-11-2021	27	16	54	41	2
12-11-2021	27	13	52	44	2
13-11-2021	27	13	56	47	2
14-11-2021	27	14	54	46	2
15-11-2021	26	14	58	47	4

WEATHER REPORT DURING WHEAT CULTIVATION (2021-22)

Source: Lovely Professional University, Punjab. Department of Agronomy, School of Agriculture.

DATE	MEAN TEMPERATURE (ºC)		RELATIVE HUMIDITY (%)		WIND SPEED (km/hr)
16-11-2021	27	13	57	48	2
17-11-2021	26	14	58	48	2
18-11-2021	27	14	57	47	2
19-11-2021	26	14	58	48	2
20-11-2021	25	13	59	49	2
21-11-2021	24	14	58	47	2
22-11-2021	24	13	59	48	2
23-11-2021	23	12	56	44	0
24-11-2021	24	12	54	46	2
25-11-2021	24	15	55	47	0
26-11-2021	21	14	56	48	0
27-11-2021	21	12	55	44	0
28-11-2021	22	10	52	41	0
29-11-2021	22	10	56	44	0
30-11-2021	23	10	54	42	0
01-12-2021	20	11	60	55	2

02-12-2021	21	10	62	54	2
03-12-2021	20	12	65	52	4
04-12-2021	22	13	65	54	0
05-12-2021	23	12	64	55	2
06-12-2021	20	10	63	58	0
07-12-2021	22	11	67	58	0
08-12-2021	22	12	78	60	2
09-12-2021	20	10	63	52	2
10-12-2021	21	10	63	53	0
11-12-2021	20	9	61	54	2
12-12-2021	22	11	62	53	4
13-12-2021	20	9	70	51	0
14-12-2021	19	9	65	50	0
15-12-2021	18	8	70	52	2
16-12-2021	19	8	66	54	4
17-12-2021	20	9	68	52	2
18-12-2021	22	11	66	50	0
19-12-2021	21	10	65	51	2
20-12-2021	19	5	68	58	0
21-12-2021	18	7	66	42	0
22-12-2021	22	10	68	51	2
23-12-2021	19	11	69	51	0
24-12-2021	19	12	65	51	2

25-12-2021	20	12	60	52	0
26-12-2021	19	11	75	52	0
27-12-2021	20	9	61	58	4
28-12-2021	18	8	64	58	0
29-12-2021	20	6	63	57	0
30-12-2021	18	6	64	52	2
31-12-2021	17	6	68	54	0
01-01-2022	18	6	75	64	0
02-01-2022	19	6	72	60	0
03-01-2022	18	12	74	65	2
04-01-2022	16	12	78	66	4
05-01-2022	15	8	72	58	2
06-01-2022	14	7	78	65	0
07-01-2022	14	8	70	64	0
08-01-2022	12	6	74	63	2
09-01-2022	11	9	74	66	2
10-01-2022	14	11	72	57	0
11-01-2022	15	11	80	68	8
12-01-2022	18	11	82	62	4
13-01-2022	17	11	78	61	2
14-01-2022	15	13	72	62	4
15-01-2022	19	12	78	64	2
16-01-2022	18	11	72	60	2

17-01-2022	18	13	76	62	4
18-01-2022	19	10	78	60	4
19-01-2022	17	10	76	60	2
20-01-2022	16	14	74	61	0
21-01-2022	15	10	70	60	0
22-01-2022	15	13	74	55	4
23-01-2022	14	12	72	58	0
24-01-2022	14	13	78	62	2
25-01-2022	15	12	74	60	4
26-01-2022	16	13	74	64	0
27-01-2022	12	10	80	68	4
28-01-2022	18	9	86	68	2
29-01-2022	18	10	78	66	0
30-01-2022	17	8	80	68	4
31-01-2022	18	8	82	70	4
01-02-2022	14	8	86	64	4
02-02-2022	15	8	84	68	Calm Condition
03-02-2022	16	8	68	60	2
04-02-2022	17	9	70	62	4
05-02-2022	16	10	72	60	2
06-02-2022	12	11	75	60	Calm Condition

07-02-2022	13	8	86	62	Calm Condition
08-02-2022	10	7	80	64	4
09-02-2022	14	7	80	66	Calm Condition
10-02-2022	12	10	72	64	4
11-02-2022	11	8	76	62	2
12-02-2022	17	8	78	60	4
13-02-2022	16	10	80	66	2
14-02-2022	17	8	82	62	4
15-02-2022	18	9	70	60	Calm Condition
16-02-2022	17	8	72	62	4
17-02-2022	18	8	74	58	2
18-02-2022	17	8	74	58	
19-02-2022	16	9	72	54	Calm Condition
20-02-2022	18	9	71	56	4
21-02-2022	21	10	70	52	Calm Condition
22-02-2022	20	11	67	50	2
23-02-2022	22	11	68	51	4
24-02-2022	20	11	67	50	Calm Condition
25-02-2022	20	12	66	52	2

26-02-2022	15	8	60	48	6
27-02-2022	18	10	62	48	2
28-02-2022	16	9	64	48	4
01-03-2022	18	10	60	48	2
02-03-2022	16	9	62	50	0
03-03-2022	17	10	60	49	4
04-03-2022	20	9	58	48	4
05-03-2022	21	10	56	46	0
06-03-2022	22	10	52	44	0
07-03-2022	20	11	54	45	4
08-03-2022	22	13	56	44	0
09-03-2022	24	18	54	42	0
10-03-2022	20	18	55	44	0
11-03-2022	20	20	56	42	4
12-03-2022	18	18	54	42	2
13-03-2022	22	20	54	44	0
14-03-2022	26	20	58	48	4
15-03-2022	28	20	50	40	4
16-03-2022	32	19	58	42	0
17-03-2022	30	22	56	40	2
18-03-2022	32	20	56	42	4
19-03-2022	32	20	54	40	0
20-03-2022	30	19	55	42	8

21-03-2022	32	23	52	40	0
22-03-2022	33	23	54	42	0
23-03-2022	34	22	52	44	0
24-03-2022	32	23	50	44	4
25-03-2022	30	21	50	42	4
26-03-2022	31	20	52	40	12
27-03-2022	32	21	50	38	0
28-03-2022	30	20	48	45	4
29-03-2022	31	19	52	48	2
30-03-2022	32	20	54	42	6
31-03-2022	32	25	50	44	4
01-04-2022	32	22	52	40	0
02-04-2022	33	23	53	42	6
03-04-2022	34	22	52	43	4
04-04-2022	30	24	48	44	12
05-04-2022	34	24	47	40	2
06-04-2022	32	24	45	38	0
07-04-2022	34	26	44	36	0
08-04-2022	35	26	42	34	0
09-04-2022	40	27	45	32	4
10-04-2022	40	27	42	30	16
11-04-2022	42	26	44	32	0
12-04-2022	44	28	48	37	4

13-04-2022	42	29	45	36	0
14-04-2022	40	26	44	34	2
15-04-2022	41	27	44	32	2
16-04-2022	40	27	45	34	4
17-04-2022	42	28	46	35	0
18-04-2022	40	28	44	30	12
19-04-2022	40	29	42	32	34
20-04-2022	37	30	38	25	12
21-04-2022	38	30	38	26	10
22-04-2022	39	29	39	27	14
23-04-2022	40	28	38	26	4
24-04-2022	42	30	36	25	22
25-04-2022	41	32	38	24	6
26-04-2022	42	31	39	22	12
27-04-2022	40	31	32	20	2
28-04-2022	42	32	31	21	10
29-04-2022	41	32	30	22	10
30-04-2022	41	32	30	21	10

WEATHER REPORT DURING RICE CULTIVATION (2022)

Source: Lovely Professional University, Punjab. Department of Agronomy, School of Agriculture.

DATE	MEAN TEMPERATURE (ºC)		RELATIVE HUMIDITY (%)		WIND SPEED (km/hr)
01-06-2022	32	31	40	37	4
02-06-2022	38	30	42	36	0
03-06-2022	40	31	34	38	22
04-06-2022	41	32	32	42	8
05-06-2022	43	30	32	40	0
06-06-2022	40	32	29	42	4
07-06-2022	40	31	30	43	5
08-06-2022	48	34	27	42	6
09-06-2022	38	32	28	40	12
10-06-2022	39	34	26	38	14
11-06-2022	40	33	62	48	26
12-06-2022	38	28	60	45	17
13-06-2022	39	34	27	36	6
14-06-2022	40	35	28	34	0
15-06-2022	36	30	52	58	21
16-06-2022	40	30	50	55	12

17-06-2022	38	34	40	37	11
18-06-2022	44	35	44	49	9
19-06-2022	40	31	42	36	13
20-06-2022	34	29	44	48	0
21-06-2022	38	29	44	49	24
22-06-2022	42	28	42	51	12
23-06-2022	40	27	44	50	26
24-06-2022	40	28	42	52	16
25-06-2022	41	30	44	49	0
26-06-2022	40	32	52	55	5
27-06-2022	38	34	48	49	1
28-06-2022	43	34	50	56	32
29-06-2022	44	32	52	58	12
30-06-2022	40	30	50	56	14
01-07-2022	38	32	58	64	40
02-07-2022	42	30	61	55	14
03-07-2022	44	32	57	58	18
04-07-2022	44	29	56	62	4
05-07-2022	42	32	60	67	10
06-07-2022	43	31	63	58	8
07-07-2022	45	32	62	67	0
08-07-2022	44	32	64	69	4
09-07-2022	40	33	62	64	0

10-07-2022	39	30	60	60	10
11-07-2022	36	33	64	62	18
12-07-2022	37	33	65	60	4
13-07-2022	37	30	60	60	20
14-07-2022	38	32	58	61	26
15-07-2022	32	32	54	61	4
16-07-2022	37	30	56	58	2
17-07-2022	36	31	54	56	0
18-07-2022	35	32	57	62	4
19-07-2022	36	32	56	67	10
20-07-2022	34	31	80	69	23
21-07-2022	29	25	86	70	8
22-07-2022	35	26	72	64	18
23-07-2022	36	28	78	68	9
24-07-2022	37	27	76	65	12
25-07-2022	34	27	64	62	14
26-07-2022	37	28	70	64	9
27-07-2022	37	27	77	69	9
28-07-2022	37	25	73	69	5
29-07-2022	30	26	74	61	13
30-07-2022	29	25	72	64	8
31-07-2022	34	24	76	65	4
01-08-2022	35	24	75	62	11

02-08-2022	36	26	78	68	1
03-08-2022	36	27	79	67	13
04-08-2022	35	26	78	68	11
05-08-2022	34	25	77	65	9
06-08-2022	34	26	78	62	4
07-08-2022	35	26	74	67	4
08-08-2022	36	25	73	62	9
09-08-2022	39	28	72	62	5
10-08-2022	39	29	78	62	5
11-08-2022	26	24	76	63	16
12-08-2022	37	25	70	61	5
13-08-2022	35	26	72	60	10
14-08-2022	35	27	71	68	9
15-08-2022	29	25	73	64	18
16-08-2022	34	25	72	64	3
17-08-2022	34	26	78	69	15
18-08-2022	33	26	78	68	8
19-08-2022	35	28	75	60	5
20-08-2022	34	27	77	61	3
21-08-2022	35	25	72	67	5
22-08-2022	33	26	78	64	5
23-08-2022	33	26	78	63	10
24-08-2022	35	26	71	60	10

25-08-2022	33	25	74	68	6
26-08-2022	34	26	77	64	8
27-08-2022	34	25	78	68	5
28-08-2022	34	25	78	69	7
29-08-2022	34	27	76	65	6
30-08-2022	35	25	72	61	9
31-08-2022	37	26	77	61	9
01-09-2022	36	27	77	62	9
02-09-2022	36	26	76	64	7
03-09-2022	36	26	74	62	6
04-09-2022	36	26	71	68	4
05-09-2022	38	25	70	61	11
06-09-2022	37	25	68	61	12
07-09-2022	38	25	72	64	10
08-09-2022	38	26	70	61	11
09-09-2022	39	26	67	60	12
10-09-2022	38	25	73	61	1
11-09-2022	38	26	78	73	10
12-09-2022	35	25	77	64	9
13-09-2022	36	23	72	64	12
14-09-2022	36	24	69	62	11
15-09-2022	33	25	70	67	8
16-09-2022	32	24	71	68	11

17-09-2022	33	21	68	61	19
18-09-2022	38	24	78	64	13
19-09-2022	38	24	74	61	17
20-09-2022	37	25	70	63	10
21-09-2022	39	25	70	62	14
22-09-2022	35	25	72	64	10
23-09-2022	34	23	71	62	14
24-09-2022	30	23	77	64	10
25-09-2022	23	21	76	63	9
26-09-2022	35	20	67	60	12
27-09-2022	35	22	70	61	10
28-09-2022	35	23	72	67	12
29-09-2022	36	23	74	60	9
30-09-2022	37	23	70	67	12
01-10-2022	37	23	55	46	6
02-10-2022	36	23	59	43	12
03-10-2022	37	23	54	45	12
04-10-2022	37	22	52	41	10
05-10-2022	37	21	54	42	7
06-10-2022	34	22	50	42	9
07-10-2022	32	21	55	46	8
08-10-2022	32	21	59	43	9
09-10-2022	32	21	54	44	8

10-10-2022	30	19	67	53	3
11-10-2022	31	20	62	55	2
12-10-2022	36	24	50	42	6
13-10-2022	32	23	59	43	2
14-10-2022	32	20	54	44	2
15-10-2022	36	24	56	47	4

WEATHER REPORT DURING PADDY STRAW COMPOSTING (2022)

Source: Lovely Professional University, Punjab. Department of Agronomy, School of Agriculture.

DATE	MEAN TEMPERATURE (ºC)		RELATIVE HUMIDITY (%)		WIND SPEED (km/hr)
16-10-2022	34	20	52	41	2
17-10-2022	32	23	54	46	4
18-10-2022	32	20	54	44	0
19-10-2022	32	21	56	45	2
20-10-2022	31	20	56	46	2
21-10-2022	31	19	54	41	3
22-10-2022	30	19	50	41	2
23-10-2022	30	20	56	44	2
24-10-2022	30	19	57	42	2
25-10-2022	29	18	57	46	3
26-10-2022	30	18	51	43	8
27-10-2022	29	18	53	43	3
28-10-2022	30	19	52	47	3
29-10-2022	29	16	54	41	2
30-10-2022	29	19	51	42	0

31-10-2022	30	19	51	42	2
01-11-2022	35	19	51	45	19
02-11-2022	34	19	58	48	17
03-11-2022	34	19	56	42	18
04-11-2022	30	19	53	44	21
05-11-2022	34	19	54	41	24
06-11-2022	33	19	56	47	26
07-11-2022	35	20	54	46	24
08-11-2022	33	19	51	48	20
09-11-2022	32	19	58	48	17
10-11-2022	24	18	59	49	16
11-11-2022	30	17	56	44	15
12-11-2022	30	16	54	46	19
13-11-2022	27	14	55	47	20
14-11-2022	24	18	52	41	11
15-11-2022	29	15	51	45	19

WEATHER REPORT DURING WHEAT CULTIVATION (2022-23)

Source: Lovely Professional University, Punjab. Department of Agronomy, School of Agriculture.

DATE	MEAN TEMPERATURE (ºC)		RELATIVE HUMIDITY (%)		WIND SPEED (km/hr)
16-11-2022	28	15	56	42	15
17-11-2022	28	13	52	47	17
18-11-2022	28	13	58	46	11
19-11-2022	28	15	51	48	21
20-11-2022	28	20	90	80	4
21-11-2022	29	20	72	58	4
22-11-2022	28	19	80	78	0
23-11-2022	28	18	71	66	10
24-11-2022	28	19	81	76	0
25-11-2022	28	17	72	67	8
26-11-2022	26	15	80	61	5
27-11-2022	26	17	80	60	5
28-11-2022	25	13	90	87	2
29-11-2022	24	14	81	62	0
30-11-2022	24	13	89	76	2
01-12-2022	25	11	89	77	0

02-12-2022	24	13	89	79	2
03-12-2022	26	14	80	68	5
04-12-2022	28	12	79	65	8
05-12-2022	27	13	80	61	2
06-12-2022	27	8	100	54	0
07-12-2022	27	9	89	60	4
08-12-2022	26	9	89	61	4
09-12-2022	28	11	89	53	0
10-12-2022	28	14	90	63	10
11-12-2022	29	13	89	57	12
12-12-2022	27	11	80	55	4
13-12-2022	27	12	90	77	10
14-12-2022	26	10	89	79	8
15-12-2022	25	10	97	65	10
16-12-2022	25	10	89	75	5
17-12-2022	27	10	90	85	5
18-12-2022	26	10	89	70	2
19-12-2022	25	11	88	75	4
20-12-2022	23	10	90	80	6
21-12-2022	25	10	89	79	5
22-12-2022	24	9	90	79	5
23-12-2022	22	9	97	75	5
24-12-2022	23	7	98	70	5

25-12-2022	19	7	98	74	6
26-12-2022	21	9	93	78	5
27-12-2022	22	9	96	78	10
28-12-2022	23	8	93	86	10
29-12-2022	21	9	98	88	6
30-12-2022	22	12	89	79	6
31-12-2022	22	8	89	77	10
01-01-2023	17	7.5	87	77	10
02-01-2023	15.8	6	97	82	7
03-01-2023	15	5	91	81	5
04-01-2023	15	4	98	75	5
05-01-2023	12	6	98	86	6
06-01-2023	11	5	97	85	5
07-01-2023	15	5	91	87	8
08-01-2023	16	7	93	77	10
09-01-2023	15	6	96	75	6
10-01-2023	17	8	92	80	10
11-01-2023	11	9	98	87	7
12-01-2023	12	10	94	86	12
13-01-2023	12.5	10	98	88	10
14-01-2023	11	9	98	86	7
15-01-2023	9	7	98	87	8
16-01-2023	13	6	98	77	10

17-01-2023	12.3	3.5	98	75	5
18-01-2023	13.5	5.1	87	74	4
19-01-2023	19	9	86	77	9
20-01-2023	14	6	87	71	3
21-01-2023	20	5	86	75	8
22-01-2023	21	6	87	70	11
23-01-2023	21	6	87	69	9
24-01-2023	18	12	87	74	5
25-01-2023	16.1	8.1	87	60	9
26-01-2023	17.8	7.8	87	59	6
27-01-2023	18.8	5.9	77	55	7
28-01-2023	18.2	7.1	77	58	7
29-01-2023	18.6	8.6	86	77	6
30-01-2023	19.2	10.1	100	100	19
31-01-2023	18.3	8.5	95	71	8
01-02-2023	18.8	6.9	96	71	14
02-02-2023	21.5	7.7	93	70	13
03-02-2023	21.5	8.4	96	74	10
04-02-2023	23	10.6	96	69	10
05-02-2023	23.3	10.9	96	67	10
06-02-2023	21	12	96	70	8
07-02-2023	23	12	72	67	12
08-02-2023	23.9	8.9	77	52	9

09-02-2023	24	10.6	74	45	9
10-02-2023	24.9	15.1	71	54	12
11-02-2023	25.9	13	76	52	11
12-02-2023	24.9	8.2	81	52	12
13-02-2023	26	5	54	33	12
14-02-2023	27	9	51	38	10
15-02-2023	23.4	14	54	37	10
16-02-2023	26.8	14.1	51	38	10
17-02-2023	26.1	13.6	54	34	7
18-02-2023	27.6	11.7	96	58	6
19-02-2023	28.7	12.6	94	54	9
20-02-2023	27.6	14.3	94	57	10
21-02-2023	27.7	16.3	94	44	13
22-02-2023	29.6	15.5	96	58	10
23-02-2023	27.7	13.7	90	58	11
24-02-2023	27.7	13.7	91	61	8
25-02-2023	27.6	14	87	62	8
26-02-2023	28.7	14.4	86	59	10
27-02-2023	29	13	81	52	8
28-02-2023	25	15	76	50	10
01-03-2023	28	14	50	48	9
02-03-2023	29	15	65	43	4
03-03-2023	24	13	58	47	14

04-03-2023	28.4	13.5	48	36	9
05-03-2023	28.3	13	38	31	10
06-03-2023	28.9	11.6	30	32	10
07-03-2023	31.3	12.8	29	31	10
08-03-2023	28.7	14	50	40	8
09-03-2023	30	15.1	50	42	9
10-03-2023	29.4	16	48	46	5
11-03-2023	29.3	15.6	80	39	9
12-03-2023	28.4	15.7	79	39	8
13-03-2023	30	17.1	75	37	10
14-03-2023	30.6	19.5	73	34	12
15-03-2023	31	15.2	72	35	11
16-03-2023	32.4	17.3	48	35	12
17-03-2023	22.8	17.1	80.8	59	2.2
18-03-2023	19.6	15.2	93	77	19
19-03-2023	25.7	14.1	92	59	1.9
20-03-2023	21.8	15.3	93	67	1.7
21-03-2023	25	11.9	93	51	0.8
22-03-2023	26.7	13.8	93	59	0.7
23-03-2023	27	12.6	94	56	1.7
24-03-2023	22.7	14.1	94	65	3.1
25-03-2023	23.8	15.6	94	61	2.5
26-03-2023	26.2	12.6	93	58	12

27-03-2023	28	15	90	40	8
28-03-2023	27	16	92	52	10
29-03-2023	33	17	88	39	4
30-03-2023	32	18	90	40	8
31-03-2023	22	18	93	68	16
01-04-2023	25.2	13.4	75	57	13
02-04-2023	25.7	13.3	60	51	9
03-04-2023	20.49	16.4	83	66	2.1
04-04-2023	27.2	16.39	64	44	2.1
05-04-2023	29.6	12.88	62	27	1.5
06-04-2023	28.7	15.38	62	33	1.9
07-04-2023	30.7	13	61	23	2
08-04-2023	31.9	11.84	64	20	1.9
09-04-2023	32.19	12.76	65	18	1.8
10-04-2023	33.56	12.8	60	22	1.9
11-04-2023	34.41	15.5	66	22	2.4
12-04-2023	34.4	20.6	85	31	12
13-04-2023	36.62	17.03	85	26	2.4
14-04-2023	37.79	16.91	85	30	1.7
15-04-2023	39.31	17.3	84	19	1.4
16-04-2023	39.51	19.16	98	22	1.9
17-04-2023	39.02	17.75	71	23	1.2
18-04-2023	37.66	21.31	72	21	2.1

19-04-2023	34.3	19.3	79	34	9
20-04-2023	32.7	14.9	73	41	6
21-04-2023	32.9	14.2	80	30	5
22-04-2023	30.8	13.8	84	34	9
23-04-2023	33.58	11.85	84	24	5
24-04-2023	35.8	13.5	84	25	4
25-04-2023	34.8	19.6	63	26	10
26-04-2023	34.2	20	79	33	11
27-04-2023	33.6	21	74	40	18
28-04-2023	35	21	79	34	9
29-04-2023	37.7	20.6	75	34	9
30-04-2023	32.8	18.7	77	38	9

LIST OF PUBLICATIONS

SL. NO	TITLE OF RESEARCH PAPER	AUTHORS	NAME OF JOURNAL	MONTH OF PUBLICATION	INDEX	ISSN
1.	"Ameliorative effects of waste decomposer and effective microorganisms on composting of paddy straw"	Johnson Yumnam*, Sandeep Menon, Jayanti Yomso and Mohit Naik	Journal of Applied and Natural Science	June, 2023	SCOPUS	ISSN: 2231-5209
2.	“Composting of Rice Straw with Waste Decomposers and Effective Microorganisms and their Effects on Compost Quality”	Johnson Yumnam*, Sandeep Menon, Mohit Naik and Jayanti Yomso	Annals of Agri Bio Research	December, 2023	SCOPUS	ISSN: 0971-9660

LIST OF CONFERNECES

SL. NO	INTERNATIONAL CONFERENCE THEME	TITLE OF ORAL PRESENTATION	PRESENTED BY
1.	“Recent trends in Smart and Sustainable Agriculture for Food Security” (SSARS-2022)	"Composting of paddy straw with waste decomposer (NCOF) and effective microorganisms for the mitigation of burning of paddy straws to improve crops production”	Johnson Yumnam
2.	“Advances in Agriculture Technology and Allied Science (ICAATAS-2022)	Composting of paddy straw with waste decomposer and effective microorganism and their effects on succeeding wheat crops	Johnson Yumnam