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Advancing Agricultural Sustainability through Community Initiatives in Odisha

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ABSTRACT

This study highlights the transformation of Jatipur village, Puri district, under the National Innovations in Climate Resilient Agriculture (NICRA) project, focusing on community-driven initiatives that promote agricultural sustainability. The implementation of advanced agricultural practices, particularly mushroom farming and vermicomposting, has significantly improved yields, economic returns, and soil fertility over three years. The NICRA Project facilitated the integration of paddy cum fish farming systems, crop diversification, and resource recycling, leading to enhanced productivity and income for the village's 72 households. Notably, paddy straw and oyster mushroom cultivation demonstrated substantial yield increases and higher benefit-cost ratios, reflecting the economic viability of these climate-resilient crops. Vermicomposting from spent mushroom substrate further supported sustainable farming practices by producing natural manure. The community's collaborative efforts have not only strengthened food security but also contributed to climate change mitigation by adopting sustainable agricultural practices. This case study serves as a model for other regions facing similar environmental challenges, emphasizing the potential for scaling up such initiatives to enhance agricultural resilience and sustainability.

Keywords: Agricultural resilience, Community, Farming, Mushroom farming, Sustainability.

INTRODUCTION

Amid growing environmental challenges, mushroom farming has emerged as a climate-resilient crop that aligns with sustainable agricultural practices by minimizing environmental impact, conserving resources, and promoting biodiversity. With its low requirements for land, water, and chemicals, mushroom cultivation supports soil health and enhances biodiversity through mycorrhizal associations (Smith and Read, 2020). As global food security becomes increasingly critical, mushrooms are recognized for their high nutritional value, including proteins, vitamins, and essential amino acids, making them vital in addressing food shortages. Their efficient production, using agricultural waste, boosts resource efficiency and strengthens food systems, particularly in vulnerable regions (Valverde *et al,* 2015). Mushroom cultivation has emerged as a promising avenue for enhancing rural livelihoods through income diversification and nutritional supplementation (Radhakrishnan *et al,* 2025).

In recent years, climate change has significantly challenged traditional agriculture in Puri district, Odisha, with erratic rainfall patterns, increasing temperatures, and frequent cyclones disrupting crop cycles and reducing productivity. This situation underscores the need for resilient farming practices like mushroom cultivation, which adapts well to the district's tropical climate and contributes to climate change mitigation. Puri's geography, featuring coastal plains, fertile agricultural lands, and sandy loam soil, is conducive to diverse agricultural activities, including mushroom farming. The district experiences average annual temperatures ranging from 25°C to 32°C and receives about 1,400 mm of rainfall, primarily during the monsoon season from June to September. These conditions are ideal for cultivating paddy straw and oyster mushrooms, which thrive on agricultural by-products, sequester carbon, and aid in bioremediation, making them an environmentally beneficial and sustainable agricultural choice (Liu *et al,* 2018; Singh and Sharma, 2021).

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Table 1. Performance of individual farming in the year 2021-22.

Technology demonstrated	No. of farmers	Area	Yield		% increase	Economics of demonstration (Rs. /ha)		
			Demo	Local		Gross Cost	Net Return	BCR
Paddy straw Mushroom Var. *Volvariella volvacea*	10	600Beds @100beds for 6 months	0.8 kg/bed	0.7 kg/bed	14.28	36000	26400	1.73
Oyster Mushroom Var. *Pleurotus sajor-caju*	10	100 Bags	1.5 kg/bag	0 kg/bag	-	4000	3000	1.5
Vermicomposting from Spent Mushroom Substrate	10	Vermi Bed @6’x4’x2’	5q/Bed	-	-	4350	650	1.14

Table 2. Performance of Community farming in NICRA village for the year 2022-23

Technology demonstrated	No. of farm families	Area	Yield		% increase	Economics of demonstration (Rs. /ha)		
			Demon.	Local		Gross Cost	Net Return	BCR
Paddy straw Mushroom Var. *Volvariella volvacea* in agro shed net (75%) house	17	1200 Beds @200 Beds for 6 months	0.9 kg/bed	0.7 kg/bed	28.57	72000	68400	1.95
Oyster Mushroom Var. *Pleurotus ostreatus*	17	200 Bags	1.8 kg/bag	1.5 kg/bag	20	8000	6400	1.8
Vermicomposting from Spent Mushroom Substrate	17	6nos. Vermi Bed@6’x4’x2’	36q @6q/Bed	-	-	26100	9900	1.37

Mushroom farming, particularly of paddy straw and oyster mushrooms, is a climate-resilient solution for the Puri district. Both varieties thrive in the region's conditions and can be cultivated year-round with proper management. Paddy straw mushrooms grow well during the hot, humid summer and early monsoon, utilizing abundant agricultural waste like rice straw, thereby supporting waste management and providing farmers with an additional income source. Oyster mushrooms are versatile, requiring minimal inputs, and can be cultivated for four months, making them ideal for small-scale and marginal farmers, especially during cooler winters and humid monsoon periods.

Economically, mushroom farming is a viable and resilient option for farmers, particularly in areas affected by climate variability. Studies from the past decade indicate that mushroom farming requires lower initial investments and operational costs compared to traditional crops, making it accessible to small-scale farmers (Royse, 2019). The diversification of income through mushroom cultivation not only mitigates financial risk but also supports local economies and food systems (Zhang *et al,* 2014). By incorporating mushroom farming into the agricultural practices of Puri district, farmers can diversify their income streams, reduce dependence on climate-sensitive crops, and enhance their resilience to the impacts of climate change. The year-round cultivation of mushrooms, supported by the district's geographical and climatic conditions, offers a sustainable and profitable alternative to traditional farming practices in the region. This research paper explores the potential of mushroom farming as a climate-resilient crop, focusing on its alignment with sustainable agriculture principles and its ability to contribute to a more resilient and secure global food system.

MATERIALS AND METHODS

Jatipur village in Puri district has undergone a significant agricultural transformation through the NICRA project. Spanning 77 hectares, with 58

Table 3. Performance of Community farming in NICRA village for the year 2023-24

Technology demonstrated	No. of farm families	Area	Yield		Per cent increase	Economics of demonstration (Rs. / Unit)		
			Demo	Local		Gross Cost	Net Return	BCR
Paddy straw Mushroom Var. *Volvariella volvacea* in rack system agro shed net (75%) house	17	1950Beds @325Beds for 6 Months	1.0 kg/ bed	0.7 kg/ bed	42.8	117000	136500	2.16
Oyster Mushroom Var. *Pleurotus ostreatus* with straw sterilization in lime (2%) for 6-7hrs	17	300 Bags	2.2 kg/ bag	1.5 kg/ bag	46.66	12000	14400	2.2
Vermicomposting from Spent Mushroom Substrate	17	6nos. Vermi Bed@6'x4'2'	54q @9q/ bed	-	-	26100	27900	2.06

hectares of cultivated and irrigated land (45 ha flood-prone), the village receives 1,406 mm of annual rainfall and consists of 72 households with a population of 386. Over the past three years, nearly 85-90% of households have relied on farming and dairy activities. Under the guidance of Krishi Vigyan Kendra (KVK) scientists, the villagers adopted sustainable agricultural practices, including a sequential paddy-cum-fish farming system, where paddy cultivation is integrated with fish farming to improve soil fertility. Fingerlings are stocked from January to April, grow out until August, and are harvested in September and October, while paddy is cultivated from June to November. The community diversified crops by growing varieties like CR Dhan 506, CR Dhan 508, Hybrid Napier, sweetcorn, marigold, and cowpea, and maintained kitchen gardens. In addition, they practiced year-round mushroom farming, farm mechanization, and installed bee boxes on bunds. The villagers also used paddy straw waste from mushroom farming for vermicomposting to produce natural manure. This holistic system not only maximizes resource use but also enhances soil health and sustainability through effective resource recycling.

The study involved implementing advanced agricultural practices in the NICRA village, Jatipur of Puri Sadar Block focusing on paddy straw and oyster mushroom cultivation, along with vermicomposting from spent mushroom substrate. Seventeen farmers participated in mushroom cultivation, while 10 to 17 farmers engaged in vermicomposting. Data on yield, costs, and returns were collected, and economic performance was analysed through benefit-cost ratios (BCR). Data on the yield of Paddy Straw Mushroom cultivation were collected from the NICRA village over a three-year period (2021-2024). The analysis focused on assessing the yield per bed and evaluating the consistency and improvement of yields over the years. Resource recycling, particularly using paddy straw waste for vermicomposting, was emphasized. The study compared demonstrated technologies with traditional practices, highlighting yield improvements and profitability for three years. The approach was community-based, aiming to enhance productivity and economic viability, with potential for scaling up these practices in similar regions.

RESULTS AND DISCUSSION

Over the last three years (2021-2023), Puri Sadar Block in Puri district, Odisha, has experienced favourable conditions for mushroom cultivation, with summer temperatures ranging from 31°C to 39°C and winter temperatures between 16°C and 25°C. The monsoon season recorded temperatures from 26°C to 34°C, creating an ideal environment for the growth of mushrooms like paddy straw and oyster varieties. Consistently high humidity, especially during the monsoon months (80% to 97%), along with moderate humidity in other seasons (45% to 82%), provides optimal moisture levels essential for successful mushroom farming, supporting both growth and productivity.

This study demonstrates significant advancements in agricultural productivity and economic viability through the adoption of improved mushroom cultivation techniques and vermicomposting in the NICRA village. Over the three years from 2021-22 to 2023-24, substantial increases in yield and net returns were observed across all activities.

The performance of individual farming in Jatipur village for 2021-22 highlighted the economic and yield benefits of integrating mushroom cultivation and vermicomposting into traditional systems in Table 1. The paddy straw mushroom (*Volvariella volvacea*) demonstrated a 14.28% yield increase with a Benefit-Cost Ratio (BCR) of 1.73, while the oyster mushroom (*Pleurotus sajor-caju*) achieved a BCR of 1.5. Vermicomposting from spent mushroom substrate resulted in a BCR of 1.14, reflecting its potential for additional income and improved soil health. Recent studies, including Sharma *et al.* (2020) and Singh *et al.* (2021), affirmed that these practices were profitable, sustainable, and suitable for smallholders. Kumar *et al.* (2019) and Rath and Mohanty (2022) also emphasized the role of mushroom farming and vermicomposting in waste management and climate resilience, making them viable for vulnerable communities like those in the NICRA Project-adopted villages.

The community farming results from the NICRA village for 2022-23 demonstrated significant yield and economic gains from adopting advanced mushroom cultivation and vermicomposting practices in Table 2.

Cultivation of paddy straw mushroom (*Volvariella volvacea*) in agro shed net houses resulted in a 28.57% higher yield (0.9 kg/bed) compared to traditional methods (0.7 kg/bed), with a favorable Benefit-Cost Ratio (BCR) of 1.95. Oyster mushroom (*Pleurotus ostreatus*) cultivation also showed a 20% increase in yield (1.8 kg/bag vs. 1.5 kg/bag) and a BCR of 1.8, indicating strong profitability. Additionally, vermicomposting of spent mushroom substrate produced 36 quintals from six vermi beds, with a BCR of 1.37, demonstrating its potential for sustainable waste recycling and soil improvement. Capacity-building efforts, including training and demonstrations, significantly improved farmers' knowledge and adoption of mushroom cultivation, although challenges such as limited credit access and delayed spawn availability remain key constraints (Rajkala *et al,* 2020).

The community farming results from the NICRA Project village for 2023-24 highlighted the impressive yield and economic benefits derived from advanced mushroom cultivation and vermicomposting practices in Table 3. The paddy straw mushroom (*Volvariella volvacea*) grown in a rack system within agro shed net houses yielded 1.0 kg/bed, a 42.8% increase over local practices (0.7 kg/bed), with a Benefit-Cost Ratio (BCR) of 2.16, showcasing its high profitability. The oyster mushroom (*Pleurotus ostreatus*), using straw sterilization with lime, achieved a yield of 2.2 kg/bag, representing a 46.66% increase compared to local methods (1.5 kg/bag), and a BCR of 2.2, indicating substantial economic returns. Additionally, vermicomposting from spent mushroom substrate produced 54 quintals from six beds, yielding a BCR of 2.06, further emphasizing its value for sustainable waste management and soil improvement. These results were consistent with recent studies that underscored the economic viability of such practices; Sharma *et al* (2020) highlighted the benefits of controlled mushroom cultivation, while Singh *et al* (2021) pointed out the advantages of vermicomposting in enhancing soil health. Furthermore, Kumar et al. (2019) and Rath and Mohanty (2022) emphasized the adaptability and profitability of mushroom farming, reinforcing the role of these technologies in promoting sustainable agricultural practices and improving farm incomes in rural communities like the NICRA village.

In 2023-24, villagers began utilizing paddy straw waste from mushroom cultivation for vermicomposting, converting it into natural manure instead of discarding it. Paddy field crop residue was recognized as an essential resource for enhancing soil fertility. Each 6x4x2 ft vermicompost polythene tank yielded 9 quintals (900 kg) of final product, using 1,800 kg of raw materials at a 50% conversion ratio. These raw materials consisted of 1,080 kg of spent mushroom substrate and 720 kg of cow dung. Annually, six community tanks produced a total of 54 quintals (5,400 kg) of vermicompost, generating Rs. 54,000 in income. The economic analysis showed a gross cost of Rs. 26,100 per unit and a net return of Rs. 27,900, with a Benefit-Cost Ratio (BCR) of 2.06, proving vermicomposting to be a cost-effective method for natural manure production, enhancing farm sustainability and profitability. Furthermore, vermicompost from spent mushroom substrate (SMS) was significantly richer in nutrients than traditional compost, with nitrogen levels of 1.5–2.5 g/kg, phosphorus at 1.0–2.0 g/kg, and potassium at 1.2–2.0 g/kg, alongside an organic matter content of 20–30%. In contrast, traditional compost contained lower nitrogen levels of 0.5–1.5 g/kg.

Vermicomposting also offers faster production cycles and greater microbial benefits, improving soil fertility and supporting sustainable agriculture, which aligns with findings by Ramesh and Singh (2018) who highlighted its environmental sustainability and economic viability. Patel *et al* (2021) similarly emphasized the role of agricultural waste in

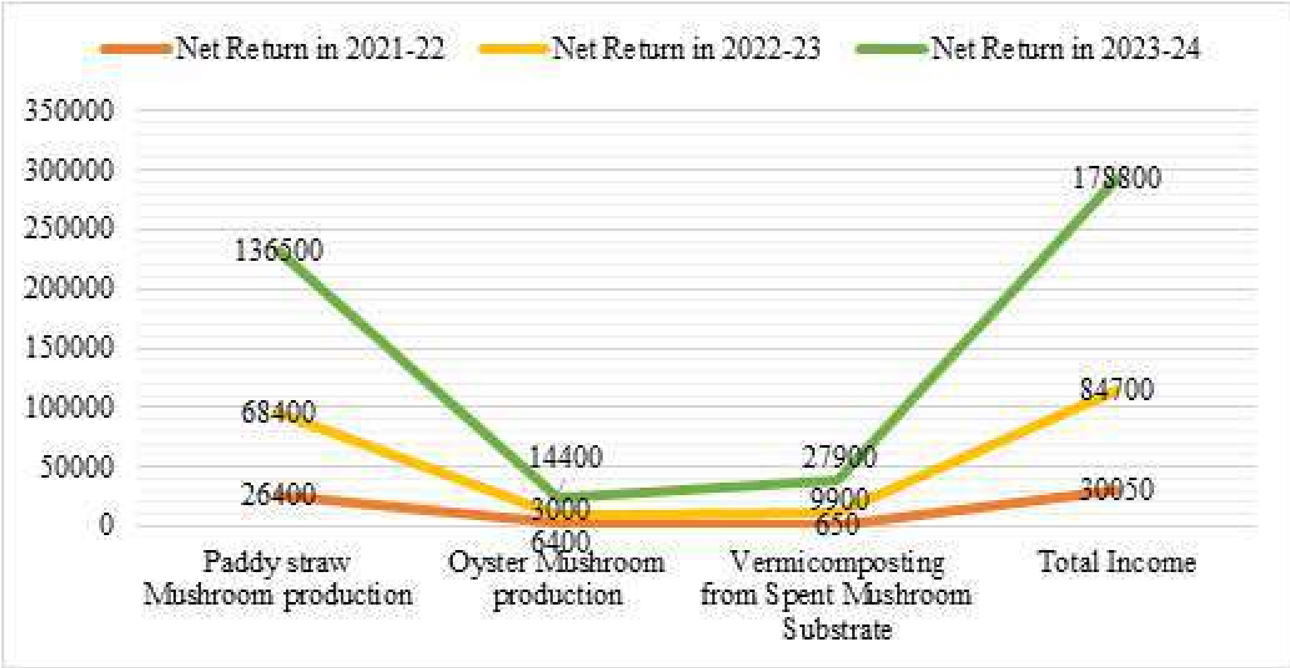

Fig 1. Year-wise economic analysis

Table 4. Comparative analysis for mushroom cultivation

Comparative analysis	Paddy Straw Mushroom Cultivation	Oyster Mushroom Cultivation
Mean Yield (2021 -2024)	0.9 Kg/Bed	1.833 Kg/Bag
Year-over-Year Percentage Increase		
- 2021-22 to 2022-23	12.5%	20.00%
- 2022-23 to 2023-24	11.11%	22.22%
Coefficient of Variation (C.V.)	9.07%	8.23%
Critical Difference (C.D.)	1.115 Kg/Bed	0.998 Kg/Bag

vermicomposting, citing its importance in promoting soil health, reducing input costs, and providing additional income for farmers. The vermicompost produced is used for kitchen gardens, as well as for cultivating banana and marigold in dyke areas, contributing to soil fertility and advancing organic farming practices within the community.

Fig. 1 highlighted the economic growth of community farming in NICRA village from 2021-22 to 2023-24, with net returns from all activities showing consistent increases. The figure illustrated the net returns from various agricultural practices, including paddy straw mushroom, oyster mushroom, and vermicomposting over three consecutive years (2021-2024).

The data revealed a significant increase in net returns from paddy straw mushroom cultivation, which peaked at Rs. 136,500 in 2022-23 and maintained a substantial return in 2023-24. In contrast, oyster mushroom cultivation exhibited a lower net return of Rs. 14,400 in 2022-23, highlighting its relatively lower profitability compared to paddy straw mushrooms. Vermicomposting demonstrated fluctuating returns, with a notable rise to Rs. 27,900 in 2022-23 before decreasing in 2023-24. Overall, the total income trajectory showed a positive trend, reaching Rs. 178,800 in 2023-24, reflecting the increasing economic viability of these sustainable practices. These findings were consistent with recent studies emphasizing the profitability of integrated farming systems; Sharma *et al* (2020) noted significant economic gains from mushroom farming, while Patel *et al* (2021) highlighted the role of waste recycling through vermicomposting in enhancing farmer incomes. Additionally, Kumar *et al* (2019) indicated that diversified agricultural practices could lead to improved financial stability for rural farmers.

Table 4 presented a comparative analysis between Paddy Straw Mushroom and Oyster Mushroom cultivation from 2021 to 2024, revealing notable differences in yield performance, growth trends, and stability. The mean yield for Oyster Mushrooms (1.833 kg/bag) significantly surpassed that of Paddy Straw Mushrooms (0.9 kg/bed), indicating a higher productivity potential for the former under the given cultivation conditions. Furthermore, the year-over-year percentage increase in yield demonstrated more rapid growth in Oyster Mushroom cultivation, with a 20.00% increase from 2021-22 to 2022-23 and 22.22% from 2022-23 to 2023-24. In contrast, Paddy Straw Mushroom cultivation showed a slower growth trajectory, with increases of 12.5% and 11.11% over the same periods. The lower Coefficient of Variation (C.V.) for Oyster Mushrooms (8.23%) compared to Paddy Straw Mushrooms (9.07%) suggested that the yield of Oyster Mushrooms was more consistent and stable over time. This reduced variability made it a more reliable option for farmers seeking predictable outcomes. The Critical Difference (C.D.) also highlighted a more substantial yield difference for Paddy Straw Mushrooms (1.115 kg/bed) compared to Oyster Mushrooms (0.998 kg/bag), pointing to greater variability in individual bed performance in Paddy Straw Mushroom cultivation.

These findings suggested that while both mushroom types were viable for cultivation, Oyster Mushrooms demonstrated superior yield, higher growth potential, and greater consistency, making them a more favorable option for farmers seeking higher productivity and stability. Several recent studies supported this observation. For instance, Khatun *et al* (2020) found that Oyster Mushrooms performed better due to their ability to adapt to a wider range of substrates and environmental conditions, contributing to their higher yields. Similarly, Sharma *et al* (2021) reported that the faster growth and greater consistency in Oyster Mushroom cultivation made it a more reliable crop compared to Paddy Straw Mushrooms. On the other hand, Paddy Straw Mushrooms, despite showing modest year-over-year improvements, required further optimization in cultivation practices to achieve comparable efficiency. This was consistent with research by Kumar *et al* (2019), who highlighted the need for enhanced techniques to improve the performance of Paddy Straw Mushrooms. Verma and Singh (2022) also emphasized the stability and lower variability of Oyster Mushrooms, reinforcing the importance of tailored interventions to boost Paddy Straw Mushroom yields while supporting the continued success of Oyster Mushrooms. These findings aligned with broader research trends in mushroom cultivation over the past five years, highlighting the need for strategic improvements in both mushroom types to maximize their potential for farmers.

CONCLUSION

The transformation of Jatipur village through the NICRA Project highlights the critical role of community-led agricultural innovations in promoting sustainability. By cultivating paddy straw mushrooms, oyster mushrooms and engaging in vermicomposting, local farmers have significantly boosted their productivity and income. The introduction of agro-shed net houses and the recycling of spent mushroom substrate have further improved farming efficiency and resource use. These initiatives have created local employment opportunities, reducing the need for migration to urban areas in search of better livelihoods. As a result, household incomes have stabilized, fostering greater economic security within the village. The adoption of these sustainable practices has also enhanced the community's resilience to climate change and economic fluctuations. These achievements demonstrate the potential for replicating such approaches in other regions, especially those facing similar challenges. The success in Jatipur illustrates how innovative farming techniques can strengthen rural economies and support long-term sustainability. By integrating these technologies, smallholder farmers can enhance both their livelihoods and the environment. Overall, the NICRA Project in Jatipur offers a model for scaling up sustainable agricultural practices to address broader social and environmental issues.

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REFERENCES

Das N and Mishra R (2020). Sustainable mushroom farming: An approach towards climate-resilient agriculture. *Indian J Agroecol* **5**(1): 64-71.

Khatun M, Islam N and Bari M S (2020). Performance evaluation of Oyster Mushroom (Pleurotus ostreatus) using different agro-wastes. *Int J Agric Res* **10**(1): 23-30.

Kumar S, Gupta R and Pandey A K (2019). Optimization of cultivation techniques for improved yield of Paddy Straw Mushroom (Volvariella volvacea). *Asian J Agric Res* **13**(3): 110-116.

Kumar S, Saha S and Gupta D (2019). Assessing the profitability of mushroom cultivation in resource-constrained environments. *Int J Agric Econ* **9**(3): 121-128.

Liu Q, Ma H, Zhang Y and Guo X (2018). Utilization of agricultural waste for the production of edible mushrooms and their role in sustainable agriculture: A review. *Bioresour Technol* **247**: 127-135.

Patel A, Mishra P and Yadav S (2021). Sustainable agriculture through resource recycling: The role of vermicomposting and agricultural waste reuse. *J Environ Manag* **27**(7): 670-680.

Patel D, Mehta S and Kumar R (2021). Utilization of agricultural waste for vermicomposting: Impact on soil health and farmer income. *Int J Recycl Org Waste Agric* **10**(2): 145-157.

Radhakrishnan A, Balan S, Indulekha V P, Simi S and Krishnan S (2021). Potential, economics, and constraints of mushroom cultivation in Wayanad, Kerala. *J Krishi Vigyan* **9**(2): 171-176.

Rajkala A, Shobana S, Kumar M A and Alagukannan G (2019). Impact of trainings and demonstrations on promotion of mushroom cultivation. *J Krishi Vigyan* **8**(1): 162-165.

Ramesh P and Singh K (2018). Economic and environmental sustainability of vermicomposting in agricultural practices. *J Environ Manage* **214**: 179-188.

Ramesh V and Singh M (2018). Economic viability of vermicomposting using agricultural waste: A case study. *Int J Environ Sci Technol* **15**(5): 1011-1020.

Rath S and Mohanty A (2022). Utilizing agricultural waste for vermicomposting: A study on economic benefits and soil quality enhancement. *J Soil Sci Plant Nutr* **22**(2): 567-578.

Roy S, Kumar A and Bhattacharya S (2017). Mushroom cultivation as a climate-resilient practice: Potential and challenges. *J Agric Res* **58**(3): 245-259.

Royse D J (2019). A global perspective on the economic impact of mushroom production and its role in addressing climate change. *J Mush Sci* **12**(2): 45-55.

Sharma A, Kumar V and Singh B (2020). Economic impact of integrating mushroom cultivation in smallholder farming systems: A case study from northern India. *J Agric Sci* **15**(2): 142-150.

Sharma P, Singh R and Chauhan S K (2021). Comparative study of yield performance of Oyster and Paddy Straw Mushrooms under controlled conditions. *J Mush Sci* **5**(2): 87-93.

Sharma R, Thakur S and Verma P (2019). Impact of community-based farming approaches on agricultural productivity and resilience. *J Sustain Agric* **12**(4): 332-345.

Singh D, Gupta R and Kaur H (2020). Role of agro-shed net houses in improving mushroom cultivation outcomes. *J Hort Sci* **35**(2): 189-198.

Singh H and Sharma S (2021). Bioremediation potential of mushrooms: An overview of recent developments. *Environ Sci Pollut Res* **28**(15): 18968-18983.

Singh R, Pandey A and Verma S (2021). Recycling spent mushroom substrate through vermicomposting: Implications for sustainable agriculture. *J Environ Manage* **287**: 112306.

Smith S E and Read D J (2020). *Mycorrhizal Symbiosis* (4th ed.). Academic Press.

Valverde M E, Hernández-Pérez T and Paredes-López O (2015). Edible mushrooms: Improving human health and promoting quality life. *In J Microbiol Art* 376387.

Verma S and Singh T (2022). Yield consistency and variability in different mushroom species: A comparative study. *Agric Rev* **43**(1): 102-108.

Zhang Y, Geng W, Shen Y, Wang Y and Dai Y (2014). Edible mushroom cultivation for food security and rural development in China: Bio-innovation, technological dissemination, and marketing. *Sustainability* **6**(5): 2961-2973.

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