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# Enhancing Crop Productivity through System of Rice Intensification and Organic Manure

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## Abstarct
Agricultural productivity plays a crucial role in sustaining global food security and addressing the challenges posed by population growth and climate change. In recent years, there has been a growing interest in adopting sustainable agricultural practices that enhance crop productivity while minimizing environmental impact. This review paper aims to provide a comprehensive analysis of the combined effects of the System of Rice Intensification (SRI) and organic manure on crop productivity, with a focus on rice cultivation. Enhancing crop productivity through the System of Rice Intensification (SRI) and organic manure is an effective approach that promotes sustainable and environmentally friendly agricultural practices. SRI is a set of principles and practices aimed at improving the productivity of rice crops while minimizing the use of water, chemical inputs, and seed requirements. Organic manure, on the other hand, refers to the use of natural materials such as compost, animal manure, and green manure to enrich the soil fertility and provide essential nutrients to the crops and contribute to enhancing crop productivity.

**Keywords**: Sustainable agricultural practices, environment impact, System of Rice intensification, organic manure, essential nutrients.

## Introduction
Rice is the most important cereal crop after wheat in India and major source of food for more than 2.7 billion people. The cultivation of rice began in Asia, particularly in the regions of China and India, where it has been a dietary staple for centuries. Over time, rice cultivation spread to other parts of the world, including Africa, the Americas, and Europe. Today, rice is grown in numerous countries, with China (145.95 million metric ton ) and India ( 132.00 million metric ton ) being the largest producers **( USDA,2022**). Rice supplies 20% and 31% of the total calories required by world and Indian population respectively. ( **Verma *et al* ., 2018) .** It is a good source of carbohydrates (77.2%), contains small amounts of protein, dietary fiber, and essential minerals such as iron and magnesium .Additionally, rice is naturally gluten-free, making it a suitable option for individuals with gluten sensitivities or celiac disease. The average productivity of rice is declining or stagnating over the years mainly due to inefficient nutrient management, availability of irrigation water at its critical stages, higher seed requirement leading to higher cost of production for farmers, uses of high amount of chemicals and pesticides leds to soil degradation, reduced soil fertility, and increased vulnerability to pests and diseases. To overcome all these problem an innovative approach to enhance rice production while minimizing resources requirements i.e System of Rice intensification. It has gained attention worldwide due to its potential for increasing

yields while reducing water usage and dependence on chemical inputs. It was developed in the 1980s by Henri de Laulanié, a French Jesuit priest, and initially adopted in Madagascar. It was basically adopted to overcome the problem of soil acidity in early eighties and follows a more comprehensive approach addressing various management practices simultaneously with promising results (**Stoop *et al.*, 2002**). The System of Rice Intensification (SRI) was introduced in India as an innovative agricultural technique with the goal of improving rice productivity by focusing on optimizing resources, improving yields, and reducing costs for farmers.

## There were several reasons why SRI was introduced in India:

- Increasing food security: India is one of the world's largest producers and consumers of rice. With a rapidly growing population, there was a need to enhance rice production to ensure food security for the population. SRI offered the potential to achieve higher yields and increase rice production without expanding the area under cultivation.
- Sustainable agriculture: SRI promotes sustainable agricultural practices by minimizing the use of chemical fertilizers and pesticides. This was particularly relevant in India, where there was a growing concern about the negative environmental impacts of intensive agriculture, such as soil degradation and water pollution.
- Water scarcity: Many regions in India face water scarcity, and traditional rice cultivation methods often require large amounts of water. SRI, on the other hand, emphasizes efficient water management techniques, such as intermittent irrigation and alternate wetting and drying, which can significantly reduce water requirements for rice cultivation.
- Smallholder farmers: India has a large population of smallholder farmers who cultivate small plots of land. SRI's focus on improved plant spacing, transplanting young seedlings, and weed management techniques made it suitable for small-scale farmers. SRI offered the potential for increased yields even with limited resources and inputs, thereby improving the livelihoods of smallholder farmers.
- Climate change adaptation: Climate change has brought increased uncertainty to agricultural production. SRI was seen as a potential adaptation strategy to cope with changing climatic conditions, as it enhances the resilience of rice plants and reduces vulnerability to droughts and floods.

The principle of the System of Rice Intensification revolves around optimizing the growing conditions for rice plants, enabling them to reach their full potential. The key principles of SRI include [**Laulanie (1993**)]

- Seedling management: SRI emphasizes the use of young and healthy seedlings with only a few days of age (10 -12 days).These seedlings are transplanted individually, spaced farther apart than traditional methods, allowing each plant to develop a stronger root system leading to improved nutrient uptake efficiency and overall plant growth.
- Transplanting: In SRI, rice seedlings are transplanted at a very early stage, typically when they have two or three leaves. This early transplantation helps the plants establish better, allows for a longer growing period , reduces the competition and helps minimize the shading effect of lower leaves. This helps lower leaves to remain photo synthetically active, for much longer, and in turn, root activity remains higher for a longer period due to the plant's enhanced supply of oxygen and carbohydrates to the roots **(Horie *et al.*, 2005**). Further, higher root activity, in turn, supplies cytokinin to the lower leaves, delaying senescence and helping to maintain photosynthetic efficiency of the plant at latter growth stages. This outcome has been confirmed by a finding where a single seedling per hill had higher yield compared to three seedlings per hill (**San-oh *et al.*, 2006).**

- Plant spacing : SRI promotes wider spacing between rice plants compared to conventional methods. The wider spacing ensures that each plant has ample space to grow, reducing competition for nutrients, water, and sunlight. Plants grown with wider spacing have more area of soil around them to draw nutrients and have better access to solar radiation for higher photosynthesis. Spacing is critical in modifying the components that influence final grain yield. The supply of resources mainly depends on the root system activity.(**Toungos and Dahiru , 2018)**
- Water management: SRI encourages a controlled and intermittent irrigation technique. Instead of continuously flooding the rice fields, SRI recommends maintaining moist soil conditions that promote root growth, nutrient uptake and the activity of beneficial soil organisms . This intermittent flooding reduces water usage and also helps to prevent weed growth.
- Soil management: SRI advocates for the use of organic matter, such as compost or farm yard manure, to improve soil fertility and structure. The incorporation of organic matter enhances soil health, nutrient availability, and water-holding capacity.
- Weed control: Conoweeder is recommended for reducing the cost of weeding by labours, which also facilitates aeration and incorporation of nutrients through the weeds.**(Dinesh *et al.*, 2019)**. SRI emphasizes mechanical weed control methods, such as hand weeding or using tools like rotary weeders, to minimize the use of herbicides. The intermittent irrigation and wider plant spacing also help reduce weed growth.

The combined effect of these principles is believed to stimulate root and shoot development, improve nutrient uptake, enhance soil health, and increase rice plant resilience. SRI has demonstrated the potential to significantly increase rice yields while using fewer inputs, such as seeds, water, and fertilizers. It has also shown positive impacts on farmers' incomes and the environment by reducing chemical inputs and conserving water resources.

**Table:1 Difference in parameters of rice in SRI and conventional method of cultivation.**

| S.N. | Parameter | SRI | Conventional method | Reference |
|---|---|---|---|---|
| 1. | Plant height | 108.6 cm | 104.3cm | Vijayakumar et al.,2006 |
| 2. | Plant height | 119.6cm | 113.2cm | Kumar et al.,2021 |
| 3. | Plant height | 119.4cm | 115.4cm | Tejendra et al.,2011 |
| 4. | Number of tillers/m | 475 | 452 | Vijayakumar et al.,2006 |
| 5. | Number of tillers/m | 308 | 281 | Kumar et al.,2021 |
| 6. | Plant dry weight(g/hill) | 9.250 | 8.900 | Debbarma et al.,2015 |
| 7 | Number of grains/panicle | 50.53 | 49.26 | Debbarma et al.,2015 |
| 8 | Yield | 6.21t/ha | 5.92t/ha | Midya et al.,2021 |
| 9 | Yield | 3.436t/ha | 3.340t/ha | Singh et al.,2021 |
| 10 | Yield | 6.7t/ha | 5.7t/ha | Mboyerwa et al.,20221 |
| 11 | B:C | 1.42 | 1.06 | Singh et al.,2021 |
| 12 | B:C | 1.46 | 1.2 | Nirmala et al.,2021 |
| 13 | B:C | 1.99 | 1.54 | Midya et al.,2021 |

**Organic Manure**: Manure is organic matter which is prepared by rotting animal dung, crop residues, peels of fruits and vegetables etc. After decomposition, they provide a wide range of nutrients to the plants. It is the most natural and chemical free substance to increase the yield of crops and to improve the production efficiency of the soil. These organic sources besides supplying N, P, and K also make unavailable sources of elemental nitrogen, bound phosphates, micronutrients, and decomposed plant residues into an available form to facilitate the plants to absorb the nutrients. Application of organic sources encouraged the growth and activity of mycorrhizae and other beneficial organisms in the soil and is also helpful in alleviating the increasing incidence or deficiency of secondary and micronutrients and is capable of sustaining high crop productivity and soil health.

- Organic manures provide numerous benefits in rice cultivation. They improve soil structure and water-holding capacity, enhance nutrient availability, promote beneficial microbial activity, and increase the organic matter content of the soil. The slow release of nutrients from organic manures ensures a sustained supply to the crop, reducing the risk of nutrient imbalances and minimizing nutrient losses through leaching.
- Nutrient release dynamics and availability The release of nutrients from organic manures depends on their composition, decomposition rate, and soil microbial activity. Nutrient release occurs through mineralization, which converts organic forms of nutrients into inorganic forms available for plant uptake. Organic manures, when properly managed, provide a continuous supply of nutrients throughout the crop's growth cycle, improving nutrient use efficiency and reducing the need for synthetic fertilizers.
- Organic manures and soil health improvement Organic manures play a vital role in improving soil health. They enhance soil structure, increase water infiltration, and improve nutrient-holding capacity. The addition of organic matter stimulates microbial activity, leading to the formation of stable soil aggregates and the release of plant growth-promoting substances. The improved soil health resulting from organic manure application enhances nutrient cycling, reduces soil erosion, and supports long-term sustainability of rice cultivation.
- Synergistic Effects of SRI and Organic Manures

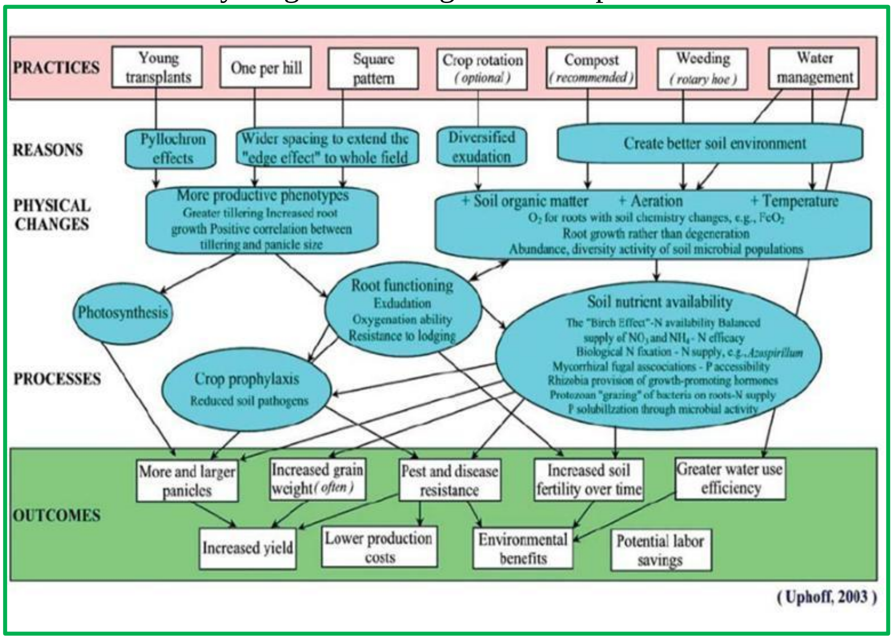
- Enhanced nutrient availability and uptake The integration of SRI with organic manures improves nutrient availability to rice plants. SRI practices, such as wider spacing and intermittent irrigation, coupled with organic manure application, promote the mineralization of nutrients and their efficient uptake by the roots. This synergy enhances nutrient use efficiency, reducing the need for synthetic fertilizers and minimizing nutrient losses to the environment.
- Improved soil structure and fertility The combination of SRI and organic manures positively influences soil structure and fertility. SRI practices enhance root growth, leading to increased organic matter deposition and root exudates. Organic manures improve soil aggregation, water-holding capacity, and nutrient retention, further enhancing the benefits of SRI. The integration of these practices promotes soil health and sustains long-term productivity.
- Reduced pest and disease incidence SRI, with its emphasis on plant vigor and soil health, contributes to pest and disease resistance in rice crops. Organic manure application enhances the plant's natural defense mechanisms and promotes beneficial soil microorganisms that suppress pests and diseases. The combined effects of SRI and organic manures reduce the need for chemical pesticides, minimizing their negative impacts on the environment and human health.
- Water use efficiency and conservation SRI practices, such as intermittent irrigation, help improve water use efficiency in rice cultivation. The combination of SRI with organic manures enhances the soil's water-holding capacity and infiltration rates, reducing water loss through runoff and enhancing water availability to the crop. This integration contributes to water conservation in rice production systems, particularly in regions prone to water scarcity.
- Climate change adaptation and mitigation SRI and organic manures offer potential strategies for climate change adaptation and mitigation in rice cultivation. SRI practices enhance resilience to climate variability by improving root systems, optimizing nutrient uptake, and increasing crop tolerance to water stress. Organic manures contribute to

carbon sequestration in the soil, reducing greenhouse gas emissions and promoting climate-smart agriculture.

By combining the principles of SRI and the use of organic manure, farmers can significantly enhance crop productivity while minimizing the negative impacts on the environment. They promote root and plant growth , optimize nutrient uptake and enhance soil health.These practices not only provide economic benefits but also contribute to long-term sustainability, soil health, and food security.

The System of Rice Intensification (SRI) aims to improve the productivity and sustainability of rice farming while minimizing the use of resources such as water, seeds, and fertilizers. Here are some Advantages of the System of Rice Intensification:

- Increased rice yields: SRI practices have been shown to significantly increase rice yields compared to conventional methods. Farmers practicing SRI have reported yield increases ranging from 20% to 100% or even more. This increase in productivity can contribute to food security and improved income for farmers.
- Water efficiency: SRI uses a water-saving approach by encouraging alternate wetting and drying of paddy fields. This practice reduces water usage by up to 30% compared to traditional continuous flooding methods. With water scarcity becoming a significant concern in many regions, SRI can help conserve water resources and make rice cultivation more sustainable.
- Reduced seed requirement: SRI promotes the use of younger and healthier seedlings, often transplanted individually. This requires fewer seeds per hectare compared to conventional practices, where seedlings are transplanted in clumps. By reducing the seed requirement, farmers can save on costs and improve seed quality.
- Soil health and fertility: SRI focuses on improving soil conditions through practices such as organic matter incorporation, reduced soil disturbance, and the use of compost or organic fertilizers. These methods enhance soil structure, nutrient availability, and microbial activity, leading to improved soil health and long-term fertility.
- Lower input costs: SRI reduces the need for expensive agrochemical inputs, including fertilizers and pesticides. By adopting organic approaches and optimizing nutrient management, farmers can minimize costs associated with chemical inputs, making rice cultivation more economically viable.
- Climate resilience: SRI practices enhance the adaptability of rice plants to changing climatic conditions. The use of younger seedlings and improved soil moisture management can help rice crops withstand periods of drought or excess rainfall. SRI can contribute to building resilience in rice cultivation systems, particularly in the face of climate change.
- Reduced greenhouse gas emissions: The water-saving



(Uphoff, 2003)

practices of SRI, such as alternate wetting and drying, help reduce methane emissions from rice fields. Methane is a potent greenhouse gas that contributes to climate change. By implementing SRI, farmers can contribute to mitigating the environmental impact of rice cultivation.

- Farmer empowerment: SRI encourages farmer participation and knowledge sharing. It emphasizes farmer experimentation, adaptation, and innovation, allowing farmers to become active agents in improving their own agricultural practices. This empowerment can lead to increased farmer confidence, improved decision-making, and a sense of ownership over their farming systems.

SRI emphasizes the use of certain principles and practices to enhance the growth and yield of rice plants. As for its future scope, SRI holds several potential benefits and opportunities:

- Increased food security: With the global population expected to reach nearly 10 billion by 2050, there is a growing need to enhance food production sustainably. SRI offers the potential to increase rice yields significantly, thereby contributing to food security in regions where rice is a staple crop.
- Climate change adaptation: Climate change poses challenges to agriculture, including erratic rainfall patterns, increased temperatures, and more frequent extreme weather events. SRI techniques, such as intermittent flooding and the use of organic matter, can help farmers adapt to these changing conditions and mitigate the impacts of climate change.
- Water conservation: Traditional rice cultivation methods are often water-intensive, requiring continuous flooding of fields. SRI promotes alternate wetting and drying (AWD) techniques, reducing water usage by up to 30-50%. As water scarcity becomes a growing concern, SRI can play a vital role in conserving this precious resource.
- Reduced environmental impact: SRI practices encourage the use of organic fertilizers, minimal or no pesticide application, and the promotion of natural pest control mechanisms. By minimizing the use of agrochemicals, SRI contributes to reducing soil and water pollution, preserving biodiversity, and improving the overall environmental sustainability of rice production.
- Enhanced farmer livelihoods: SRI's focus on maximizing yields and minimizing input costs can improve the economic viability of rice farming. By reducing the need for expensive inputs like seeds and fertilizers, SRI can lead to higher income and improved livelihoods for farmers, particularly smallholders who often face financial constraints.
- Knowledge transfer and adaptation: SRI is an evolving methodology that encourages farmer experimentation and adaptation to local conditions. Its principles can be adapted to suit different agro-ecological zones and rice varieties, fostering knowledge exchange and community engagement among farmers.
- Integration with technology: The future scope of SRI lies in the integration of innovative technologies such as precision agriculture, remote sensing, and data analytics. These technologies can help optimize SRI practices, provide real-time monitoring of crop growth, and support decision-making for farmers and policymakers.

While the System of Rice Intensification (SRI) offers numerous advantages and benefits, it is important to acknowledge some of its limitations and potential disadvantages. Here are a few:

- Increased labor requirements: SRI practices often involve manual transplanting of young seedlings and meticulous field management, which can be labor-intensive. This can pose challenges for farmers who have limited access to labor or face labor shortages.

- Knowledge and training requirements: SRI requires farmers to have a good understanding of the practices involved, such as transplanting techniques, water management, and weed control. Adopting SRI may require training and technical assistance, and farmers may need time to acquire the necessary knowledge and skills.
- Initial investment and infrastructure: Implementing SRI practices may require certain investments, such as purchasing specific equipment or infrastructure for water management. This initial investment can be a barrier for resource-constrained farmers, especially those in low-income regions.
- Adoption challenges in certain contexts: SRI practices may not be universally applicable or feasible in all rice-growing regions due to variations in climate, soil conditions, and local farming practices. Some areas may have limitations in implementing certain SRI techniques, such as AWD irrigation, due to water availability or infrastructure constraints.
- Pest and disease management: While SRI promotes reduced chemical inputs, the reliance on natural pest and disease management methods can sometimes be challenging, especially in areas with high pest and disease pressure. Integrated pest management strategies need to be well-designed and effectively implemented to mitigate these risks.
- Yield variability: The yield outcomes of SRI can vary depending on several factors, including farmer expertise, adherence to recommended practices, local conditions, and pest and disease pressures. Achieving consistent and high yields with SRI may require careful monitoring, adaptation, and fine-tuning of practices.
- Adaptation period: Transitioning from conventional rice farming to SRI practices may require a period of adjustment and adaptation. Farmers may need time to optimize their practices, refine their techniques, and overcome initial yield variations before fully realizing the potential benefits of SRI.

## Conclusion

The integration of the System of Rice Intensification (SRI) with organic manures presents a promising approach for sustainable rice production. The combined benefits of SRI and organic manures include increased yield, improved nutrient management, enhanced soil health, reduced pest and disease incidence, and better water use efficiency the System of Rice Intensification holds promising potential as a sustainable and productive agricultural approach. Its future scope encompasses addressing food security, climate change adaptation, water conservation, environmental sustainability, improved livelihoods, knowledge transfer, and integration with modern technologies. By embracing SRI and further research and development, we can unlock its full potential and contribute to a more sustainable and resilient future for rice production

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