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ENHANCING GROWTH AND YIELD VIA MANUAL TRANSPLANTING IN THE SYSTEM OF RICE INTENSIFICATION: A CASE STUDY IN ESCALER, MAGALANG, PAMPANGA, PHILIPPINES

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Abstract

Rice (Oryza sativa L.) stands as the primary staple food for over half of the global population. Projections indicated that by 2025, global rice production would need to increase by approximately 60% to meet rising food demands (Fageria, 2007). Irrigated rice cultivation, which consumes the largest share of water among agricultural activities, faces sustainability challenges due to escalating water scarcities (Bouman et al., 2005). The System of Rice Intensification (SRI) emerged as an alternative farming approach for small-scale farmers, enhancing land and water productivity while optimizing resource utilization. SRI emphasized fostering robust, extensive root systems capable of withstanding drought, waterlogging, and wind damage. Unlike conventional rice cultivation methods, SRI techniques focused on stronger root and stem structures, increasing tiller numbers, and ultimately boosting yields. SRI management advocated for early transplanting to extend the vegetative growth phase and promoted single seedling placement per hill to reduce competition and minimize shading from lower leaves (Tanaka, 1958; Horie et al., 2005). This strategy sustained the photosynthetic activity of lower leaves for extended periods, ensuring heightened root activity through enhanced oxygen and carbohydrate supply. Initial experiments involved transplanting very young rice seedlings, typically aged between 8 to 12 days, with wide spacing (25x25 cm) of single seedlings (NARC, 2005). SRI represented a holistic methodology aimed at bolstering the productivity of irrigated rice farming through refined management of plants, soil, water, and nutrients. By creating favorable conditions, particularly in the root zone, SRI practices fostered healthier soil and plants, fostering greater root development and nurturing soil organism diversity. The study evaluated the growth and yield of four rice varieties—NSIC Rc 436, NSIC Rc 440, NSIC Rc 442, and NSIC Rc 222—under SRI and traditional methods. A Randomized Complete Block Design (RCBD) was employed with two sets of trials, each consisting of three replications. The SRI method involved transplanting 12-day-old seedlings manually with single seedlings per hill at a spacing of 25 cm x 25 cm. In contrast, the traditional method involved transplanting 21-day-old seedlings manually using two to four seedlings per hill. Growth parameters such as plant height, tiller number, leaf area index, and root development were monitored throughout the growing season. Yield-related parameters were measured at harvest to evaluate the effectiveness of SRI compared to traditional practices. The findings revealed that SRI consistently outperformed traditional methods, achieving higher yields and economic returns. NSIC Rc 442 demonstrated superior performance, underscoring the importance of varietal selection based on cultivation methods and environmental conditions. SRI's lower total expenses and higher net incomes highlighted its potential for resource optimization and cost-effectiveness. This study underscored SRI's potential to improve food security and agricultural sustainability by enhancing rice productivity, optimizing resource use, and increasing economic

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efficiency. Based on these findings, recommendations included promoting SRI practices through training and support, emphasizing the importance of varietal selection, investing in capacity-building initiatives, supporting research and innovation, advocating for supportive policies, and establishing robust monitoring and evaluation systems. These steps are crucial for accelerating SRI adoption, improving rice productivity, and enhancing farmer livelihoods, thereby contributing to sustainable agricultural development and food security.

Keywords: Water Efficiency, Planting Technologies, Deep Root, Rice Intensification.

1. INTRODUCTION

Rice (Oryza sativa L.) stands as the primary staple food for over half of the global population. Projections suggest that by 2025, global rice production will need to increase by approximately 60% to meet rising food demands (Fageria, 2007). Among agricultural activities, irrigated rice cultivation consumes the most significant share of water, making its sustainability vulnerable to escalating water scarcities (Bouman et al., 2005). The System of Rice Intensification (SRI), abbreviated as SRI, emerges as an alternative farming approach for small-scale farmers seeking to enhance land and water productivity while optimizing resource utilization. SRI emphasizes fostering robust, extensive root systems capable of withstanding drought, waterlogging, and wind damage. Departing from conventional rice cultivation methods, SRI techniques focus on fostering stronger root and stem structures, increasing tiller numbers, and ultimately boosting yields.

SRI management advocates for early transplanting to extend the vegetative growth phase and advocates for single seedling placement per hill to reduce competition and minimize shading from lower leaves (Tanaka, 1958; Horie et al., 2005). This strategy sustains the photosynthetic activity of lower leaves for extended periods, ensuring heightened root activity through enhanced oxygen and carbohydrate supply. Initial experiments involved transplanting very young rice seedlings, typically aged between 8 to 12 days, with wide spacing (25x25 cm2) of single seedlings (NARC, 2005). SRI represents a holistic methodology aimed at bolstering the productivity of irrigated rice farming through refined management of plants, soil, water, and nutrients. By creating favorable conditions, particularly in the root zone, SRI practices foster healthier soil and plants, fostering greater root development and nurturing soil organism diversity. Originally developed by Jesuit agriculturist Fr. Henri de Laulanie and his colleagues in Madagascar during the 1980s and 1990s, SRI aimed to address the low yields experienced by Malagasy farmers. In 1990, Fr. De Laulanie and his colleagues established the NGO Association Tefy Saina ('to improve the Mind') to advance SRI and disseminate it among Malagasy farmers. Training provided by Tefy Saina resulted in remarkable yield increases, with farmers achieving average yields of 8 tons/hectare compared to their previous average of only 2 tons/hectare, while simultaneously reducing costs for water, seeds, and external inputs. Recognizing SRI's potential, the Cornell International Institute for Food, Agriculture, and Development (CIIFAD) collaborated with Tefy Saina in 1994 (Stoop et al., 2006). As water scarcity increasingly constrains agriculture, SRI's appeal is expected to grow. With more frequent and severe droughts, the ability of SRI methods to encourage larger and deeper root systems offers enhanced resilience to adverse climatic conditions. Global agriculture faces twin challenges: the imperative to sustainably increase food production to feed a growing population

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amid mounting water scarcity (Bouman, 2007). Drought events have led to a 12.5% reduction in rice yield in 2006, with national productivity dropping to 2.71 mt/ha in 2009 from 2.91 mt/ha in 2008 (MoAC, 2010).

2. OBJECTIVES

1. To assess the growth patterns of selected rice varieties under manual transplanting methods;
2. To evaluate the yield potential of different rice varieties when cultivated using the System of Rice Intensification (SRI) approach;
3. To compare the performance of various rice varieties in terms of growth and yield under manual transplanting within the SRI framework;
4. To identify best practices for manual transplanting techniques to maximize growth and yield outcomes for specific rice varieties;
5. To analyze data to determine correlations between specific transplanting techniques and growth/yield outcomes; and
6. To investigate the adaptability of selected rice varieties to the SRI method and their resilience in varying environmental conditions.

3. METHODOLOGY

The study was conducted in Escaler, Magalang, Pampanga, Philippines. The experimental crop comprised four inbred rice varieties: NSIC Rc 436, NSIC Rc 440, NSIC Rc 442, and NSIC Rc 222, selected for their relevance to the study's objectives. A Randomized Complete Block Design (RCBD) was employed with two sets of trials, each consisting of three replications and one treatment, involving these four rice varieties. Trial 1 focused on the System of Rice Intensification (SRI) method, where 12-day-old seedlings were transplanted manually using single seedlings per hill with a spacing of 25cm x 25cm. The same rice varieties were included in Trial 2, representing farmer's practice, where 21-day-old seedlings were transplanted manually using two to four seedlings per hill. Each trial aimed to evaluate the growth and yield performance under different cultivation practices, providing insights into the effectiveness of the SRI method compared to traditional practices. In assessing growth patterns, plots were prepared with uniform soil and environmental conditions, and growth parameters such as plant height, tiller number, leaf area index, and root development were monitored throughout the growing season. For evaluating yield potential, different rice varieties suitable for SRI were chosen, and yield-related parameters were measured at harvest. The yield potential of each variety under the SRI approach was compared. Experiments were conducted to compare the performance of varieties under both manual transplanting and SRI methods. Growth and yield parameters were recorded and statistically analyzed to assess their performance under different cultivation methods. Field trials were conducted to identify the best transplanting techniques, and growth/yield outcomes were monitored and analyzed. The most effective techniques were

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identified to maximize growth and yield outcomes. Statistical analysis was performed to find correlations between specific transplanting techniques and growth/yield outcomes, considering factors like transplanting depth, spacing, and timing. Rice varieties were selected based on their adaptability to the SRI method, and experiments were conducted to assess their resilience in varying environmental conditions. Key factors influencing adaptability were identified. Prior to the study, soil sampling was conducted, and soil samples were analyzed in the laboratory. Land preparation, seedling preparation, transplanting, intermittent irrigation, fertilization, and expected output were also part of the methodology. Data gathered included the number of productive plants, plant height, length of panicles, length of roots, weight of 1000 grains, grain weight per plot, moisture content, and computed yield per hectare. Cost and return analysis were recorded to calculate the Return on Investment (ROI). Finally, statistical analysis was performed using Analysis of Variance (ANOVA), and the significance of differences between means was determined using the Least Significant Difference (LSD) at a 5% probability level.

Figure 1: System of Rice Intensification Lay out

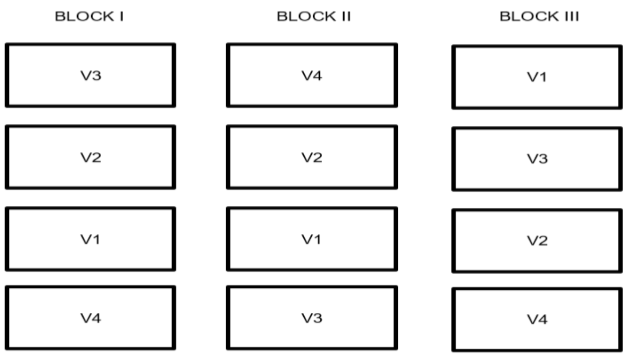
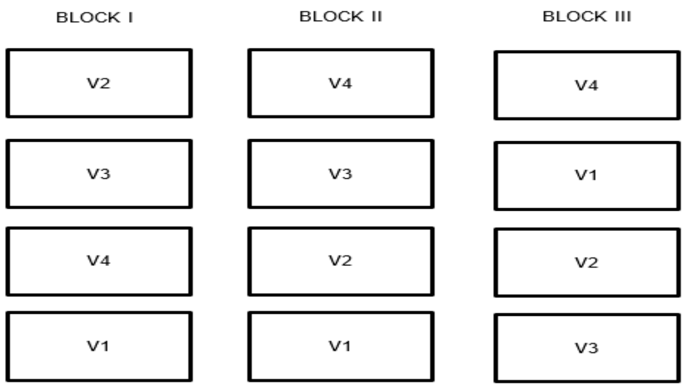


Figure 2: Farmer's Practice



Note:

Plot Size – 4m x 6m
Distance between Blocks – 2m
Distance between Plots – 1m
Total Area – 920m^2

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The data to be gathered for the study includes:

1. Number of productive plants, counted from different sample plants to assess productivity.
2. Plant height, measured at maturity from various sample plants using a meter stick.
3. Length of panicles, measured at maturity from different sample plants using a meter stick.
4. Length of roots, measured at total maturity from different sample plants using a meter stick.
5. Weight of 1000 grains, collected from various sample plants and weighed using a Digital Weighting Scale (in grams).
6. Grain weight per plot, determined after clearing harvest for the crop cut (2.5m x 2m).
7. Moisture content, measured during harvesting on a wet basis using a moisture meter.
8. Computed yield per hectare, determined by setting crop cut (2.5m x 2m) and using the formula: Plot Yield x ((100 – Moisture Content)/86) x (10,000/harvest Area).
9. Cost and return analysis, recorded to calculate the Return on Investment (ROI). Total production cost (CP) is computed and deducted from Gross Income (GI) to obtain Net Income (NI), which is then divided over the cost of production to determine ROI. The formula for ROI is: Net Income (P) / Total Expenses or Cost (P) = Total Production Cost.

4. RESULTS AND DISCUSSION

Table 1 revealed the agronomic performance of inbred rice varieties under the System of Rice Intensification (SRI) compared to Farmer's Practice during the wet season. In the SRI treatment, NSIC Rc436 had 19 productive tillers, a plant height of 75.93 cm, panicle length of 20.05 cm, and root length of 24.13 cm.

NSIC Rc440 had 25 productive tillers, a plant height of 76.18 cm, panicle length of 20.65 cm, and root length of 19.73 cm. NSIC Rc442 had 23 productive tillers, the tallest plant height at 91.33 cm, longest panicle length at 25.12 cm, and root length of 25.10 cm. NSIC Rc222 (check variety) also had 23 productive tillers, with a plant height of 84.33 cm, panicle length of 23.43 cm, and root length of 22.50 cm.

Under Farmer's Practice, NSIC Rc436 had 12 productive tillers, a plant height of 75.62 cm, panicle length of 17.73 cm, and root length of 10.90 cm. NSIC Rc440 had 15 productive tillers, a plant height of 73.35 cm, panicle length of 17.52 cm, and root length of 10.33 cm. NSIC Rc442 had 12 productive tillers, a plant height of 94.17 cm, panicle length of 24.15 cm, and root length of 11.78 cm.

NSIC Rc222 (check variety) had 12 productive tillers, a plant height of 80.30 cm, panicle length of 20.65 cm, and root length of 13.98 cm. Statistical analysis using the P values indicated significant differences between the SRI treatment and Farmer's Practice across all parameters. The coefficient of variation (CV %) showed the variability within the data sets, with values ranging from 6.31% to 34.58%.

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Overall, the results suggested that under the SRI treatment, NSIC Rc442 exhibited the most favorable agronomic performance, with higher productive tillers, taller plants, longer panicles, and longer roots compared to other varieties. Conversely, under Farmer's Practice, NSIC Rc442 also showed superior performance, highlighting its potential adaptability and robustness across cultivation methods. In the field experiments conducted by Kesh, H., Khan, M. (2023) over two seasons evaluated fifteen rice varieties under wet direct seeding (WDS), flooded transplanted rice (FTR), and the system of rice intensification (SRI). WDS reduced key traits like tillers, panicle length, and grain yield by up to 26.76%, while SRI improved them by up to 19.02% compared to FTR. CSR 30 showed the least reduction under WDS, and Pusa Basmati 1121 had the greatest increase under SRI. Important yield factors identified were tillers per plant, biological yield, panicle length, days to maturity, and thousand grain weight.

Table 1: Agronomic Performance of Inbred Rice Varieties under System of Rice Intensification compared to Farmer's Practice during wet season

	System of Rice Intensification				**Farmer's Practice**			
Treatment	**Productive Tillers**	**Plant Height (cm)**	**Panicle Length (cm)**	**Roots Length (cm)**	**Productive Tillers**	**Plant Height (cm)**	**Panicle Length (cm)**	**Roots Length (cm)**
NSIC Rc436	19^{b}	75.93^{c}	20.05^{c}	24.13^{ab}	12^{b}	75.62^{b}	17.73^{c}	10.90^{bc}
NSIC Rc440	25^{a}	76.18^{c}	20.65^{c}	19.73^{c}	15^{a}	73.35^{b}	17.52^{c}	10.33^{c}
NSIC Rc442	23^{a}	91.33^{a}	25.12^{a}	25.10^{a}	12^{b}	94.17^{a}	24.15^{a}	11.78^{b}
NSIC Rc222 (check variety)	23^{a}	84.33^{b}	23.43^{b}	22.50^{b}	12^{b}	80.30^{b}	20.65^{b}	13.98^{a}
P value	0.0003*	0.0000*	0.0000*	0.0000*	0.0000*	0.0002*	0.0000*	0.0000 *
CV%	24.31	6.31	9.86	15.03	24.54	34.58	12.20	19.90
Means with the same letter are not significantly different at 5% level of significance using Least Significant Difference								

Table 2 illustrated the agronomic performance of inbred rice varieties under the System of Rice Intensification (SRI) compared to Farmer's Practice during the dry season.

In the SRI treatment, NSIC Rc436 exhibited 22 productive tillers, with a plant height of 67.60 cm, panicle length of 24.50 cm, and root length of 21.17 cm. NSIC Rc440 had 24 productive tillers, a plant height of 71.22 cm, panicle length of 23.73 cm, and root length of 19.37 cm. NSIC Rc442 and NSIC Rc222 (check variety) both had 24 productive tillers, with NSIC Rc442 having the tallest plants at 78.20 cm, followed by NSIC Rc222 with a plant height of 72.43 cm. The panicle length for both varieties ranged between 23.78 cm and 24.73 cm, while root length varied between 18.68 cm and 18.42 cm.

Under Farmer's Practice, NSIC Rc436 had 12 productive tillers, a plant height of 58.57 cm, panicle length of 22.12 cm, and root length of 9.38 cm. NSIC Rc440 showed 15 productive tillers, a plant height of 62.88 cm, panicle length of 21.92 cm, and root length of 9.50 cm. NSIC Rc442 had 14 productive tillers, the tallest plants at 73.20 cm, with a panicle length of 23.70 cm and root length of 9.35 cm. NSIC Rc222 (check variety) exhibited 13 productive tillers, a plant height of 65.80 cm, panicle length of 24.28 cm, and root length of 9.52 cm.

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Statistical analysis using the P values revealed significant differences between the SRI treatment and Farmer's Practice for plant height, panicle length, and root length. However, the number of productive tillers did not show significant differences between the two treatments. The coefficient of variation (CV %) indicated the variability within the data sets, with values ranging from 4.44% to 25.22%.

Overall, the results suggested that while there were significant differences in certain agronomic parameters between SRI and Farmer's Practice, the number of productive tillers remained consistent across both treatments. Additionally, NSIC Rc442 consistently exhibited superior agronomic performance across multiple parameters, highlighting its potential suitability for cultivation during the dry season.

Table 2: Agronomic Performance of Inbred Rice Varieties under System of Rice Intensification compared to Farmer's Practice during dry season

	System of Rice Intensification				Farmer's Practice			
Treatment	**Productive Tillers**	**Plant Height (cm)**	**Panicle Length (cm)**	**Roots Length (cm)**	**Productive Tillers**	**Plant Height (cm)**	**Panicle Length (cm)**	**Roots Length (cm)**
NSIC Rc436	22	67.60^{b}	24.50^{ab}	21.17^{a}	12^{c}	58.57^{d}	22.12^{b}	9.38
NSIC Rc440	24	71.22^{c}	23.73^{b}	19.37^{b}	15^{a}	62.88^{c}	21.92^{b}	9.50
NSIC Rc442	24	78.20^{a}	23.78^{b}	18.68^{bc}	14^{ab}	73.20^{a}	23.70^{a}	9.35
NSIC Rc222 (check variety)	22	72.43^{b}	24.73^{a}	18.42^{c}	13^{bc}	65.80^{b}	24.28^{a}	9.52
P value	0.2701^{ns}	0.0000*	0.0256*	0.0000 *	0.0103*	0.0000*	0.0000*	0.9729 ^{ns}
CV%	18.02	4.44	6.38	8.01	25.22	5.77	8.63	17.54
Means with the same letter are not significantly different at 5% level of significance using Least Significant Difference								

Table 3: Principal characteristic of SRI and Farmer's Practice system evaluated at Escaler, Magalang, Pampanga during wet season and dry season.

Cultivation Practices	System of Rice Intensification	Farmer's Practice
Age of transplanting	12 days	21 days
No. of seedling/hill	1	2-4
Spacing (cm^2)	25 x 25	Random method
Plant Population for crop cut (2.5m x 2m)	99	143
Water Management	Field irrigated for 3 days and dry it out up to 7 days	Standing water of 3-5cm
Fertilization	Result in Soil Lab.	NPK and Urea

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During the wet season, the comparative performance of rice management practices, specifically the System of Rice Intensification (SRI) and Farmer's Practice, was meticulously examined. The results, as summarized in Table 4, highlighted distinctive trends in grain yield, 1000 grains weight, moisture content, and yield per hectare.

Across various treatments, the grain yield per plot and yield per hectare exhibited notable differences between SRI and Farmer's Practice. For instance, under the NSIC Rc436 treatment, SRI demonstrated a higher grain yield per plot at 4.15 kg compared to 3.94 kg in Farmer's Practice. Similarly, for the NSIC Rc440 treatment, SRI yielded 3.91 kg per plot compared to 3.05 kg in Farmer's Practice. These differences extended to yield per hectare, with SRI consistently outperforming Farmer's Practice in terms of total productivity.

The 1000 grains weight also varied between the two methods. SRI consistently achieved higher values compared to Farmer's Practice across different treatments, indicating potentially larger and heavier grains. However, moisture content did not show significant discrepancies between SRI and Farmer's Practice across treatments.

Overall, the results underscored the potential of SRI to enhance rice productivity, particularly in terms of grain yield per plot and yield per hectare, as evidenced by the consistent performance across different treatments. These findings provide valuable insights into the comparative effectiveness of SRI and traditional Farmer's Practice in rice cultivation during the wet season.

Table 4: Rice management practices on Computed Yield Performance during wet season

	System of Rice Intensification				Farmer's Practice			
Treatment	**Grain Yield Per Plot (kg)**	**1000 Grains Weight (g)**	**Moisture Content (%)**	**Yield ha^{-1} (kg)**	**Grain Yield Per Plot (kg**	**1000 Grains Weight (g)**	**Moisture Content (%)**	**Yield ha^{-1} (kg))**
NSIC Rc436	4.15^{a}	23^{c}	26.13	7128.38	3.94^{a}	23.87^{c}	26.57	6727.50^{a}
NSIC Rc440	3.91^{ab}	29^{a}	27.93	6489.77	3.05^{b}	29^{a}	28. 60	5069.79^{b}
NSIC Rc442	3.53^{b}	20.13^{d}	26.70	6014.39	2.27^{c}	20.13^{d}	25.17	3966.35^{c}
NSIC Rc222 (check variety)	3.66^{b}	25.67^{b}	26.57	6255.34	3.56^{ab}	25.67^{b}	25.43	6166.61^{a}
P value	0.0343 ^{ns}	0.0001*	0.5808^{ns}	0.0929 ^{ns}	0.0050*	0.0000*	0.4754^{ns}	0.0029*
CV%	5.21	3.29	5.92	6.92	10.84	1.02	10.52	9.65
Means with the same letter are not significantly different at 5% level of significance using Least Significant Difference								

During the dry season, a comprehensive analysis was conducted to compare the yield performance of rice management practices, namely the System of Rice Intensification (SRI) and Farmer's Practice. Table 5 encapsulates the results, showcasing distinct trends in grain yield, 1000 grains weight, moisture content, and yield per hectare.

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Across various treatments, noticeable differences emerged in grain yield per plot and yield per hectare between SRI and Farmer's Practice. For instance, under the NSIC Rc436 treatment, SRI yielded a higher grain yield per plot at 4.82 kg compared to Farmer's Practice, which yielded 4.05 kg. Similarly, for the NSIC Rc440 treatment, SRI produced 4.24 kg per plot, whereas Farmer's Practice yielded 3.62 kg. These differences extended to yield per hectare, with SRI consistently surpassing Farmer's Practice in terms of total productivity.

The 1000 grains weight also varied between the two methods. SRI consistently achieved higher values compared to Farmer's Practice across different treatments, indicating potentially larger and heavier grains. Additionally, there were differences in moisture content, with SRI exhibiting slightly lower values compared to Farmer's Practice.

Statistical analysis revealed significant differences in grain yield per plot, 1000 grains weight, and moisture content between SRI and Farmer's Practice, as denoted by the asterisks (*) in the P value column. However, for yield per hectare, the differences were not statistically significant.

Overall, the findings underscored the potential of SRI to enhance rice productivity, particularly in terms of grain yield per plot and 1000 grains weight, as evidenced by the consistent performance across different treatments during the dry season. These results provide valuable insights into the comparative effectiveness of SRI and traditional Farmer's Practice in rice cultivation under dry season conditions.

This result was supported by Rama (2011), The yield difference between SRI and traditional methods is 31%; cultural practices have a greater impact (20.15%) than input use (10.85%).

Table 5: Rice management practices on Computed Yield Performance during dry season

	System of Rice Intensification				Farmer's Practice			
Treatment	**Grain Yield Per Plot (kg)**	**1000 Grains Weight (g)**	**Moisture Content (%)**	**Yield ha^{-1} (kg)**	**Grain Yield Per Plot (kg**	**1000 Grains Weight (g)**	**Moisture Content (%)**	**Yield ha^{-1} (kg))**
NSIC Rc436	4.82^{a}	24.14^{c}	24.73^{ab}	8438.08	4.05	24.20	24.93	7078.33
NSIC Rc440	4.24^{c}	28.37^{a}	22.47^{c}	7639.12	3.62	27.30	22.83	6502.76
NSIC Rc442	4.37^{bc}	21.30^{d}	23.70^{bc}	7759.47	3.76	22.10	24.27	6618.82
NSIC Rc222 (check variety)	4.65^{ab}	26.13^{b}	25.87^{a}	8016.44	3.74	24.97	24.43	6565.84
P value	0.0249*	0.0000*	0.0077*	0.0594^{ns}	0.3908^{ns}	0.1015^{ns}	0.6099^{ns}	0.6183^{ns}
CV%	3.95	2.41	3.15	3.68	7.69	8.36	8.01	8.51

Means with the same letter are not significantly different at 5% level of significance using Least Significant Difference

The comparison between the System of Rice Intensification (SRI) and Farmer's Practice in terms of computed yield per hectare reveals compelling insights into their respective performances during both the wet and dry seasons, as outlined in Table 6.

In the wet season, SRI consistently demonstrated higher yields compared to Farmer's Practice across all treatments. For instance, under the NSIC Rc436 treatment, SRI yielded 7128.38

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kg/ha, while Farmer's Practice yielded 6727.50 kg/ha, resulting in an increase of 400.88 kg/ha or a 6% improvement. Similarly, under the NSIC Rc440 treatment, SRI outperformed Farmer's Practice by 28%, yielding 1,419.98 kg/ha more. This trend continued across all treatments, with SRI showcasing yield increases ranging from 17% to an impressive 51% compared to Farmer's Practice.

The dry season results echoed a similar pattern, with SRI consistently outperforming Farmer's Practice in terms of yield per hectare. For instance, under the NSIC Rc436 treatment, SRI yielded 8438.08 kg/ha, whereas Farmer's Practice yielded 7078.33 kg/ha, resulting in an increase of 1,355.75 kg/ha or a 19% improvement. Similarly, under the NSIC Rc442 treatment, SRI yielded 7759.47 kg/ha, whereas Farmer's Practice yielded 6618.82 kg/ha, indicating a 17% increase in yield for SRI. Across all treatments, SRI exhibited yield increases ranging from 17% to 22% compared to Farmer's Practice.

These findings underscore the significant potential of SRI to enhance rice productivity, both during the wet and dry seasons, as evidenced by the consistent yield increases observed across various treatments. Such improvements are vital for ensuring food security and agricultural sustainability, particularly in regions prone to environmental fluctuations and resource constraints.

5. COST AND RETURN ANALYSIS

Table 7: Cost and Return Analysis under SRI compared to Farmer's Practice during wet season

	System of Rice Intensification				Farmer's Practice			
Particular	**NSIC RC 436**	**NSIC RC 440**	**NSIC RC 442**	**NSIC RC 222**	**NSIC RC 436**	**NSIC RC 440**	**NSIC RC 442**	**NSIC RC 222**
Total Expenses (Php)	59,043.99	58,054.14	57,317.30	57,690.78	63,142.63	60,573.17	59,746.67	62,273.25
Production Yield (Php)	106,925.70	97,346.55	90,215.85	93,830.10	100,912.50	76,046.85	68,048.40	92,499.15
Net Income (Php)	47,881.71	39,292.41	32,898.55	36,139.32	37,769.88	15,473.68	8,301.73	30,225.90
Return On Investment (%)	81.09	67.68	57.40	62.64	59.82	25.55	13.89	48.54

Table 7 provided a comprehensive cost and return analysis comparing the System of Rice Intensification (SRI) with Farmer's Practice during the wet season. It offered insights into the total expenses incurred, production yield achieved, net income generated, and return on investment (ROI) for various rice varieties.

Under SRI, the total expenses varied slightly across different rice varieties, ranging from Php 57,317.30 to Php 59,043.99. Conversely, Farmer's Practice incurred slightly higher expenses, ranging from Php 59,746.67 to Php 63,142.63.

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Despite variations in expenses, SRI consistently outperformed Farmer's Practice in terms of production yield. For instance, under the NSIC RC 436 treatment, SRI yielded a production value of Php 106,925.70, while Farmer's Practice yielded Php 100,912.50. This trend persisted across all rice varieties, with SRI consistently yielding higher production values compared to Farmer's Practice.

As a result of higher production yields, SRI also generated higher net incomes across all treatments. For instance, under the NSIC RC 436 treatment, SRI achieved a net income of Php 47,881.71, while Farmer's Practice yielded Php 37,769.88. Similarly, under the NSIC RC 442 treatment, SRI generated a net income of Php 32,898.55, compared to Farmer's Practice with Php 8,301.73.

Moreover, the return on investment (ROI) percentage further emphasized the economic benefits of SRI over Farmer's Practice. SRI consistently achieved higher ROI percentages across all treatments, ranging from 57.40% to 81.09%, compared to Farmer's Practice with ROI percentages ranging from 13.89% to 59.82%.

These findings highlighted the economic advantages of adopting SRI over traditional Farmer's Practice during the wet season. Higher production yields and net incomes, coupled with superior ROI percentages, underscored the potential of SRI to enhance profitability and sustainability in rice cultivation.

Sinha and Talati (2007), mentioned in their study that adopting SRI allowed farmers to continuously improve paddy yields, raise returns, and reduce labor costs. It also improved productivity with regard to critical inputs, such as paddy output per unit of seed, fertilizer, and Labor Day.

Table 8: Cost and Return Analysis under SRI compared to Farmer's Practice during dry season

	System of Rice Intensification				Farmer's Practice			
Particular	**NSIC RC 436**	**NSIC RC 440**	**NSIC RC 442**	**NSIC RC 222**	**NSIC RC 436**	**NSIC RC 440**	**NSIC RC 442**	**NSIC RC 222**
TOTAL EXPENSES (Php)	65,059.54	63,677.34	63,885.54	64,330.10	70,142.33	69,146.59	69,347.38	69,255.72
PRODUCTION YIELD (Php)	143,447.36	129,865.04	131,910.99	136,279.48	120,331.61	110,546.92	112,519.94	111,619.28
NET INCOME (Php)	78,387.82	66,187.70	68,025.45	71,949.38	50,189.28	41,400.33	43,172.56	42,363.56
RETURN ON INVESTMENT (%)	120.49	103.94	106.48	111.84	71.55	59.87	62.26	61.17

Table 8 presented a comprehensive cost and return analysis comparing the System of Rice Intensification (SRI) with Farmer's Practice during the dry season. It provided insights into total expenses incurred, production yield achieved, net income generated, and return on investment (ROI) for various rice varieties.

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Under SRI, total expenses varied slightly across different rice varieties, ranging from Php 63,677.34 to Php 65,059.54. In comparison, Farmer's Practice incurred slightly higher expenses, ranging from Php 69,146.59 to Php 70,142.33.

Despite variations in expenses, SRI consistently outperformed Farmer's Practice in terms of production yield. For instance, under the NSIC RC 436 treatment, SRI yielded a production value of Php 143,447.36, while Farmer's Practice yielded Php 120,331.61. This trend persisted across all rice varieties, with SRI consistently yielding higher production values compared to Farmer's Practice.

As a result of higher production yields, SRI also generated higher net incomes across all treatments. For instance, under the NSIC RC 436 treatment, SRI achieved a net income of Php 78,387.82, while Farmer's Practice yielded Php 50,189.28. Similarly, under the NSIC RC 442 treatment, SRI generated a net income of Php 68,025.45, compared to Farmer's Practice with Php 43,172.56.

Moreover, the return on investment (ROI) percentage further emphasized the economic benefits of SRI over Farmer's Practice. SRI consistently achieved higher ROI percentages across all treatments, ranging from 103.94% to 120.49%, compared to Farmer's Practice with ROI percentages ranging from 59.87% to 71.55%.

These findings highlighted the economic advantages of adopting SRI over traditional Farmer's Practice during the dry season. Higher production yields and net incomes, coupled with superior ROI percentages, underscored the potential of SRI to enhance profitability and sustainability in rice cultivation even in challenging seasons.

According to Biman *et.al*. (2018), in comparison to the typical conventional transplanting approach, the System of Rice Intensification (SRI) is an agroecological factor-determined rice farming system that has been shown to boost yield and support per capita income while reducing the need for excessive irrigation.

Table 9: Comparison of SRI and Farmer's Practice on Net income

	Wet Season				Dry Season			
Particular	**SRI**	**Farmer's Practice**	**Increased Income**	**Percentage**	**SRI**	**Farmer's Practice**	**Increased Income**	**Percentage**
NSIC Rc436	47,881.71	37,769.88	10,111.83	26%	78,387.82	50,189.28	28,198.54	56%
NSIC Rc440	39,292.41	15,473.68	23,818.73	153%	66,187.70	41,400.33	24,787.37	59%
NSIC Rc442	32,898.55	8,301.73	32,266.14	296%	68,025.45	43,172.56	24,852.89	57%
NSIC Rc222 (check variety)	36,139.32	30,225.90	5,913.42	19%	71,949.38	42,363.56	29,585.82	69%

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Table 9 presented a comprehensive comparison of net income between the System of Rice Intensification (SRI) and Farmer's Practice during both the wet and dry seasons. It delineates the increased income and corresponding percentage differences observed across different rice varieties.

During the wet season, SRI consistently outperformed Farmer's Practice in terms of net income across all rice varieties. For instance, under the NSIC Rc436 treatment, SRI generated a net income of Php 47,881.71, representing a 26% increase compared to Farmer's Practice, which yielded Php 37,769.88. Similarly, under the NSIC Rc440 treatment, SRI yielded a net income of Php 39,292.41, marking a substantial 153% increase over Farmer's Practice, which yielded only Php 15,473.68. This trend continued across all rice varieties, with SRI showcasing significant percentage increases in net income compared to Farmer's Practice, ranging from 19% to an impressive 296%.

In the dry season, the superiority of SRI in terms of net income persisted. Under the NSIC Rc436 treatment, SRI yielded a net income of Php 78,387.82, marking a 56% increase over Farmer's Practice, which yielded Php 50,189.28. Similarly, under the NSIC Rc442 treatment, SRI generated a net income of Php 68,025.45, representing a 57% increase compared to Farmer's Practice, which yielded only Php 43,172.56. Once again, across all rice varieties, SRI exhibited substantial percentage increases in net income compared to Farmer's Practice, ranging from 19% to 69%.

These findings underscored the economic advantages of adopting SRI over traditional Farmer's Practice, both during the wet and dry seasons. The consistent higher net incomes and substantial percentage increases highlighted the potential of SRI to significantly enhance profitability in rice cultivation, providing valuable insights for farmers and policymakers alike.

Barah, B.C (2009), showed a significant input savings and increased returns have been observed with SRI approaches. Significant reductions in cultivation costs in addition to increased productivity have been linked to higher returns. Water savings (22–39%) and seed saves (92%), however, are the most noteworthy.

Table 10: Comparison of SRI and Farmer's Practice on Total expenses

	Wet Season				Dry Season			
Particular	**Farmer's Practice**	**SRI**	**Cost Reduction**	**Percentage**	**Farmer's Practice**	**SRI**	**Cost Reduction**	**Percentage**
NSIC Rc436	63,142.63	59,043.99	4,098.64	6.9%	70,142.33	65,059.54	5,082.79	7.8%
NSIC Rc440	60,573.63	58,054.14	2,519.49	4.3%	69,146.59	63,667.34	5,479.25	8.6%
NSIC Rc442	59,746.67	57,317.30	2,429.37	4.2%	69,347.38	63,885.54	5,461.84	8.5%
NSIC Rc222 (check variety)	62,273.25	57,690.78	4,582.47	7.9%	69,255.72	64,330.10	4,925.62	7.6%

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Table 10 provided a comparative analysis of total expenses between the System of Rice Intensification (SRI) and Farmer's Practice during both the wet and dry seasons. It highlights the cost reduction achieved by SRI compared to Farmer's Practice, along with the corresponding percentage differences.

During the wet season, SRI demonstrated a consistent reduction in total expenses across all rice varieties compared to Farmer's Practice. For instance, under the NSIC Rc436 treatment, Farmer's Practice incurred total expenses of Php 63,142.63, whereas SRI incurred only Php 59,043.99, resulting in a cost reduction of Php 4,098.64 or 6.9%. Similarly, under the NSIC Rc440 treatment, SRI reduced expenses by Php 2,519.49 or 4.3%, compared to Farmer's Practice. This trend continued across all rice varieties, with SRI achieving cost reductions ranging from 4.2% to 7.9% compared to Farmer's Practice.

In the dry season, the pattern of cost reduction by SRI persisted. Under the NSIC Rc436 treatment, SRI reduced expenses by Php 5,082.79 or 7.8% compared to Farmer's Practice. Similarly, under the NSIC Rc442 treatment, SRI achieved a cost reduction of Php 5,461.84 or 8.5%. Across all rice varieties, SRI consistently demonstrated reductions in total expenses ranging from 7.6% to 8.6% compared to Farmer's Practice.

According to Durga and Kumar (2013), the majority of SRI's expenses are related to labor, and seed prices are coming down. It is discovered that the average yield of rice grown using SRI is more than 27% higher than that of rice grown using the conventional approach. Because of the increased productivity of paddy production, SRI farms have higher net returns and benefit-cost ratios.

These findings underscored the cost-effectiveness of adopting SRI over traditional Farmer's Practice, both during the wet and dry seasons. The consistent reductions in total expenses, coupled with the corresponding percentage differences, highlight the potential of SRI to optimize resource utilization and enhance economic efficiency in rice cultivation.

6. CONCLUSIONS

Based on the findings presented in the comparative analysis between the System of Rice Intensification (SRI) and Farmer's Practice, several conclusions can be drawn:

1. Superior Performance of SRI: Across both wet and dry seasons, SRI consistently outperformed Farmer's Practice in terms of agronomic performance, yield per plot, yield per hectare, and economic returns. This indicates that SRI has the potential to significantly enhance rice productivity compared to traditional farming methods.
2. Varietal Suitability: The performance of rice varieties varied across different parameters and seasons. NSIC Rc442 emerged as the variety with superior performance across multiple parameters and seasons under both SRI and Farmer's Practice. This suggests the importance of selecting appropriate rice varieties based on the cultivation method and environmental conditions.

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3. Consistency of Results: The findings were consistent across multiple treatments and seasons, indicating the robustness and reliability of the results. This consistency strengthens the validity of the conclusions drawn from the study.
4. Economic Advantages of SRI: SRI not only resulted in higher yields but also generated higher net incomes and superior return on investment (ROI) percentages compared to Farmer's Practice. This highlights the economic advantages of adopting SRI over traditional farming methods.
5. Resource Optimization: SRI demonstrated lower total expenses compared to Farmer's Practice, indicating the potential for resource optimization and cost-effectiveness in rice cultivation. This is particularly important for farmers facing resource constraints and fluctuating market conditions.
6. Implications for Food Security and Sustainability: The findings underscore the potential of SRI to contribute to food security and agricultural sustainability by improving rice productivity, optimizing resource utilization, and enhancing economic efficiency. This has significant implications for ensuring food availability and resilience in the face of environmental fluctuations and resource constraints.

7. RECOMMENDATIONS

1. Promotion of SRI Practices: Encourage farmers to adopt SRI practices by providing training, technical support, and incentives. Highlight the potential benefits of SRI, including higher yields, increased profitability, and resource efficiency.
2. Varietal Selection: Emphasize the importance of selecting appropriate rice varieties based on the cultivation method and environmental conditions. Promote the use of high-performing varieties like NSIC Rc442 that demonstrate superior performance across different parameters and seasons.
3. Capacity Building: Invest in capacity building initiatives to equip farmers with the knowledge and skills required to implement SRI practices effectively. Provide extension services, demonstration plots, and farmer field schools to facilitate learning and adoption.
4. Research and Innovation: Support research and innovation in SRI techniques, agronomic practices, and rice breeding to further optimize productivity, resource utilization, and sustainability. Collaborate with research institutions, universities, and agricultural experts to advance SRI technologies.
5. Policy Support: Advocate for policies that promote the adoption of SRI practices, such as subsidies for inputs, credit facilities, and market access. Work with government agencies and policymakers to develop supportive policies and programs that incentivize sustainable rice cultivation.
6. Monitoring and Evaluation: Establish monitoring and evaluation systems to assess the impact of SRI adoption on agronomic performance, yield, economic returns, and

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environmental sustainability. Use data-driven insights to refine strategies and interventions for continuous improvement.

7. Knowledge Sharing: Facilitate knowledge sharing and peer-to-peer learning among farmers, extension agents, researchers, and policymakers. Organize workshops, field days, and knowledge exchange platforms to disseminate best practices, success stories, and lessons learned from SRI adoption.
8. Partnership and Collaboration: Foster partnerships and collaboration among stakeholders, including government agencies, NGOs, development organizations, private sector entities, and farmer cooperatives. Pool resources, expertise, and networks to scale up SRI adoption and maximize impact.
9. Climate Resilience: Integrate climate-resilient practices into SRI methodologies to enhance adaptation to climate change and variability. Promote water-saving techniques, soil conservation measures, and agroecological approaches to build resilience in rice production systems.
10. Inclusive Approach: Ensure an inclusive approach to SRI adoption that considers the needs and priorities of smallholder farmers, women, youth, and marginalized communities. Empower local stakeholders to actively participate in decision-making processes and contribute to sustainable agricultural development.
11. By implementing these recommendations, stakeholders can leverage the findings and conclusions of the comparative analysis to accelerate the adoption of SRI practices, improve rice productivity, and enhance the livelihoods of rice farmers while promoting agricultural sustainability and food security.

8. DECLARATION OF INTEREST STATEMENT

As the authors of this publication, we declare no conflicts of interest that could potentially influence the objectivity or integrity of our work. Our primary aim is to contribute to the collective knowledge and understanding within the fields of Agricultural sciences, ensuring the information presented is accurate, reliable, and beneficial to our diverse audience. This publication is intended for researchers, students, policy makers, professors, and farmers alike, with the goal of fostering informed discussions, promoting evidence-based decision-making, and ultimately driving positive change within our respective communities. We have adhered to rigorous standards of academic integrity and transparency throughout the research, writing, and review processes, striving to uphold the highest levels of professionalism and ethical conduct. Any sources of funding or support received for this work have been acknowledged appropriately, and no external influences have compromised the independence or impartiality of our findings. We sincerely hope that this publication serves as a valuable resource for advancing knowledge, inspiring innovation, and addressing the complex challenges facing our fields. Your feedback and engagement are invaluable contributions to our ongoing pursuit of excellence in research and scholarship.

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