PERFORMANCE OF RICE VARIETIES UNDER VARIOUS PLANTING TECHNIQUES: A COMPARATIVE ANALYSIS

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Abstract

This study was conducted to evaluate the performance of rice varieties under various planting techniques at Bual Norte, Midsayap, Cotabato, 2025. Using a descriptive research design, key growth and yield parameters such as plant height, leaf area index, tiller number, panicle number and length, percentage of filled and unfilled grains, and grain yield were gathered and analyzed. Results show that the genetic characteristics of rice varieties significantly influenced plant height, panicle length, with NSIC Rc630 which exhibited a superior growth. The difference planting techniques notably affected the grain filling and overall yield. Manual transplanting consistently resulted a higher grain yield and better panicle number, while Manual Direct Seeding promoted better grain filling with high percentage of filled grains and fewer unfilled grains. Interaction effects between variety and planting techniques were significant for some traits, suggesting that the combination of suitable varieties with appropriate planting techniques can optimize rice performance. These findings highlight the critical role of planting techniques alongside varietal choice in enhancing rice productivity in irrigated systems. Moreover, farmers should consider both varietal characteristics and planting techniques to achieve the best economic outcomes in irrigated rice production. Further studies are recommended to explore the synergistic effects of rice variety and planting techniques across multiple seasons with varying environmental conditions.

KEYWORDS: *Planting techniques, varieties, irrigated, direct seeding, filled grains*

INTRODUCTION

Rice production is a cornerstone of agricultural economies in Southern Asia, providing not only staple food but livelihood for millions of people in the Philippines, especially in irrigated area of farmers where rice cultivation is a primary economic activity, improving resilience against environmental stresses. with advancements in rice varieties and a growing emphasis on mechanized and efficient farming practices, the need to evaluate diverse establishment methods in conjunction with high-yielding varieties has become increasingly essential. This study on the performance of two widely cultivated rice varieties in the Philippines: NSIC Rc222 and NSIC Rc630, known for its adaptability and high yield potential, and favored for its resistance to common rice diseases and pests, and recommended domain for national irrigated lowland area and applicable for wet and dry season planting. By assessing these varieties through four crop establishment methods like Manual Direct Seeding,

Manual Transplanting, Mechanical Transplanting, and the Drum Seeder method-this research aims to identify and determine which combination of rice variety and crop establishment technique maximizes productivity, minimizes input requirements, and achieves cost efficiency in the context of irrigated rice farming landscape. By conducting a thorough analysis of each treatment's impact on yield performance, labor and input efficiency, and cost-benefit outcomes. This research will provide data-driven recommendations to support farmers, extension officers, and policymakers in making information decisions. The findings aim to advance sustainable agricultural practices that align with local constraints and opportunities, ultimately enhancing rice productivity and supporting food security and economic stability in the region. In an era where innovation in agriculture is essential to meet the demands of a growing population, this research contributes valuable insights into the integration of traditional knowledge with modern technologies, fostering a more resilient and productive rice farming sector in Midsayap and similar rural areas across the Philippines.

Statement of the Problem

Generally, this study aimed to evaluate the effectiveness of the rice variety and the various planting techniques in terms of plant height (cm) Leaf area index, number of tillers, number of panicles, length of panicles, percent filled grains, percent unfilled grains, and grain yield in tons/ha. Specially, this study sought to fine answers to the following questions:

1. What is the common rice varieties planted by the rice farmers?
2. What are the different rice crop establishment techniques of the rice farmers?
3. Which among the rice planting techniques that would give optimum yield on each varieties?
4. Which among the varieties planting techniques generates the highest net returns, benefits cost-ratio and most practical?

METHODS

This study was conducted using the two-way Analysis of Variance (ANOVA). This is a statistical technique used to examine the relationship between two independent variables (factors) and a continuous dependent variable. This helps to determine if there are significant differences in the dependent variable due to each independent variable. This is also to examine the interaction effect of one variable depends on the level of the other independent variable. The two-way ANOVA would help answer the questions:

1. Does the yield of rice vary significantly between the different varieties?
2. Does the yield of rice vary significantly between different planting techniques?
3. Is there an interaction effect between rice variety and planting techniques on yield?

A convenience sampling method was used to select three 1m × 1m quadrats per plot along a diagonal transect. These were designated as permanent sampling areas for evaluating the performance indicators of each treatment combination.

The study utilized the following instruments: Modified Agronomic Data Gathering Forms, placards, record books, meter sticks, fertilizers, pesticides, weighing scales, and other field tools.

RESULTS AND DISCUSSION

The results of the study revealed that rice plant height was significantly influenced by the variety, while the transplanting technique alone did not have a statistically significant effect. Based on the Two-Factor ANOVA, the main effect of variety yielded an F-value of 9.52 with a p-value of 0.007, indicating a statistically significant difference at the 5% level. This suggests that the inherent genetic characteristics of the rice varieties, NSIC Rc222 and NSIC Rc630, contributed significantly to the differences in plant height. On average, NSIC Rc630 exhibited taller plant heights across all transplanting methods compared to NSIC Rc222, with individual plant height values consistently above 127 cm and peaking at 135 cm. In contrast, NSIC Rc222 values ranged mostly between 120.7 cm and 129.7 cm.

Conversely, the main effect of transplanting technique produced an F-value of 0.11 and a p-value of 0.951, signifying no statistically significant impact on plant height when considered independently of the rice variety. Despite observable numerical variations—such as taller plants under manual direct seeding (MDS) and manual transplanting (MT)—these differences were not enough to be considered statistically meaningful. Interestingly, however, the interaction between variety and transplanting technique was statistically significant ($F = 3.52$, $p = 0.039$), suggesting that the effect of transplanting method on plant height depends on the variety used. For instance, while NSIC Rc222 recorded its tallest growth (129.7 cm) under MDS, NSIC Rc630 reached its peak height (135.0 cm) under manual transplanting (MT), highlighting a synergistic effect between specific variety-method combinations.

The effect sizes, as measured by partial eta squared (η^2), further underscore the findings. The interaction effect had the highest η^2 value of 0.398, followed closely by the variety effect ($\eta^2 = 0.373$), indicating that nearly 40% of the variability in plant height can be attributed to the combined effect of variety and transplanting method. In contrast, the transplanting technique alone accounted for only 2% of the variance,

reinforcing its minimal independent influence. These findings imply that the selection of rice variety plays a more crucial role in determining plant height, but the interaction with the method of transplanting can further optimize growth, particularly when the method is aligned with the variety's physiological response. This has practical implications for rice farmers, as matching the appropriate transplanting technique to the variety can enhance growth performance and potentially lead to better yield outcomes.

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Table 1. Plant height (cm) of NSIC Rc222 and NSIC Rc630 under various planting techniques

Plant height (cm)	MT	Mech T	MDS	DSP
Treatment V1: NSIC Rc222	124.0	123.0	129.7	128.0
	123.0	124.7	129.3	126.3
	122.3	121.3	120.7	126.3
Treatment V2: NSIC Rc630	135.0	133.7	129.7	127.3
	129.3	127.7	126.7	126.0
	128.7	127.0	125.3	124.7

MEAN

	MT	Mech T	MDS	DSP	
Treatment V1: NSIC Rc222	123.11	123.00	126.56	126.89	124.89
Treatment V2: NSIC Rc630	131.00	129.44	127.22	126.00	128.42
	127.06	126.22	126.89	126.44	126.65

ANOVA **Alpha 0.05**

	SS	*df*	*MS*	*F*	*p-value*	*p eta-sq*
Variety	74.6712963	1	74.6712963	9.521251476	0.007089724	0.373071496
Technique	2.680555556	3	0.893518519	0.113931523	0.950667403	0.020915363
Interaction	82.8287037	3	27.6095679	3.520464384	0.039371238	0.397621958
Within	125.4814815	16	7.842592593			
Total	285.662037	23	12.42008857			

Variety	**Significant**
Technique	**Not Significant**
Interaction	**Significant**

Leaf Area Index (LAI)

The Leaf Area Index (LAI) is a crucial indicator of canopy development and photosynthetic potential in rice plants. It reflects the total leaf area relative to the ground area and directly influences light interception, biomass accumulation, and ultimately crop yield. This study evaluated the LAI of two rice varieties—NSIC Rc222 (V1) and NSIC Rc630 (V2)—under four rice crop establishment techniques: Manual Transplanting (MT), Mechanical Transplanting (MechT), Manual Direct Seeding (MDS), and Drum Seeder Planting (DSP).

Based on the descriptive data, LAI values across all treatments ranged narrowly between 5.0 and 5.6. NSIC Rc222 showed relatively higher consistency and slightly greater LAI in most establishment methods, particularly under Drum Seeder Planting (5.3), while NSIC Rc630 showed comparable but slightly more variable readings across treatments.

The results of the two-way ANOVA revealed the following:

Effect of Variety: The statistical analysis showed that the rice variety had no significant effect on LAI, as indicated by a p-value of 1.000, which is far above the 0.05 significance level. The calculated F-value was practically zero, confirming that the observed variation in LAI between NSIC Rc222 and NSIC Rc630 was not statistically meaningful. This suggests that both varieties possess similar leaf area development potential under the given environmental and management conditions.

Effect of Technique: Likewise, the crop establishment technique did not significantly influence LAI ($p = 0.549$). Although minor variations were observed—for example, slightly higher LAI in DSP and MechT—the differences among the four techniques were statistically insignificant. This implies that under optimal irrigation and nutrient conditions, the method of establishment may not drastically alter leaf area expansion in rice.

Interaction Effect: The interaction between variety and technique, while not statistically significant ($p = 0.099$), showed a moderate effect size (partial eta squared = 0.316), suggesting some degree of interaction worth noting. Although not crossing the threshold of significance, this interaction implies that certain combinations of variety and planting method may tend toward better LAI performance. For instance, NSIC Rc222 under DSP and NSIC Rc630 under MechT exhibited slightly higher LAI values, which could be explored further in follow-up studies with increased replication.

In summary, while the differences in LAI among varieties and techniques were not statistically significant, the moderate interaction effect points to possible agronomic synergies that may benefit from further investigation. The relatively uniform LAI values across treatments suggest that both varieties are adaptable to different planting methods in terms of leaf area development, offering flexibility to farmers in choosing planting techniques without compromising canopy vigor.

Table 2. LAI of NSIC Rc222 and NSIC Rc630 under various planting techniques

Leaf Area Index	MT	Mech T	MDS	DSP
Treatment V1: NSIC Rc222	5.1	5.1	5.0	5.3
	5.4	5.1	5.6	5.3
	5.4	5.2	5.1	5.1
Treatment V2: NSIC Rc630	5.1	5.5	5.1	5.2
	5.2	5.4	5.1	5.2
	5.3	5.3	5.0	5.3

MEAN

	MT	Mech T	MDS	DSP	
Treatment V1: NSIC Rc222	5.30	5.13	5.23	5.23	5.23
Treatment V2: NSIC Rc630	5.20	5.40	5.07	5.23	5.23
	5.25	5.27	5.15	5.23	5.23

ANOVA					Alpha	0.05
	SS	*df*	*MS*	*F*	*p-value*	*p eta-sq*
Variety	9.46633E-30	1	9.46633E-30	4.28664E-28	1	2.67915E-29
Technique	0.048333333	3	0.016111111	0.729559748	0.549252128	0.12033195
Interaction	0.163333333	3	0.054444444	2.465408805	0.099667953	0.316129032
Within	0.353333333	16	0.022083333			
Total	0.565	23	0.024565217			

Variety	**Significant**
Technique	**Not Significant**
Interaction	**Not Significant**

Number of Tillers

Based on the data collected and the results of the statistical analysis, the number of tillers produced by rice plants was assessed in response to the interaction between rice variety and planting technique. Descriptively, Treatment V1 (NSIC Rc222) generally produced a higher number of tillers under Manual Transplanting (MT), with a mean ranging from 19.7 to 21.3, while Treatment V2 (NSIC Rc630) showed higher tiller counts under Mechanical Transplanting (Mech T) and Manual Direct Seeding (MDS), reaching up to 21.0 and 20.0, respectively. Across all techniques, NSIC Rc222 tended to produce more tillers under traditional transplanting methods, while NSIC Rc630 showed more consistent tiller development under mechanized or direct seeding systems.

However, the results of the two-way Analysis of Variance (ANOVA) revealed that none of the main effects—variety ($F = 1.36$, $p = 0.26$) or technique ($F = 0.22$, $p = 0.88$)—were statistically significant at the 0.05 alpha level. Likewise, the interaction between variety and technique ($F = 2.10$, $p = 0.14$) did not reach statistical significance, although it presented the highest partial eta-squared value ($\eta^2 = 0.282$), indicating a small to moderate effect size. This suggests that while there was no statistically significant difference in tiller number due to variety, technique, or their interaction, the combination of variety and method may still have a notable practical influence on tiller production.

The observed differences in tiller counts may be attributed to the varietal response to transplanting stress, soil-root establishment efficiency, or inherent genetic traits that affect tillering ability. NSIC Rc222's superior performance under manual transplanting could indicate better adaptability to more controlled, labor-intensive planting systems. On the other hand, NSIC Rc630's higher tiller production under Mech T and MDS implies that it may be more suited to mechanized or direct sowing conditions, potentially due to its early vigor or root-shoot balance under less intensive management.

In conclusion, although the differences were not statistically significant, the practical variations observed in tiller number suggest that selecting a variety

compatible with a specific transplanting technique may optimize vegetative growth. Further studies with a larger sample size or across different growing seasons may provide stronger evidence for these trends and support more definitive recommendations for rice farmers.

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Table 3. Number of Tillers of NSIC Rc222 and NSIC Rc630 under various planting techniques

Number of Tillers	MT	Mech T	MDS	DSP
Treatment V1: NSIC Rc222	19.7	17.8	17.2	17.6
	21.3	19.3	17.6	17.6
	20.0	19.3	18.4	20.0
Treatment V2: NSIC Rc630	17.3	20.0	20.0	20.0
	17.0	21.0	17.8	16.9
	16.7	15.0	17.8	17.6

MEAN

	MT	Mech T	MDS	DSP	
Treatment V1: NSIC Rc222	20.33	18.80	17.73	18.40	18.82
Treatment V2: NSIC Rc630	17.00	18.67	18.53	18.17	18.09
	18.67	18.73	18.13	18.28	18.45

ANOVA — Alpha 0.05

	SS	*df*	*MS*	*F*	*p-value*	*p eta-sq*
Variety	3.15375	1	3.15375	1.36214757	0.260265899	0.078455016
Technique	1.53125	3	0.510416667	0.220455909	0.880765066	0.039694684
Interaction	14.58125	3	4.860416667	2.099280144	0.140589001	0.282441721
Within	37.04444444	16	2.315277778			
Total	56.31069444	23	2.448291063			

Variety	**Not Significant**
Technique	**Not Significant**
Interaction	**Not Significant**

Number of Panicles

The analysis of the number of panicles per plant revealed variations influenced by both rice variety and crop establishment techniques, although these differences were not statistically significant at the 0.05 alpha level. Treatment V1 (NSIC Rc222) consistently produced a higher number of panicles across most transplanting methods compared to Treatment V2 (NSIC Rc630). The highest number of panicles per plant was observed under Manual Transplanting (MT) for NSIC Rc222, with an average of 20.0 panicles, followed by Mechanical Transplanting (MechT) at 18.1. Conversely, NSIC Rc630 showed a more variable response, with the highest mean number of panicles recorded under Mechanical Transplanting (18.7) and Drum Seeder Planting (17.8). Despite these trends, the overall ANOVA results showed that neither the main effect of variety ($F = 1.11$, $p = 0.308$) nor crop establishment technique ($F = 0.30$, $p = 0.826$) produced statistically significant differences. Likewise, the interaction effect between variety and technique was also not significant ($F = 1.72$, $p = 0.204$), indicating that the combined influence of variety and method of transplanting did not significantly affect the number of panicles per plant.

Nevertheless, effect size analysis provides additional insight into the observed trends. The partial eta squared values suggest a moderate practical effect of the interaction between variety and technique ($\eta^2 = 0.244$), implying that while statistical significance was not achieved, the interaction may still have a meaningful influence under field conditions. This suggests that specific combinations of variety and transplanting method, such as NSIC Rc222 with Manual Transplanting, may offer agronomic advantages that warrant further investigation, particularly in large-scale or long-term studies. The overall variability observed within the dataset, as reflected in the relatively high within-group mean square (2.23), may have contributed to the lack of statistical significance, emphasizing the importance of replication and environmental control in future experiments.

In conclusion, while the number of panicles per plant was numerically higher for NSIC Rc222 and under manual transplanting, the statistical analysis does not support definitive claims about superiority based on variety or method alone. However, the observed patterns suggest that varietal response to specific crop establishment techniques remains a promising area for further research, particularly in optimizing grain yield through improved panicle production.

Table 4. Number of Panicles of NSIC Rc222 and NSIC Rc630 under various planting techniques

Number of Panicles	MT	Mech T	MDS	DSP
Treatment V1: NSIC Rc222	18.7	17.8	17.2	17.6
	21.3	18.3	17.6	17.6
	20.0	19.3	18.4	19.0
Treatment V2: NSIC Rc630	17.3	20.0	19.0	20.0
	17.0	21.0	17.8	16.9
	16.7	15.0	17.8	16.6

MEAN

	MT	Mech T	MDS	DSP	
Treatment V1: NSIC Rc222	20.00	18.47	17.73	18.07	18.57
Treatment V2: NSIC Rc630	17.00	18.67	18.20	17.83	17.93
	18.50	18.57	17.97	17.95	18.25

ANOVA — Alpha 0.05

	SS	*df*	*MS*	*F*	*p-value*	*p eta-sq*
Variety	2.470416667	1	2.470416667	1.106845053	0.308399295	0.064701881
Technique	1.997916667	3	0.665972222	0.298382078	0.826052556	0.05298245
Interaction	11.49791667	3	3.832638889	1.71717486	0.203647176	0.243553346
Within	35.71111111	16	2.231944444			
Total	51.67736111	23	2.246841787			

Variety	**Not Significant**
Technique	**Not Significant**
Interaction	**Not Significant**

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Length of Panicles

Based on the analysis of variance (ANOVA) and the observed data, the study reveals notable insights into how rice variety and planting technique affect the length of panicles, a critical agronomic parameter associated with yield potential in rice plants.

The results show a statistically significant main effect of rice variety on panicle length ($F = 16.36$, $p = 0.00094$), with a partial eta squared (η^2) of 0.506, indicating that approximately 50.6% of the variation in panicle length can be attributed to the rice variety alone. This strong effect size underscores the influence of genetic factors on this particular growth trait.

Among the two rice varieties evaluated, NSIC Rc630 consistently produced longer panicles compared to NSIC Rc222 across all transplanting techniques. For example, in the mechanical transplanting method, NSIC Rc630 achieved a panicle length of up to 33.7 cm, whereas NSIC Rc222 reached only 23.0 cm under the same method. Even in direct seeding methods such as MDS and DSP, NSIC Rc630 outperformed NSIC Rc222 in terms of panicle development.

In contrast, the main effect of transplanting technique was not statistically significant ($F = 0.91$, $p = 0.459$), suggesting that the method of crop establishment, when considered independently of variety, did not have a substantial impact on panicle length. This implies that while transplanting method may influence other agronomic parameters, its role in determining panicle length is relatively minor.

Moreover, the interaction effect between rice variety and transplanting technique was also not significant ($F = 0.36$, $p = 0.781$), indicating that the performance of the rice varieties in terms of panicle length was consistent across different methods of planting. In other words, the superior panicle length observed in NSIC Rc630 was not dependent on the specific planting technique used.

The descriptive data further reinforce these statistical findings. For instance, NSIC Rc630 reached a maximum panicle length of 33.7 cm (Mechanical Transplanting) and an average length consistently higher than that of NSIC Rc222, which peaked at 28.0 cm (Drum Seeder Planting) but generally exhibited shorter panicles overall.

In summary, the findings demonstrate that genetic variety plays a significantly greater role than planting method in influencing panicle length. These results highlight the importance of selecting high-performing rice varieties such as NSIC Rc630 to achieve desirable growth characteristics, particularly in terms of reproductive development, regardless of the planting techniques employed.

Table 5. Length of Panicles (cm) of NSIC Rc222 and NSIC Rc630 as applied with different transplanting methods.

Length of Panicles (cm)	MT	Mech T	MDS	DSP
Treatment V1: NSIC Rc222	24.3	23.0	21.7	28.0
	23.0	28.7	24.3	22.3
	22.3	21.3	20.7	20.3
Treatment V2: NSIC Rc630	26.5	33.7	29.7	27.3
	29.3	27.7	26.7	26.0
	28.7	27.3	25.3	24.7

MEAN

	MT	Mech T	MDS	DSP	
Treatment V1: NSIC Rc222	23.21	24.33	22.22	23.55	23.33
Treatment V2: NSIC Rc630	28.17	29.54	27.22	26.00	27.73
	25.69	26.94	24.72	24.78	25.53

ANOVA Alpha 0.05

	SS	*df*	*MS*	*F*	*p-value*	*p eta-sq*
Variety	116.306713	1	116.306713	16.36063237	0.00093925	0.505572085
Technique	19.38566111	3	6.461887037	0.908980707	0.458601459	0.145615985
Interaction	7.716846296	3	2.572282099	0.361837771	0.781399597	0.063534135
Within	113.743	16	7.1089375			
Total	257.1522204	23	11.18053132			

Variety	**Significant**
Technique	**Not Significant**
Interaction	**Not Significant**

Percent Filled Grains

Based on the data on percent filled grains, the study revealed important insights regarding the influence of rice variety and rice planting techniques on this growth parameter.

The ANOVA results indicated that the technique of transplanting had a statistically significant effect on the percent filled grains ($F = 5.35$, $p = 0.0096 < 0.05$). This suggests that the choice of crop establishment method plays a vital role in determining grain filling efficiency. In contrast, variety (NSIC Rc222 vs NSIC Rc630) did not show a significant effect on filled grain percentage ($p = 0.14$), nor did the interaction between variety and technique ($p = 0.58$). This implies that although different methods of planting have measurable effects on filled grain percentage, these effects are consistent across both varieties tested, and no particular variety responded more favorably to a specific method than the other.

Looking at the treatment means, Manual Direct Seeding (MDS) consistently resulted in the highest percentage of filled grains for both varieties, with NSIC Rc222 averaging approximately 84.87% and NSIC Rc630 averaging 85.57%. This was followed

closely by Drum Seeder Planting (DSP), then Mechanical Transplanting (MechT), and lastly Manual Transplanting (MT), which yielded the lowest percentage of filled grains in both varieties. These results may be attributed to more optimal spacing and less transplanting stress in direct seeding methods, which could lead to better grain development.

The post hoc tests further support these findings. A significant difference was only observed between Manual Transplanting and Manual Direct Seeding ($p = 0.0013$), indicating that direct seeding significantly improved grain filling compared to manual transplanting. The comparisons between other methods did not show significant differences, despite some numerical variations in mean filled grain percentage.

In terms of effect size, technique had a large effect on filled grain percentage (partial eta squared = 0.50), further emphasizing the importance of planting method over variety in influencing this particular growth parameter. This suggests that adopting more efficient and less labor-intensive establishment techniques, such as MDS or DSP, may lead to improved grain quality and potentially higher yield.

In summary, the method of rice establishment significantly affects the percent filled grains, while the choice of variety does not. Manual Direct Seeding emerged as the most favorable technique in terms of grain filling, underscoring its potential for enhancing productivity in irrigated rice systems.

Table 6. Percent filled grains of NSIC Rc222 and NSIC Rc630 under various planting techniques

Filled Grain Percentage (%)	MT	Mech T	MDS	DSP
Treatment V1: NSIC Rc222	82.7	81.7	84.0	86.7
	81.7	83.3	86.2	84.2
	81.0	84.0	84.4	81.8
Treatment V2: NSIC Rc630	83.7	84.4	87.4	86.0
	82.2	86.3	85.3	84.7
	80.2	85.7	84.0	83.3

MEAN

	MT	Mech T	MDS	DSP	
Treatment V1: NSIC Rc222	81.79	83.01	84.85	84.22	83.47
Treatment V2: NSIC Rc630	82.00	85.46	85.57	84.68	84.43
	81.90	84.23	85.21	84.45	83.95

ANOVA Alpha 0.05

	SS	*df*	*MS*	*F*	*p-value*	*p eta-sq*
Variety	5.532800463	1	5.532800463	2.412791165	0.139902469	0.13103886
Technique	36.82962731	3	12.27654244	5.353660109	0.009571456	0.500951005
Interaction	4.64774213	3	1.549247377	0.675609107	0.579515076	0.112433946
Within	36.68979259	16	2.293112037			
Total	83.6999625	23	3.639128804			

Variety	**Not Significant**
Technique	**Significant**
Interaction	**Not Significant**

POST HOC TEST	P-Value (T-Test)	SIGNIFICANT?
Manual Transplanting VS Mechanical Transplanting	0.020378	NO
Manual Transplanting VS Manual Direct Seeding	0.001325	YES
Manual Transplanting vs Drum Seeder Planting	0.016373	NO
Mechanical Transplanting vs Manual Direct Seeding	0.293216	NO
Mechanical Transplanting vs Drum Seeder Planting	0.832087	NO
Manual Direct Seeding vs Drum Seeder Planting	0.426731	NO

Percent Unfilled Grains

Based on the data presented, the percentage of unfilled grains in rice plants varied notably across different transplanting techniques and varieties, reflecting the influence of both factors on reproductive development and grain filling. Overall, NSIC Rc222 (V1) and NSIC Rc630 (V2) exhibited varying levels of unfilled grains across all methods, with V2 generally showing slightly lower percentages, although this difference was not statistically significant.

The Analysis of Variance (ANOVA) revealed that the main effect of the rice variety on the percentage of unfilled grains was not significant at the 0.05 level ($F = 2.41$, $p = 0.1399$). This indicates that the choice between NSIC Rc222 and NSIC Rc630 did not independently result in significant differences in the proportion of unfilled grains. The interaction effect between variety and transplanting technique was also found to be statistically insignificant ($F = 0.68$, $p = 0.5795$), suggesting that the performance of a variety did not depend significantly on the crop establishment method used in terms of this growth parameter.

However, the planting technique itself had a statistically significant effect on the percentage of unfilled grains ($F = 5.35$, $p = 0.0096$). This result suggests that the method of planting, regardless of variety, had a substantial influence on the number of grains that failed to fill. Notably, among all techniques, Manual Direct Seeding (MDS) consistently recorded the lowest mean percentage of unfilled grains for both varieties, indicating a potential advantage of this method in promoting grain development.

The post hoc analysis using pairwise t-tests further supported this finding. It showed a significant difference between Manual Transplanting (MT) and Manual Direct Seeding (MDS) ($p = 0.0013$), implying that MDS significantly reduced unfilled grains compared to MT. Interestingly, although MT also showed numerically higher unfilled grain percentages than Mechanical Transplanting (MechT) and Drum Seeder Planting (DSP), these differences were not statistically significant at the 0.05 level.

These findings imply that Manual Direct Seeding (MDS) may be more effective in enhancing grain filling in rice crops compared to other transplanting techniques, potentially due to less transplanting shock, better root establishment, or more favorable spacing. While varietal differences between NSIC Rc222 and NSIC Rc630 existed in raw values, these differences were not strong enough to be statistically meaningful in influencing unfilled grain percentages.

In summary, the study concludes that the various planting techniques has a more profound impact on grain filling than the choice of variety. Manual Direct Seeding emerged as a promising technique for minimizing unfilled grains, which could contribute to improved grain quality and overall yield. These insights may be valuable for farmers and agricultural practitioners aiming to optimize their rice production systems under similar agroecological conditions.

Table 7. Percent unfilled grains of NSIC Rc222 and NSIC Rc630 under various planting techniques

Unfilled Grains (%)	MT	Mech T	MDS	DSP
Treatment V1: NSIC Rc222	17.3	18.3	16.0	13.3
	18.3	16.7	13.8	15.8
	19.0	16.0	15.6	18.2
Treatment V2: NSIC Rc630	16.3	15.7	12.7	14.0
	17.9	13.7	14.7	15.3
	19.8	14.3	16.0	16.7

MEAN

	MT	Mech T	MDS	DSP	
Treatment V1: NSIC Rc222	18.21	16.99	15.15	15.78	16.53
Treatment V2: NSIC Rc630	18.00	14.54	14.43	15.32	15.57
	18.10	15.77	14.79	15.55	16.05

ANOVA **Alpha 0.05**

	SS	*df*	*MS*	*F*	*p-value*	*p eta-sq*
Variety	5.532800463	1	5.532800463	2.412791165	0.139902469	0.13103886
Technique	36.82962731	3	12.27654244	5.353660109	0.009571456	0.500951005
Interaction	4.64774213	3	1.549247377	0.675609107	0.579515076	0.112433946
Within	36.68979259	16	2.293112037			
Total	83.6999625	23	3.639128804			

Variety	**Not Significant**
Technique	**Significant**
Interaction	**Not Significant**

POST HOC TEST	P-Value (T-Test)	SIGNIFICANT?
Manual Transplanting VS Mechanical Transplanting	0.020378	NO
Manual Transplanting VS Manual Direct Seeding	0.001325	YES
Manual Transplanting vs Drum Seeder Planting	0.016373	NO
Mechanical Transplanting vs Manual Direct Seeding	0.293216	NO
Mechanical Transplanting vs Drum Seeder Planting	0.832087	NO
Manual Direct Seeding vs Drum Seeder Planting	0.426731	NO

Grain Yield (tons/ha)

The study examined the grain yield performance (in tons per hectare) of two rice varieties—NSIC Rc222 and NSIC Rc630—under four different transplanting techniques: manual transplanting (MT), mechanical transplanting (Mech T), manual direct seeding (MDS), and direct seeding with pre-germinated seeds (DSP). The results indicate variability in grain yield across both transplanting methods and rice varieties, with notable patterns emerging.

From the data, NSIC Rc222 consistently produced higher yields across all transplanting methods compared to NSIC Rc630. For instance, NSIC Rc222 yielded as high as 5.72 t/ha under MT, while NSIC Rc630 peaked at 5.89 t/ha under MT as well—but on average, NSIC Rc222 maintained higher grain yield in most transplanting techniques. However, statistical analysis using ANOVA revealed that the varietal effect on grain yield was not significant (p = 0.185), indicating that the difference in average yields between NSIC Rc222 and Rc630 was not large enough to be considered statistically meaningful at the 5% significance level. This suggests that although Rc222 appears numerically superior, both varieties responded similarly in terms of yield performance.

The transplanting method, however, showed a statistically significant effect on grain yield (p = 0.0063), with a high effect size (partial eta squared = 0.527), indicating that over 52% of the variance in yield can be attributed to the transplanting technique alone. Among all treatments, manual transplanting (MT) consistently resulted in the highest average yields for both varieties, followed by mechanical transplanting (Mech T). The direct seeding with pre-germinated seeds (DSP) and manual direct seeding (MDS) methods yielded the lowest averages. These results highlight those transplanting methods involving more precise and stable seedling establishment, such as MT and Mech T, likely lead to better plant vigor and ultimately higher grain yield.

The interaction between variety and transplanting technique was not statistically significant (p = 0.755), indicating that the influence of transplanting method on yield was consistent across both varieties. In other words, while transplanting technique significantly influenced grain yield, this influence did not depend on which variety was used. Both varieties responded similarly across transplanting methods, reinforcing the conclusion that transplanting method is the dominant factor affecting yield in this study.

The analysis clearly indicates that transplanting method plays a crucial role in determining grain yield, more so than the variety itself. Manual transplanting remains the most effective approach in terms of productivity, followed by mechanical transplanting. While NSIC Rc222 showed slightly better yield performance overall, the difference compared to Rc630 was not statistically significant. These insights support the recommendation that optimizing transplanting methods may offer greater yield benefits than solely focusing on varietal selection within this experimental context.

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Table 8. Grain Yield (tons/ha) of NSIC Rc222 and NSIC Rc630 under various planting techniques

Grain Yield (tons/ ha)	MT	Mech T	MDS	DSP
Treatment V1: NSIC Rc222	5.38	5.26	5.13	4.58
	5.58	5.25	4.68	5.08
	5.72	5.12	5.05	5.57
Treatment V2: NSIC Rc630	5.18	5.05	4.45	4.72
	5.49	4.65	4.85	4.98
	5.89	4.78	5.12	5.25

MEAN

	MT	Mech T	MDS	DSP	
Treatment V1: NSIC Rc222	5.56	5.21	4.95	5.08	5.20
Treatment V2: NSIC Rc630	5.52	4.83	4.81	4.98	5.03
	5.54	5.02	4.88	5.03	5.12

ANOVA **Alpha** **0.05**

	SS	*df*	*MS*	*F*	*p-value*	*p eta-sq*
Variety	0.040865005	1	0.040865005	1.915117354	0.185398261	0.106899515
Technique	0.380833273	3	0.126944424	5.949184941	0.006332783	0.527292294
Interaction	0.025588421	3	0.008529474	0.399729387	0.755071832	0.069723533
Within	0.341409926	16	0.02133812			
Total	0.788696625	23	0.034291158			

Variety **Not Significant**
Technique **Significant**
Interaction **Not Significant**

POST HOC TEST	P-Value (T-Test)	SIGNIFICANT?
Manual Transplanting VS Mechanical Transplanting	0.00467	YES
Manual Transplanting VS Manual Direct Seeding	0.00132	YES
Manual Transplanting vs Drum Seeder Planting	0.01637	NO
Mechanical Transplanting vs Manual Direct Seeding	0.37220	NO
Mechanical Transplanting vs Drum Seeder Planting	0.95392	NO
Manual Direct Seeding vs Drum Seeder Planting	0.42673	NO

Return of Investment of Calculation and Comparison

The analysis of the economic performance of various rice planting techniques—manual transplanting, mechanical transplanting, manual direct seeding, and drum seeder planting—reveals significant insights into their relative profitability and practical implications for rice farmers. Among the four techniques evaluated, manual transplanting emerged as the most economically advantageous, with a net profit of ₱77,141.00 and the highest return on investment (ROI) of 1.72. This means that for every peso invested, there was a ₱1.72 return, suggesting a highly cost-effective and profitable approach under the existing production and market conditions. The high yield (5,985 kg) and relatively moderate production cost (₱44,953.00) contributed to the superior financial performance of this method, underscoring its suitability for small to medium-scale farmers who rely on affordable yet productive practices.

The mechanical transplanting method, while requiring a higher input cost of ₱51,993.00, also demonstrated strong economic viability, with a substantial net profit of ₱71,916.60 and an ROI of 1.38. This indicates that the use of mechanized technology, despite its relatively higher initial investment, can still yield considerable financial returns. The slight improvement in yield (6,074 kg) compared to manual transplanting highlights the potential of mechanization to enhance productivity and reduce labor dependency. The favorable ROI reflects not only profitability but also long-term sustainability, particularly for farmers with access to capital or those operating on a larger scale where efficiency gains can offset operational costs.

Manual direct seeding also produced a favorable outcome, with a gross yield of 5,117 kg and an ROI of 1.32, translating to a net profit of ₱59,433.80. Though it yielded slightly less than the transplanting methods, its appeal lies in the lower labor requirement and relatively simple operational demands. This makes manual direct seeding an attractive option for resource-constrained farmers aiming to balance input savings with reasonable yield outcomes. The ROI reflects the method's potential to generate meaningful returns, making it economically viable, particularly where labor availability or costs are a limiting factor.

Lastly, the drum seeder planting method, while yielding the lowest gross income (₱92,779.20) and net profit (₱47,326.20), still delivered a positive ROI of 1.04. Although this figure is the lowest among the four methods, it nonetheless confirms that the method is profitable, albeit marginally. The relatively lower yield (4,548 kg) may reflect limitations in seedling establishment uniformity or field adaptability. However, the technology's labor-saving feature and mechanized precision could be advantageous in the long run, especially with further refinement and adoption. This suggests that while drum seeding currently yields modest returns, it holds potential for future optimization, particularly in contexts where labor is scarce or expensive.

Overall, the ROI-based analysis clearly demonstrates that all four rice establishment methods studied are economically viable, each offering varying degrees of profitability and operational efficiency. Manual transplanting stands out as the most profitable, followed by mechanical transplanting and manual direct seeding, with drum seeding showing potential for improvement. These findings are critical for guiding farmers, agricultural extension agents, and policymakers in selecting the most appropriate rice planting techniques based on farm size, available resources, labor conditions, and financial goals. The insights gained also support broader efforts to promote sustainable and efficient rice production practices across different farming systems.

Table 9. Calculation of ROI for Manual Transplanting

COST AND RETURN ANALYSIS	**44,953.00**
A. Gross yield in cavan: cavans 119.70(5,985 kg)	
B. Ave. weight in Kg = 68 kg	
C. Price per Kg= (wet) P/kg=15 Dry P/kg=	
Gross Income= A (119.70) x 68) X P (15)=122,094.00	
Net Profit= Gross Income-Total Expenses (122,094.00 – 44,953) =	
Return On Investment = Net Profit / Total Expenses	
= 77,141.00/ 44,953.00	
ROI = 1.72	

Table 10. Calculation of ROI for Mechanical Transplanting

COST AND RETURN ANALYSIS	**51,993.00**
A. Gross yield in cavan: cavans 121.48(6074 kg)	
B. Ave. weight in Kg = 68 kg	
C. Price per Kg= (wet) P/kg=15 Dry P/kg=	
Gross Income= A (6074) x 68) X P (15)=123.909.60	
Net Profit= Gross Income-Total Expenses (123,909.60 – 51,993) =71,916.6	
Return On Investment = Net Profit / Total Expenses	
= 71,916.60/ 51,993.00	
ROI = 1.38	

Table 11. Calculation of ROI for Manual Direct Seeding

COST AND RETURN ANALYSIS	44,953.00
A. Gross yield in cavan: cavans 102.34(5,117 kg)	
B. Ave. weight in Kg = 68 kg	
C. Price per Kg= (wet) P/kg=15 Dry P/kg=	
Gross Income= A (102.34) x 68) X P (15)=104,386.80	
Net Profit= Gross Income-Total Expenses (104,386.80 – 44,953) = 59,433.80	
Return On Investment = Net Profit / Total Expenses	
= 59,433.80/ 44,953.00	
ROI = 1.32	

Table 12. Calculation of ROI for Drum Seeder Planting

COST AND RETURN ANALYSIS	45,453.00
A. Gross yield in cavan: cavans 90.96(4548 kg)	
B. Ave. weight in Kg = 68 kg	
C. Price per Kg= (wet) P/kg=15 Dry P/kg=	
Gross Income= A (4,546) x 68) X P (15)=92,779.20	
Net Profit= Gross Income-Total Expenses (92,779.20– 45,453) =	
Return On Investment = Net Profit / Total Expenses	
= 59,433.80/ 44,953.00	
ROI = 1.04	

Summary

This study investigated the agronomic performance of two rice varieties, NSIC Rc222 and NSIC Rc630, under four different rice planting techniques—Manual Direct Seeding (MDS), Manual Transplanting (MT), Mechanical Transplanting (MechT), and Drum Seeder Planting (DSP)—in irrigated areas. Using a descriptive research design, key growth and yield parameters such as plant height, leaf area index (LAI), tiller number, panicle number and length, percentage of filled and unfilled grains, and grain yield were measured and analyzed. Results showed that the genetic characteristics of the rice varieties significantly influenced traits like plant height and panicle length, with NSIC Rc630 generally exhibiting superior growth in these parameters. However, the establishment technique notably affected grain filling and overall yield. Manual

Transplanting consistently resulted in higher grain yield and better panicle number, while Manual Direct Seeding promoted better grain filling, reflected by higher percentages of filled grains and fewer unfilled grains. Interaction effects between variety and transplanting technique were significant for some traits, suggesting that the combination of suitable varieties with appropriate establishment methods can optimize rice performance. Overall, the study highlights the critical role of planting techniques alongside varietal choice in enhancing rice productivity in irrigated systems

Conclusion

The study concludes that while rice variety significantly affects growth traits such as plant height and panicle length, the choice of planting techniques plays a more decisive role in grain filling efficiency and final grain yield in irrigated rice production. Manual Transplanting emerged as the superior technique for maximizing grain yield for both NSIC Rc222 and NSIC Rc630, likely due to better plant spacing and root development. Conversely, Manual Direct Seeding showed advantages in increasing the percentage of filled grains and reducing unfilled grains, indicating its potential for improving grain quality. The interaction between variety and transplanting technique was significant for certain traits, emphasizing that aligning variety-specific physiological traits with appropriate establishment methods can further optimize growth and yield. These findings suggest that farmers should consider both varietal characteristics and transplanting methods to achieve the best agronomic and economic outcomes in irrigated rice cultivation.

Recommendations

Based on the findings of this study, the following recommendations are proposed:

1. Adopt Manual Transplanting (MT) as the preferred rice planting technique in irrigated areas when the primary goal is to maximize grain yield, given its superior performance in yield and panicle production across both varieties studied.
2. Consider Manual Direct Seeding (MDS) for improving grain filling and grain quality, as it significantly increases the percentage of filled grains and reduces unfilled grains, potentially benefiting farmers prioritizing grain quality or labor efficiency.
3. Select rice varieties according to their specific growth traits—for instance, NSIC Rc630 for taller plants and longer panicles—which can complement particular planting techniques to optimize performance.
4. Further research is recommended to explore the synergistic effects of rice variety and planting techniques across multiple seasons and varying

environmental conditions to validate these findings and refine recommendations.

5. Extension programs and training should be conducted to educate farmers on the benefits and management practices of different planting techniques, enabling informed decision-making tailored to local conditions and resource availability.

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REFERENCES

Abedin, M.J., Salam, M. A., & Islam, M. S. (2018). Effectiveness of drum seeder for direct seeded rice production. *Bangladesh Journal of Agriculture Research*, 43(3), 561-569 https:// dol.org/10.3329/bjar. V4313.38321.

Ali, R., & Rehman S., (2020). Economic evaluation of mechanical transplanting in rice production: A case study. *Journal of Agricultural Economics and Development*, 4(2), 145-155.

Ali, S. Khan, H., & Raza, A. (2020). Labor and input cost analysis of manual versus mechanical rice planting. *Asian Journal of Agricultural Science*, 12(1), 45-50.

Bharate, R. C., & Singh, K. M., (2021). Adoption of mechanical transplanting for rice production and its implication for yield. *Journal of Agricultural Machinery and Engineering*. 6(4), 233-242.

Bautista AP *et al.* 2023. Adoption and Performance of Direct-seeded Rice (DSR) Technology in the Philippines. Philipp J Sci 152(2): 459–484. https://doi.org/10.56899/152.01.37.

Chaitanya, D.N.V., Arunkumar, S., Akhilesh, G.B., Kumara, G.S., Babua, K.N.V.S.A. (2018). Design of Rice Transplanter. IOP Conf. Series: Materials Science and Engineering. 377(2018) 012037 doi:10.1088/1757-899X/377/1/012037.

Chandra, S., & Yadav, D. S., (2020). Comparative performance of direct seeding and transplanting in rice cultivation. *Indian Journal of Agronomy*. 65(2), 117-124.

Chakraborty, D.; Ladha, J.K.; Rana, D.S.; Jat, M.L.; Gathala, M.K.; Yadav, S.; Rao, A.N.; Ramesha, M.S.; Raman, A. A global analysis of alternative tillage and crop establishment practices for economically and environmentally efficient rice production. *Sci. Rep.* 2017. 7. 9342.

Chauhan, B. S., Mahajan, G., Sardana, V., Timsina, J., & Jat, M. L. (2020) Productivity and resource efficiency in rice production systems: A review of crop establishment techniques. Field Crop Research, 234, 36-44. https://doi.org/10.1016/j-fcr. 2019.02.003.

Dingkuhn, M., & Sow, A., (2019). Mechanized versus manual transplanting in rice: Comparing resources use efficiency. *Journal of crop Production*, 18(3), 145-156.

Fanish SA (2016) Enhancing resource use efficiency (RUE) under direct seeded rice (DSR) system: a review. Am Eurasian J Agric Environ Sci 16(9):1534–1544

Joseph F. Rickman, Frank Mussgnug, C.M. Khanda, Swetapadma D. Satpathy, Nabakishore Parida, Kapil Singla, Vivek Kumar, Narayan C. Banik, Wasim Iftikar, Amit Mishra, Sudhir Yadav, Virender Kumar, R.K. Malik, and Andrew J. McDonald Adapted from: R.K. Malik, B.R. Kamboj, M.L. Jat, H.S. Sidhu, Anil Bana, Vicky Singh, Y.S. Saharawat, A. Pundir, Rasool Dar Sahnawaz, T. Anuradha, N. Kumaran, and Raj Gupta. 2011. No-till and unpuddled mechanical transplanting of rice. Operational manual, Cereal Systems Initiative for South Asia, New Delhi, India. (2015) p 13.

Gaikwad, P.B., Shahare, P.U., Pathak, S.V. and Aware, V.V. (2014). Development and performance evaluation of four row self-propelled paddy transplanter. *International Journal of Agricultural Engineering*. 8(1): 9-14.

Garcia, S., & Mendoza, D. A. (2019). Yield potential and agronomic performance of NSIC Rc222 In various Philippine regions. *Philippine Agricultural Scientist*, 102(1),43-51.

Gao P. (2017). Design and Simulation of Splitting Mechanism for Narrow Row Variable Spacing Rice Transplanter. Shandong.

Gonzales, R. R., & San Pedro, M.P. (2018) Enhancing rice productivity through high-yielding varieties: Case study of NSIC Rc222.*Philippine Journal of Crop Science*, 43(2),89-98.

Guan, H., & Xie, Z.(2018). Weed management efficiency in drum-seeded rice and its impact on yield. Agronomy Journal, 105(2), 341-348. https://doi.org/10.2134/agronj2018.04.0320.

Iqbal, M., Haque, M. E., & Aslam, A. (2019). Comparative yield performance of direct seeded and transplanted rice. *International journal of Agronomy and Crop Science*, 28(3), 234-241.

Islam, M.S., Ali, M. S., & Jahan, N. (2019). Comparative yield performance of direct seeded and transplanted rice. *Journal of Crop Science*, 54(1). 221-227.

Janiya, J. D., & Ratnayake, N. P. (2019). Labor-saving potential of manual direct seeding in rice. *Journal of Agriculture and Rural Development*, 20(3), 139-148.

Kanlaya, S., Waraporn, W., Jirapong, J., Yoichiro, K. (2019). Farmer-participatory evaluation of mechanized dry direct-seeding technology for rice in northeastern Thailand, Plant Production Science, 22:1, 46-53. DOI: https://doi.org/10.1080/1343943X.2018.1557530

Kim, T.H., Lee, See, S. Y., & Park, J. H. (2019). Economic viability of mechanical transplanting in rice production. *Journal of Agricultural Engineering*, 15(2), 98-106.

Kumar, R., Singh, A., & Chauchan, Y. (2019). Comparative study of crop establishment methods in rice and their economic feasibility. *Asian Juornal of Agronomy*, 17(2),101-110.

Lao, A. P., & Miranda, V. T. (2019). Evaluating manual transplanting effectiveness in enhancing rice yield and stability. *Philippine Rice Research Journal*, 12(3), 167-178.

Mahajan, G., & Verma, V. T., (2019). Benefits of drum seeder technology for smallholder rice farmers. *Agricultural Mechanization in Asia, Africa, and Latin America,* 52(4), 25-30.

Malik, F., & Khurana, S. (2020). Cost-benefit analysis of diseases-resistant rice varieties using drum seeder techniques. *Journal of Rice Research*, 9(1),56-64.

Naresh, R., Gupta, A., & Sharma, P. (2020). Mechanized transplanting: Reducing labor demand and improving yields. Journal of Agronomy and Agricultural Engineering, 33(4), 303-314.

Oikawa, A., & Matsumoto, Y. (2019). Agronomic response of high-yielding varieties to different establishment techniques. *Plant production Science*, 22(1), 12-20.

Pathak, H., & Singh, S. (2019). Environmental benefits of water management in rice transplanting system: A methane emissions analysis. *Environmental Management Journal*, 43(3), 212-220.

Ponnuswamy K, Santhi P, Kempuchetty N, and Subramanium M. (1999) Effect of various methods of establishment on growth and yield of rice. Oryza. 36(3): 294-295.

Rana, S., & Timsina, J. (2017). Direct seeding and drum seeding as alternatives to transplanting for sustainable rice production. *Sustainable Agriculture Reviews*, 30, 209-228.

Robles, L. F., & Santos, J. E. (2018). Evaluating the adaptability of high-yielding rice varieties in different Philippine regions: NSIC Rc222 case study. *Journal of Philippine Agriculture and Resources*, 23(2), 78-89.

Saito, H., & Suzuki, N. (2021). Mechanization in rice production and environmental sustainability. Journal of Agricultural Science and Technology, 23(3),210-221.

Sharma, R., & Yadav, R. (2021) Comparative yield performance of manual and mechanized transplanting in rice. Indian Journal of Agricultural Research, 89(1), 12-22.

Singh, S., & Pathak, H. (2020). Impact of crop establishment techniques on yield and methane emission in rice. Journal of Environmental Science, 64(3), 201-213.

Singh, G., Sharma, T.R., Bockhop, C.W., (1985). Field performance evaluation of a manual rice transplanter. J. Agric. Engg. Res. 32: 259-268.

Singh G. Singh R.G, Singh O.P, Kumar T, Mehta R.K, Kumar V. and Singh P.P (2005) Effect of weed management practices on direct seeded rice (Oryza sativa) under puddle low lands. Indian Journal of Agronomy, 50(1): 35-37.

S.V. Balbhudhe, D. H. Baghele, D.N. Shirke, M.C. Gaikwad, P.S. Bobde, U.G. Bisen, H.M. Bansod, Int. J. Ana. Exp. FEA, 3 (2016) 9-12.

Talhelm, T. (2022). The Rice Theory of Culture. Online Readings in Psychology and Culture, 4(1). https://doi.org/10.9707/2307-0919.1172.

R.J. Cabangon *et al.* Comparing water input and water productivity of transplanted and direct-seeded rice production systems Agric. Water Manage. (2002)

V.K. Arora *et al.* Puddling, irrigation, and transplanting-time effects on productivity of rice–wheat system on a sandy loam soil of Punjab India. Soil Till. Res. (2006)

Wei Y., Wu D., Wei D., Zhao Y., Wu J., Xie X., Improved lignocellulose-degrading performance during straw composting from diverse sources with actinomycetes inoculation by regulating the key enzyme activities. Bioresour. Technol. 2019;271:66–74.

Z. Li et al. Research Progress of Rice transplanting mechanization Nongye Jixie Xuebao/transactions of the Chinese Society for Agricultural Machinery (2018)

Z. Liu et al. teady-state analysis of multi-objective genetic algorithm in aeroengine sensor Journal of Sensing Technology (2023)

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