



ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2026): 4.97
IJAFS 2026; 8(2): 442-449
www.agriculturaljournals.com
Received: 05-01-2026
Accepted: 08-02-2026

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Evaluation of Drought-Tolerant Rice Variety (Swarna Samriddhi) under Rainfed Conditions in the Western Undulating Zone of Odisha

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DOI: <https://www.doi.org/10.33545/2664844X.2026.v8.i3f.1278>

Abstract

A field experiment was conducted during Kharif 2025 at Pipalpadar village of Narla block, Kalahandi district under the National Innovations in Climate Resilient Agriculture (NICRA) project to evaluate the drought tolerant rice variety Swarna Samriddhi in comparison with Pratikshya and Ranidhan under rain-fed conditions. The experiment was laid out in Randomized Block Design with thirteen replications. Significant differences were observed among varieties for plant height, maturity duration, effective tillers, panicle length, flag leaf traits, grains per panicle, test weight and grain yield at 1% probability level. The highest grain yield (44.5 q ha⁻¹) was recorded in Swarna Samriddhi, representing 13.5% and 20.3% yield advantage over Pratikshya (39.2 q ha⁻¹) and Ranidhan (37.0 q ha⁻¹), respectively. Swarna Samriddhi also recorded superior performance in effective tillers (14 hill⁻¹), panicle length (25.8 cm), grains per panicle (159) and test weight (24.36 g). The coefficient of variation (CV) remained within acceptable limits ($\approx 6-7\%$), indicating good experimental precision. Economic analysis revealed maximum gross return (Rs. 1,16,250 ha⁻¹), net return (Rs. 54,870 ha⁻¹) and B:C ratio (1.89) in Swarna Samriddhi, followed by Pratikshya and Ranidhan. The findings establish the varietal superiority and drought adaptability of Swarna Samriddhi under rainfed conditions of Western Odisha.

Keywords: Rice, drought tolerance, rainfed ecosystem, yield attributes, climate resilience, B:C ratio, NICRA

Introduction

Rice is the dominant cereal crop of Odisha and plays a vital role in sustaining rural livelihoods (Nayak *et al.*, 2019) ^[1]. The state contributes substantially to India's rice production, though productivity remains vulnerable to climatic aberrations (Directorate of Rice Research, 2012). In Kalahandi district, rice cultivation is predominantly rainfed, making it highly susceptible to intermittent drought and erratic monsoon distribution (Nayak *et al.*, 2021) ^[3]. The district lies in the Western Undulating Zone of Odisha, where uneven topography, light-textured soils, and limited irrigation facilities intensify moisture stress during the cropping season. Consequently, yield instability is common, particularly in years of delayed monsoon onset or prolonged dry spells. Rainfed rice ecosystems in this region are largely dependent on seasonal rainfall and low external inputs. Moisture stress during critical stages such as tillering, panicle initiation, and grain filling significantly affects effective tiller number, spikelet fertility, and grain weight (Saikumar *et al.*, 2016) ^[4]. The fact of predominance of small and marginal farmers with limited adaptive capacity, enhancing varietal resilience remains a practical and cost-effective strategy for stabilizing productivity. Climate-resilient and drought-tolerant rice varieties are increasingly promoted to stabilize production in such fragile ecosystems (Thakur *et al.*, 2017) ^[5]. Drought tolerant genotypes maintain better tillering, efficient photosynthesis and improved grain filling under soil moisture deficit (Malik *et al.*, 2020 and Saxena *et al.*, 2002) ^[6, 7]. In addition, such varieties often possess adaptive traits like deeper root systems and improved water-use efficiency, enabling them to sustain yield under intermittent moisture stress (Sarma *et al.*, 2023 and Ranjan *et al.*, 2022) ^[8, 9]. Swarna Samriddhi is a drought tolerant rice variety recommended for rainfed ecosystems.

It is considered suitable for moisture-limited environments due to its stable yield potential and adaptability. However, varietal performance may vary across locations depending on soil type, rainfall pattern, and management practices. In Kalahandi, farmers commonly cultivate Pratikshya and Ranidhan, but their performance under drought conditions is often inconsistent. Therefore, comparative evaluation under farmers' field conditions is essential to validate the agronomic and economic advantages of improved varieties. Therefore, the present study was undertaken under the facilities of NICRA to assess agronomic, yield and economic performance of rice varieties in relation to occurring stress scenario (Singh *et al.*, 2024) ^[10]. Through frontline demonstrations in farmers' fields, it is imperative to assess the performance of rice varieties for drought tolerance and component traits contributing towards high yield under water stress situation (Dar *et al.*, 2020) ^[11], thereby contributing to climate-resilient rice cultivation in the rainfed ecosystems of Western Odisha.

Materials and Methods

Experimental Site and Topography

The field investigation was carried out during the Kharif 2025 season at Pipalpadar village under Narla block of Kalahandi district, Odisha. The experimental field is geographically situated at latitude 20.085882° N and longitude 83.386595° E, falling under the Western Undulating Agro-Climatic Zone of Odisha at an elevation of about 278 meters above mean sea level.

The topography of the selected field was medium lowland in nature, suitable for rainfed transplanted rice cultivation. The soil of the experimental plot was clay loam in texture with moderate water holding capacity. Prior to crop establishment, composite soil samples were collected and analyzed following standard laboratory procedures. The soil was found to be moderately fertile with medium organic carbon status and neutral reaction, making it suitable for kharif paddy cultivation under rainfed conditions.

Weather Conditions During the Cropping Period

Kalahandi district experiences a tropical sub-humid climate characterized by a hot summer, monsoon rainfall during June-September, and a mild winter. The south-west monsoon is the principal source of precipitation, contributing the major share of annual rainfall. During the Kharif 2025 cropping season, a total rainfall of 1,151.7 mm was received from June to November, with the highest

monthly rainfall recorded in September (284.0 mm), followed by July (266.8 mm). Rainfall during June, August, and October was 190.9 mm, 213.2 mm, and 196.8 mm, respectively, while no rainfall was recorded in November. The total number of rainy days during the cropping period was 70 days, with monthly values ranging from 11 days in October to 18 days in July. The well-distributed rainfall during the monsoon months ensured adequate soil moisture availability, which was conducive for crop establishment and vegetative growth. However, comparatively higher rainfall in September may have created transient waterlogging conditions in poorly drained fields, potentially affecting root aeration and nutrient uptake. The absence of rainfall in November indicates the onset of terminal moisture stress, which could influence grain filling and maturity depending on soil moisture reserves.

The maximum temperature during the crop growth period ranged from 29.7°C (November) to 32.9°C (June), whereas the minimum temperature varied between 15.2°C (November) and 25.0°C (June). Relative humidity remained relatively high during the monsoon months, with maximum relative humidity ranging from 75.1% to 84.9%, and minimum relative humidity ranging from 64.9% to 82.5%. The prevailing temperature regime during early growth stages was within the optimal range for crop development; however, relatively higher temperatures during June may have imposed mild heat stress during initial establishment. High relative humidity during the monsoon period favored vigorous vegetative growth but may also have increased the risk of pest and disease incidence. The decline in temperature and humidity towards November created relatively favorable conditions for reproductive development and crop maturation.

Bright sunshine hours (BSH) were comparatively lower during the peak monsoon period (28.9 hours in July) and increased progressively towards the later stages of the crop, reaching a maximum of 175.1 hours in November, with a total of 486.5 hours recorded during the experimental period. Reduced sunshine hours during July and August might have limited photosynthetic efficiency due to persistent cloud cover, potentially affecting biomass accumulation. In contrast, the gradual increase in sunshine hours from September onwards likely enhanced photosynthetic activity, thereby supporting better assimilate partitioning and grain development during the reproductive and maturity stages.

Table 1: Monthly weather information of experimental site

Month	Temperature		Humidity		Rainfall (mm)	Rainy day	BSH (Hr)
	T (min.)	T (max.)	Rh(max.)	Rh(min.)			
Jun	25.0	32.9	70.7	76.4	190.9	13.0	47.0
Jul	24.3	30.9	81.7	84.6	266.8	18.0	28.9
Aug	24.3	32.8	80.4	84.3	213.2	15.0	60.2
Sep	23.9	32.2	80.4	84.4	284.0	13.0	73.3
Oct	22.5	31.1	82.5	84.9	196.8	11.0	102.0
Nov	15.2	29.7	64.9	75.1	0.0	0.0	175.1
Average	22.53	31.6	76.77	81.62	1151.7 (Total)	70 (Total)	486.5 (Total)

Source: AMFU, RRTTS, Bhawanipatna, Kalahandi

Meteorological observations including temperature, rainfall, relative humidity, rainy days, and bright sunshine hours were obtained from the nearest meteorological observatory located at RRTTS, Bhawanipatna. The prevailing weather

conditions were conducive for evaluating the performance, drought tolerance, and adaptability of the test variety under real farmer field conditions.

Experiment Details

Experimental Setup

The study was conducted under farmer's field conditions following a systematic experimental approach. The crop was raised following standard agronomic recommendations for rainfed transplanted rice. Observations were recorded from representative sampling units within the cultivated field to assess varietal performance.

The experimental evaluation focused on the drought tolerant rice variety Swarna Samriddhi under practical field conditions to examine its growth behaviour, yield attributes, and economic viability.

Treatment Groups

The experiment consisted of the following treatment:

- **Swarna Samriddhi (Test Variety):** A drought tolerant rice variety evaluated for its performance under rainfed ecosystem of Western Odisha.
- **Pratikshya:** A high-yielding and extensively cultivated rice variety used as a standard check to compare the growth, yield attributes, and economic performance of Swarna Samriddhi under rainfed conditions.
- **Ranidhan:** A locally adapted rice cultivar included as a comparative genotype to assess varietal performance and adaptability under the experimental agro-ecological situation.

The performance of Swarna Samriddhi was assessed under farmers' management practices and compared with general local cultivation standards prevailing in the village.

Replications

The experiment was conducted with ten replications for each rice variety under a Randomized Block Design to improve experimental accuracy and dependability. Adequate replication helps to account for inherent field variability and reduces the magnitude of random error, thereby enabling more precise estimation of treatment effects and valid statistical interpretation.

Observations on growth and yield parameters were recorded from several randomly selected locations within the farmer's field to avoid site-specific bias. Random sampling techniques were employed during data collection to ensure that the recorded measurements accurately reflected the overall field condition and to further minimize experimental and sampling errors.

Maintaining Recommended Practices

The crop was established through transplanting method using healthy seedlings. Recommended agronomic practices including proper land preparation, nursery management, transplanting spacing, nutrient management, weed control, and plant protection measures were followed as per the package of practices recommended for Odisha.

Fertilizer application was done based on general recommended dose for medium land situation. Necessary plant protection measures were adopted as and when

required. The crop was grown predominantly under rain-fed conditions, without any supplemental irrigation in the experiment.

Data Collection

Observations were systematically recorded at various stages of crop development to examine the comparative performance of Swarna Samriddhi and the other tested varieties under field conditions. Detailed data on key agronomic, morphological, phenological, yield, and economic traits were collected at appropriate growth intervals to obtain a comprehensive evaluation of varietal response. The parameters documented included plant height, total crop duration, effective tillers per hill, panicle length, flag leaf length and area, days to flowering, lodging incidence, grains per panicle, test weight, kernel dimensions (length and breadth) and grain yield. Grain yield was determined based on the total harvested produce from each plot and subsequently expressed in quintals per hectare. Economic assessment was carried out by estimating gross income, net income, and benefit-cost ratio using the prevailing market price of paddy and the standard cost of cultivation to assess overall profitability.

Test Variety: Swarna Samriddhi

Swarna Samriddhi is a drought-tolerant rice variety developed for cultivation under rainfed medium land ecosystems, particularly in areas prone to intermittent dry spells. It is well adapted to the agro-climatic conditions of Eastern and Central India and is suitable for states such as Odisha, Chhattisgarh, Jharkhand, and parts of West Bengal where rainfall variability frequently affects crop performance. The variety possesses medium plant height, good tillering capacity, and sturdy culms that confer resistance to lodging under moisture stress and heavy wind situations.

In addition to its drought adaptability, Swarna Samriddhi exhibits moderate tolerance to major rice diseases such as blast and bacterial leaf blight, contributing to yield stability under field conditions. The variety produces long slender grains with acceptable milling and cooking quality, meeting consumer and market preferences. Owing to its stable productivity, stress tolerance, and economic viability, Swarna Samriddhi is considered a suitable varietal option for rainfed and drought-prone ecosystems of Eastern India.

Experimental Findings

The collected data were compiled and analyzed using standard statistical and economic computation methods. Growth parameters, yield attributes, and economic indicators were evaluated to assess the overall performance of Swarna Samriddhi under rainfed conditions of Narla block. The results obtained from the field investigation provide a comprehensive understanding of varietal adaptability, productivity, and profitability under drought-affected agro-ecosystem of Kalahandi district.

Table 2: Comparative performance of rice varieties under rainfed conditions (Kharif 2025)

Sl. No.	Particulars	Swarna Samriddhi	Pratikshya	Ranidhan
1	Plant height (cm)	101	105	110
2	Maturity duration (days)	137	134	143
3	No. of effective tillers/hill	14	12	10
4	Panicle length (cm)	25.8	24.6	23.4

5	Flag leaf length (cm)	41	35	38
6	Flag leaf area (cm ²)	46.74	44.02	42.10
7	Days to 50% flowering	109	108	112
8	No. of grains/panicle	159	148	145
9	Test weight (g)	24.36	24.10	23.50
10	Kernel length (mm)	5.41	5.18	4.90
11	Kernel breadth (mm)	2.20	2.26	2.08
12	Grain yield (q/ha)	44.5	39.2	37.0
13	Lodging	Non-lodging	Non-lodging	Moderate lodging
14	Grain type	Long slender	Short bold	Long slender
15	Return from grain yield (Rs.)	1,02,350	90,610	85,571
16	Return from straw yield (Rs.)	13,900	12,700	12,050
17	Gross return (Rs.)	1,16,250	1,03,310	97,621
18	Net return (Rs.)	54,870	41,930	36,241
19	B:C ratio	1.89	1.68	1.59

N.B.: Cost of cultivation = Rs. 61380/ha; Selling price of paddy = Rs. 2,300/quintal

Table 3: ANOVA of 12 traits of Rice Genotypes for drought tolerance

SI No.	Parameter	Replication MS	Variety MS	Error MS	F value	Significance
1	Plant height (cm)	346.61	67.6	339.15	0.19	
2	Maturity duration (days)	1.02	260.43	1.65	157.3	**
3	No. of effective tillers/hill	0.74	48.7	1.14	42.55	**
4	Panicle length (cm)	0.07	9.7	0.13	70.8	**
5	Flag leaf length (cm)	1.26	87.43	1.06	82.25	**
6	Flag leaf area (cm ²)	0.06	41.47	0.14	283.99	**
7	Days to 50% flowering	444.59	1003.33	452.14	2.21	
8	No. of grains/panicle	1.79	549.73	1.65	331.31	**
9	Test weight (g)	0.02	1.94	0.01	126.89	**
10	Kernel length (mm)	0.002	0.065	0.003	253.27	**
11	Kernel breadth (mm)	0.002	0.084	0.001	59.37	**
12	Grain yield (q/ha)	1.55	145.43	0.46	315.85	**

The analysis of variance (ANOVA) indicated statistically significant genotypic effects for the majority of the traits evaluated under rainfed conditions. Highly significant ($p \leq 0.01$) differences among varieties were observed for maturity duration, effective tillers per hill, panicle length, flag leaf length, flag leaf area, grains per panicle, test weight, kernel length, kernel breadth, and grain yield, as evidenced by high estimates of F values of respective traits. This suggests the predominance of genetic variability governing these traits and highlights the differential response of genotypes under drought stress environments.

Conversely, non-significant variation for plant height and days to 50% flowering indicates relatively low genotypic influence or greater environmental buffering for these characters. The magnitude of error mean squares was comparatively low for most traits, reflecting adequate experimental control and precision. The significant mean sum of squares due to varieties for key yield-contributing traits and grain yield further substantiates the potential for effective selection and genetic improvement of drought-tolerant rice genotypes under similar agro-ecological conditions.

Table 4: SE(m) and CD of traits of rice genotypes

SI No.	Parameter	SEm ($\pm$)	CD ($p \leq 0.01$)
1	Plant Height (cm)	5.82	-
2	Maturity Duration (days)	0.40	1.21
3	No. of effective tillers/hill	0.33	1.01
4	Panicle Length (cm)	0.11	0.35
5	Flag Leaf Length (cm)	0.32	0.97
6	Flag Leaf Area (cm ²)	0.12	0.36
7	Days to 50% flowering	6.72	-
8	No. of grains/panicle	0.40	1.22
9	Test Weight (g)	0.03	0.11
10	Kernel Length (mm)	0.01	0.04
11	Kernel Breadth (mm)	0.01	0.03
12	Grain Yield (q/ha)	0.21	0.64

The estimates of standard error of mean (SEm $\pm$) and critical difference (CD) at 1% level of significance provide an assessment of the precision and reliability of the experimental data as well as the extent of variability among genotypes. The relatively low SEm values observed for most of the traits indicate high experimental accuracy and minimal random variation. The computed CD values at $p \leq$

0.01 for key agronomic and yield attributes such as maturity duration, effective tillers per hill, panicle length, flag leaf traits, grains per panicle, test weight, kernel dimensions, and grain yield suggest that the observed inter-varietal differences for these characters are statistically robust and can be reliably used for comparison and selection. The absence of CD values for plant height and days to 50%

flowering corroborates the non-significant variation detected in the ANOVA, indicating that differences among genotypes for these traits were not sufficiently large to surpass the threshold of statistical significance. Furthermore, the narrow CD values for yield and its contributing traits reflect greater sensitivity of these parameters in distinguishing varietal performance under rainfed conditions. Overall, these statistical parameters validate the consistency of the dataset and reinforce the significance of observed differences among the rice genotypes.

Results and Discussion

The analysis of variance (Table 3) demonstrated pronounced genotypic variability for the majority of the traits evaluated under rainfed conditions, with highly significant ($p \leq 0.01$) varietal effects observed for key growth, yield, and grain quality parameters. The relatively low magnitude of error mean squares and corresponding SEM values (Table 4) indicate high experimental precision and reliability of the dataset, thereby strengthening the validity of the statistical inferences.

Plant height exhibited non-significant variation ($F = 0.19$), indicating that the observed numerical differences among genotypes (101-110 cm) were largely influenced by environmental variation rather than genetic factors. A similar non-significant trend was observed for days to 50% flowering ($F = 2.21$), suggesting phenological stability among the tested varieties under the prevailing agro-climatic conditions. In contrast, maturity duration showed a highly significant varietal effect ($F = 157.3$; $CD = 1.21$ days), confirming the presence of exploitable genetic variability for crop duration. Highly significant differences were recorded for the number of effective tillers per hill ($F = 42.55$; $CD = 1.01$), with Swarna Samriddhi producing a significantly higher number of tillers (14 hill^{-1}) compared to Pratikshya (12 hill^{-1}) and Ranidhan (10 hill^{-1}). Since the inter-varietal differences exceeded the CD at $p \leq 0.01$, the superiority of Swarna Samriddhi for this trait can be considered statistically robust. Drought-tolerant genotypes are known to maintain tiller survival under moisture stress due to improved carbohydrate remobilization (Khan *et al.*, 2020 and Pathak *et al.*, 2018). Panicle length also exhibited a strong varietal effect ($F = 70.8$; $CD = 0.35$ cm), with Swarna Samriddhi (25.8 cm) significantly outperforming the other genotypes, indicating enhanced reproductive development. Flag leaf length ($F = 82.25$; $CD = 0.97$ cm) and flag leaf area ($F = 283.99$; $CD = 0.36$ cm) differed significantly among genotypes, with Swarna Samriddhi recording higher values. These traits are critical determinants of photosynthetic efficiency, and their significant enhancement suggests improved assimilate production under moisture-limited conditions. Similarly, the number of grains per panicle showed a highly significant response ($F = 331.31$; $CD = 1.22$), where Swarna Samriddhi

(159 grains) was statistically superior to Pratikshya (148 grains) and Rani Dhan (145 grains). The narrow CD value relative to the magnitude of mean differences highlights the strong discriminatory power of this trait and its importance in determining yield potential. These findings indicate enhanced sink strength and reproductive efficiency in the drought-tolerant genotype. Studies have reported that tolerant varieties sustain reproductive development by maintaining higher relative water content and better stomata regulation (Saxena *et al.*, 2002 and Bernier *et al.*, 2009) [7, 15]. Test weight ($F = 126.89$; $CD = 0.11$ g) and kernel dimensions, including kernel length ($F = 253.27$; $CD = 0.04$ mm) and kernel breadth ($F = 59.37$; $CD = 0.03$ mm), also showed highly significant variation, reflecting distinct genetic control over grain quality traits. The low SEM values associated with these parameters further confirm the consistency and precision of the measurements.

Grain yield exhibited a highly significant varietal effect ($F = 315.85$; $CD = 0.64 \text{ q ha}^{-1}$), indicating strong genetic differentiation among the genotypes under rainfed conditions. Swarna Samriddhi recorded the highest yield (44.5 q ha^{-1}), which was significantly superior to Pratikshya (39.2 q ha^{-1}) and Ranidhan (37.0 q ha^{-1}), as the observed differences were several-fold higher than the critical difference. The high F-value coupled with a relatively low CD underscores the robustness of this result and confirms the consistency of yield superiority. This advantage can be attributed to the cumulative effect of superior yield-contributing traits, particularly effective tillers, panicle length, grains per panicle, and test weight, which collectively enhanced source-sink relationships under moisture stress dynamics under rain-fed environments (Hazra *et al.*, 2021 and Subedi *et al.*, 2024) [16, 17]. Higher test weight and improved kernel characteristics further indicate efficient grain filling under drought conditions. Similar findings have been reported in drought tolerant rice varieties under rain-fed ecosystems (Saxena *et al.*, 2002 and Dar *et al.*, 2020) [7, 11].

Economic analysis further reinforced the agronomic findings, with Swarna Samriddhi recording the highest gross return (Rs. 1,16,250 ha^{-1}), net return (Rs. 54,870 ha^{-1}), and benefit-cost ratio (1.89). In comparison, Pratikshya and Ranidhan registered lower economic returns, with B:C ratios of 1.68 and 1.59, respectively. The economic superiority aligns with the statistically validated yield advantage, indicating that the observed differences are not only significant but also practically meaningful. Similar economic superiority of stress-tolerant varieties under climate-resilient agriculture programs has been documented by Thakur and Uphoff (Thakur *et al.*, 2017) [5]. Overall, the integration of statistical significance with agronomic and economic performance highlights the strong adaptive potential of Swarna Samriddhi for rainfed and drought-prone ecosystems of Western Odisha.

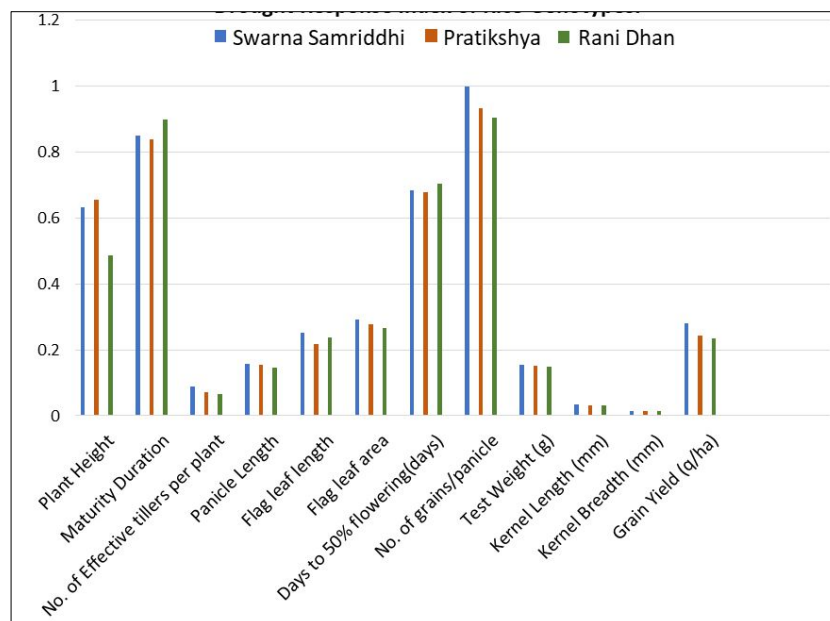


Fig 1: Drought Response Index of Rice varieties

The Drought Response Index (DRI) was calculated to obtain a composite measure of varietal performance under moisture stress by integrating major yield-contributing traits. The selected parameters included number of effective tillers per hill, panicle length, number of grains per panicle, and grain yield. Each trait was first normalized by dividing the observed value of a genotype by the maximum value recorded for that trait among all genotypes, thereby converting the data into a dimensionless scale ranging from 0 to 1. Subsequently, the normalized values of all selected traits were averaged to obtain the mean index value for each genotype. The genotype with the highest composite value was assigned a DRI of 100, and the DRI values of the remaining genotypes were expressed proportionally. This normalization-based approach minimizes scale variation among traits and provides an integrated assessment of drought tolerance by capturing the cumulative effect of key yield components. The Drought Response Index (DRI), computed from the normalized values of key yield-contributing traits such as effective tillers per hill, panicle length, number of grains per panicle, and grain yield, revealed clear differences in varietal performance under rainfed conditions. Among the tested genotypes, Swarna

Samriddhi recorded the highest DRI value (100), followed by Pratikshya (≈ 90.4) and Ranidhan (≈ 84.6), indicating its superior adaptability to moisture stress environments. The higher index value of Swarna Samriddhi is attributed to its consistently better performance across all contributing traits, particularly in effective tillers per hill (14 hill^{-1}), panicle length (25.8 cm), grains per panicle (159), and grain yield (44.5 q ha^{-1}), as presented in Table 2. The index-based approach effectively eliminates scale differences among traits and integrates their cumulative contribution into a single composite value, thereby providing a holistic assessment of drought tolerance. The comparatively lower DRI values of Pratikshya and Ranidhan reflect their reduced efficiency in maintaining yield components under moisture-limited conditions. The results clearly demonstrate that the superiority of Swarna Samriddhi is not confined to a single trait but is the outcome of coordinated improvement in multiple yield attributes. Thus, the significantly higher DRI value of Swarna Samriddhi confirms its stable and resilient performance under rainfed conditions, highlighting its suitability for cultivation in drought-prone ecosystems of the Western Undulating Zone of Odisha.

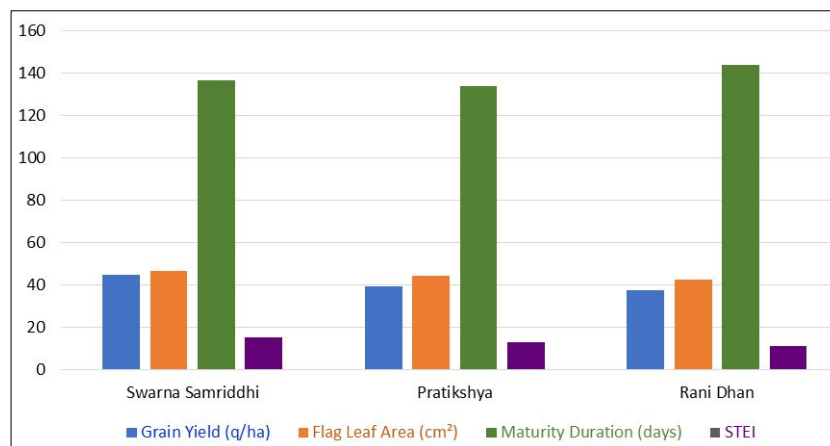


Fig 2: Stress Tolerance Efficiency Index (STEI) of Rice Varieties

The Stress Tolerance Efficiency Index (STEI) was computed to quantify the efficiency of different rice genotypes in converting photosynthetic potential into economic yield within a given growth duration under rainfed conditions. The index integrates key physiological and yield determinants, namely grain yield, flag leaf area, and maturity duration, thereby providing a composite measure of resource-use efficiency under moisture stress environments.

The analysis revealed distinct varietal differences in STEI values, clearly reflecting the differential physiological efficiency among the tested genotypes. Swarna Samriddhi recorded the highest STEI value (15.17), followed by Pratikshya (12.93) and Ranidhan (10.97). The STEI of Swarna Samriddhi was approximately 17% higher than Pratikshya and 38% higher than Ranidhan, indicating its superior ability to convert assimilatory surface area into grain yield without a proportional increase in crop duration. The higher STEI observed in Swarna Samriddhi can be attributed to its optimal balance between source and sink components, particularly its relatively larger flag leaf area and higher grain yield performance under stress conditions. This suggests enhanced photosynthetic efficiency, improved assimilate partitioning, and more effective translocation of photosynthates towards grain formation. In contrast, the comparatively lower STEI values of Pratikshya and Rani Dhan indicate reduced efficiency in biomass utilization and assimilate conversion under similar environmental conditions. The STEI-based evaluation complements the findings of the Drought Response Index (DRI) and grain yield analysis, collectively reinforcing the superior adaptive capacity of Swarna Samriddhi under rainfed ecosystems. The consistency of its performance across both composite indices highlights its physiological resilience and suitability for cultivation in drought-prone regions of the Western Undulating Zone of Odisha.

Conclusion

The findings of the present study, conducted under rainfed conditions during Kharif 2025, demonstrated distinct varietal differences in growth and yield performance. Swarna Samriddhi exhibited clear superiority over Pratikshya and Ranidhan in key yield-contributing traits, particularly effective tillers per hill, panicle length, and number of grains per panicle, which collectively translated into a significantly higher grain yield (44.5 q ha⁻¹). The statistical evidence at the 1% level of significance confirmed the robustness of these differences under the prevailing agro-climatic conditions.

In addition to its agronomic advantages, Swarna Samriddhi generated higher economic returns, as reflected by greater gross and net income and an improved benefit : cost ratio compared to the other tested varieties. The combination of stable yield performance, non-lodging behaviour, and economic profitability underscores its suitability for cultivation in rainfed and drought-affected regions. Therefore, Swarna Samriddhi can be considered a promising varietal option for enhancing productivity and farm profitability in the rainfed ecosystems of Western Odisha. Adoption of such drought-resilient varieties may play a vital role in improving production stability and strengthening the adaptive capacity of farmers in climate-vulnerable areas.

Acknowledgement

This research was supported by the Indian Council of Agricultural Research, Department of Agricultural Research and Education, Government of India through the National Innovations in Climate Resilient Agriculture (NICRA Project) under Krishi Vigyan Kendra, Kalahandi.

References

1. Nayak AK, Shahid M, Nayak AD, *et al.* Assessment of ecosystem services of rice farms in eastern India. *Ecol Process.* 2019;8:35. doi:10.1186/s13717-019-0189-1.
2. Directorate of Rice Research. Annual report 2011-12. Hyderabad: ICAR-Directorate of Rice Research; 2012. Available from: https://www.icar-iirr.org/AnnualReports/DRR_Annual%20Report_2011_12.pdf
3. Nayak SP, Variar M, Das SR, Hossain SM, Banik NC, Khandai S, *et al.* Rice production manual for Odisha. Los Baños: International Rice Research Institute; 2021. Available from: https://www.researchgate.net/publication/359984512_Rice_Production_Manual_for_Odisha
4. Saikumar S, Varma CMK, Saiharini A, Kalmeshwer Nagendra GPK, Lavanya K, Ayyappa D. Grain yield responses to varied levels of moisture stress at reproductive stage in an interspecific population derived from Swarna/Oryza glaberrima introgression line. *NJAS Wageningen J Life Sci.* 2016;78:111-122. doi:10.1016/j.njas.2016.05.005.
5. Thakur AK, Uphoff N. How the system of rice intensification can contribute to climate-smart agriculture. *Agron J.* 2017;109:1-20. doi:10.2134/agronj2016.03.0162.
6. Malik HN, Panda A, Behera S, Rahman FH. A comparative study of different moisture stress tolerant rice varieties in Kalahandi district of Odisha. *Int J Plant Soil Sci.* 2020;32(7):1-6.
7. Saxena NP, O'Toole JC, editors. Field screening for drought tolerance in crop plants with emphasis on rice: Proceedings of an international workshop held 11-14 Dec 2000. Patancheru: ICRISAT; 2002. Available from: https://oar.icrisat.org/364/1/CO_0022.pdf
8. Sarma B, Kashtoh H, Lama Tamang T, Bhattacharyya PN, Mohanta YK, Baek KH. Abiotic stress in rice: Physiological responses and tolerance mechanisms. *Plants.* 2023;12(23):3948. doi:10.3390/plants12233948.
9. Ranjan A, Sinha R, Singla-Pareek SL, Pareek A, Singh AK. Shaping the root system architecture in plants for adaptation to drought stress. *Physiol Plant.* 2022;174:e13651.
10. Singh PK, Singh SK. Assessment of stress tolerant rice (*Oryza sativa* L.) varieties under rainfed conditions of south-east Bihar. *Int J Res Agron.* 2024;7(SP-12):31-34.
11. Dar MH, Waza SA, Shukla S, Zaidi NW, Nayak S, Hossain M, *et al.* Drought tolerant rice for ensuring food security in eastern India. *Sustainability.* 2020;12(6):2214. doi:10.3390/su12062214.
12. Filazzola A, Cahill JF Jr. Replication in field ecology: Identifying challenges and proposing solutions. *Methods Ecol Evol.* 2021. doi:10.1111/2041-210X.13657.

13. Khan MIR, Palakolanu SR, Chopra P, Rajurkar AB, Gupta R, Iqbal N, *et al.* Improving drought tolerance in rice: Ensuring food security through multidimensional approaches. *Physiol Plant*. 2020;1-24.
14. Pathak H, Nayak AK, Jena M, Singh ON, Samal P, Sharma SG. Rice research for enhancing productivity, profitability and climate resilience. Cuttack: ICAR-National Rice Research Institute; 2018. Available from: https://icar-nrri.in/wp-content/uploads/2019/02/Rice_Research_book_nrri.pdf
15. Bernier J, Serraj R, Kumar A, Venuprasad R, Impa S, Gowda RPV, *et al.* The large-effect drought-resistance QTL qtl12.1 increases water uptake in upland rice. *Field Crops Res*. 2009;110(2):139-146. doi:10.1016/j.fcr.2008.07.010.
16. Hazra KK, Swain DK, Singh SS. Crop performance and soil-plant nutrient dynamics in rice-lentil system altered with rice cultivation practices in alkaline soil. *Eur J Agron*. 2021;130:126352. doi:10.1016/j.eja.2021.126352.
17. Subedi S, Pokhrel A, Awasthi K, Dhami J, Adhikari B. Assessing the contribution of nutrients to yield of rice varieties through omission plot techniques in Lamjung, Nepal. *J Agric Anim Sci*. 2024;38:1-12. doi:10.3126/jjaas.v38i1.73073.