# Assessment of Stress Tolerant Rice Varieties under Rain Fed Condition in North Eastern Ghat of Odisha

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author SM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SS and PKP managed the analyses of the study. Author FHR managed the literature searches. All authors read and approved the final manuscript.*

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## ABSTRACT

A field experiment was conducted during *kharif* 2019 at NICRA villages *viz*. Nada, Chikili and Chopara of Krishi Vigyan Kendra, Ganjam1 through technology demonstration to analyse the performance of stress tolerant rice varieties under rainfed condition. Three different drought tolerant rice varieties i.e. *MTU-1010, Sahabhagidhan and Swarna Shreya* with ten replications were taken in random block design with improved package of practices compared to farmers' practice. The results of technology demonstration revealed that growing of Swarna Shreya recorded higher growth parameters compared to other treatments with ten days delayed maturity. Improved practice of Swarna Shreya ($T_3$) recorded higher number of filled grains panicle$^{-1}$ (135.4±5.41), spikelet fertility (95.0±0.33 %), panicle length (24.8±1.45 cm) and 1000 grain weight (25.7±0.52 g) compared to other two treatments. Significantly higher grain yield (3588±169.5 kg ha$^{-1}$) and straw yield (7591±236.9 kg ha$^{-1}$) were recorded compared to farmers' practice (2632±125.1 kg ha$^{-1}$ and 5934±366.4 kg ha$^{-1}$, respectively). Swarna Shreya recorded higher gross

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return (Rs 67037±2980.2 ha$^{-1}$), net return (Rs 37037±2980.2 ha$^{-1}$), B: C ratio (2.23±0.20) and profitability (Rs. 101.5±8.16 ha$^{-1}$ days) with as compared to farmers' practice of growing MTU 1010.

## 1. INTRODUCTION

Rice is the predominant crop of Odisha with a total coverage of 41 lakh ha which is about 65% of the total cultivable area of the state. Area under rice crop in Ganjam district of the state is 251.86 thousand ha [1]. A large portion about 70% of area under rice in India is drought prone varieties [2]. There is hardly any scope to replace the rice crop considering the precipitation of less than 1500 mm rainfall during the monsoon season. Owing to climate variation and climate extremes, rice yield fluctuates by up to 32%, which is about 3 million tons of annual yield loss [3]. This yield vulnerability in rice production stems from irregular rainfall pattern during growing season resulting to widespread drought [4]. Additionally, climate change has been predicted to increase the frequency and intensity of extreme weather conditions such as severe drought, heat stress and flood. Drought has been recognized as the primary constraint to *rainfed* rice production [5]. Drought is a major abiotic stress that adversely affects the rice growth, mostly in the *rainfed* ecosystem that ultimately affects the biomass production and yield [6]. Rice needs to adapt a series of physiological mechanisms with complicated regulatory network to fight and cope up with the unfavourable conditions due to drought stress.

However, multiple cropping system using short duration rice varieties and intensive input management may enhance the land use efficiency and increase the production level if sowing of *rabi* crops are made in time [7]. Upland rice in India is grown during the wet season (June-Sept). Selecting a suitable variety which matches the rainfall duration will be a major non-monetary input in upland cultivation. Upland rice cultivars with drought avoidance (through deep root systems) and drought recovery abilities are preferred. Because of the absence of high-yielding, good-quality drought-tolerant varieties, farmers in the *rainfed* ecosystem continue to grow these varieties. Hence, there remains a scope to introduce a short duration high yielding rice variety in existing rice-based cropping system in mid central table land zone of Odisha. Rice is a versatile crop having maturity duration varying from 80 days to 180 days that can be grown under wide range of climatic conditions including water stagnation to aerobic condition. Achieving self-reliance in rice production and maintaining price stability are important objectives in low-income countries because of the importance of this crop in providing national food security and income for low-income people [8]. There is hardly any scope to replace the rice crop considering the precipitation of less than 1500 mm rainfall during the monsoon season. However, multiple cropping system including short duration rice varieties and intensive crop management may enhance the land use efficiency, water use efficiency and increase the production level if sowing of *rabi* crops are made in advance with respect to water availability.

## 2. MATERIALS AND METHODS

The study was carried out through on farm testing in *kharif*-2019 at NICRA villages i.e. Nada (19.9202° N, 84.7517° E), Chikili (19.5564° N, 85.0052° E), and Chopara (19.9522° N, 84.7592° E) of Ganjam district under of Odisha with an objective to evaluate short duration drought tolerant varieties of rice. Climate of Ganjam district is fairly hot and humid monsoon and average rainfall during the study period from June to October was 1052 mm. The soil in the experimental site was slightly acidic in reaction (pH 5.88), sandy loam in texture, low organic carbon content (0.49%), low in available nitrogen (215.3 kg ha$^{-1}$), medium in available phosphorus (20.3 kg ha$^{-1}$), and high in available potassium (286.6 kg ha$^{-1}$) content [9,10] . The experiment was laid out in random block design comprising three treatments i.e. $T_1$: Cultivation of MTU-1010, $T_2$: Cultivation of Sahabhagi $T_3$: Cultivation of Swarna Shreya and with ten replications considering each farmer as a replication. KVK, Ganjam-I conducted 6 ha demonstration in Ganjam district i.e. mostly drought prone area of NICRA villages and training was given to selected farmer groups regarding cultivation package and comparative benefits were also discuss on the bases of micro-situation of farming. KVK provided all the technical help by training follow up farmer meeting and discussion. Also leaflets and pamphlets on improved

package of practices of rice cultivation were distributed among the farmers in the village. Details of the variety chosen for the experiment were given in Table 1.

The crops were sown in 4th week of June and harvested during 3rd to 4th week of October. Ten different farmers each having 0.6 ha area of land cultivated the short duration drought tolerant rice varieties with recommended package of practices. Ten farmers from another area for comparing the impact of practices were also selected. Details of farmers' practice and improved practice are given in Table 2.

Observations on different growth and yield parameters were taken and economic analysis was done by calculating cost of cultivation, gross return, and net return. Final crop yield (grain and straw) was recorded and the gross return was calculated based on prevailing market price. Profitability of the system was calculated by dividing the net return ha$^{-1}$ in a sequence by 365 days. The production efficiency value was calculated by dividing the total grain production ha$^{-1}$ with total duration of crop. Tabular analysis involving simple statistical tools like mean was done by standard formula to analyse the data and draw conclusions and implications [11]. The analysis and interpretation of data were studied using the Fischer's method of analysis of variance technique as described by [11]. The level of significance used in F and t test was p=0.05 and critical difference values were calculated where F test was found significant.

## 3. RESULTS AND DISCUSSION

### 3.1 Effect on Growth Attributes

Results of the experiment indicated that the improved practice treatment $T_3$ (Swarna Shreya) showed 10 days delay in maturity (120 days) with significantly taller plant height (116.3±11.64 cm), higher total dry matter (490.3±11.8.17 g m$^{-2}$) and higher number of effective tillers hill$^{-1}$ (13.2±1.30) compared to farmers' practice of growing MTU 1010 variety as indicated in table 3. However, plant height of Swarna Shreya and Sahabhagidhan were found to be at par with each other. Plant height is one of the important growth parameters of any crop as it determines or modifies yield contributing characteristics and finally shapes the grain yield [12]. It is a complex character and is the end product of several

genetically controlled factors mostly governed by the genetic make-up of the genotypes, generally depends on their number of internodes and length of internodes [13]. Variation in total dry matter production might be due to differential genetic makeup of varieties and ability to accumulate the photosynthates in the vegetative plant parts. Among the various yield components, productive tillers are very important as the final yield is mainly a function of the number of panicles bearing tillers per unit area [14]. Significant differences in plant growth characteristics of rice as influenced by various genotypes under drought conditions were also reported by Parashivamurthy et al. [15], Sarker et al. [16] and Pradhan et al. [17].

### 3.2 Effect on Yield and Yield Parameters

Results of demonstration showed that improved practice of Swarna Shreya ($T_3$) recorded higher number of filled grains panicle$^{-1}$ (135.4±5.41), spikelet fertility (95.0±0.33 %), panicle length (24.8±1.45 cm) and 1000 grain weight (25.7±0.52 g) compared to other treatments. Lowest number of unfilled grains panicle$^{-1}$ (7.20±0.55 %) was recorded in $T_3$ (Swarna Shreya) as indicated in Table 4. MTU-1010 showed the lowest yield attributes except unfilled grains panicle$^{-1}$. This finding was in corroborated with findings of Pandey and Shukla, 2015. The candidate rice varieties exhibited highly significant differences on 1000 grain weight (Table 4). Similar results were reported by Gupta and Sharma [18] and Sonam et al. [19]. The variation in thousand seed weight might be due to the differences in length and breadth of the seeds that were partly controlled by the genetic make-up of the genotypes [13]. These results are also in confirmatory with Sneha et al. [20] and Mallik et al. [21].

Further analysis of yield parameters showed that $T_3$ (Swarna Shreya) variety recorded significantly higher grain yield (3588.7±169.5 kg ha$^{-1}$), straw yield (7591±236.9 kg ha$^{-1}$) and harvest index (32.1±0.50 %) than Sahabhagidhan and MTU 1010 (Table 5). The lowest grain yield, straw yield and harvest index was recorded by $T_1$ (MTU 1010). This might be due to the production of higher vegetative biomass production, large panicles and high tillering capacity, number of effective tillers plant$^{-1}$ and number of grains panicle$^{-1}$. Significantly higher production efficiency (29.2±1.30 kg ha$^{-1}$ day$^{-1}$) was recorded from the treatment $T_3$ (Swarna Shreya) while the

**Table 1. Characteristics of varieties grown in experiment**

| Technology options | Variety | Varietal characteristics |
|---|---|---|
| T$_1$ | MTU 1010 | 120-125 days duration, semi dwarf (108 cm) long slender super fine grain with BPH and blast resistance, suitable for medium land situation, average yield 40-45 q ha$^{-1}$ |
| T$_2$ | Sahabhagidhan | Early duration (105-110 days) dwarf statured (85-90 cm), extremely drought tolerance, appropriate for upland, rainfed direct seeded as well as transplanted situation, produces yellow (golden) husked long bold seeds and average efficiency of 20-25 q ha$^{-1}$ under stress and 38-45 q ha$^{-1}$ without stress. Resistance to leaf blast, moderate resistant to brown spot, sheath rot, stem borer, and leaf folder. |
| T$_3$ | Swarna Shreya | Suitable for aerobic and water limiting condition, rainfed low land and direct seeded aerobic condition. Maturity period: 120-125 days. Average productivity : 45-50 q ha$^{-1}$ |

**Table 2. Comparison of farmers' practice and practice followed in demonstration**

| Sl no. | Particulars | Existing farmers' practices | Improved practices for demonstration |
|---|---|---|---|
| 1 | Variety | MTU 1010 | Sahabhagidhan and SwarnaShreya |
| 2 | Time of sowing | 3$^{rd}$ week of June | 3$^{rd}$ week of June |
| 3 | Method of sowing | Broadcasting | Line transplanting |
| 4 | Seed rate | 50 kg ha$^{-1}$ | 50 kg ha$^{-1}$ |
| 5 | Seed treatment | No seed treatment | Seed treatment with thiram @ 2 g kg$^{-1}$ seed |
| 6 | Fertilizer management | Imbalance use of fertiliser | 80-40-40 kg N-P2O$_5$-K$_2$O ha$^{-1}$ |
| 7 | Weed management | No use of herbicide | Hand weeding and use of herbicide |
| 8 | Plant protection | Injudicious use of plant protection chemicals | Need based plant protection measures. |

**Table 3. Performance of stress tolerant rice varieties on growth attributes**

| Treatments | Plant height (cm) | Total dry matter (g m$^{-2}$) | No. of tillers m$^{-2}$ | No. of effective tillers hill$^{-1}$ | Maturity duration (days) |
|---|---|---|---|---|---|
| T$_1$ MTU 1010 | 103.2±7.09 | 412.5±7.23 | 13.4±1.44 | 11.6±1.44 | 113.0 |
| T$_2$ Sahabhagidhan | 108.3±5.62 | 440.1±6.63 | 11.8±1.54 | 10.2±1.10 | 110.0 |
| T$_3$ Swarna Shreya | 116.3±11.64 | 490.3±8.17 | 14.8±1.01 | 13.2±1.30 | 123.0 |
| S.E(m)± | 2.8 | 2.4 | 0.4 | 0.39 | -- |
| C.D. (0.05) | 8.3 | 7.2 | 1.2 | 1.17 | -- |
| No. of repetitions | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |

**Table 4. Performance of stress tolerant rice varieties on yield attributes**

| Treatment | No. of filled grains panicle[-1] | No. of unfilled grains panicle[-1] | Spikelet fertility (%) | Panicle length (cm) | 1000 grain weight (g) |
|---|---|---|---|---|---|
| T[1]- MTU 1010 | 112.8±4.28 | 11.31±0.72 | 90.9±0.49 | 21.1±1.14 | 23.4±0.57 |
| T[2]- Sahabhagidhan | 123.7±6.63 | 8.89±0.42 | 93.3±0.54 | 23.3±1.57 | 24.1±0.58 |
| T[3]- Swarna Shreya | 135.4±5.41 | 7.20±0.55 | 95.0±0.33 | 24.8±1.45 | 25.7±0.52 |
| S.Em± | 1.6 | 0.15 | 0.12 | 0.40 | 0.2 |
| C.D. (p=0.05) | 4.7 | 0.46 | 0.36 | 1.19 | 0.5 |
| No. of repetitions | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |

**Table 5. Performance of stress tolerant rice varieties on yield and yield attributes**

| Treatment | Grain yield (kg ha^{-1}) | Straw yield (kg ha^{-1}) | Harvest index (%) | Production efficiency (kg ha^{-1} day^{-1}) |
|---|---|---|---|---|
| T[1]- MTU 1010 | 2632.0±125.1 | 5934.2±366.4 | 30.8±1.09 | 23.3±1.11 |
| T[2]- Sahabhagidhan | 2985.0±169.4 | 6462.6±345.8 | 31.6±0.56 | 27.1±1.54 |
| T[3]- Swarna Shreya | 3588.7±169.5 | 7591.8±236.9 | 32.1±0.50 | 29.2±1.30 |
| S.E(m)± | 42.1 | 94.8 | 0.21 | 0.4 |
| C.D. (0.05) | 125.0 | 281.5 | 0.63 | 1.1 |
| No. of repetitions | 10.0 | 10.0 | 10.0 | 10.0 |

**Table 6. Performance of stress tolerant rice varieties on economics**

| Treatment | Gross return (Rs ha^{-1}) | Net return (Rs ha^{-1}) | B:C ratio | Profitability (Rs ha^{-1} day^{-1}) |
|---|---|---|---|---|
| T[1]- MTU 1010 | 49166±2337.8 | 19166±2337.8 | 1.64±0.08 | 52.5±6.40 |
| T[2]- Sahabhagidhan | 55759±3163.5 | 25759±3163.5 | 1.86±0.11 | 70.6±8.67 |
| T[3]- Swarna Shreya | 67037±2980.2 | 37037±2980.2 | 2.23±0.20 | 101.5±8.16 |
| S.E(m)± | 785.9 | 785.9 | 0.03 | 2.2 |
| C.D. (0.05) | 2334.6 | 2334.6 | 0.08 | 6.4 |
| No. of repetitions | 10.0 | 10.0 | 10.0 | 10.0 |

lowest value was observed from cultivation of MTU 1010 (23.3). This confirms the report of Islam et al. [22] that varieties with longer growth duration usually produce more grain yield than the varieties with shorter growth duration. The difference in yield was also attributed to the number of productive tillers, varietal yielding capabilities and also to the growth performance of every variety tested [23].

## 3.3 Economics

An analysis on economics revealed that SwarnaShreya recorded higher gross return (Rs. 67037±2980.2 ha$^{-1}$), net return (Rs. 37037±2980.0 ha$^{-1}$) and B: C ratio (2.23±0.20) as compared to farmers practice of growing MTU 1010 as indicated in Table 5. $T_3$ treatment (Swarna Shreya) also recorded significantly higher profitability (Rs.101.5±8.16 ha$^{-1}$ day$^{-1}$) followed by $T_2$ (Sahabhagidhan). Lowest value was observed from $T_1$ (Rs. 52.5±6.40 ha$^{-1}$ day$^{-1}$). Mitra et al. [24] also reported the advantages of growing newly introduced variety over the traditional with higher return, the variation in net return and benefit-cost ratio may be attributed to the variation in the price of agri-inputs and produce.

## 3.4 Farmer's Feedback

The HYV Swarna Shreya produced higher yield with more tillering capacity and resistance to drought. Overall, the performance of experiment results suggested that it has the potential for increase yield of the farmers as well as profitability from unit land area.

## 4. CONCLUSION

Thus, existing HYV of rice MTU 1010 may be replaced with HYV Swarna Shreya because of higher productivity, income and drought tolerant capacity. HYV Swarna Shreya was found to be suitable since it fits well to the existing farming situation and increased productivity and profitability of land.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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