Original Research Article

Efficacy of DroughtTolerant Rice Variety Swarna Shreya in North-Eastern Ghat Zone of Odisha through Frontline Demonstration

ABSTRACT:

A continuous3 year demonstration using drought tolerant rice variety Swarna Shreya was carried out in participatory mode in farmers' field during *Kharif* season 2019, 2020 and 2021 at Lathipadsa village of Surada block of Ganjam district under north-eastern ghat zone of odisha.Major constraints of traditional rice cultivation arethe low productivity in upland areas due to lack of knowledge and partial adoption of recommended package of practices by rice growing farmers. Also because of less water sometime farmers do not take any crop. Therefore, present demonstration programme has been undertaken to popularize/introduce stress tolerant rice var. Swarna Shreya in drought prone and upland areas of Ganjam district of Odisha. The yield improvement due to the improved practices was 18.69 percent over farmers' practice. An average yield of 38.33 q ha^{-1} was recorded under demonstration plots as compared to 32.17 q ha^{-1} in farmers practice plots. Average technology gap, extension gap, technology index was 6.67 q ha^{-1}, 6.17 q ha^{-1}, 14.81 per cent under three year frontline demonstration programme wererecorded. The stress tolerant rice variety Swarna Shreya gave higher net return of Indian Rupee (INR) 33500, 40655 and INR 45350 ha^{-1} as compared to farmers practices with INR 26100, 23520 and 24650 ha^{-1} during Kharif season of 2019, 2020 and 2021, respectively. The benefit cost ratio (B:C ratio) of rice cultivation under improved practices were found to be 1.95, 2.13 and 2.08 as compared to 1.67, 1.60 and 1.58 under farmers practices.

Key word: Rice, Growth, Yield, Yield attribute, Stress tolerant, Odisha,

INTRODUCTION: Rice being one of the most important staple food crops in the world after wheat and is the primary source of calories for about half of mankind. It provides around 27 per cent of dietary energy, 15 per cent of dietary protein and 3 percent of dietary fat to global population. The area under its cultivation is 167 million hectares producing 770 million tons and a productivity of 4.60 tons/ha in the world (FAOSTAT, 2017). It is cultivated under diverse ecologies ranging from irrigated to rainfed upland to rainfed lowland to deep water. Drought is the most widespread and damaging of all environmental stresses. Drought can develop at any stage of the crop in unbunded or bunded upper fields upon the cessation of rainfall for a few consecutive days, often resulting in a severe growth, physiology and yield reduction through alternation in morphological, physiological and metabolic traits. The frequent occurrence of drought has been identified as the key to the low productivity of rice in rainfed ecosystems, particularly in the eastern region of India (Kumar et al.[7]; Verulkaret al.[17]). Understanding of physiological and biochemical mechanisms that enable plants to adapt to water deficits and maintain growth and productivity during stress periods could help in screening and selection of tolerant genotypes and using these traits in breedingprograms. Severe drought in the wet season not only had an adverse effect on rice production but also reduced the area sown under wheat, pulses, and oilseeds in the subsequent dry season because of the unavailability of sufficient moisture in the soil, thereby reducing the production of these crops and creating food insecurity in the country. In rainfed areas, upon failure of rain or a long dry spell between two spots of rain, drought stress can occur at the seedling, vegetative and reproductive stages of the rice.It can be intermittent drought depending on the rainfall pattern and distribution (Kumar, [8]). Among all these, a drought at the reproductive stage has been identified as the most detrimental to grain yield. Moreover, in most rainfed regions, the probability of occurrence of terminal reproductive-stage drought is high due to the early withdrawal of monsoon rains (Kumar et al. [6]). Rice productivity in these drought prone areas is poor and unstable; emphasis is shifting towards drought prone rainfed rice areas which offer a great potential in enhancing rice production and productivity. Most of the current high-yielding rice varieties IR 64, IR 36, MTU 1010, MTU 1001, RajendraSweta, RajendraBhagwati, RajendraMahsuri, Sarjoo 52 and Naveenare being grown in drought-prone areas of eastern India; which were originally developed for irrigated ecology, and they are extremely sensitive to drought at any crop growth stage. Several earlier studies also reported that the high yield loss of those varietiesis due to drought at any stage of the rice crop.

Drought prone rice areas in eastern states of India

The eastern region comprises of Bihar, Eastern Uttar Pradesh, Odisha, West Bengal, Jharkhand, Chhattisgarh and plains of Assam, represents 21.85% geographical area of the country and supports to 33.64% of country’s rice production (Bhatt et.al, [1]). Though the region is endowed with rich natural resources but the production level remained low. In eastern India, rice production is directly correlated with regional and national food security. The challenge ofincreasedwater scarcity and frequent occurrence of drought are threatening the food security in the eastern region. Eastern India accounts for 71.84 million ha geographical area, and 27.26 million ha rice area, of which nearly 4.28 million ha rice area is prone to frequent drought.

MATERIALS AND METHODS

Frontline Demonstrations (FLDs) in rice were carried out in participatory mode in farmers' field during *Kharif* seasons of 2018, 2019 and 2020 at Lathipada(19.7769˚ N, 84.5275˚ E) village of Ganjam district by RESILIENCE Project, funded by Norway Govt., worked under Odisha University of Agriculture and Technology, Odisha. The foundation seeds of improved rice variety Swarna Shreya were procured from Odisha State Seed Corporation Ltd. for demonstration purpose. The soil of the experimental site was sandy loam in texture, nearly neutral in reaction and variable soil status in all places.

Swarna Shreya is drought tolerant aerobic rice variety and recommended for cultivation under aerobic situation in rainfed medium land and poorly irrigated areas. Swarna Shreya is a semi-dwarf (105-110 cm) variety which flowers in about 85 days and matures in 115-120 days under transplanted condition.This variety is resistant to leaf blast and moderately resistant to neck, blast, brown spot, RTD and sheath rot. It was released during 2009 in India by National Rice Research Institute, Cuttack, Odisha and Narendra Dev University of Agriculture and Technology (NDUAT), Kumarganj, Faizabad, Uttar Pradesh, India.

A total of 35 demonstrations in 16.17 ha area were conducted in the selected villages of Ganjamdistrict. In local check plots, existing practice of transplanting with rice variety Lalat andMTU-1001 was followed by the farmers. The complete package of practices approach demonstrated in farmers field through demonstrations including improved variety, recommended seed rate, seed treatment, sowing method, fertilizer dose, weed management and plant protection which are presented in Table 1. All inputs including seeds, fertilizers, pesticides, weedicides etc. were used in the demonstrated plots whereas the farmers' practices plots were devoid of these improved practices. Different data *viz.* number of matured panicles m^{-2}, number of filled grains per panicle, test weight (g) and grain yield (q ha^{-1}) were collected from different demonstrations for three years. The farmers involved in demonstrations were facilitated by RESILIENCE

Project scientists in performing proper field managements like timely sowing of nursery in bed, transplanting of seedling, spraying of weedicide and insecticides and harvesting of crops. During the growing period of rice, different extension activities like farmers' training, diagnostic visits, soil health day, field days etc. were undertaken which benefited the farmers of the district. The average data were collected from both the demonstrations and farmers' fields. Data on crop yield were recorded per twenty five square meter observation method and collected randomly from 3 to 4 places both for demonstrations and farmers fields. Average collected data of three years were analysed using simple statistical tools. The technology gap, extension gap and technology index, according to Samui et al. [13] were calculated using the formulae given below:

$$\text{Technology gap} = \text{Potential yield} - \text{Demonstration yield}$$

$$\text{Extension gap} = \text{Demonstration yield} - \text{Farmers}'\text{practice yield}$$

$$\text{Technology index}\ (\%) = \frac{\text{Potential yield} - \text{Demonstration yield}'}{\text{Potential yield}}\ \text{x}\ 100$$

Table 1. Improved practices and farmers practices of rice under Frontline Demonstrations

Sl. No.	Particulars	Improved practices for demonstration	Existing Farmer practices	GAP
1	Variety	Swarna Shreya	Lalat, MTU 1001	Full gap
2	Field preparation	Ploughing, Harrowing and puddling	Ploughing, Harrowing and puddling	-
3	Seed rate	50 kg ha^{-1}	70 kg ha^{-1}	High seed rate
4	Seed treatment	Thiram@ 2g kg^{-1} of seed	No seed treatment	Full gap
5	Nursery management and transplanting	Nursery seeding is done during May to June and transplanting is done during July	Nursery seeding is done during May to June and transplanting is done during July	-
6	Sowing method	Line transplanting	Random transplanting	Full gap
7	Fertilizer dose	NPK @ 80:40:40 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + well decomposed FYM @ 5 tha^{-1}	Imbalance use of fertilizer/ Without recommendation	Partial gap
8	Weed management	Pretilachlor @ 0.75 l/ha within 3 DAT along with bispyribac	Hand weeding	Partial gap

		sodium @ 25 g/ha at 25 DAT		
9	Plant protection	Need based plant protection measures	Injudicious use of plant protection chemicals	Full gap

Table 2. Growth and yield attributing traits of rice var. Swarna Shreya and famers' practice during Kharif seasons of 2019, 2020 and 2021

Yield attributes	**Demonstration**	**Farmers' practice**
Plant height (cm)	127.8-130.0	124.0-128.0
No. of matured panicles m^{-2}	265-290	198-210
Panicle length (cm)	26-29	22-24
No. of effective tiller/hill	11-13	9-10
No. of filled grains $panicle^{-1}$	137-148	110-125
Test weight (g)	24.5-25	23.5-25

Table 3. Yield performance of rice variety Swarna Shreya and farmers' practice during *Kharif* seasons of 2019, 2020 and 2021

***Kharif*season**	**No. of Demonstrations**	**Area (ha)**	**Demo yield (q ha^{-1})**	**Farmers practice yield (q ha^{-1})**	**Yield increase over farmers practice (%)**
2019	4	0.6	35	33	6.06
2020	10	4.27	38.2	31.2	21.21
2021	21	11.3	41.8	32.3	28.79
Mean	11.67	5.31	38.33	32.17	18.69

Table 4. Impact assessment of rice var. SwarnaShreya on technology gap, extension gap and technology index

***Kharif* season**	**Technology gap (q ha^{-1})**	**Extension gap (q ha^{-1})**	**Technology index (%)**
2019	10	2	22.22
2020	6.8	7	15.11
2021	3.2	9.5	7.11
Mean	6.67	6.17	14.81

Table 5. Impact of Frontline demonstration on horizontal spread of rice var. Swarna Shreya

Year	Area of demonstration (ha)	No. of farmers	Technology spread in demonstrated village		Technology spread in outside of demonstrated village		Increase in adoption over initial year
			No. of farmers	Area (ha)	No. of farmers	Area(ha)	
2019	0.6	04	03	1.8	04	2.1	
2021	11.3	21	26	12.5	12	8.6	53 times

RESULT AND DISCUSSION

Differences were observed between demonstration practice and farmer's practice with respect to recommended varieties, seed treatment, method of sowing, fertilizer dose, method of fertilizer application, weed management and plant protection measures (Table 1). The recommended varieties, seed treating chemical, herbicide and plant protection chemicals in demonstrated plot were used by the farmers as per the recommendation of project scientists and other cultural practices were timely performed by the farmer under the direct supervision of scientists of RESILIENCE Project.

Growth and Yield attributes and Yield

Plant height data indicated that Swarna Shreya exhibited the highest value (127.8-130.0 cm). Yield attributes of improved practices indicated that the number of matured panicles per square meter (265-290), Panicle length (26-29 cm), No. of effective tiller/hill (11-13), number of filled grains per panicles (137-148) and test weight (24.5-25 g) were higher as compared to 198-210, 22-24 cm, 110-125 and 23.5-25 g under farmers practice (Table 2). These results are also in accordance with previous researchers Samant et al.[12], Mishra et al. [11], Malik et al. [9]. Similar results were reported by Gupta and Sharma [5] and Singh et al. [15]. 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. These results are also in confirmatory with Sneha et al. [16] and Mallik et al. [9].

The yield data indicated that through frontline demonstration, rice yield ranged from 35.0 q ha^{-1} to 41.80 q ha^{-1} in demonstration plots and from 31.0 q $ha^{-1}$to 33.0 q ha^{-1} in farmers practice plot in three years demonstrations during Kharif 2018, 2019 and 2020 (Table 3). The results revealed that average yield of rice through FLDs during three years were38.33 q ha^{-1} under demonstration plots as compared to 32.17 q ha^{-1} in farmers practice plots. This might be due to the production of higher number of effective tillers/ plant and number of grains /panicle. This result clearly indicated the higher average yield in demonstration plots over the years compared to farmers practice was due to knowledge and adoption of improved practices. The yield enhancement due to the improved practices ranged between 6.0 to 28.79 percent over farmers' practice. The percent increase in yield over farmers' practice was highest during *Kharif*-2021(Table 2). Corroborative results in rice and others crops were also given by Malik et al. [9], Samant et al.[12], Mishra et al. [11].

Technology gap

The technology gap, the differences between potential yield and yield of demonstration plots was 10.0, 6.8 and 3.2 q ha^{-1} during Kharif 2019, 2020 and 2021, respectively. Average data indicated that technology gap under three years programme was 6.67 q ha^{-1} (Table 4). This might be due to the soil fertility status, agricultural practices, local climatic situation and overcome by adopting efficient management practices.

Extension gap

In the present frontline demonstration, the extension gap of 2.0, 7.0 and 9.5 q ha^{-1} was observed during Kharif 2019, 2020 and 2021, respectively. On an average extension gap under three year frontline demonstrationprogramme was observed to be 6.17q ha^{-1}. This extension gap necessitates the need to bring awareness among the farmers for adoption of improved stress/drought tolerant rice varieties. These findings are in similarity with Goswami et al. [4] and Singh *et al.* 2018 [14].

Technology index

It refers to the ratio between technology gap and potential yield expressed in percentage. The technology index shows the feasibility and performance of the demonstrated technology at the farmers' field. The lower value of technology index shows the efficacy of good performance of technological interventions. In present demonstration, the technology index varied from 7.11 to

22.22 per cent (Table 4). Similar findings were reported by Girish et al. [3]. The average technology index was recorded as 14.81 per cent in rice crop during the three consecutive years of demonstration programmes. Technology index can be reduced with proper adoption of demonstrated technological interventions to increase the yield potential of rice crop. It shows the effectiveness and good performance of technological interventions.

Economic return

The cultivation of stress tolerant rice variety SwarnaShreya gave ahigher net return of Indian Rupee (INR) 33500, 40655 and INR 45350 ha^{-1}, respectively as compared to farmers practices with INR 26100, 23520 and 24650 ha^{-1} , respectively during Kharif season of 2019, 2020 and 2021 (Table 6). The benefit cost ratio (B:C ratio) of rice cultivation under improved practices was found to be 1.95, 2.13 and 2.08 as compared to 1.67, 1.60 and 1.58 under farmers practices. The economic viability of improved demonstrated technology over existing farmers practice was calculated depending on theprevailing price of inputs and outputs cost and it was expressed in term of B:C ratio. The additional cost increase in farmer's practice was mainly due to more cost involved in weeding mandays. In the present demonstration, theincrease in net returns over farmers practice varied from 28.35 to 141.30percent. The improved practices showed amaximum 141.30percent increase in net returns over farmers' practice during Kharif season of 2021. This might be due to higher yield obtained under improved practices compared to farmers practice. These results are also in conformity with the findings of Malik et al. [9], Singh et al. [14] and Girish et al. [3].

Area Expansion and Farmer's Feedback

The HYV Swarna Shreya produced higher yield with more tillering capacity under water stress condition. Overall, the performance of experiment results suggested that it has the potential for increasing the yield of the farmers as well as profitability from unit land area.

Along with improvement in yield and net return farmers preferenece or adoption of this variety has increased by 53 times (Table 5.) over initial year of demonstration both within and outside the village. This might be due to high yield and the incent price farmer getting during drought condition and upland area.

CONCLUSION

Based on three years of frontline demonstrations, it can be concluded that the yield potential of rice cultivar under stress condition increased to a great extent by adopting resilient variety and demonstrations of established technology. Drought tolerant rice variety Swarna Shreya produced higher yield (38.33 q ha^{-1}) with more tillering capacity (13 no of effective tillers) and resistance to drought. The frontline demonstration had a greater acceptance with improved practices and resulted in higher profitability (33500, 40655 and INR 45350 ha^{-1}) for the farming community under drought situationunder medium landsituation of Odisha. Thus, it is recommended that the improved practice needs to be popularized to decrease the technology gap, extension gap, technology index and there by yield gap so as to increase the income of farmers.

Table 6. Economic analysis of improved practice and farmers' practices

*Kharif*season	Demonstration					Farmers practice			
	Cost of cultivation (INR ha^{-1})	Gross return (INR ha^{-1})	Net return (INR ha^{-1})	B:C ratio	Increase in net returns over farmers practice (%)	Cost of cultivation (INR ha^{-1})	Gross return (INR ha^{-1})	Net return (INR ha^{-1})	B:C ratio
2019	35275	68775	33500	1.95	28.35	38745	64845	26100	1.67
2020	36050.6	76705.6	40655	2.13	72.85	39129.6	62649.6	23520	1.60
2021	42012	87362	45350	2.08	83.98	42857	67507	24650	1.58

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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