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ADAPTIVE PERFORMANCE OF RESILIENT RICE VARIETIES UNDER CLIMATE STRESS CONDITION IN WEST GARO HILLS, MEGHALAYA- A NICRA BASED ASSESSMENT

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ABSTRACT

Meghalaya, a state in the North East India, experiences diverse temperatures and rainfall patterns, particularly due to its varying altitudes. This climatic unpredictability often results in flash flood, which significantly affect rice production in the state. Due to aberrant climatic condition like flash flood and drought like situation, it causes great yield loss mostly to small and marginal farmers. To address this challenge, ICAR - Krishi Vigyan Kendra, West Garo Hills conducted an On Farm Trial during the Kharif season of 2025 to assess the performance of climate resilient rice varieties viz., Ranjit Sub-1, Bahadur Sub-1 and Gitesh in the adopted village. Ranjit Sub-1 and Bahadur Sub-1 are submergence-tolerant varieties, while Gitesh is suitable for staggered transplanting and shows resilience under prolonged stress conditions. The study revealed that the variety Gitesh outperformed other varieties in terms of yield under normal condition producing 43.20 q/ha, followed by Ranjit Sub-1 (39.40 q/ha) and Bahadur Sub-1 (38.80 q/ha), while, the local variety yield the lowest (26.8 q/ha). Although Ranjit Sub-1 and Bahadur Sub-1 performed relatively better during submergence caused by flash floods, Gitesh stood out with its better adaptability, maintaining higher yields during extended dry spells and also under partial submergence. These results position Gitesh as a promising variety for mitigating climate-related challenges in rice cultivation, while Ranjit Sub-1 and Bahadur Sub-1 offered more reliability in areas prone to flash flood condition.

Keywords **:** Climate change, rice, flash flood, drought, Meghalaya.

Introduction

Rice, which is one of the major staple foods for every individual all over the country. Compared to current rice production of 107 MT in India, future rice production due to climate change with medium emission is projected to be 104 MT during mid-century (2021-2050) and 101 MT during end century (2071-2100) (Kishore *et al*., 2024; Palanisami *et al*., 2017). Rice cultivation is central to Meghalaya's agriculture, serving as a major staple food crop and covering a significant portion of the cropped area of 1.08 lakh ha with an annual production of 2.79 lakh MT (Statistical Handbook Meghalaya, 2023). The state cultivates various types of rice, including Sali (Kharif/winter rice), Ahu (autumn rice), Boro (spring/summer rice) and *jhum* rice While rice production is substantial, the state faces challenges such as a lower-than-national average yield and a deficit in rice grain production due to various biotic and abiotic factors (Kumar *et al*., 2017).

Rice plays a vital part in the social economy, and consistent rice production is required to ensure future food security (Alexandratos and Bruinsma, 2012). Climate change poses a significant threat to rice production, particularly in vulnerable regions like West Garo Hills district of Meghalaya, India, where agriculture heavily relies on rainfall.

The National Innovations in Climate Resilient Agriculture (NICRA) project was launched to address these challenges by developing and promoting climate-resilient agricultural technologies and practices. A

crucial component of this project involves the identification and evaluation of rice varieties that can withstand climate-related stresses such as drought, floods, and temperature fluctuations. Recent years sometimes along with flash flood, drought like situation also arises and affected huge area of rice due to aberrant climatic condition (Nath *et al*., 2024). Climate-resilient rice varieties under the NICRA project has shown promising results in various regions. These varieties are specifically bred to exhibit enhanced tolerance to adverse climatic conditions while maintaining or improving yield potential. However, many of the current studies that predict the impact of future climate change on rice yield are affected by uncertainties such as climate models, climate scenarios, model parameters and structure, and showing great differences (Na Li *et al*., 2024). By minimizing the negative impacts of climate variability, these resilient varieties contribute more to stable and predictable yields for farmers, reducing the risk of crop failure and income loss. A recent study by Palanisami *et al*. (2015) on the impact of climate change on rice production in selected river basins had indicated that there will be marginal reduction in rice yield and production in the future.

Studies have shown significant adoption rates of climate-resilient rice varieties in project areas, indicating their acceptance and perceived benefits by the farming communities. This adoption is often linked to increased awareness and the effectiveness of demonstration programs.

The adoption of these varieties has been associated with increased profitability for farmers due to higher and more stable yields, leading to improved livelihoods. Several climate-resilient rice varieties have been introduced and evaluated under the NICRA project across different vulnerable regions in India. These include submergence tolerant varieties like Ranjit Sub-1 and Bahadur Sub-1 capable of withstanding flooding for up to 15 days and short duration varieties such as Gitesh, which can escape short-term stresses or fit into altered cropping patterns due to climate variability.

Considering the aforementioned factors, the current study was undertaken in NICRA adopted villages (Marapara, Rongbokgre, and Rimrangpara) to assess the performance of climate resilient rice varieties and its adaptability to West Garo Hills district of Meghalaya.

Materials and Methods

The NICRA project often involves participatory varietal selection, where farmers are involved in evaluating and selecting varieties that perform well under their specific agro-climatic conditions and meet their preferences. The study was conducted in the climate-affected West Garo Hills district of Meghalaya, where 60 farmers were interviewed. Paddy is the principal crop in this region, but its growing season has been severely impacted by erratic rainfall patterns. The introduction of improved rice varieties is being explored as a strategy to mitigate these challenges.

A On-Farm Trials (OFT) were carried out during Kharif season of 2024 at three villages namely Marapara, Rongbokgre, and Rimrangpara covering 60 nos. of rice growing tribal farmers in the West Garo Hills district of Meghalaya. Experimental plots in flood-prone villages were selected, and detailed information on flood and drought events, along with the productivity of existing traditional varieties, was collected from participating farmers.

The technological options (TO) evaluated included one climate-resilient sali rice variety, *Gitesh*, and two submergence-tolerant sali rice varieties, *Ranjit sub-1* and *Bahadur sub-1* The variety *Gitesh* was developed by ICAR–National Rice Research Institute and released in 2018, while *Ranjit sub-1* and *Bahadur sub-1* were developed by Assam Agricultural University, Jorhat, and also released in 2018 (Table 1) (Thakuria *et al*. 2023).

Seeds were sown in nursery beds on 20th June 2025 at all locations, and transplanting was carried out between 10th to15th July 2025 using seedlings aged 21–25 days, maintaining a spacing of 20 cm × 15 cm. After few months of transplanting, the experimental plots were submerged by flash floods from 3rd to 7th October 2025 (Fig. 1). Additionally, drought-like conditions occurred during three separate rainless periods: 24th–30th August (7 days), 9th –13th September (5 days), and 15th –20th September (6 days).

As West Garo Hills is an organic district by default, no synthetic fertilizers were applied. Farmers used only farmyard manure (FYM) during nursery raising. Data were recorded on plant height, days to 50% flowering, days to maturity, number of effective tillers per plant, grains per panicle, yield, gross return, net return, and benefit-cost ratio (B:C).

The research should specify a Randomized Complete Block Design (RCBD) using farmer fields as blocks and rice varieties as treatments, following participatory on-farm trial methodology, ensuring proper replication and randomization to enable statistically robust analysis.

Table 1: Source of technology for the trail/testing

Technologies/ varieties	Year of released	Source of technology
Ranjit Sub-1	2019	Assam Agricultural University, Jorhat
Bahadur Sub-1	2018	
Gitesh	2018	ICAR- National Rice Research Institute

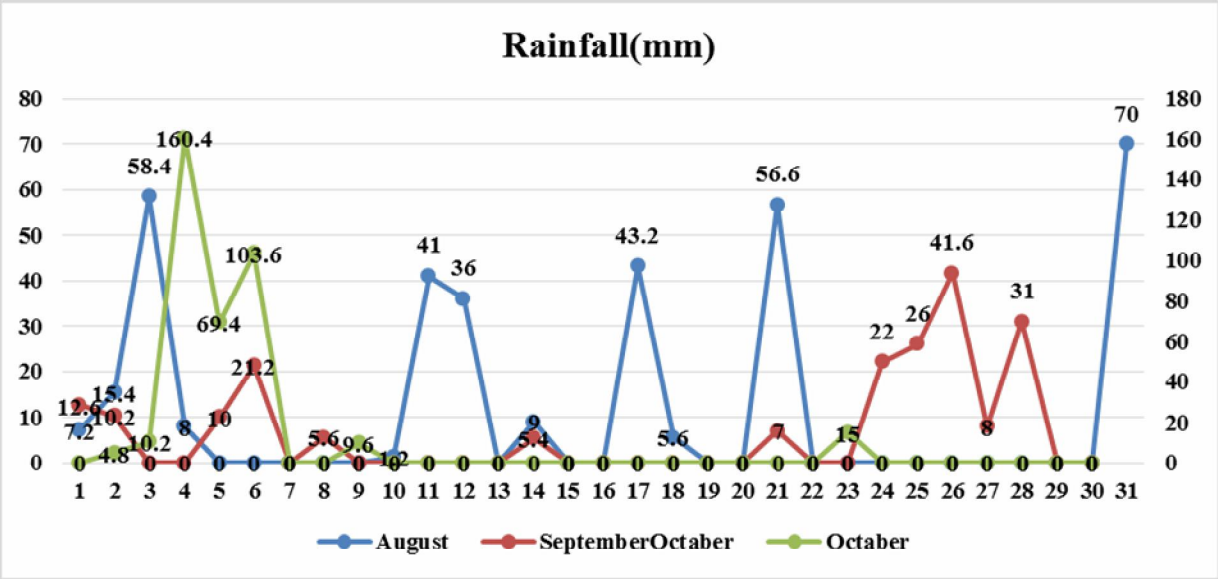

Fig. 1: Rainfall recorded during August to October, 2024 in the study area

Results and Discussion

The present study highlighted significant importance of climate-resilient rice varieties such as Ranjit Sub-1 and Bahadur Sub-1 and Gitesh in boosting agricultural productivity and enhancing resilience against floods by the former two varieties and extended dry spells as well as under partial submergence by latter variety in vulnerable villages like Marapara, Rongbokgre and Rimrangpara of West Garo Hills district. The findings from the OFT revealed a significant variation and outperformed the local check. The comparison of the characteristic feature of three climate resilient rice varieties (Ranjit Sub-1, Bahadur Sub-1 and Gitesh) and a local type based on their growth, adaptability, yield, and stress tolerance is given in table 2. In response to this, a technological intervention was introduced in the form of the high-yielding rice variety 'Gitesh,' known for its flexibility in seedling age requirements ranging from 30 to 60 days (Sarma and Saikia, 2009). In terms of growth, Ranjit Sub-1 recorded the highest plant height (136.2 cm) and produced a moderate number of tillers, while Bahadur Sub-1 recorded the least plant height (114.3 cm) with similar tillering capacity aligning with the study of Bhattacharjee *et al*. (2024), who also reported superior performance Ranjit Sub-1 and Bahadur Sub-1 highlighting their potential to address climate related challenges. In addition, Pathak and Singh (2019) reported similar yield advantages and submergence tolerance of *Sub1* varieties. This tolerance to submergence is completely due to the presence of the *Sub1* gene, which confers this valuable trait (Mackill *et al*., 2012; Girijarani *et al*., 2024). However, Gitesh, though moderate in plant height (less than Ranjit Sub – 1), produced the highest number of tillers (22.5), leading to greater yield potential, whereas the local variety recorded the least number of tillers (12.3) and lowest plant height as compare all the resilient varieties studied. Additionally, in terms of adaptability, Ranjit Sub-1, Bahadur Sub-1 and the local variety are suitable for lowland conditions, while Gitesh can grow in both lowland and medium land, making it more versatile. Crop duration ranged from 150–160 days for the improved varieties, while the local type matures earlier (140–145 days). Grain type also differs: the improved varieties have medium slender grains, generally preferred by consumers, whereas the local variety produces short bold grains.

Yield performance of the improved varieties highlighted the clear advantages over the local type. Under normal conditions, Gitesh recorded the highest yield (43.20 q/ha), followed by Ranjit Sub-1 (39.40 q/ha) and Bahadur Sub-1 (38.80q/ha), while the local variety lags far behind with only 26.8 q/ha. However, under flash flood condition, Ranjit Sub-1 and Bahadur Sub-1 performed better due to their submergence

tolerance, while Gitesh excels under drought and partial submergence, maintaining a higher yield than the others. The Local variety, however, lacks stress tolerance and performed poorly under adverse conditions. Similar finding was reported by Nath *et al*. (2024), on yield performance of the existing recently popular submergence tolerant rice variety Ranjit Sub-1. Overall, Ranjit Sub-1 and Bahadur Sub-1 are best suited for flood-prone lowlands, Gitesh is highly productive and drought-resilient with broader adaptability, and the Local variety, though early maturing, is inferior in yield, grain quality, and stress tolerance. Yield of all the crops demonstrated at NICRA farms found measurable difference with increase in yields said by Medhi *et al*., 2018.

Table 2: Characteristics of the varieties selected for the demonstration

Characters	Ranjit Sub-1	Bahadur Sub-1	Gitesh	Local
Plant height (cm)	136.20	114.32	121.25	116.21
Nos. of tillers/plant	18.30	16.28	22.50	12.30
Suitable land type	Low land	Low land	Low land & medium land	Low land
Duration(days)	150-155	150-155	150-160	140-145
Grain type	Medium slender	Medium slender	Medium slender	Short bold
Yield in normal condition (q/ha)	39.40	38.80	43.20	26.80
Yield in flash flood like situation (q/ha)	33.80	32.30	30.40	-
Yield in drought like situation (q/ha)	27.80	28.20	34.80	-
Special character	Submergence tolerant for 2 weeks	Submergence tolerant for 2 weeks	Staggered planting	Normal

Furthermore, the performance of three climate resilient rice varieties - Ranjit Sub-1, Bahadur Sub-1, Gitesh and a local type under the same sowing conditions were recorded and compared to obtain the superior varieties under west Garo Hills condition (Table 3). All the varieties were sown on 20th June 2024, but their harvesting dates varied, with Ranjit Sub-1 maturing the earliest (20th November), followed by Bahadur Sub-1 (22nd November) and Gitesh (26th November), while local variety matured late (2nd December). The number of days to 50% flowering also differed like Gitesh flowered the earliest (115 days), while Ranjit Sub-1 took the longest (122 days).

In terms of yield components, Gitesh again performed best, recording the highest number of effective tillers per square meter (319.52) and grains per panicle (152.51), while the local variety showed the weakest performance with only 208.13 effective tillers per square meter and 119.80 grains per panicle. These yield attributes translated into higher productivity, with Gitesh yielding 43.20 q/ha under normal conditions, followed by Ranjit Sub-1 (39.40 q/ha) and Bahadur Sub-1 (38.80 q/ha). The yield of rive variety was also recorded 51-54q/ha as reported by Das *et al*., 2023. In contrast, the local variety, produced only 26.80 q/ha. This study is in concurrent with that of Roy *et al*. (2024) who recorded significant increase in yield and also accompanied by the higher net returns leading to adoption of Gitesh variety.

Economic analysis further strengthens the advantage of improved varieties. Despite having the same cost of cultivation (Rs. 38,650/ha) for Ranjit Sub-1, Bahadur Sub-1 and Gitesh, their gross returns were much higher compared to the local type, which had a lower cultivation cost (Rs. 32,200/ha) but the least gross return (Rs. 40,200/ha). Net returns were highest for Gitesh (Rs. 26,150/ha), followed by Ranjit Sub-1 (Rs. 20,450/ha) and Bahadur Sub-1 (Rs. 19,550/ha), while the local variety revealed a net return of only Rs. 8,000/ha. This is reflected in the benefit-cost (B:C) ratio, where Gitesh again led with 1.68, followed by Ranjit Sub-1 (1.53) and Bahadur Sub-1 (1.51) with the least in local variety (1.24).

Table 3: Performance of climate resilient rice varieties at farmers' field

Parameters	Ranjit Sub-1	Bahadur Sub-1	Gitesh	Local
Date of sowing	20.06.24	20.06.24	20.06.24	20.06.24
Date of harvesting	20.11.24	22.11.24	26.11.24	02.12.24
Days to 50% flowering	122	118	115	120
Effective tillers/m^2	296.18	287.27	319.52	20.8.13
Grain/ panicle	146.72	141.58	152.51	119.80
Yield (q/ha) under normal condition	39.40	38.80	43.20	26.80
Cost of cultivation (Rs. /ha)	38650	38650	38650	32200
Gross return (Rs. /ha)	59100	58200	64800	40200
Net return (Rs. /ha)	20450	19550	26150	8000
B:C ratio	1.53	1.51	1.68	1.24

With the help of molecular markers, a major QTL for submergence tolerance Ranjit sub-rainfed lowland mega variety Ranjit of N.E. India, by backcrossing followed by two generations of selfing (Deka *et al*., 2017).

Conclusion

The climate-resilient rice variety Gitesh produced a higher number of effective tillers even under partial submergence and drought-like conditions, resulting in slightly higher yields compared to the Ranjit Sub-1. Therefore, along with the submergence-tolerant varieties like Ranjit Sub-1 and Bahadur Sub-1, the climate-resilient variety Gitesh may also be recommended for cultivation in the West Garo Hills district of Meghalaya, considering its yield advantage and economic benefits. Furthermore, prolonged dry spells during the cropping period can adversely affect yield and yield attributes. Therefore, under such conditions, Gitesh is likely to perform better than the currently popular submergence-tolerant varieties Ranjit Sub-1 and Bahadur Sub-1.

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Author contribution

T.K.D.- Conceptualization, Methodology, Investigation, Supervision, Data curation, Formal analysis, Validation, Writing-original draft, review & editing. S.C.-Data curation, Methodology, Investigation, Writing–review & editing. M.S.S.- Rainfall data curation, Reference formatting, Writing-review & editing. N.A.S.-Data curation, Methodology, Investigation, Writing - review & editing

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