

Evaluating climate-resilient rice varieties in eastern Arunachal Pradesh

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ABSTRACT

A two-location field experiment was conducted across farmers' fields in the Namsai district of Arunachal Pradesh to evaluate the productivity and complete economic performance of climate-resilient rice varieties. The experiment was laid-out in a Randomized Block Design (RBD) and 10 replications. The selected sites were uniform in soil properties, texture, topography, and similar histories of fertilizer application. Four rice varieties Swarna Sub-1, Gitesh, Luit, farmers' local variety Khampti Lahi were evaluated in two locations; Wagon 1 and Mengkeng Khampti. Standard agronomic practices were uniformly applied across all treatments and locations. Growth parameters (plant height, number of tillers/m², and effective tillers/m²), yield attributes, and grain yield were recorded, while economic parameters such as cost of cultivation, gross return, net return, and benefit-cost ratio (B: C) were also calculated. Results indicated that the Swarna Sub-1 variety exhibited significantly superior growth characteristics, yield attributes, and grain yield (47.84 and 46.28 q/ha) compared to the local variety (Khampti Lahi) (32.25 and 30.25 q/ha) in Wagon 1 and Mengkeng Khampti locations, respectively. The Gitesh and Luit varieties also showed significantly higher grain yields (40.36 and 40.24 q/ha, and 33.8 and 35.91 q/ha, respectively) than the local variety, though slightly lower than Swarna Sub-1. Economic analysis revealed that Swarna Sub-1 achieved the highest gross return (106081 and 102297/ha), net return (70,421 and 71128 q/ha), and B:C ratio (2.97 and 3.29), followed by Gitesh and Luit, in both Wagon 1 and Mengkeng.

Keywords: Climate-resilient, Swarna Sub-1, Gitesh, Luit, Khampti Lahi and rice productivity

INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food that forms the backbone of the agricultural economy in Arunachal Pradesh, a region characterized by its diverse agroecological landscapes and significant climatic variability. The Eastern Himalayas, which

encompasses Arunachal Pradesh is known to be hotspots for genetic diversity of rice, possessing a wide range of traits necessary for adaptation to various environmental stresses (Choudhury *et al.*, 2014). However, climate extremes, such as droughts and floods, pose severe challenges to sustain rice productivity, impacting both economic stability and food security in this region (Sandhu *et al.*, 2019). Climate change impacts on rice cultivation are well-documented, particularly in areas like the Indo-Gangetic plains, which share similar climatic challenges as plain areas of Arunachal Pradesh. These include rise in temperature and variability in monsoon rains, affecting

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Khampti, respectively. Our experimental findings suggest that Swarna Sub-1, Gitesh, and Luit are promising climate-resilient rice varieties capable of enhancing productivity and farmers' income in the Namsai district of Arunachal Pradesh.

phenology, irrigation needs, and ultimately, yields (Singh *et al.*, 2024). There is a pressing need for adaptive crop management and the development of rice varieties resilient to these climatic stresses to minimize agricultural losses and enhance productivity (Urfels *et al.*, 2021).

Flooding poses a significant challenge to rice production in the eastern region of Arunachal Pradesh. This area, with its unique geographical and climatic conditions, is susceptible to various degrees of flooding due to heavy monsoon rains and glacial lake outbursts. Floods often lead to substantial loss of rice yield, affecting regional food security and the livelihood of local farmers. To mitigate these impacts, it is essential to employ adaptive strategies like using flood-tolerant rice varieties known for better yields under submerged conditions. Studies from other flood-prone regions suggest significant productivity gains with the adoption of such resilient strains, demonstrating an effective adaptation mechanism that could be adapted in the local context of Arunachal Pradesh (Dar *et al.*, 2017).

Based on the above facts, it was hypothesized that flood-tolerant varieties may withstand the flood conditions and may improve the production and profitability of rice. The objective of this study was to evaluate the different climate resilient rice varieties on growth, productivity and profitability of rice under rainfed conditions of the eastern Arunachal Pradesh region. The ICAR-Krishi Vigyan Kendra, Namsai, had taken up demonstration programme under the National Innovation in Climate Resilient Agriculture (NICRA) project implemented in 2021-22. The present investigation was to assess the performance of submergence-tolerant rice variety "Swarna Sub-I", staggered planting rice variety "Gitesh", short-duration rice variety "Luit" for post-flood situation, and the indigenous rice variety "Khamti Lahi" in farmers' fields at different locations of Namsai district.

MATERIALS AND METHODS

The experiment was carried out during Kharif season of 2022 and 2023 by Krishi Vigyan Kendra, Namsai district in two villages such as Wagon-I (Latitude-27.579982; Longitude- 95.967927) and

Mengkeng Khamti (Latitude- 27.644908; Longitude-95.929908) of Piyong circle of Namsai district. These two villages were highly climate vulnerable especially flood conditions. In Mengkeng Khamti village most of the area prone to flood situation from June to July in *kharif* season. The soil of experimental sites was sandy loam with uniform soil properties, texture, topography, and similar histories of fertilizer application. The soil nutrient status of experimental site mentioned in Table 1. The experiment was laid out in a Randomized Block Design (RBD) and 10 replications. The treatments included four rice varieties: T_1 – Swarna Sub-1, T_2 – Gitesh, T_3 – Luit, and T_4 – the farmers' local variety (Khampti Lahi) in two locations: Wagon 1 and Mengkeng Khampti. Standard agronomic practices were uniformly applied across all treatments. The nursery was raised and healthy rice seedlings were transplanted at 21 days after sowing (DAS) for Swarna Sub-I, 35 DAS for Gitesh and 25 DAS for Luit. The transplanting and harvesting schedule of different varieties were mentioned in Table 2. Recommended seed rate was 40 kg/ha and spacing 20×10cm was followed in both the locations. Farm Yard Manure was applied @ 15t/ha and manual hand weeding done for control of weeds. Plant protection measures have been followed as per the recommendation. Harvesting was done at 130, 150, 90 days after transplanting in Swarna Sub-1, Gitesh, and Luit, respectively.

Table 1. The soil nutrient status of the experimental plots

Soil test Parameters	Wagen-I	Mengkeng Khamti
pH	6.5	6.5
EC (dSm ⁻¹)	22.7	29.8
Available N (Kg ha ⁻¹)	223	209
Available P ₂ O ₅ (Kg ha ⁻¹)	15.2	14.7
Available K ₂ O (Kg ha ⁻¹)	145	149
Organic carbon (%)	0.39	0.37

Growth parameters (plant height and effective tillers/m²), yield attributes (no. of panicles/m²), and grain yield were recorded. Economic parameters, including cost of cultivation, gross return, net return, and benefit-cost ratio (B: C) were also calculated. Gross returns, net returns, and cost of cultivation were worked out for indi-



Fig. 1. Flood condition in Mengkeng Khampti village of Namsai district

vidual treatments by taking into account all the expenses; the cost of cultivation and gross returns were calculated based on the market price of inputs (i.e., land preparation, seed, fertilizer, irrigation, weeding, plant protection, and harvesting) and output market price (paddy yield). Gross returns are considered as the total income received from the paddy. Net returns and the benefit-cost ratio were calculated by following equations.

$$\text{Net returns (Rs/ha)} = \text{Gross returns (Rs/ha)} - \text{Cost of cultivation (Rs/ha)}$$

$$\text{Benefit cost ratio} = \frac{\text{Net returns (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

Statistical analysis

All data were statistically analysed using the 'Analysis of Variance' technique applicable to randomized complete block design (Gomez and Gomez, 1984); the significance of differences between the treatments was determined by the 'F

test'. To evaluate the significant difference between the treatments, the least significant difference (LSD) at the $p \leq 0.05$ level was calculated.

RESULTS AND DISCUSSION

Flood Response and Varietal Performance

The onset of flooding in the first week of July significantly affected the early staggered sowings during both years of the experiment. The first staggered planting of Gitesh (07th July 2022 and 09th July 2023) was severely damaged due to submergence. However, subsequent staggered plantings (2nd and 3rd) showed better establishment and survival. The Swarna Sub-1 variety, sown on 07th July 2022 and 09th July 2023, showed remarkable flood tolerance, surviving submergence for up to 7 days, and exhibited no lodging or mortality, thus safeguarding yield potential under flood stress. Similarly, the post-flood sowing of Luit (25th July 2022 and 28th July 2023) established well after the floodwaters receded and performed better than the local check. On the contrary, the Khampti Lahi variety, despite being sown at the same time as Swarna Sub-1, was highly susceptible to flood conditions, showing severe lodging, yellowing, and plant death due to poor tolerance to submerged conditions.

Growth attributes

Growth attributes such as plant height and no. of ear-bearing tillers were significantly influenced by the climate resilient varieties at Wagon 1 and Mengkeng Khampti locations (Table 2).

Table 2. Sowing and harvesting schedule of climate-resilient varieties during the two years of the experiment

Variety	Transplanting dates		Harvesting dates	
	2022	2023	2022	2023
Swarna Sub-1 (flood-tolerant variety)	07 July 2022	09 July 2023	1 st December 2022	02 December 2023
Githesh (staggered sowing variety)	1 st Staggered: 07 July 2022	09 July 2023	5 th November 2022	6 th November 2023
	2 nd Staggered: 15 July 2022	15 th July 2023	10 th November 2022	13 th November
	3 rd Staggered: 23 July 2022	24 th July 2023	25 th November 2022	202326 th July 2023
	25 th July 2022	28 th July 2023	30 th October 2022	28 th October 2023
Luit (post flood tolerant variety)				
Khampti Lahi	07 July 2022	09 July 2023	28 th November 2022	30 th November 2023

Among the climate resilient varieties, Swarna sub-1 has significantly higher plant height and no. of ear-bearing tillers/m² compared to the Khampti Lahi variety at Wagon 1 and Mengkeng Khampti locations. Similarly, Gitesh and Luit varieties performed better than Khampti lahi at both locations. The Swarna Sub 1 and Gitesh varieties increased the plant height by 36.1% and 26.3% over the Khampti Lahi variety at both locations. Similarly, no. of ear-bearing tillers/m² increased by 87.3%, 80% with Swarna Sub-1, and Gitesh, respectively, at Wagon 1 and 87%, 73.8%, respectively, at Mengkeng Khampti over the control (Khampti Lahi). Dar *et al.* 2017 also reported that Swarna Sub 1 increased the plant height, number of tillers, and overall crop improvement and resilience under environmental conditions like flooding.

Yield attributes

The panicles/m² were significantly influenced by the climate resilient varieties at Wagon 1 and Mengkeng Khampti locations of the Namsai district. Swarna Sub 1 recorded significantly higher no. of panicles/m², followed by Gitesh, Luit, over the control (Khampti Lahi) at both locations. The no. of panicles/m² was increased by 86.9%, 82.1% with Swarna Sub-1 at Wagon 1 and Mengkeng Khampti, respectively, over the control (Khampti Lahi). The results were supported by the findings of Dhar *et al.* (2017).

Grain yield

Climate-resilient rice varieties significantly influenced the grain yield at both locations of the Namsai district. The Swarna Sub 1 variety produced significantly higher grain yield, followed by Gitesh and Luit over the control (Khampti Lahi). The grain yield was increased in Swarna Sub-1 and Gitesh by 48.3% and 25.1% at Wagon 1 and 53% and 34.8% at Mengkeng Khampti, respectively, over the control (Khampti Lahi). The re-

sults were supported by Dar *et al.* (2013), Swarna Sub 1 has been shown to offer substantial improvements in yield when fields are submerged, with an approximate 45% increase in yields compared to the existing popular varieties under flooding conditions. The introduction of Swarna Sub 1 in flood-prone regions like coastal Odisha has led to a significant increase in paddy cultivation and yields, proving more advantageous than traditional varieties even during non-flooding periods (Dar *et al.*, 2017). Swarna Sub-I variety survived from the submerged nursery bed upto 7 days which has positive impact on the livelihood of the poor farmers of the rainfed lowland region prone to submerged condition.

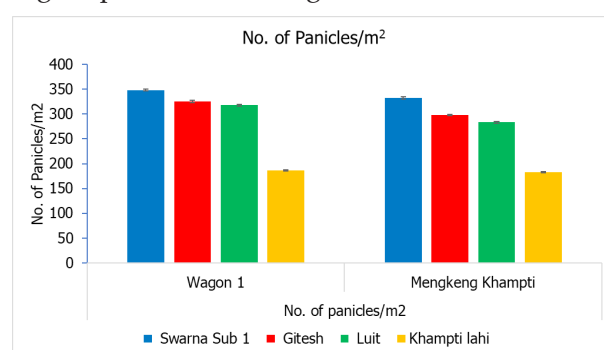


Fig. 2. Effect of climate resilient varieties on yield attributes of rice under various locations of Namsai dist.

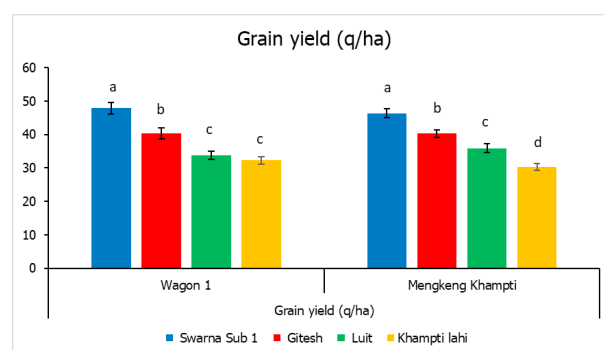


Fig. 3. Effect of climate resilient varieties on grain yield of rice under various locations of Namsai district.

Table 3. Effect of climate resilient varieties on growth attributes of rice under various locations of Namsai district.

Treatment	Plant height (cm)		No. of ear-bearing tillers/m ²	
	Wagon 1	Mengkeng Khampti	Wagon 1	Mengkeng Khampti
Swarna Sub 1	127.05a	118.93a	338.5a	326.6a
Gitesh	117.93b	112.64b	323.6b	303.7b
Luit	99.12c	101.59c	318.6b	305.9c
Khampti lahi	93.323c	87.34d	180.7c	174.7d



Fig 4. Swarna Sub-1 variety tolerated to flood condition



Fig 5. Swarna Sub-1 tolerated to flood condition while Khampti Lahi variety prone to lodging under flood conditions

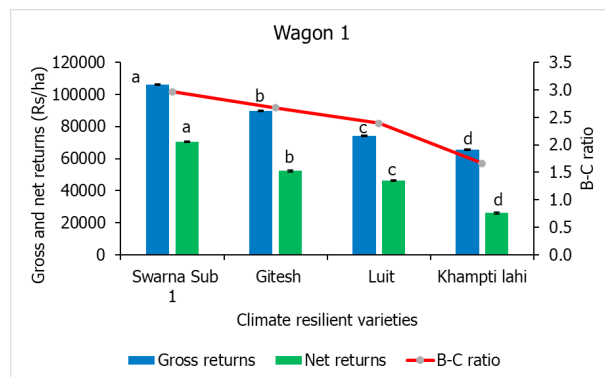


Fig 6. Effect of climate resilient varieties on economics of rice in Wagon 1

Economics

The economic parameters, such as gross returns, net returns, and benefit-cost ratio, were significantly influenced by the climate-resilient varieties at both locations of the Namsai district. The Swarna Sub 1 variety had significantly higher gross returns, net returns, and benefit-cost ratio, followed by Gitesh and Luit over the control. The

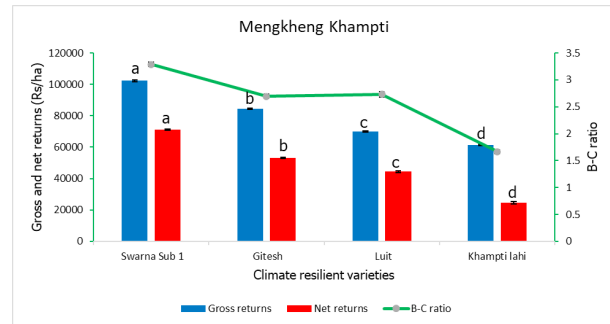


Fig 7. Effect of climate resilient varieties on economics of rice in Mengkeng Khampti

gross returns, net returns, and benefit-cost ratio were increased by 62%, 170.6%, and 78.1% at Wagon 1 and 66.6%, 190.6%, and 97% at Mengkeng Khampti, respectively, over the control (Khampti Lahi). The results were supported by the findings of Dhar *et al.* (2017).

CONCLUSION

It could be concluded that the submergence-tolerant variety Swarna Sub-I, significantly improved the growth attributes, yield attributes and yield as well as economics of *kharif* paddy followed by staggered planting variety Gitesh and short duration variety Luit under flooded conditions of Mengkeng Khampti and Wagon 1 villages of Namsai district of Arunachal Pradesh. Hence, Swarna Sub-1, Gitesh, and Luit are promising climate-resilient rice varieties capable of enhancing productivity and farmers' income in the Namsai district of Arunachal Pradesh.

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