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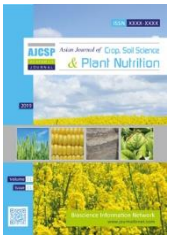

Farmer-led promotion of late blight-resistant potato varieties to enhance productivity in northern Bangladesh

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ABSTRACT

Late blight (Phytophthora infestans) is the principal constraint limiting potato yield and stability during the Rabi season in Bangladesh due to humid and cool agro-climates. This study field-tested and disseminated two late blight-resistant cultivars, BARI Alu-53 and BARI Alu-77, through farmer-participatory trials across Kurigram, Lalmonirhat, Nilphamari, and Rangpur during 2022–23. Eleven on-farm randomized block trials compared these cultivars against the susceptible control, BARI Alu-25. Data on disease incidence, tuber yield, agronomic traits, and farmer assessments were collected. BARI Alu-53 and Alu-77 significantly reduced late blight incidence (2.5–6%) compared to 20–45% in the control and improved yield (3–18% higher). Fungicide application frequency was reduced to 0–2 sprays per season compared to 10–15 in susceptible varieties. Farmers appreciated the improved quality, taste and market value of the tubers. These resistant varieties are highly suitable for sustainable potato cultivation in late blight-prone regions. The study emphasizes the importance of policy support in quality seed multiplication, farmer training and broader dissemination to enhance potato productivity and ensure ecological sustainability.

Key Words: *Late blight, resistant potato varieties, Farmer-led dissemination and Potato productivity*

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I. Introduction

Potato (*Solanum tuberosum* L.) is the third most important food crop worldwide after rice and wheat and a staple for millions in Bangladesh. Northern Bangladesh holds particular importance for potato cultivation due to its favorable agro-climatic conditions, experienced farming community, and well-established cropping systems. With annual production reaching approximately 10 million metric tons from over 0.5 million hectares (FAO, 2022), the sector has significant economic and nutritional value. However, potato productivity is threatened by the persistent risk of late blight disease.

Late blight, caused by the hemibiotrophic oomycete Phytophthora infestans, remains one of the most devastating diseases affecting potato worldwide, capable of causing 30–100% yield losses under favorable conditions (Hossain et al., 2015; Islam et al., 2019). The pathogen thrives in the cool and humid conditions of the Rabi season, severely affecting foliage and tubers. In Bangladesh, the traditional reliance on fungicides to manage late blight necessitates 10–15 spray applications per season, raising input costs and environmental and health risks (Chowdhury et al., 2018).

A more sustainable solution lies in developing and promoting genetically resistant varieties. The Tuber Crops Research Centre (TCRC) of BARI has developed late blight-resistant varieties such as BARI Alu-53 and BARI Alu-77, combining resistance with high yield potential and consumer-preferred traits like tuber size and taste (TCRC, 2021). Compared to earlier resistant varieties, BARI Alu-53 and Alu-77 represent improved resistance stability and broader adaptability. Previous studies (Haque et al., 2013; Hossain et al., 2014) have demonstrated how disease management and optimized agronomic practices can mitigate late blight damage. However, barriers to adoption include poor access to resistant seed, inadequate extension, and limited participatory evaluation. Participatory varietal selection (PVS) and on-farm trials have been effective in increasing adoption by involving farmers in the selection process (Ashrafuzzaman et al., 2018; Rahman et al., 2020). This study aimed to evaluate the performance of BARI Alu-53 and Alu-77 under farmer-managed conditions in Northern Bangladesh and assess yield, disease resistance and farmer perceptions to support scalable adoption.

II. Materials and Methods

Study area

The study was conducted during Rabi season (November 2022 to March 2023) in four districts of Northern Bangladesh: Kurigram, Lalmonirhat, Nilphamari, and Rangpur. These districts were selected based on their agro-ecological suitability for potato cultivation and recurrent incidence of late blight disease. The average annual temperature ranges from 10°C to 25°C during Rabi, with relative humidity of 70-85% – a favorable microclimate for P. infestans proliferation (BBS, 2021).

Trial design and implementation

A total of 11 participatory field trials were established across the four districts under the supervision of On-Farm Research Division (OFRD), BARI, Rangpur. Each participating farmer was allocated 8 decimals (0.0324 ha) of land for trial plots and provided with 40 kg seed tubers each of BARI Alu-53 and BARI Alu-77, totaling 880 kg across all locations. BARI Alu-25, a commonly cultivated but late blight-susceptible variety, was used as the control.

All trials followed a randomized block design (RBD) under farmer management with technical support. Planting was carried out between 15 November and 4 December 2022. Standard agronomic practices, including TCRC-recommended fertilizer doses, land preparation, irrigation, earthing up, and haulm pulling were uniformly applied. Routine training was provided to farmers on seed handling, irrigation scheduling, integrated disease management, and harvesting techniques. While fungicide sprays were routinely applied for BARI Alu-25, the resistant varieties received 0-2 sprays based on disease observation.

Data collection and analysis

Data on total tuber yield (expressed in tons per hectare, t ha^{-1}), late blight incidence (measured as percentage of foliage infection), and other prevalent diseases such as common scab and viral symptoms were recorded from all trial plots. Yield measurements were standardized by calculating the harvested tuber weight relative to the precise plot area (0.0324 ha) to ensure consistency across all locations.

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Disease incidence was assessed through periodic field observations during the crop growth cycle, employing standardized visual scoring techniques to quantify foliar infection severity. Descriptive statistical analyses, including calculation of means, ranges, and percentage yield increases over the susceptible control variety BARI Alu-25, were performed to evaluate varietal performance.

Additionally, feedback from farmers on the taste, quality, culinary suitability, and marketability of tubers was collected through structured questionnaires and informal interviews. This participatory evaluation provided insight into end-user preferences, thereby enabling a comprehensive assessment of the new varieties' potential impact on potato productivity and livelihoods in late blight-prone regions.

III. Results

Tuber yield performance

The tuber yield data collected from eleven farmer-managed field trials across Kurigram, Lalmonirhat, Nilphamari and Rangpur districts demonstrated the superior performance of the late blight resistant varieties BARI Alu-53 and BARI Alu-77 compared to the control variety BARI Alu-25. The yields of BARI Alu-53 ranged from 24.0 to 31.0 t ha^{-1}, while BARI Alu-77 yielded between 26.0 and 31.0 t ha^{-1}. The control variety, BARI Alu-25, recorded yields ranging from 23.7 to 29.0 t ha^{-1}.

The most notable yield increase was observed in Kakina, Lalmonirhat, where BARI Alu-53 showed a 14.81% increase and BARI Alu-77 a 6.17% increase over the control. Similar trends were seen in other locations, with mean yield increases for BARI Alu-53 ranging from 3.14% to 14.81% and for BARI Alu-77 from 4.30% to 9.86% over BARI Alu-25 (Table 01).

Table 01. Yield (tha^{-1}) of newly released late blight resistant potato variety at farmer's field during 2022-2023

Location	Farmers (no)	BARI Alu-53	BARI Alu-77	Control (BARI Alu-25)	% Yield increase in BARI Alu-53 over control (tha^{-1})	% Yield increase in BARI Alu-77 over control (tha^{-1})
Chilmari, Kurigram	F(1)	28.0	27.60	26.80	4.48	2.99
	F(2)	29.76	30.64	29.04	2.48	5.51
	Mean	**28.88**	**29.12**	**27.92**	**3.44**	**4.30**
Dhaperhat,	F(1)	25.0	26.50	24.68	1.30	7.37
	F(2)	24.90	26.20	23.70	5.06	10.55
	Mean	**24.95**	**26.35**	**24.19**	**3.14**	**8.93**
Khalashpir, Pirganj, Rangpur	F(1)	28.15	28.65	26.40	6.63	8.52
	F(2)	28.0	29.70	27.30	2.56	8.79
	F(3)	28.70	29.70	26.45	8.51	12.29
	Mean	**28.28**	**29.35**	**26.72**	**5.86**	**9.86**
Joldhaka, Nilphamari	F(1)	29.60	28.40	27.10	9.23	4.80
	Mean	**29.60**	**28.40**	**27.10**	**9.23**	**4.80**
Kakina, Lalmonirhat	F(1)	31.0	29.0	27.0	18.52	7.41
	F(2)	30.0	26.0	25.50	24.0	4.0
	F(3)	30.0	31.0	29.0	3.45	6.90
	Mean	**30.33**	**28.67**	**27.17**	**14.81**	**6.17**

Late blight and other disease incidence

Significant differences in disease incidence were recorded among the varieties. BARI Alu-53 exhibited the lowest late blight foliage infection rates, ranging from 2.5% in Kurigram to 5% in Nilphamari. BARI Alu-77 showed slightly higher late blight infection, ranging from 3.33% to 6%. In contrast, the susceptible control, BARI Alu-25, experienced substantially higher infection rates, varying between 20% and 45% depending on location (Table 02).

Incidence of other diseases, such as common scab and viral symptoms, was also lowest in BARI Alu-53, with scab ranging from 1.0% to 2.33% and viral infection from 1.5% to 4%, whereas BARI Alu-25 had comparatively higher rates.

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Table 02. Diseases incidence (%) of newly released late blight resistant potato variety at farmer's field during 2022-2023

Location	Farmers (no)	BARI Alu-53			BARI Alu-77			BARI Alu-25 (Control)		
		Common scab	Virus	Late blight	Common scab	Virus	Late blight	Common scab	Virus	Late blight
Chilmari, Kurigram	F(1)	1	2	3	2	2	4	0	2	25
	F(2)	2	3	2	3	1	5	1	3	30
	Mean	**1.5**	**2.5**	**2.5**	**2.5**	**1.5**	**4.5**	**0.5**	**2.5**	**27.5**
Dhaperhat,	F(1)	1.5	1.5	5	1	3	7	2	3	20
	F(2)	1	2	3	2.6	2	2	1.5	1	45
	Mean	**1.25**	**1.75**	**4**	**1.8**	**2.5**	**4.5**	**1.75**	**2**	**32.5**
Khalashpir, Pirganj, Rangpur	F(1)	0	3	4	1	3	5	2	1	20
	F(2)	1	4	2	2	4	3	1.5	4	40
	F(3)	2	6	6	3	3	2	2	3	45
	Mean	**1**	**4.33**	**4**	**2**	**3.33**	**3.33**	**1.83**	**2.67**	**35**
Joldhaka, Nilphamari	F(1)	1	2	5	0	5	6	3	3	30
	Mean	**1**	**2**	**5**	**0**	**5**	**6**	**3**	**3**	**30**
Kakina, Lalmonirhat	F(1)	1.5	1.5	5	1	3	7	2	3	20
	F(2)	1	2	3	2.6	2	2	1.50	1	40
	F(3)	2.33	3	6	3	1	5	1	3.5	45
	Mean	**1.61**	**2.17**	**4.67**	**2.2**	**2**	**4.67**	**1.50**	**2.5**	**35**

Farmer perception and market acceptance

Farmers' evaluations of the new varieties were overwhelmingly positive. Feedback collected through structured interviews and informal group discussions indicated that BARI Alu-53 and BARI Alu-77 were preferred for their superior yield, uniform tuber size, marketability, and taste. The varieties were reported to fetch higher prices at local markets due to their attractive appearance and consumer acceptance. Several farmers also expressed appreciation for the reduced need for fungicide applications, which not only lowered costs but also reduced their exposure to chemicals. The demand for quality seed of BARI Alu-53 and BARI Alu-77 for the subsequent planting season was high, signaling strong potential for diffusion.

IV. Discussion

The findings of this study demonstrate the superior performance of genetically resistant potato varieties, BARI Alu-53 and BARI Alu-77, over the susceptible control variety, BARI Alu-25, under farmer-managed conditions in late blight-prone districts of Northern Bangladesh. The observed yield advantages, reaching 18.52% over the control, confirm the genetic potential and field adaptability of these improved cultivars.

The higher yields of BARI Alu-53 and BARI Alu-77 can be attributed to their resistance to foliar diseases, enhanced canopy architecture, and efficient resource use, as observed in earlier studies on the performance of elite germplasm (Haque et al., 2009; TCRC, 2022). This supports the notion that yield stability under biotic stress is closely linked to varietal resistance and morphological traits conducive to photosynthetic efficiency.

The significant reduction in late blight incidence in BARI Alu-53 (2.5–5%) and BARI Alu-77 (3.3–6%) compared to the control (up to 45%) is consistent with results from previous field and screen house evaluations (TCRC, 2021). Late blight remains one of the most destructive diseases globally, with potential crop losses of 30–100% in the absence of effective control (Hossain et al., 2015; Islam et al., 2019). Therefore, integrating host resistance is an ecologically and economically viable strategy, particularly in high-risk regions such as northern Bangladesh.

Conventional management of late blight relies on frequent fungicide applications, often involving 10 to 15 sprays per season (Chowdhury et al., 2018). Such chemical-dependent approaches elevate production costs, pose health hazards, and harm the environment. The reduced fungicide use (0–2 applications) observed in the resistant varieties significantly lowers the chemical burden, contributing to safer production systems, aligning with principles of agroecological intensification and the sustainable intensification framework endorsed by modern crop management programs.

Notably, the resistant varieties also exhibited broader disease resilience, showing lower incidences of common scab and viral infections, confirming their multi-disease resistance potential. Similar multi-pathogen resistance has been previously emphasized as essential for climate-resilient potato production (Goswami et al., 2010).

Farmer feedback reinforces the on-station findings, with participants reporting higher income potential, improved market acceptance due to tuber uniformity and taste, and reduced need for chemical inputs. These results validate the participatory varietal selection (PVS) model as a powerful extension tool, consistent with the findings of Ashrafuzzaman et al. (2018) and Rahman et al. (2020), who noted enhanced farmer ownership, quicker dissemination, and stronger impact when improved varieties are introduced through participatory and decentralized approaches.

Moreover, past research by Haque et al. (2013) demonstrated that late blight severity in susceptible cultivars like Raja could be mitigated by optimizing planting dates and fungicide schedules. However, these integrated strategies often require precise timing and external inputs. By contrast, the genetic resistance offered by BARI Alu-53 and BARI Alu-77 provides a low-cost, farmer-friendly alternative that is more robust under variable smallholder management systems.

V. Conclusion

This study confirms the superior agronomic performance of BARI Alu-53 and BARI Alu-77 over the susceptible control variety BARI Alu-25 under late blight-prone field conditions. Both varieties significantly reduced late blight incidence and improved tuber yield across four districts of Northern Bangladesh. Positive farmer feedback on marketability and demand for future seed supplies indicate strong potential for widespread adoption. Future programs should focus on seed multiplication, farmer training, and linking with value chains to ensure large-scale dissemination.

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