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ENHANCING POTATO PRODUCTIVITY IN BANGLADESH: GAMMA IRRADIATION-INDUCED RESISTANCE TO BACTERIAL WILT CAUSED BY *Ralstonia solanacearum*

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Abstract

Bacterial wilt caused by *Ralstonia solanacearum* is one of the most devastating disease affecting potato cultivation in Bangladesh, resulting in substantial yield losses and posing a major barrier to sustainable production and export competitiveness. This study aimed to investigate the potential of gamma irradiation to induce resistance against bacterial wilt in potato cultivars and improve overall productivity. Field experiments were conducted across three major potato-growing regions-Mymensingh, Rangpur, and Cumilla-using eight widely cultivated potato varieties: Asterix, Granola, Musica, Cumbia, Cardinal, Diamond, Santana, and Sunshine. Dry tubers were irradiated with gamma rays at doses of 20, 30, 40 Gy, and the resulting M_1V_1 generation was cultivated for performance evaluation. Molecular identification of *R. solanacearum* from tuber and soil samples using species-specific primers (PS-1/PS-2) confirmed a consistent 553 bp amplicon, validating pathogen presence. Results indicated that gamma irradiation induced variable morphological and pathological responses across cultivars. At 20 Gy, Asterix and Cardinal demonstrated notable increases in tuber number and weight, suggesting a stimulatory effect on growth and yield. In contrast, higher doses (30 Gy and 40 Gy) were more effective in reducing the incidence of bacterial wilt, likely through mutation-induced resistance mechanisms. These findings underscore gamma irradiation's dual role in enhancing both disease resistance and yield potential.

Keywords: Potato, Bacterial wilt, Gamma irradiation, Disease incidence.

Introduction

Potato (*Solanum tuberosum* L.), a member of the Solanaceae family, is among the four most widely cultivated food crops globally, alongside rice, wheat, and maize. Bangladesh ranks among the top four potato-producing countries in Asia, reflecting its strategic importance to national food security and the rural economy. In addition to being a dietary staple, potatoes are also industrially important as raw materials for alcohol, starch-based products, and processed foods (Awasthi & Verma, 2017; Molla *et al.*, 2020). Despite its economic and nutritional significance, potato yield is frequently compromised by susceptibility to biotic stresses, especially soil-borne pathogens such as *Ralstonia solanacearum*, and various viruses (Chakrabarti *et al.*, 2022; Islam *et al.*, 2018). Managing these diseases often requires application of chemical pesticides, which escalates production

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costs, threatens environmental sustainability, and limits export potential due to residue concerns. Globally, potatoes are cultivated on about 18 million hectares, with a production of 359 million tons in 2020. China (78.2 million tons) and India (51.3 million tons) lead in production, while Bangladesh ranks seventh, having increased its output from 10.1 to 11 million metric tons between 2021 and 2023 (FAO, 2022; BBS, 2023). *Ralstonia solanacearum*, a soil-borne, gram-negative bacterium, causes bacterial wilt or brown rot in potatoes, leading to yield losses ranging from 60% to 90% under conducive conditions (Khairy *et al.*, 2021; Elhalag *et al.*, 2023). This pathogen's widespread adaptability, long soil survival, and difficulty in eradication make it one of the most serious threats to sustainable potato production, particularly in tropical and subtropical climates like Bangladesh. Given these challenges, the use of mutation breeding through gamma irradiation offers a promising alternative to conventional disease management strategies. Gamma rays have been shown to induce beneficial genetic variations in several crops, enhancing resistance to biotic and abiotic stresses, including in potatoes (Ahloowalia *et al.*, 2004; Hasan *et al.*, 2023; Park *et al.*, 2021).

Therefore, urgent need to develop resistant, high-yielding potato cultivars suitable for export and local production without the heavy reliance on agrochemicals. With Bangladesh striving to expand its footprint in international potato markets, mitigating losses from bacterial wilt is essential for maintaining quality and phytosanitary standards. Moreover, understanding the physiological and molecular responses of irradiated potato genotypes against *R. solanacearum* will help to build foundational knowledge for future breeding and biotechnology interventions. Therefore, this research aims to explore the effectiveness of gamma irradiation in enhancing resistance against bacterial wilt and improving tuber yield and quality, contributing to sustainable and climate-resilient potato cultivation

Materials and Methods

Experimental site

The lab experiment was conducted in the Molecular laboratory of the Plant Pathology Division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh and field experiment was carried out at farmer’s field in Mymensingh, Rangpur, and Cumilla during August 2022 to March 2023. Each experimental plot measured 3.30 m × 0.75 m and was separated from adjacent plots by a buffer zone to prevent cross-contamination. Radiation was applied by using ^{60}Co gamma irradiator (GC-5000) manufactured by the Board of Radiation and Isotope Technology (BRIT), Mumbai, India in BINA.

Treatments

Four treatments of 0 Gy (control), 20 Gy, 30 Gy and 40 Gy were applied on eight varieties such as Asterix, Cardinal, Cumbia, Diamond, Granola, Musica, Santana, and Sunshine which were collected from Bangladesh Agricultural Development Corporation (BADC), Bangladesh. Each treatment group had three replications, resulting in a total of 24 experimental plots.

Planting of M_1V_1 generation after irradiation

Dry tubers of eight potato cultivars were irradiated with different doses of gamma rays (20 Gy, 30 Gy, and 40 Gy). The irradiated and non-irradiated (control) tubers were sown immediately after irradiation to obtain M_1V_1 generation. A split plot design with three replications was used. The main plots were randomly assigned to the cultivars and gamma-irradiation treatments were arranged over the subplot. The distance between plants was 20 cm x 60 cm. During harvesting period, 5 kilograms of potato tuber samples were collected from each field in a random manner for further laboratory analysis. *R. solanacearum* was detected by PCR technique using PS-1/PS-2 primers (Hossain *et al.,* 2022). The irradiated and non-irradiated tuber was stored at Postharvest Lab, BINA at 20°C with a relative humidity of 80-85% until the end of shelf life.

Soil sample collection

Approximately 300-400 grams of soil were collected from each field for determining the population of brown rot bacteria per gram of soil using the dilution plate technique. Then, *R. solanacearum* was detected by PCR technique using PS-1/PS-2 primers (Hossain *et al.*, 2022).

Isolation and morphological identification of bacterial wilt pathogen

At first, infected tubers were surface sterilized 10% by Clorox and then tubers were cut into pieces and placed in a zipper bag containing 1 ml of Casamino acid-peptone-glucose CPG broth. Using a rolling pin, the cut pieces were thoroughly crushed with the CPG broth. Subsequently, 1 ml of the crushed solution was transferred from the zipper bag to an Eppendorf tube. All the tubes were placed in a shaker for a period of 24 hours to create a homogenized solution. After 24 hours, Triphenyl Tetrazolium Chloride (TTC) media was prepared and one loopful of solution from the Eppendorf tube was streaked in the plate for bacterial culture growth and kept it at 27°C for a period of 24-48 hours (Abd Alamer *et al.,* 2020).

Molecular identification of *R. solanacearum* before and after irradiation

Genomic DNA extraction

The genomic DNA of *R. solanacearum* was extracted using Wizard® Genomic DNA Purification Kit following the manufacturer’s instructions. Species-specific primers, PS-1 (5’AGTCGAACGGCAGCGGGGG3’) & PS-2 (5’GGGGATTTCACATCGGTCTT GCA3’) were used to confirm the *Ralstonia solanacearum* through PCR (Hossain *et al.* 2022). The PCR reactions were performed in 25 µl of reaction mixture for each DNA template. For analyzing the markers, preparation of PCR reaction was performed. Preparation of PCR reaction included 2µL of 100 ng DNA template, 5 µL PCR master mix (GoTaq® G2 Green Master Mix which contains green buffer, dNTPs and 4 mM $MgCl_2$ from Promega Company), 1µL of primer, 2 µL Nuclease free water for making 10µL PCR reactions mixture. Then, the denaturation temperature was set at 94°C for 45 seconds, annealing at

Tm of each primer for 60 sec and the elongation temperature was set at 72°C for 90 seconds continued up to 35 cycles. The PCR products were resolved in 1.5% agarose gel using 1X TBE buffer at 80 V for 120 min.

Data analysis

Experimental data were analyzed using Statistix10 software. A one-way analysis of variance (ANOVA) was employed to evaluate the effects of different treatments, and when significant differences were identified ($p<0.05$), Fisher's Least Significant Difference (LSD) test was applied for post hoc comparisons.

Results and Discussion

Morphological variation

Plant height (cm)

In Mymensingh, Cardinal exhibited the highest height at 20 Gy (65.47 cm), contrasting with Cumbica's notable reduction at 40 Gy (30.87 cm). In Rangpur, Cumbica significantly grew at 30 Gy (54.87 cm), while Sunshine notably reduced at 40 Gy (21.13 cm). In Cumilla, control-treated Asterix had the highest height (65.06 cm), and Santana exhibited a significant reduction at 30 Gy (18.87 cm) (Table 1-3).

Table 1. Effect of gamma irradiation on plant height of eight potato cultivars in M_1V_1 generation at Mymensingh region

Treatment	Plant height (cm)							
	Asterix	Cardinal	Cumbica	Dimont	Granola	Musica	Santana	Sunshine
0 Gy	54.88a	45.73b	59.00a	51.47a	37.80a	46.33a	51.20a	51.80a
20 Gy	51.00ab	65.47a	45.87ab	50.13a	50.20a	49.27a	46.53ab	49.33a
30 Gy	47.47ab	58.40ab	51.47a	36.6a	43.07a	46.20a	39.80ab	47.33a
40 Gy	36.67b	51.13ab	30.87b	33.4a	33.93a	41.73a	35.47b	37.20a
CV (%)	16.15	14.78	18.25	25.12	24.67	9.95	16.99	17.65
LSD (5%)	15.33	16.29	17.07	21.53	20.33	9.12	14.68	16.37

Values within the same column followed by the same letters are not significantly different, using DMRT at 5% level.

Table 2. Effect of gamma irradiation on plant height of eight potato cultivars in M_1V_1 generation at Rangpur region

Treatment	Plant height (cm)							
	Asterix	Cardinal	Cumbica	Dimont	Granola	Musica	Santana	Sunshine
0 Gy	37.33a	32.27b	42.13bc	36.6a	27.33a	30.13a	37.27a	31.47a
20 Gy	34.73a	42.13a	44.93b	39.73a	27.87a	39a	37.27a	31.4a
30 Gy	36.27a	42.73a	54.87a	41.6a	33.53a	39.93a	37.27a	27.93a
40 Gy	35.8a	42.4a	37.93c	43.4a	29.27a	29.87a	37.27a	21.13b
CV (%)	10.77	9.89	4.72	11.62	14.73	17.85	24.50	10.39
LSD (5%)	7.75	7.88	4.24	9.37	8.68	12.39	16.24	5.81

Values within the same column followed by the same letters are not significantly different, using DMRT at 5% level.

Table 3. Effect of gamma irradiation on plant height of eight potato cultivars in M_1V_1 generation at Cumilla region

Treatment	Plant height (cm)							
	Asterix	Cardinal	Cumbica	Dimont	Granola	Musica	Santana	Sunshine
0 Gy	65.06a	57a	60.93a	57.4a	50.93a	50.07a	58.73a	57.27a
20 Gy	57.4b	54.4a	55.2ab	53a	49.2ab	43.67a	44.33ab	54.47ab
30 Gy	57.27b	51.13a	49b	54.2a	46.27ab	41.93a	18.87b	46.13bc
40 Gy	51.4c	55a	31c	48.6a	43.67b	25.6b	29.2b	36.2c
CV (%)	4.17	7.85	10.50	15.28	6.88	14.78	37.01	11.42
LSD (5%)	4.82	8.53	10.28	16.28	6.53	11.90	27.94	11.07

Values within the same column followed by the same letters are not significantly different, using DMRT at 5% level

Number of stems per plant

In Mymensingh, Cardinal displayed the highest mean stem count (8.13) in the control group, while Asterix had the lowest at 40 Gy (2.87). Increasing gamma irradiation led to varying responses, particularly in cultivars like Cardinal and Cumbica. In Rangpur, Dimont peaked at 40 Gy (6.87), with Santana recording the lowest at 40 Gy (1.13). Cumbica and Sunshine displayed significant variations in stem numbers across irradiation levels. In Cumilla, Cardinal reached the highest at 20 Gy (7.47), and Santana had the lowest at 30 Gy (0.87) (Table 4-6).

Table 4. Effect of gamma irradiation on the number of stems per plant of eight potato cultivars in M_1V_1 generation at Mymensingh region

Treatment	No. of stems/plant							
	Asterix	Cardinal	Cumbica	Dimont	Granola	Musica	Santana	Sunshine
0 Gy	4.33ab	8.13a	4.27a	3.67a	3.53a	5.00a	3.47a	2.93a
20 Gy	4.53ab	5.13ab	5.07a	5.07a	5.20a	3.60a	3.47a	3.53a
30 Gy	4.67a	4.73b	3.93a	4.00a	4.73a	4.67a	4.07a	3.67a
40 Gy	2.87b	4.33b	3.80a	4.60a	3.13a	4.80a	3.33a	3.47a
CV (%)	20.62	27.61	21.76	34.68	34.50	32.21	21.91	42.23
LSD (%)	1.69	3.08	1.86	3.00	2.86	2.91	1.57	2.87

Values within the same column followed by the same letters are not significantly different, using DMRT at 5% level.

Table 5. Effect of gamma irradiation on number of stems per plant of eight potato cultivars in M_1V_1 generation at Rangpur region

Treatment	No. of stems/plant							
	Asterix	Cardinal	Cumbica	Dimont	Granola	Musica	Santana	Sunshine
0 Gy	3.67a	5.4a	2.87a	3.33b	2.8a	2.93ab	1.93a	2.33a
20 Gy	3.4a	3.93a	2.4ab	5.47ab	3.27a	3.07a	1.53a	1.87a
30 Gy	3.53a	3.53a	2.2ab	4.8ab	2.8a	2.67ab	1.33a	1.47a
40 Gy	3.33a	4.73a	1.2b	6.87a	1.8a	1.87b	1.13a	1.73a
CV (%)	24.06	28.87	33.39	27.49	38.49	21.03	34.15	31.42
LSD (%)	1.67	2.54	1.45	2.81	2.05	1.11	1.01	1.16

Values within the same column followed by the same letters are not significantly different, using DMRT at 5% level.

Table 6. Effect of gamma irradiation on number of stems per plant of eight potato cultivars in M_1V_1 generation at Cumilla region

Treatment	No. of stems/plant							
	Asterix	Cardinal	Cumbica	Dimont	Granola	Musica	Santana	Sunshine
0 Gy	3.13b	5.87a	3.53a	3.87a	5.53a	2.8a	2.87a	3.33a
20 Gy	5.67a	7.47a	3.33a	4.67a	5.87a	3a	3.13a	4.33a
30 Gy	6.33a	7.27a	3.2a	4.27a	4.93a	3.13a	0.87b	2.87a
40 Gy	6.33a	6.47a	2.47a	5a	5.07a	1.67b	1.4b	2.13a
CV (%)	16.56	12.39	35.67	15.84	11.49	15.35	31.81	36.87
LSD (%)	1.78	1.68	2.23	1.41	1.23	0.81	1.31	2.33

Values within the same column followed by the same letters are not significantly different, using DMRT at 5% level.

Number of tubers per plant

In Mymensingh, Cardinal recorded the highest mean tuber count (25.27) in the control group, while Sunshine had the lowest at 40 Gy (4.93). Generally, tuber numbers increased with rising radiation levels, notably at 20 Gy and 30 Gy, though Cumbica and Santana exhibited sensitivity with significant reductions at higher levels. In Rangpur, Cardinal peaked at 20 Gy (17.67), while Cumbica recorded the lowest at 40 Gy (2.4). Overall, tuber numbers decreased with increased irradiation, with Granola and Musica displaying higher sensitivity. In Cumilla, Cardinal again had the highest at 40 Gy (19.87), while Santana showed sensitivity with a significant reduction at 30 Gy (Table 7-9). In summary, gamma irradiation influenced tuber numbers, showcasing cultivar-specific responses in distinct regions.

Table 7. Effect of gamma irradiation on number of tubers per plant of eight potato cultivars in M_1V_1 generation at Mymensingh region

Treatment	No. of tubers per plant							
	Asterix	Cardinal	Cumbica	Dimont	Granola	Musica	Santana	Sunshine
0 Gy	7.33a	25.27a	7.27a	9.80a	9.00a	7.00a	6.60a	6.20a
20 Gy	8.80a	8.93b	9.07a	13.67a	13.33a	14.27a	8.00a	6.00a
30 Gy	8.20a	9.60b	9.33a	12.20a	13.13a	16.40a	7.80a	6.80a
40 Gy	6.40a	7.00b	7.00a	12.40a	11.47a	15.53a	7.33a	4.93a
CV (%)	18.57	17.3	64.87	42.05	47.52	50.19	24.60	34.51
LSD (%)	2.85	4.39	10.58	10.10	11.14	13.34	3.65	4.13

Values within the same column followed by the same letters are not significantly different, using DMRT at 5% level.

Table 8. Effect of gamma irradiation on number of tubers per plant of eight potato cultivars in M_1V_1 generation at Rangpur region

Treatment	No. of tubers per plant							
	Asterix	Cardinal	Asterix	Dimont	Asterix	Musica	Asterix	Sunshine
0 Gy	11.6a	12.53a	10.33a	8.93a	9a	7.73a	6.13a	6.8a
20 Gy	8.33a	17.67a	7.07a	12.73a	10a	9a	6a	8.6a
30 Gy	9.8a	14.87a	6.8ab	11.27a	10.13a	7.267a	3.13a	6.6a
40 Gy	10.93a	12.93a	2.4b	12.33a	10.47a	6.4a	3.33a	5.73a
CV (%)	28.49	23.58	33.53	16.98	28.99	18.97	33.29	29.28
LSD (%)	5.79	6.83	4.46	3.84	5.73	2.88	3.09	4.06

Values within the same column followed by the same letters are not significantly different, using DMRT at 5% level.

Table 9. Effect of gamma irradiation on number of tubers per plant of eight potato cultivars in M_1V_1 generation at Cumilla region.

Treatment	No. of tubers per plant,							
	Asterix	Cardinal	Cumbica	Dimont	Granola	Musica	Santana	Sunshine
0 Gy	8.47b	19.73ab	9.9a	8.43b	11.8a	11.73a	6.93a	10.6a
20 Gy	11.4a	22.8a	8.1b	15.33a	10.93a	7.73b	5.03ab	10.9a
30 Gy	10.67ab	16.93b	5.83c	12.67a	10.77a	8.4ab	2.67b	6.43b
40 Gy	11ab	19.87ab	4.07d	11.6ab	10a	5.73b	4.5ab	4.43b
CV (%)	13.73	8.12	6.49	15.60	17.94	19.97	30.34	17.77
LSD (%)	2.85	3.22	0.90	3.74	3.90	3.35	2.90	2.87

Values within the same column followed by the same letters are not significantly different, using DMRT at 5% level.

Weight of tubers per plant (kg)

In Mymensingh, Cardinal recorded the highest mean tuber weight (0.53 kg) in the control, while Asterix displayed the lowest at 40 Gy (0.15 kg). Generally, tuber weight decreased with increasing irradiation levels, particularly impacting Granola, Musica, and Santana. In Rangpur, Asterix and Cardinal achieved the highest at 20 Gy (0.48 kg), while Cumbica exhibited the lowest at 40 Gy (0.05 kg). Tuber weight reduction with elevated irradiation levels was observed across all cultivars, with Granola and Musica demonstrating notable sensitivity. In Cumilla, Cumbica had the highest control weight (0.58 kg), while Santana displayed the lowest at 30 Gy (0.08 kg) (Table 10-12). The trend of tuber weight reduction with higher irradiation levels was consistent across cultivars, with Dimont and Asterix showing relatively higher resistance.

Table 10. Effect of gamma irradiation on weight of tubers per plant of eight potato cultivars in M_1V1 generation at Mymensingh region.

Treatment	weight of tubers per plant (kg)							
	Asterix	Cardinal	Cumbica	Dimont	Granola	Musica	Santana	Sunshine
0 Gy	0.46a	0.53a	0.45a	0.45a	0.29a	0.34a	0.46a	0.43a
20 Gy	0.40a	0.40ab	0.36a	0.28ab	0.36a	0.40a	0.37ab	0.27b
30 Gy	0.30ab	0.33b	0.30a	0.22b	0.30a	0.41a	0.20b	0.20b
40 Gy	0.15b	0.23b	0.16a	0.27ab	0.19a	0.33a	0.19b	0.16b
CV (%)	29.28	24.94	71.57	32.22	36.60	26.94	31.39	30.14
LSD (%)	0.19	0.19	0.45	0.20	0.21	0.20	0.19	0.16

Values within the same column followed by the same letters are not significantly different, using DMRT at 5% level.

Table 11. Effect of gamma irradiation on weight of tubers per plant of eight potato cultivars in M_1V_1 generation at Rangpur region

Treatment	weight of tubers per plant (kg)							
	Asterix	Cardinal	Cumbica	Dimont	Granola	Musica	Santana	Sunshine
0 Gy	0.48a	0.38ab	0.44a	0.45a	0.31a	0.44a	0.41a	0.34a
20 Gy	0.48a	0.48a	0.41a	0.31b	0.28a	0.35ab	0.29ab	0.29a
30 Gy	0.46ab	0.32ab	0.33a	0.32b	0.26a	0.21ab	0.10b	0.23a
40 Gy	0.34b	0.32b	0.05b	0.28b	0.20a	0.19b	0.20ab	0.09b
CV (%)	13.68	21.32	33.70	13.80	23.53	36.24	60.76	25.02
LSD (%)	0.12	0.16	0.21	0.09	0.12	0.21	0.31	0.12

Values within the same column followed by the same letters are not significantly different, using DMRT at 5% level.

Table 12. Effect of gamma irradiation on weight of tubers per plant of eight potato cultivars in M_1V_1 generation at Cumilla region

Treatment	weight of tubers per plant (kg)							
	Asterix	Cardinal	Cumbica	Dimont	Granola	Musica	Santana	Sunshine
0 Gy	0.41a	0.43a	0.58a	0.40a	0.37a	0.56a	0.46a	0.50a
20 Gy	0.29b	0.31bc	0.41b	0.29ab	0.24b	0.35bc	0.28ab	0.47ab
30 Gy	0.33ab	0.28c	0.34b	0.25b	0.20b	0.4b	0.08b	0.31bc
40 Gy	0.32ab	0.37ab	0.22c	0.25b	0.14c	0.30c	0.41a	0.20c
CV (%)	16.40	10.20	9.48	21.30	10.19	10.94	39.30	24.54
LSD (%)	0.11	0.07	0.07	0.13	0.05	0.09	0.24	0.18

Values within the same column followed by the same letters are not significantly different, using DMRT at 5% level.

Bacterial wilt incidence of eight potato cultivars after irradiation

The effect of gamma irradiation at higher doses (30 Gy and 40 Gy) effectively reduces bacterial wilt incidence in all cultivars in M_1V_1 generation at Mymensingh, Rangpur, and Cumilla regions (Fig. 1).

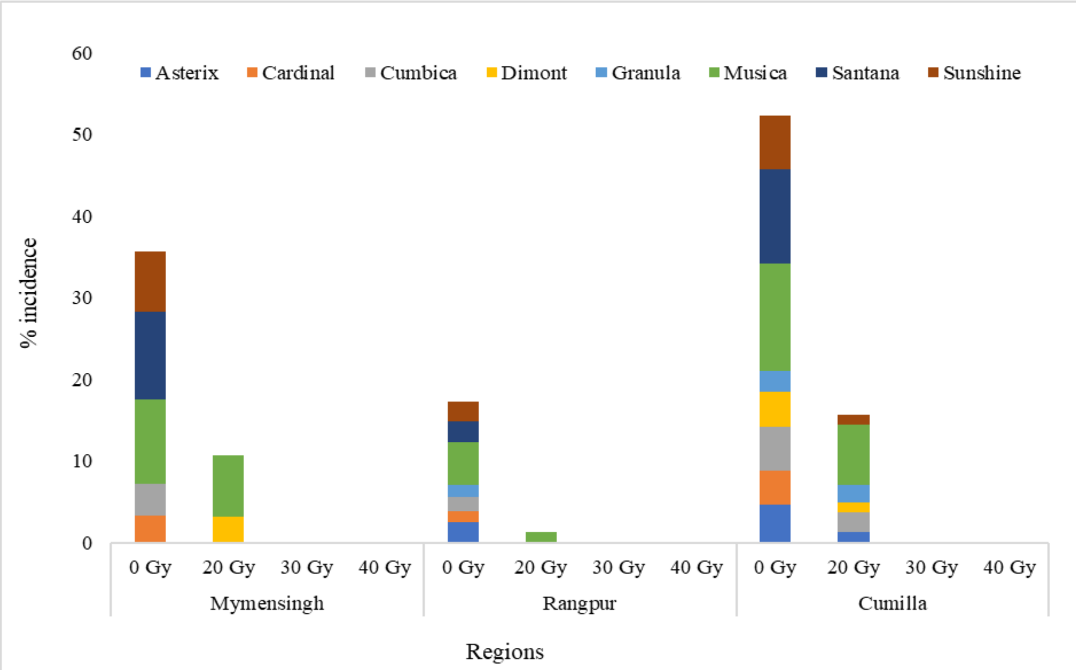

Fig. 1. Percent bacterial wilt incidence of eight potato cultivars in M_1V_1 generation at Mymensingh, Rangpur, and Cumilla regions.

Identification and Purification of *R. solanacearum* isolates

The bacterium was isolated from the collected samples and identified based on the colony morphology (Fig. 2) on TTC media.

Fig. 2. Pink color colony produced on TTC medium by *R. solanacearum*.

Molecular Detection of *R. solanacearum* from soil before and after irradiation

The molecular detection of *R. solanacearum* was done using PS-1/PS-2 primers. The results demonstrated that PS-1/PS-2 primers successfully amplified a specific DNA fragment, measuring 553 base pairs, in all tested *R. solanacearum* isolates (Fig. 3).

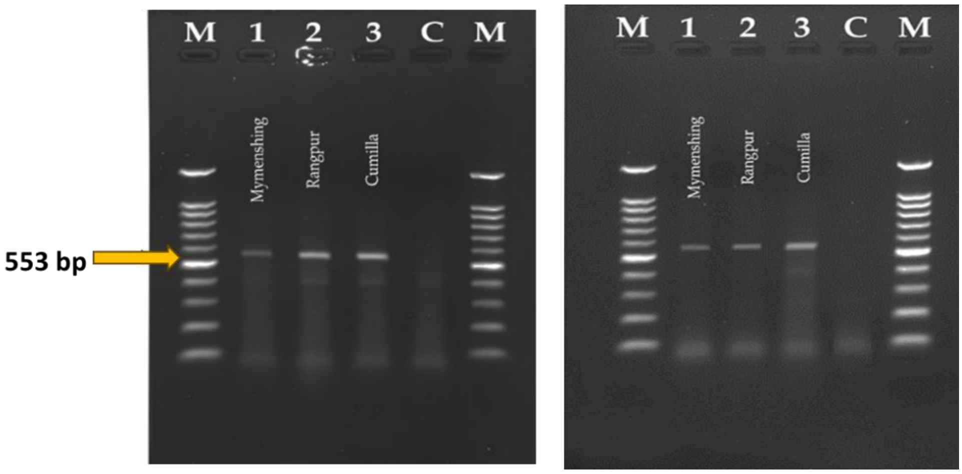

Fig. 3. *R. solanacearum* from soil before irradiation (left) and after irradiation (right) by PCR-reaction with species-specific primers PS-1 and PS-2. Here, M = 100 bp DNA ladder, Lane 1 = Mymensingh, 2 = Rangpur, 3 = Cumilla and C = Control (Nuclease-free water instead of DNA template).

Detection of *R. solanacearum* from potato tuber before and after irradiation

The results demonstrated that the PS-1/PS-2 primers successfully amplified a specific DNA fragment, measuring 553 base pairs, in all tested *R. solanacearum* isolates (Fig. 4).

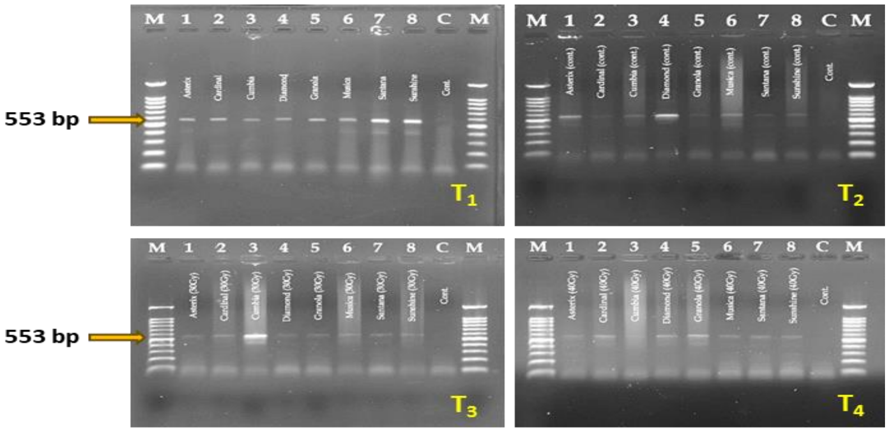

Fig. 4. *R. solanacearum* from potato tuber with species-specific primers PS-1 and PS-2 after different irradiation, where T_1 = 0 Gy, T_2 = 20 Gy, T_3 = 30 Gy, T_4 = 40 Gy. Here, M = 100 bp DNA ladder, 1 = Asterix, 2 = Cardinal, 3 = Cumbia, 4 = Dimont, 5 = Granola, 6 = Musica, 7 = Santana, 8 = Sunshine and C = Control.

The study demonstrated the influence of gamma irradiation on various morphological and yield-related traits across eight potato cultivars under field conditions in Bangladesh. Gamma irradiation significantly affected plant height, stem number, tuber number, and tuber weight in a cultivar-and dose-dependent manner, aligning with previous reports highlighting the mutagenic and physiological effects of ionizing radiation on potato and other crops (Hasan *et al.*, 2023; Park *et al.*, 2021). Plant height responses varied across locations and cultivars. Lower doses (20-30 Gy) occasionally stimulated growth in some cultivars like Cardinal and Asterix, while higher doses (40 Gy) often caused significant reductions. This decline in height at higher doses is likely linked to radiation-induced damage to meristematic tissues or disruption of hormonal balance, leading to dwarfism (Mohamed *et al.*, 2021). Gamma irradiation has been shown to impair auxin biosynthesis and transport, which directly affects stem elongation and shoot development (Al-Safadi *et al.*, 2019).

Dwarfism and morphological abnormalities such as stunted growth, leaf deformation, and altered branching patterns observed in the M1V1 generation are consistent with mutation-induced physiological disruptions. These effects can be attributed to DNA damage, chromosomal aberrations, and altered expression of genes regulating growth (Singh *et al.*, 2022; Alam *et al.*, 2020). While such changes are sometimes deleterious, they also offer opportunities to identify beneficial mutations for future breeding. Stem and tuber number per plant also responded variably to irradiation. Moderate stimulation was observed at 20–30 Gy in some cultivars, while others showed reduced performance at higher doses. This variability reflects the stochastic nature of mutation breeding, where random mutations can result in either beneficial or detrimental effects (Kinyua *et al.*, 2022). Asterix and Cardinal consistently showed better adaptability and productivity under irradiation, indicating their potential as candidate varieties for further selection.

Tuber weight per plant generally declined at higher radiation doses (30-40 Gy), particularly in sensitive cultivars like Musica and Granola. These reductions are likely due to impaired source-sink translocation efficiency, reduced chlorophyll content, or root development disruption under radiation stress (Zhou *et al.,* 2020; Iqbal *et al.,* 2022). However, Cardinal and Dimont retained reasonable tuber mass, suggesting a degree of inherent tolerance. Importantly, bacterial wilt incidence caused by *Ralstonia solanacearum* was significantly reduced at 30 and 40 Gy doses across all cultivars and regions. This supports previous findings that gamma irradiation can enhance disease resistance by activating defense pathways or by introducing mutations in susceptibility genes (Haque *et al.,* 2024). The successful molecular detection of *R. solanacearum* using species-specific primers (PS-1/PS-2) confirmed the effectiveness of both pathogen identification and post-irradiation resistance screening. The high coefficients of variation (CV%), particularly for stem number and tuber traits, reflect increased variability due to mutation effects. While CV values exceeding 25% are generally discouraged in agronomic trials, they are common in mutation breeding where heterogeneous responses are expected (Ahmadikhah *et al.,* 2023). These variations, although posing statistical limitations, also represent genetic diversity, which is crucial for selecting improved lines.

Conclusions

Among the eight tested varieties, Cardinal, Asterix, and Dimont showed promising responses, with improved tuber number and weight at lower doses (20-30 Gy) and reduced bacterial wilt incidence at higher doses (30-40 Gy). The molecular detection of *Ralstonia solanacearum* confirmed the pathogen’s presence in all regions, and its incidence declined significantly in irradiated treatments, indicating induced resistance. Although some variability and morphological abnormalities were observed, the findings highlight gamma irradiation as a potential tool for developing disease-resistant, high-yielding potato genotypes suitable for both domestic cultivation and export.

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