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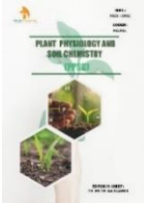

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RESEARCH ARTICLE

CHEMICAL PRIMING OF POTATO TO EXPLORE SPROUTING AND SEEDLING GROWTH POTENTIALITY

A.H.M Motiur Rahman Talukder[a*], A. K. M. Zonayed-Ull-Noor[b], Faruque Ahmed[a], Istiak Ahmed[c*], A.A.M. Mohammad Mustakim[a], Nadira Mokarroma[a], Lutfun Nahar[d]

[a] Plant Physiology Division, Bangladesh Agricultural Research Institute (BARI), Gazipur-1701
[b] On-Farm Research Division, Bangladesh Agricultural Research Institute (BARI), Sherpur-2100
[c] Agricultural Statistics and ICT Division, Bangladesh Agricultural Research Institute (BARI), Gazipur-1701
[d] Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka-1207
[*]Corresponding Author Email: istiak@bari.gov.bd; motiurbari@yahoo.com
First author and second author contributed equally to this study.

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ABSTRACT

Generally, intact tubers are used as propagating materials for potato crops under field condition, where they typically emerge within 14-15 days. Similarly, the BARI Alu-62 is a potato cultivar commonly propagated using intact tuber. However, exceptionally it faces issues with an unusually high mean emergence time and low emergence percentage under field condition, leading to inconsistency problems reported by local growers. Consequently, a study was conducted to expedite the dormancy breakdown and improve emergence rates (%) through chemical priming. The tuber seeds of *Solanum tuberosum* treated with gibberellic acid (GA_3) @ 0.1% and potassium nitrate (KNO_3) @ 1.0%, either individually or in synergy, revealed that GA_3 alone and its combination with KNO_3 significantly boosted dormancy breakdown and enhanced emergence rates. The application of GA_3 alone, as well as its combined use with KNO_3, led to the fastest seedling emergence (14-15 days), highest emergence rates (78-80%), and vigorous seedling growth, marked by superior leaf area, total dry matter (TDM), and enhanced yield along with key yield-supporting traits. The greatest plant height was achieved with GA_3 @ 0.1%, both individually and in combination with KNO_3 @ 1.0%. In conclusion, GA_3 @ 0.1%, either alone or combined with KNO_3 @ 1.0%, emerged as the most effective priming strategy for breaking dormancy and accelerating emergence in BARI Alu-62.

KEYWORDS

Phenotyping, Nutrients, EDA, RCBD, GA_3, and KNO_3

1. INTRODUCTION

Seed dormancy under natural conditions renders seeds inactive, inhibiting germination and enabling them to withstand adverse environmental challenges (Sohindji et al., 2020). Although seed dormancy supports offspring survival, it is typically unfavorable when targeting large-scale production of economic and tuber crops. Seed dormancy arises from various factors, such as an impermeable seed coat that restricts water and oxygen, underdeveloped or dormant embryos, and the presence of germination-inhibiting compounds. Based on crops, different methods are available that can regulate the seed dormancy and control germination to ensure successful seedling establishment. These methods include rupturing seed coats, treating seeds with hot water to remove waxes, surface inhibitors, and exposing seeds to different conditions like heat, cold, or light and different chemical treatments. Numerous researchers have suggested that chemical priming shortens the sprouting time and accelerates the germination rate of various crop species. Additionally, they opined that chemical method is particularly effective for tuber crops (Esztergályos and Polgár, 2021). Previous studies led by researchers have shown that chemicals such as Gibberellins (GA_3) and potassium nitrate (KNO_3) are used to break the seed dormancy and promote seed germination (Sarihan et al., 2005; Gashi et al., 2012; Ding et al., 2007; Gao et al., 2011; Cárdenas et al., 2013; Koyuncu, 2005; Mello et al., 2009; Golmohammadzadeh et al., 2015; Forte et al., 2019). Gibberellin (GA_3) speeds up germination by first boosting the embryo's growth potential and subsequently stimulating the synthesis of hydrolytic enzymes. Throughout the germination, GA_3 facilitates seed coat softening and stimulates the production of the α-amylase enzyme, which converts starch into glucose. Alternatively, KNO_3 can influence on seed germination by attributing the oxidized nitrogen molecules like NO_3 or NO and potassium ions (K^+) (Mirmazloum et al., 2020; Thongtip et al., 2022). The NO_3 ion promotes the responsiveness of the seed to light, hence reducing the light demands (Bian et al., 2013). KNO3 improves water absorption by altering water potential, which subsequently increases water intake and stimulates auxin production and respiration during germination. Exogenous KNO_3 decreases ABA levels and raises GA_4 levels, which increases the GA to ABA ratio and encourages germination (Vidal et al., 2018).

Potato is an important tuber crops that ensuring the food security in Bangladesh. Depending on the variety, it typically takes 14 to 15 days for normal emergence at the field level. If the tuber seed potatoes do not emergence during this period, they are likely to be wasted. The Tuber Crops Research Center (TCRC) of the Bangladesh Agricultural Research Institute (BARI) is concentrated on developing potato varieties with various characteristics and one hundred and two potato cultivars have been released by BARI so far. Among these potato varieties, BARI Alu-62 has the longest dormancy period and takes more times for seedling emergence, which is a genetic trait. While this variety is beneficial from a preservation perspective but, it is losing popularity among farmers because of its prolonged seedling emergence time in the field. In this case, it is crucial to shorten the field emergence period by eliminating the variety's dormancy. However, this present study was undertaken with an objective to evaluate the effect of the individual and combined application

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of gibberellic acid (GA_3) and KNO_3 on tuber dormancy breakdown and emergence accelerations of potato cv. BARI Alu-62 seed tubers at different immersion times.

2. Materials and Methods

A study in the research field of the Plant Physiology Division, Bangladesh Agricultural Research Institute (BARI) was carried out during rabi (winter) (mid-October to Mid-March) growing season of 2022. The study aimed to investigate the impact of chemical priming on breaking dormancy and enhancing the sprouting process of BARI Alu-62. The study site was situated between 23°53' to 24°21' N latitude and 90°09' to 92°39' E longitude, approximately 25 km north of Bangladesh's bustling capital city, Dhaka (https://en.banglapedia.org/index.php/Gazipur_District, accessed on 30 May, 2022). Tuber seeds of the potato variety BARI Alu-62 were sourced from the breeder seed Production Center at the Bangladesh Agricultural Research Institute (BARI), located in Debiganj, Panchagarh (26°27'12" N, 88°45'33" E).

2.1 Preparation of test solutions

2.1.1 Gibberellin (GA_3) @ 0.1%

In order to maintain a concentration of 1.0 g in liter^{-1}, 20 grams of gibberellic acid powder were dissolved in 20 liters of water to create a GA_3 @ 0.1% solution.

2.1.2 Potassium nitrate (KNO_3) (1.0%)

A solution of KNO_3 (1.0%) was prepared by dissolving 200 grams of Potassium nitrate (KNO_3) powder in 20 liters of water, maintaining a concentration of 10 g liter^{-1} water. The following design (Table 1) was used to observe the breakdown of dormancy and acceleration of emergence in tuber seeds of a potato variety before sowing.

Table 1: Treatment plan for potato tubers using different chemicals and water

Treatment	Soaked in water (h)	Soaked in GA_3 (0.1%)	Soaked in KNO_3 (1.0%)	Soaked in GA_3 (0.1%) × KNO_3 (1.0%)	Total number of tuber seed
Control (T_1)	12	-	-	-	144
Singly GA_3 (0.1%) (T_2)	-	12	-	-	144
Singly KNO_3 (1.0%) (T_3)	-	-	12	-	144
Combination of GA_3 (0.1%) × KNO_3 (1.0%) (T_4)	-	-	-	12	144

The study was designed using a Randomized Complete Block Design (RCBD) with three replications. Potato tubers treated with various chemicals and water namely T_1, T_2, T_3 and T_4 mentioned in (Table 1) were randomly assigned to each of the three blocks in this experiment. Each plot was measured 2.4 m × 3.5 m. The seed tubers were manually planted with a spacing of 60 cm × 25 cm at a depth of 5 cm in furrows, followed by earthing up. To combat root-knot nematodes in *Solanum tuberosum*, Furadan 5G was strategically applied at a dosage of 20 kg per hectare directly into the furrows prior to the earthing-up process. Fertilizer application adhered to the guidelines outlined, with nutrients supplied at rates of 150-45-125-20 kg ha^{-1} for N, P, K, and S, respectively (Ahmmed et al., 2018). These were delivered using urea, triple superphosphate (TSP), muriate of potash (MOP), and gypsum. During the final land preparation, the entire dose of TSP, MOP, gypsum, and half the urea was incorporated as a foundational treatment. The remaining urea was applied 30 days after planting (DAP), and earthing up was performed to protect the tubers from direct sunlight and promote tuber bulking, ensuring ease of harvest. The crop received two irrigations during its life cycle, at 20 and 45 DAP. To evaluate the effects of chemical treatments on germination, the potato tubers were noticed by digging up the soil and observations were made on sprouting potato tuber daily. The number of emerged potato seedlings were recorded each day, and the emergence percentages were calculated weekly. Emergence dates were recorded when about 90% of the plants outgrowth of the soil, while maturity was marked by the onset of leaf yellowing, with observations conducted every 2 to 3 days intervals. The total tuber yield (t ha^{-1}) from a 1.2 m × 3.5 m area was recorded at harvest, including both marketable and non-marketable tubers. Yield-related parameters were recorded from two randomly selected plants plot^{-1} at field maturity. Plant height, leaf area plant^{-1}, and dry weights of plant parts were measured by collecting two plants from plot^{-1} at 30 DAP, and at 15-day intervals thereafter, up to harvest. Two plants were harvested from each plot at 30, 45, 60, 75 DAP, and at harvest. Leaf area plant^{-1} was measured using an automatic leaf area measuring meter (LI-3100 C; Li-cor, USA). The total plant biomass was separated into leaves, stems, roots, and tubers. These parts were dried in an oven at 80 °C for 72 hours, and the dry weight was recorded. At harvest, the nitrogen (%), phosphorus (%), potassium (%), calcium (%) and sodium (%) content of the tubers was determined following the procedure outlined by (Dev et al., 2020). The collected data were analyzed using analysis of variance (ANOVA) for a Randomized Complete Block Design. Least Significant Difference (LSD) values were determined at the 0.05 probability level for cases where the F-test showed statistical significance. The "R" program, created by the R Core Team in 2019, was used to analyze the data and explain the findings. As significant interaction effects were observed for all parameters, the individual effects are not presented in the following section.

3. Results

In case overall phenological parameters, the study considered data in 5 parameters namely; Days to emergence (days), Emergence percentage (%), Tuber length (mm), Tuber diameter (mm), and Yield (t ha^{-1}). A box plot of standardized mean was presented in Figure 1, showing the distribution of the parameters.

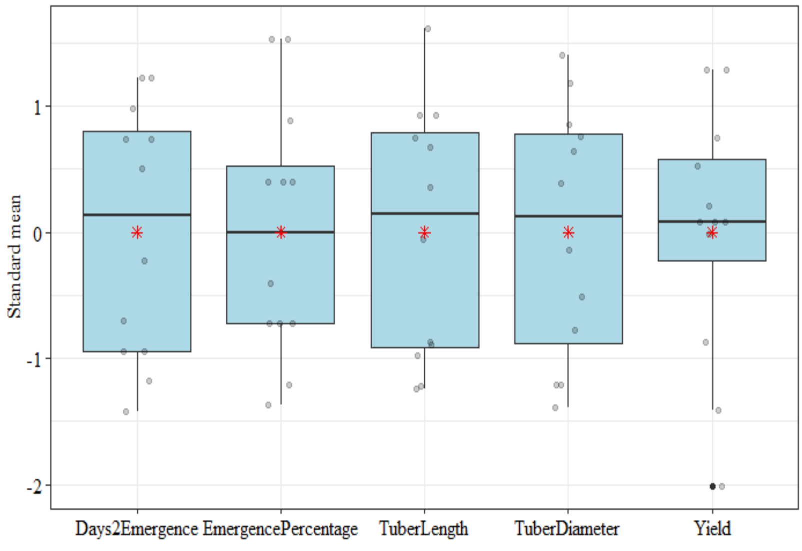

Figure 1: Box plot of standardized mean of the phenological parameters

The red asterisk (*) indicated the standardized mean value. As the mean and median are approximately same, thus all the parameters were at least approximately normally distributed without having outliers. Before performing ANOVA, the study checks the assumptions. For normality of errors, homogeneity of variances, and independence from errors the study used Shapiro-Wilk normality test (W), Bartlett test (Bartlett's K-squared), and Durbin-Watson test (DW) respectively. In table 2 displayed the outcomes.

Table 2: P-value of the W, Bartlett's K-squared, and DW test for overall phenotypic parameter

Test	Days to emergence	Emergence (%)	Tuber length	Tuber diameter	Yield
Normality of errors	0.39	0.71	0.11	0.22	0.56
Homogeneity of variances	0.93	0.38	0.91	0.90	0.85
Independence from errors	0.66	0.22	0.42	0.76	0.70

The null hypothesis for W test assumes the errors are normally distributed, for Bartlett's K-squared test assumes the variances are homogenous, and for DW test assumes the errors are independently distributed. According to Table 2, all the p-values are superior than 0.05. Thus, the null assumption is not rejected by the investigation. indicating all the assumptions for ANOVA were not violated. The ANOVA outcome was displayed in Table 2.

Table 3: Mean comparison of chemical treatment effect on emergence, yield and yield supporting traits of potato cultivar BARI Alu-62

Treatments	Days to emergence	Emergence (%)	Tuber length	Tuber diameter	Yield (t ha^{-1})
Control	22.0 ±1.0^{a}	55.0 b	41.6 b	28.98 b	12.8 b
GA_3 (0.1%)	14.0±1.53^{b}	80.0 a	43.7 b	29.48 b	14.3 ab
KNO_3 (1.0%)	21.0±1.53^{a}	58.0 b	40.78 b	29.04 b	13.7 ab
GA_3 (0.1%) × KNO_3 (1.0%)	15.0±2.08^{b}	78.0 a	47.9 a	36.83 a	14.5 a
CV (%)	3.56	4.82	3.94	8.73	6.13
$LSD_{0.05}$	0.95	6.52	3.43	5.42	1.69

Emergence is the various superficial growths of plant tissue, typically involving both the outer layer and the tissues just beneath it. Days required for emergence of potato seedlings on soil surface differed meaningfully when tuber treated with singly GA_3 (0.1%), KNO_3 (1.0%) and their combinations (Table 3). The application of GA_3 (0.1%) alone, as well as its combination with KNO_3 (1.0%), significantly sped up tuber emergence compared to both the control (non-treated) and KNO3 (1.0%) treatments. In general, tubers treated with GA3 (0.1%) alone and with a combination of GA3 (0.1%) and KNO3 (1.0%) had minimum seedling emergence durations of 14 and 15 days, respectively. Gibberellic acid enhances the germination of latent seeds of several crops, according to (Ding et al., 2007; Mello et al., 2009; Patel et al., 2018; Iralu and Upadhaya, 2018). The present study's findings are consistent with these findings. In addition, the control (non-treated) and tubers treated with KNO_3 (1.0%) alone had the longest durations for seedling emergence.

Data analysis showed that seed emergence percentages were significantly affected by individual factors, GA_3 and KNO_3, as well as their combination (GA_3 × KNO_3) at a $p < 0.05$ level of significance. The maximum germination (%) was achieved with the GA_3 (0.1%) treatment, outperforming all other single treatments. This was followed by the GA_3 × KNO_3 combination, which also produced a higher germination percentage than any of the individual treatments. However, the GA_3 treatment alone did not considerably raise the final seedling emergence (%). A similar investigation on *Cordia biosseri* showed a significant proportion of dormant seeds, with GA_3 treatment effectively breaking seed dormancy (Fulbright, 1992; Schuch et al. 2001). Whether KNO_3 and GA_3 were applied separately or together, there were notable differences in the tuber yield (t ha^{-1}). Applying GA3 and KNO3 together resulted in the highest yield (14.5 t ha^{-1}), followed by applying GA_3 (0.1%) and KNO_3 (1.0%) separately, which directly lead to the highest emergence (%). The results obtained indicate that treatment with GA_3 improved the production of fruits, are consistent with the current findings (El-Sese, 2005). Furthermore, they found that increasing the rates at which potassium (K) fertilizers were applied to pepper plants enhanced their overall production, marketable yield, commercial fruit yield, and average overall yield $plant^{-1}$ (Golcz et al., 2012).

3.1 Phenotypic parameters evaluated over time

There were three phenotypic parameters evaluated over time namely; Plant height (cm), Leaf Area Index, and Total dry matter (gm^{-2}) production.

3.2 Plant height

The table presents the plant height of BARI Alu-62, measured at five growth intervals (30, 45, 60, 75, and 90 days after planting, DAP), as influenced by four treatments: Control, GA_3 (0.1%), KNO_3 (1.0%), and a combination of GA_3 (0.1%) × KNO_3 (1.0%). Significant variations in plant height were observed across treatments and growth stages, indicating the differential effects of the growth regulators on the crop's development (Table 4). Plant height was considerably differed for single GA_3 and combination of GA_3 × KNO_3 treated tubers compared to control and single KNO_3 treated tubers. Plant height was increased by KNO_3 treated tuber which was closely similar rate to control and plant height was comparatively 5.64% taller (Control); for untreated treated tuber when treated with KNO_3 application. Plants that were the longest 26.10, 36.3; 27.7, 30.0; 32.1, 31.9; 35.6, 30.4; 47.3, 36.9 cm at 30, 45, 60, 75, 90 days after planting observed from the tuber treated by single GA_3 (1.0%), combination of GA_3 (0.1%) × KNO_3 (1.0%). The enhanced plant height could be attributed to the stimulation of cell division and elongation triggered by KNO3 and GA3 application, as highlighted by Kazemi (2014) in a study on tomato crops. Plant height was seen to be higher after emergence till harvest than in other treatment. This could be due to the natural gibberellin levels in various plant stages, which promote vegetative development by causing vigorous division of cells and elongation in the apical meristems. Gibberellins may also have contributed to the plant's notable height increase by influencing the process of photosynthesis, which in turn allows the plants to efficiently use the products of photosynthesis.

Table 4: Plant height of BARI Alu-62 at different days after planting as influenced by application of different chemicals treatments

Treatments	Plant height (cm) at different Days After Planting				
	30	45	60	75	90
Control	22.30 ab	25.5 bc	27.6 b	29.9 b	32.8 b
GA3 (0.1%)	26.10 a	27.7 ab	32.1 a	35.6 a	47.3 a
KNO3 (1.0%)	20.10 b	24.50 c	25.3 b	27.8 b	32.6 b
GA3 (0.1%) × KNO3 (1.0%)	26.3 a	30.0 a	31.9 b	30.4 b	36.9 b
CV (%)	9.43	5.57	9.88	5.55	11.4
$LSD_{0.05}$	4.46	2.99	5.34	3.43	8.53

3.3 Leaf Area Index (LAI)

Both GA_3 and KNO_3, along with their combination, had a significant ($p \leq 0.05$) impact on the leaf area index of the potato variety BARI Alu-62, driving notable changes in growth (Table 5). The Leaf Area Index (LAI) showed a significant increase from 30 to 75 days after planting (DAP), but began to decline by 90 DAP. Interestingly, after 30 days, the GA_3, KNO_3, and combined treatments did not surpass the LAI of the control plants. Fortunately, the maximum LAI at 60 DAP (0.432, 0.505); 75 DAP (0.518, 0.612) and 90 DAP (0.435, 0.391) was produced through single GA3 and combination of GA_3 × KNO_3 application. Compared to control and KNO3 treatments, seeds treated with single GA3 and GA3 × KNO3 sprays had higher leaf area at later growth stages. In a similar vein, Dev et al. (2020) discovered that, in comparison to single KNO3 (1.0%) and control treatments, the plants treated with GA_3 250 × KNO_3 1.0% had the largest leaf area, followed by GA_3 500 × KNO_3 0.5%. GA3 demonstrated its beneficial effects on enlargement by stimulating leaf development in *Citrus aurantifolia*, *Citrus limon*, and *Eriobotrya japonica* (Meshram et al. 2015; Dzayi and Rahman, 2010; Shabaq, 2013).

Table 5: Leaf Area Index (LAI) of BARI Alu-62 at different days after planting as influenced by application of GA_3 and KNO_3

Treatments	LAI at different Days After Planting				
	30	45	60	75	90
Control	0.207 a	0.226 c	0.321 b	0.461 b	0.283 c
GA3 (0.1%)	0.0843 c	0.327 b	0.432 a	0.518 b	0.435 a
KNO3 (1.0%)	0.139 b	0.422 a	0.413 ab	0.425 c	0.353 b
GA3 (0.1%) + KNO3 (1.0%)	0.100 c	0.218 c	0.505 a	0.612 a	0.391 a
CV (%)	6.192843	8.797011	12.1282	9.537372	9.661674
$LSD_{0.05}$	0.01641438	0.0524043	0.1012245	0.09257393	0.0739788

3.4 Total Dry Matter (TDM) production (g m^{-2})

Significant variations were observed across treatments in the TDM production (g m^{-2}) of the potato variety BARI Alu-62, with notable differences at every sampling point, ranging from 30 to 90 DAP (Table 6). TDM was enhanced dramatically from 30 to 90 DAP, and more production was observed when sampling 75 to 90 DAP. With the exception of the 30 DAP sampling, results indicated that the peak dry mass was attained when the potato tuber were treated with the single aqueous solution of GA_3 (0.1%), KNO_3 (1.0%) and followed by the solution containing GA_3 (0.1%) ×KNO_3 (1.0%) over control. GA3 (0.1%) showed the highest TDM values at all sampling points, particularly at 90 DAS, where it significantly outperformed all other treatments. This suggests that GA3 is a potent growth stimulant, especially in later stages of growth. KNO_3 (1.0%) produced moderate results, consistently improving growth over the control, but it never reached the levels seen with GA_3. The combined treatment of GA_3 and KNO_3 showed a synergistic effect in some stages, particularly from 75 DAS onward, but did not surpass GA_3 in effectiveness. Consistent with the present study, found that, KNO_3-treated seeds promoted higher dry weight in Passion flower seedlings, while GA3 application boosted dry weight in *Carica papaya* and *Citrus maxima* respectively (Cárdenas et al., 2013; Meena and Jain, 2012; Parab et al., 2017; Harsha et al., 2017). The observed increase in dry weight can be attributed to the enhanced growth of roots and branches. This elongation of shoots and roots facilitated improved carbon assimilation and translocation within the plant, ultimately contributing to the higher total dry weight of the seedlings.

Table 6: TDM (gm^{-2}) of BARI Alu-62 at different days after planting as influenced by application of GA_3 and KNO_3

Treatments	TDM (gm^{-2}) at different Days After Planting				
	30	45	60	75	90
Control	23.93 a	40.10 b	68.70 d	169.66 b	246.8 d
GA3 (0.1%)	11.53 c	67.97 a	170.40 a	216.31 a	408.2 a
KNO3 (1.0%)	15.88 b	67.21 a	98.80 c	142.95 c	272.7 c
GA3 (0.1%) + KNO3 (1.0%)	9.98 c	41.88 b	130.23 b	257.15 a	318.1 b
CV (%)	9.464904	6.648735	5.212603	5.782607	6.361288
$LSD_{0.05}$	2.899358	7.21182	12.18552	21.1154	36.40338

3.5 Tuber Nutrient Traits

The study considered nitrogen (N), phosphorus (P), potassium (K), sodium (Na), and calcium (Ca) in offspring tubers as nutrient parameters. According to Table 7, all the p-values are greater than 0.05. Thus, the study fails to reject the null hypothesis indicating all the assumptions for ANOVA were not violated. The ANOVA outcome was shown in Table 8.

Table 7: P-value of the W, Bartlett's K-squared, and DW test for tuber nutrient parameters

Test	N (%)	P (%)	K (%)	Na (%)	Ca (%)
Normality of errors	0.44	0.54	0.98	0.51	0.72
Homogeneity of variances	0.19	0.09	0.32	0.81	0.36
Independence from errors	0.17	0.85	0.89	0.12	0.68

The interaction between GA_3 and KNO_3 significantly impacts on the levels of nitrogen (N), phosphorus (P), potassium (K), sodium (Na), and calcium (Ca) in offspring tubers (Table 8). The nitrogen (N) content in tubers was notably higher with the application of single treatments of GA_3 and KNO_3, as well as their combination, compared to the control. Overall, offspring tubers derived from main tubers treated with GA_3 had higher nitrogen (N) content than those from KNO_3-treated tubers. The P (%) content significantly varied among the treatments, as evidenced by the statistical analysis. The highest P (%) content, 0.50%, was observed in tubers treated with the combined application of GA_3 (0.1%) and KNO_3 (1.0%), followed closely by individual applications of GA_3 (0.1%) and KNO_3 (1.0%), each resulting in a P content of 0.49%. These values were significantly higher than the control, which exhibited the lowest P content at 0.45%. Offspring tubers derived from seed tubers treated with the combined application of GA_3 (0.1%) and KNO_3 (1.0%) showed the highest concentrations of potassium (K) at 2.24%, sodium (Na) at 1.11%, and calcium (Ca) at 0.44%. This was much greater than the individual treatments of GA_3 (0.1%) and KNO_3 (1.0%), which resulted in K contents of 2.01% and 1.96%, respectively. The individual application of GA_3 (0.1%) resulted in a Na content of 0.98%, which was significantly higher than the KNO_3 (1.0%) treatment (0.81%) and the control (0.69%). The individual application of GA_3 (0.1%) also led to a higher Ca content (0.39%) compared to KNO_3 (1.0%) (0.31%) and the control (0.17%). The control group exhibited the lowest potassium (K), sodium (Na) and calcium (Ca) content, indicating that both GA_3 and KNO_3 positively influenced nutrient accumulation, with the combined application being the most effective. In line with the current study, they observed elevated nitrogen and phosphorus levels in the leaves of *Cucumis sativus* plants treated with GA_3 and KNO_3 (Pal et al., 2016). In contrast to our findings, researcher reported that while GA3 application had no significant impact on leaf NPK content, KNO3 treatment notably influenced the NPK levels in *Solanum lycopersicum* leaves (Kazemi, 2014).

Table 8: Nutrient (%) in Tuber of BARI Alu-62 as influenced by the application of singly GA_3 and KNO_3

Treatments	N (%)	P (%)	K (%)	Na (%)	Ca (%)
Control	1.23 b	0.45 b	1.76 c	0.69 c	0.17 c
GA_3 (0.1%)	1.76 a	0.49 a	2.01 b	0.98 b	0.39 ab
KNO_3 (1.0%)	1.64 a	0.49 a	1.96 b	0.81 c	0.31 b
GA_3 (0.1%) × KNO_3 (1.0%)	1.58 a	0.50 a	2.24 a	1.11 a	0.44 a
CV (%)	6.67	3.55	4.53	7.02	13.16
$LSD_{0.05}$	0.21	0.03	0.18	0.13	0.09

4. Conclusion

The combined and individual use of GA_3 and KNO_3 worked cooperatively to break dormancy and boost the sprouting of *Solanum tuberosum* tubers. In summary, applying GA_3 at 0.1% offers a simple, efficient, and practical solution to fast-track dormancy breakdown and boost the emergence of *Solanum tuberosum* tubers.

Conflict of interest statement

The authors declare that they have no conflicts of interest. This includes any financial or non-financial interests that could inappropriately influence or be perceived to influence the work reported in this manuscript. Specifically, the authors confirm that they have no financial relationships or non-financial relationships that could affect the research presented.

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Author's Contribution

The research idea was imagined by authors **A.H.M Motiur Rahman Talukder** and **A. K. M. Zonayed-Ull-Noor**. The theoretical framework was developed, and the calculations were carried out by Authors **A.H.M Motiur Rahman Talukder, A. K. M. Zonayed-Ull-Noor, Istiak Ahmed**. The analytical techniques were validated by authors **Faruque Ahmed, A.A.M. Mohammad Mustakim, Nadira Mokarroma, Lutfun Nahar**. Throughout the investigation, authors **Faruque Ahmed** and **Lutfun Nahar** offered direction and oversight. Each contributor actively participated in the results discussion and helped write final manuscript.

Availability of data and material

All information and resources utilized to bolster the study's findings will be made available upon request from the corresponding author.

Code availability

Upon request, the corresponding author will provide all of the materials and data utilized in this study's analysis.

Ethics approval

The corresponding author, on behalf of all authors, confirms compliance with the study's requirements:

- The content provided is the authors' original work and has not been previously published.
- The paper is not submitted elsewhere.
- The paper authentically reflects the authors' research and insights.
- All contributors have been duly credited for their impactful contributions.

Consent to participate

The study doesn't employ any human volunteers; instead, it uses information gathered from other sources.

Consent for publication

The corresponding author has obtained consent from all authors for the publication in the specified journal. I confirm reviewing and approving the content and article for Springer Nature Journal publication. I acknowledge Springer Nature journals are widely accessible in print, online, and via diverse channels. This journal's content is accessible to everyone, from plant science experts to journalists and the public.

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