Effective Chemical Treatments for Breaking Dormancy and Enhancing Sprouting in Freshly Harvested Potato Tubers

Commented [A1]: Effect Chemical Treatments for Breaking Dormancy and Enhancing Sprouting in Freshly Harvested Potato Tubers in Nepal

ABSTRACT:

This study aims to improve low potato production in Dolakha, Nepal, by identifying effective chemical treatments to break dormancy in freshly harvested tubers that improves seed viability and germination rates.The study used a Completely Randomized Design (CRD) with three replications. It tested eight treatments: gibberellic acid (GA3) at 50 ppm and 100 ppm, benzyl amino purine (BAP) at 50 ppm and 100 ppm, sugar solutions (0.5% ethanol + 1% sugar, 0.5% ethanol + 10% sugar, and 50% sugar) and distilled water. Medium-sized Ms-42.3 tubers were soaked in these treatments for two hours before being stored in a dark room.Results showed that GA3 at 100 ppm was the most effective treatment, reducing the days first to sprout emergence to 1.8 days and breaking dormancy in 2.63 days. It also produced the longest sprouts, measuring up to 17.70 mm at 50 days. In contrast, the control group (distilled water) had the slowest sprouting, with a maximum of 15.20 days to first emergence, and the shortest sprouts, up to 4.53 mm at 50 days. In conclusion, GA3 significantly enhanced sprouting speed, sprout density, and length compared to other treatments, offering a practical solution to improve potato production in low-tech settings. Future research should explore different potato varieties and environmental conditions to optimize these treatments further. This study provides valuable insights into effective sprouting techniques, potentially boosting agricultural productivity in similar regions.

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1. INTRODUCTION

Potato *(Solanum tuberosum)*, an annual plant in the nightshade family (Solanaceae), originated from South America [1]. It is rich in nutrients like carbohydrates, vitamins (especially B1, B3, B6, and vitamin C), protein, and minerals like potassium, phosphorus, and magnesium [3]. It is fourth most important after rice, maize, and wheat in terms of production and productivity in Nepal [2]. In Nepal, cultivated in 1, 98,788 ha with 332523 mt production and 16.73 mt/ha productivity contributing 2.17% to the GDP and 6.57% to the AGDP whereas Dolakha accounts

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It is abundant in minerals like potassium, phosphorus, and magnesium, as well as nutrients like protein, carbs, and vitamins (particularly B1, B3, B6, and C).

for 3069 ha area, yielding 55917 mt annually with the productivity of 18.22 mt/ha (MoALD, 2020/21).

A state of halted growth in the morphology and annul cycles results in dormancy[4]. Various factors influence tuber dormancy such as temperature, moisture, and genetics [5]. Different *Solanum* species exhibit varying dormancy lengths. Tuber dormancy length can range from 20 days to 8 years in different species. [6]. Tubers are dormant after harvest and only start sprouting after a period of postharvest storage, with dormancy-breaking and sprout growth initiated by biochemical changes [7]. Chemicals like Cytokinin, ABA, and ethylene are responsible for dormancy in potatoes, and various methods like heat treatment and GA3 can help promote earlier sprouting and improve tubers [8].

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Dormancy of a potato tuber is a physiological state characterized by a period during which autonomous growth of the sprout is suspended even under optimal sprouting conditions i.e. darkness, 15 to 20°C, and relative humidity of about 90 %. [9]. During dormancy, potato tubers do not undergo biological processes but do not sprout immediately. Sprouts start growing intensively with root formation after dormancy is broken, converting tubers into a source of nutrients for developing sprouts [10]. Various physical, chemical, and hormonal treatments can induce sprouting [11]. Gibberellic acid and cytokinins like BAP are commonly used treatments. Proper cleaning and concentration are important for GA3 treatment, with increased endogenous gibberellin levels observed before dormancy is broken [12]. GA3 at 5 ppm and 10 ppm can treat old and bruised tubers, improving performance and productivity [13]. Exogenous cytokinins can also break dormancy, with BAP being widely used to stimulate cell division and morphogenesis [14]. Higher concentrations of BAP have shown faster dormancy breaking and better germination rates in potato varieties [15]. In vitro studies show thatethanol treatment breaks dormancy of potato tuber by inducing the growth of the apical bud. Primary alcohol breaks the dormancy but not by secondary alcohols, and the effect of ethanol on sprouting and gene expression in tuber tissue was blocked by an inhibitor of alcohol dehydrogenase [16]. The concentration of ethanol (95%) varies based on the dormancy stage. The sprouting rate increases with 1% or 8% sucrose in medium. Sprouts visible in 3 days with ethanol treatment, reaching close to 100% sprouting by day 5 or 6 [17]. In contrast, sugar solution treatment results in 50%

sprouting in the dark, 50% in semi-dark, and 100% in light within 12-16 days. Sprouts start within 16 days of treatment [18].

Due to insufficient technology and dependency on conventional agriculture, the production of potatoes is still very low compared to the attainable yield and yield of neighboring countries like India and China[19]. The purpose of this research is to identify effective treatments for breaking dormancy in freshly harvested potato tubers, enabling their use as seed potatoes in Dolakha. This will help farmers improve crop rotation, ensure better germination, and meet early market demands. The study will also assess the efficacy of various chemical treatments on potato sprouting.

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2. MATERIALS AND METHODOLOGY

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2.1 Experimental site

The research was conducted in Dolakha District, Nepal, at an altitude of 1950 meters. The area has a sub-tropical climate with annual rainfall of about 2,091 mm and temperatures ranging from 7°C to 27°C. The study was conducted from March to June 2023.

2.2. Experimental design

The research used a Completely Randomized Design (CRD) with three replications and eight different treatments using various concentrations of GA3, BAP, ethanol, and sugar. Tubers were placed on paper plates in a storeroom and treated with these chemicals to test sprouting. Medium-sized tubers (25-35 grams) of the Ms-42.3 variety were chosen, and cleaned, and 15 potatoes were used for each test.

2.3. Sample collection Preparation of chemical treatment

The tubers required for the research experiment were collected locally from Bhimeswor municipality, Dolakhaand were harvested in early March. Ms-42.3 variety was used because it's widely grown and preferred by local farmers. Medium-sized tubers (25-35 grams) were chosen after cleaning and sorting them. The treatments were made by mixing different chemicals with distilled water, except for GA3 and BAP, which were first dissolved in a strong base (NAOH) before being mixed with water. Tubers were washed with tap water, and then soaked in the chemical treatments for two hours. For the control group, tubers were soaked in distilled water

for two hours. After soaking, the tubers were dried and kept in a dark room for the rest of the observation period.

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2.4. Treatments details

The treatments are as follows: T1 is the control, T2 and T3 use 50 ppm and 100 ppm Gibberellic acid, T4 and T5 use 50 ppm and 100 ppm cytokinin (Benzyl Amino Purine), and T6, T7, and T8 use 0.5% ethanol + 1% sugar, 0.5% ethanol + 10% sugar, and a 50% sugar solution, respectively.

2.5. Data observation

Five tubers were randomly selected from each experimental unit through simple random sampling and data were observed on a regular basis. Data were collected on the following parameters:

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2.5.1 Days to first emergence of sprouts

The total days required to induce the emergence of first sprouting were recorded as the days to first emergence. It was obtained by counting the days for the emergence of the first sprout after treating the tubers with respective treatments. It was observed regularly after carrying out the treatment and the days after treatment when the first sprout occurred was noted for each sample tuber.

2.5.2 Days for dormancy breakdown

Dormancy was considered to be broken when more than 80% of sample tubers showed about 2 mm long sprouts.

2.5.3 Number of sprouts per tuber

It is also known as sprout density. It is measured by counting the number of sprouts in each sprouted sample tuber. The observation was taken in 10, 20, 30, 40, 50 days after treatments.

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2.5.4 Sprout length per tuber

The sprout length was measured with the help of the scale in millimeters (mm). The sample of five tubers was selected randomly, measured, and recorded every 10-day interval at 10, 25, 30, 40, and 50 days after treatments.

2.6 Statistical analysis

All the collected data throughout the experimental period were tabulated in Ms-Excel and subjected to R studio software for statistical analysis. Data were subjected to a one-way (treatments) analysis of variance (ANOVA) and significant mean differences werecompared by using Duncan's Multiple Range Test (DMRT) at a 0.05 percent level of significance.

3. RESULT AND DISCUSSION

3.1 Days to the first emergence of sprouts:

The results of the experiment demonstrated that treatment with different amounts of chemicals (BAP, ethanol, sugar, and gibberellic acid) had a substantial impact on the days when sprouts first appeared (Table 1). Gibberellic acid at 100 ppm (1.8) showed the minimum days to initial emergence, while Gibberellic acid at 50 ppm (2.06) showed the sameresults. The result obtained from 50 ppm GA3, 100 ppm BAP and 50% sugar solution was statistically similar.The experiment revealed that the control group had a maximum number of days until the first emergence (15.20).Based on the overall findings, it can be inferred that gibberellic acid was more effective than other treatments in promoting the initial signs of sprouting since GA3 promotes cell elongation in plants. The increased cell elongation facilitates the expansion of the shoot and root systems, allowing the sprouts to push. The outcomes align with the discoveries made by other scholars[20]&[21]. Rahman et al. have demonstrated that a reduction in the number of days to 50% sprouting was the outcome of raising the GA3 concentration. Similar to Zaghum et al. conclusion that treatment with 300g sugar powder in 600ml water solution i.e. 50% sugar solution produced a 50% sprout percentage in dark conditions, 50% in semi-dark conditions, and 100% in open conditions over 12–16 days since sugar acts as a nutrient source to potato tuber and also creates create an osmotic potential that can draw moisture from the potato tuber's inner cells [18]. This initiates the sprouting process and encourages the growth of buds or eyes. The presence of ethanol in the media affects the rate at which microtubers sprout when placed in a medium containing either 1% or 8% sucrose. At both high and low sucrose levels in the medium, day 5 or 6 saw almost 100% of the seeds germinate [17].

3.2. Days to breaking the dormancy:

Using various chemical concentrations (BAP, sugar, ethanol, and gibberellic acid) has a significant effect on how quickly potato tubers break dormancy. The results show that these treatments can greatly reduce the number of days needed for tubers to break dormancy compared to the control group (Table 1).Gibberellic acid at 100 ppm (2.63) was found to require the fewest days to break dormancy, trailed by Gibberellic acid at 50 ppm (3.06). The control group experienced a maximum of 27.26 days for the potato to emerge from dormancy. The results of using 50% sugar solution and 50 ppm GA3 were statistically equivalent, although BAP 100 ppm (3.63), BAP ppm (4.83), and 50% sugar solution (4.26) also assisted in ending potato dormancy earlier.Overall, GA3 is the most effective at breaking dormancy in potato tubers. BAP and sugar solutions are also useful for this purpose. All three treatments work by mobilizing stored nutrients and overcoming dormancy inhibitors.During the observation period, a high dose of gibberellic acid i.e. 100ppm was more effective than 10ppm GA3 treatments in breaking of potato tubers. This finding was aligned with the findings ofSalimiet al.[22]. This result is also consistent withTurnip et al.[23], who reported that soaking the potato tuber seeds in a cytokinin solution shortened the dormancy release time by 12.58 days as compared to the period without soaking the potato tuber seeds in a cytokinin solution.

3.3. Number of sprouts per tuber (sprout density):

Table 2 illustrates the results of the analysis of variance, which indicated that the number of sprouts per tuber was found to be significantly impacted by different treatments applied at successive data recordings. The 100 ppm Gibberellic acid (3.27) had the greatest number of sprouts at 10 DAT, while the control group had the lowest number of sprouts in the study (0.00). In Gibberellic acid 100 ppm (3.60) at 20 DAT, the highest number of sprouts per tuber was noted. In control, the bare minimum of sprouts per tuber (1.20) was seen. When compared to Gibberellic acid 50 ppm (3.26) and 0.5% ethanol + 10% sucrose (3.26), which had the fewest sprouts in the control (1.80), Gibberellic acid 100 ppm (3.80) contained the most sprouts at 30 DAT. At 40 DAT, it was discovered that the number of sprouts per tuber was much larger in Gibberellic acid 100 ppm (3.93), while the lowest number of sprouts was obtained at the control (1.86). The results from 40 DAT and 50 DAT showed the same sprout density, with no

consistent rise. Increased concentrations of GA3 were associated with similar outcomes to

Treatments	Days to emergence	Days to dormancy break down

generating more sprouts[24]&[21].These findings are similar to the results ofRossouw[25] where the result obtained by them indicates that a lower concentration of cytokinin resulted in more sprout growth than a higher concentration.

3.4. Length of sprout per tuber

The impact of different chemical treatments on the length of sprouts(Table 3). The experiment demonstrated that, in comparison to the control, sprout length was significantly impacted by varying treatment concentrations. Gibberellic acid at 100 ppm (8.33 mm) produced the longest sprouts on 10 DAT, while the control group did not develop any sprouts at all. The length of sprouts per tuber in Gibberellic acid 100 ppm at 20 DAT is 10.80 mm, the longest among the other treatments, and 1.26 mm, the shortest in the control. The results from the 30-day assay also show that 100 ppm of gibberellic acid produces the longest sprouts, measuring 13.20 mm, whereas the control group shows the shortest sprouts, measuring 2.20 mm. The highest length of sprouts was seen at 40 DAT and 50 DAT in Gibberellic acid 100 ppm 15.20 mm & 17.70 mm, respectively, followed by Gibberellic acid 50 ppm 13.73 mm & 14.70 mm. In both observations, the control group produced the shortest sprout length. The control treatment yielded 3.33 mm at 40 DAT and 4.53 mm at 50 DAT. This result demonstrated that the length of the sprout rises along with an increase in GA3 and BAP concentration. (Solomon I. Shibairo, 2006). The sprout length increased with an increase in GA3 concentration. With longer storage times, sprout length rose in every treatment[21]&[11].

Table 1. Effect of different chemical doses on the first emergence of sprouts on potato tuber.

GA3 50 ppm	2.06^{cd}	3.06^{d}
GA3 100 ppm	1.80^{d}	2.63^{d}
BAP 50 ppm	2.86^{c}	4.83^{bcd}
BAP 100 ppm	2.26^{cd}	3.63^{cd}
0.5% ethanol + 1% sucrose	3.83^{b}	6.50^{b}
0.5% ethanol + 10% sucrose	2.80^{b}	5.56^{bc}
Sugar 50%	2.23^{cd}	4.26^{bcd}
Control	15.20^{a}	27.26^{a}
LSD	0.86	2.25
SEM(+-)	0.10	0.26
F-probability	<0.001	<0.001
CV%	12.14	18.04
Grand mean	4.13	7.22

Note: CV= Coefficient of Variation, LSD=Least Significant Difference, SEM=Standard Error of Mean.The column with the same letter (s) in superscript indicates no significant difference

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between treatments.. '***'Significant at 0.001 Level of Significance; '**' Significant at 0.01Level of significance; '*' Significant at 0.05 Level of Significance.

Table 2. The number of sprouts per tuber induced by different chemical doses on potato tuber.

Treatments	10 DAT	20 DAT	30 DAT	40 DAT	50 DAT
GA3 50 ppm	3.00^{a}	3.26^{ab}	3.26^{ab}	3.26^{ab}	3.26^{ab}
GA3 100 ppm	3.27^{ab}	3.60^{a}	3.8^{a}	3.93^{a}	3.93^{a}
BAP 50 ppm	2.53^{bc}	2.86^{abc}	2.93^{ab}	2.93^{abc}	2.93^{abc}
BAP 100 ppm	2.13^{c}	2.40^{bc}	2.60^{bc}	2.73^{bc}	2.73^{bc}
0.5% ethanol + 1% sucrose	2.93^{ab}	3.00^{abc}	3.06^{ab}	3.20^{ab}	3.20^{ab}
0.5% ethanol + 10% sucrose	2.46^{bc}	3.13^{abc}	3.26^{ab}	3.46^{ab}	3.46^{ab}
Sugar 50%	2.00^{c}	2.30^{c}	2.53^{bc}	2.63^{bc}	2.63^{bc}
Control	0.00	1.20^{d}	1.80^{c}	1.86^{c}	1.86^{c}
LSD	0.67	0.91	0.95	1.07	1.07
SEM(+-)	0.07	0.09	0.10	0.15	0.15

F-probability	<0.001	<0.01	<0.05	<0.05	<0.05
CV%	17.08	19.49	18.92	21.41	21.41
Grand mean	2.29	2.72	2.90	2.90	2.90

Note: CV=Coefficient of variation, LSD=Least Significant Difference, SEM=Standard Error of Mean. The column with the same letter (s) in superscript indicates no significant difference between treatments. '***' Significant at 0.001 Level of Significance; '**' Significant at 0.01 Level of Significance; '*' Significant at 0.05 Level of Significance.

Table 3: Sprout length per tuber (mm) induced by different chemical doses.

Treatments	10 DAT	20 DAT	30 DAT	40 DAT	50 DAT
GA3 50 ppm	7.73	10.33^{a}	12.33^{a}	13.73^{a}	14.70^{b}
GA3 100 ppm	8.33	10.80^{a}	13.20^{a}	15.20^{a}	17.70^{a}
BAP 50 ppm	4.26	6.06^{bc}	8.20^{b}	9.26^{bc}	11.03^{c}
BAP 100 ppm	5.73	8.00^{b}	8.93^{b}	11.06^{b}	13.06^{bc}
0.5% ethanol + 1% sucrose	3.06	4.93^{c}	6.86^{b}	8.00^{c}	10.30^{c}
0.5% ethanol + 10% sucrose	3.73	5.53^{c}	7.00b	8.46^{bc}	10.73^{c}

Sugar 50%	5.06	6.86^{bc}	8.53^{b}	9.80^{bc}	11.36^{c}
Control	0.00	1.26^{d}	2.20^{c}	3.33^{d}	4.53^{d}
LSD	1.79	2.10	1.90	2.63	14.53
SEM(+-)	0.18	0.22	0.20	0.27	0.30
F-probability	<0.001	<0.001	<0.001	<0.001	<0.001
CV%	21.83	18.08	13.08	15.44	14.53
Grand mean	4.74	6.72	8.40	9.85	11.67

Note: CV=Coefficient of variation, LSD=Least Significant Difference, SEM=Standard Error of Mean. The column with the same letter (s) in superscript indicates no significant difference between treatments. '***' Significant at 0.001 Level of Significance; '**' Significant at 0.01 Level of Significance; '*' Significant at 0.05 Level of Significance.

4. CONCLUSION

This study found that gibberellic acid (GA3) is very effective at breaking dormancy and encouraging sprouting in freshly harvested potato tubers. Specifically, GA3 at 100 ppm not only speeds up the time it takes for sprouts to appear but also increases both the number and length of the sprouts.The results show that GA3 helps potatoes sprout faster and grow better, which can improve seed potato quality and meet early market demands. This research provides valuable insights by showing that GA3 is more effective than other treatments, which could enhance potato production in areas with limited technology.However, the study only tested one type of potato and in a specific location. Future research should test different potato varieties and conditions to confirm these findings and improve sprouting methods for various environments.

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