

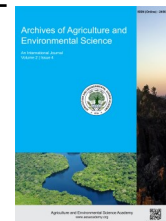


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ORIGINAL RESEARCH ARTICLE



## Concentration of Thiourea is effective in breaking the dormancy of potato (*Solanum tuberosum* L.) varieties

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### ABSTRACT

Potato germination is highly sensitive to ecological conditions. High altitude and low annual average temperature result in tuber dormancy and poor sprouting. Dormancy has become a significant constraint for lowering potato production, which hinders the possibility of growing two crop cycles per year. An experiment was conducted from February to April 2020. Two major potato varieties (Desiree and Cardinal) were treated with four Thiourea concentrations (0, 1, 2, and 3%) in a two factorial, completely randomized block design with three replications. Tubers were soaked for 2 hours in different Thiourea solution as per treatments, air dried until excess solution was removed and kept in a dark room on plastic trays. With the progress of experiment dormancy breaking and sprouting parameters like early sprouting, dormancy breaking, sprout length and sprout density were recorded. It was found that Thiourea has a significant effect on all observed attributes as per varieties of potato. For Desiree variety, Thiourea (1%) decreased dormancy period by 22 days compared to control (Desiree\*Thiourea 0%) and produced the longest average sprout of 7.36cm at 49 days after treatment (DAT). On the other hand, for the Cardinal variety, Thiourea (3%) decreased tuber dormancy by 27 days compared to control (Cardinal\*Thiourea 0%) and produced sprout of 7.75 cm at 49 DAT. In case of sprouts/tuber 1% and 3% Thiourea produced 4.13 and 1.91 sprouts/tubers in Desiree and Cardinal, respectively. The overall mean finding indicate that, 1% and 3% Thiourea concentration was significantly superior for breaking dormancy and enhancing sprouting of potato varieties of Desiree and Cardinal respectively.

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### INTRODUCTION

Potato (*Solanum tuberosum* L.) is a vital food crop primarily grown in Nepal's mid-hill region. In most developing countries such as Nepal, Potato is an important cash crop to resolve food insecurity and reduce poverty among smallholder farmers (Timilsina *et al.*, 2011). Several ecological conditions, such as temperature, humidity, light, and soil, play a key role during several developmental phases of potato, such as germination, sprouting, vegetative growth, and maturity. In potatoes, the tuber germination and establishment stage is susceptible to severe cold leading to the tuber's dormancy. Dormancy is

defined as the rest period under which sprouts fails to develop from any bud of tuber even though tuber is kept in ideal condition (Reust *et al.*, 2001). The tuber's dormancy period is governed by several factors, i.e., potato cultivar, growing condition, storage duration, and tuber size (Emilsson, 1949; Lommen, 1994; Wierseman *et al.*, 1987; El Nashar *et al.*, 1995). The tuber's dormancy results in low sprouting and poor establishment of the crop even in favourable growing conditions, one of the major causes of the decline in potato production (Haider *et al.*, 2019). Also, more extended dormancy of tuber affects the possibility of cultivating potato more than once per year in various regions. It is essential to break the dormancy of the

potato tuber. Tuber treatment with a chemical such as Gibberellic acid, Thiourea, Ethylene Chlorohydrin, carbon disulfide, and Bromoethane can remove the tuber's dormancy (Bryan, 1989; Otroshy, 2006; Rezaei and Soltani, 1996). In recent years, Thiourea, growth promoter and Nitrogenous compound are found effective in breaking both environmental and innate imposed seed dormancy and promotion of seed germination (El-Keblawy and Gairola, 2017).

Thiourea is defined as a catalyze inhibitor, which plays a crucial role in stimulating potato tuber germination. Application of Thiourea at appropriate concentration supports the germination process and develops multiple sprouts per eye of potato tuber (Germchi et al., 2011; Rehman et al., 2002). It was reported that potato tuber treated with Thiourea and hydrogen peroxide was found to have the early breaking of dormancy, i.e., 6 days and 10 days, respectively (Bajji et al., 2007). In Thiourea's case, soaking the potato tuber in 1%, aqueous solution for one hour is suggested to break the tubers' dormancy (Bryan, 1989; Germchi et al., 2011). Simialrly, (Nasiruddin et al., 2016) reported that tuber soaked in 3% Thiourea for 1 hour developed sprouts in 18.75 days, dormancy breaking at 36.5 days while for control it took 28.75 days and 64.25 days, respectively. However, another report has shown that the treatment of freshly harvested minituber with 20 g/l Thiourea for 3 hours was effective than 30 g/l for dormancy reduction (Hosseini et al., 2011).

Although Thiourea is used for breaking of dormancy of potato tuber (Wahid and Farooq, 2017). Still, very few research work have been conducted that compares the effectiveness of various concentrations of Thiourea for dormancy breaking along with the potato varieties. To address this knowledge gap, this research will help to study the effect of different concentration of Thiourea in breaking of tuber dormancy as per varieties. The major significance of this research will be recommending effective dose of Thiourea that will overcome tuber dormancy and promote sprouting behavior for different potato varieties under study. It is expected that, finding of this study will directly benefit potato growers to shorten dormancy period and improve sprouting length and density in tuber even at unfavourable conditions.

## MATERIALS AND METHODS

### Experiment design

An experiment was conducted from 16<sup>th</sup> February to 16<sup>th</sup> April 2020 under Prime Minister Agriculture Modernization Project, Potato zone, Dailekh, Nepal. The experiment followed two factorial CRD designs with two popular potato varieties of Dailekh, i.e., Desiree and Cardinal, as the first factor and different Thiourea concentrations (0, 1, 2, and 3%) as the second factor so, in total there are 8 treatments. Table 1 shows all the physio-chemical traits of the experiment.

### Treatment of tubers

Freshly harvested potato tubers of both varieties, i.e., Desire and Cardinal, were collected. Altogether 300 potato tubers of

uniform shape and size were collected, i.e., 150 tubers of each type. The average weight of the tuber was 30-40 g. Thiourea solution of different concentrations (1, 2, and 3%) was prepared by dissolving a calculated amount of Thiourea (Granules) in distilled water in separate plastic buckets. For a 1% solution, 30gm of Thiourea was dissolved in 3 litres of distilled water. Similarly, 60g and 90g Thiourea were dissolved in 3 litres of distilled water for 2% and 3% solution. One week after harvest, potato tubers were treated with varying concentrations of Thiourea. Each treatment had ten potato tubers of uniform shape and size. The tubers were soaked in the solution for 2 hours. While for control, the tuber was soaked in distilled water for the same period. After that, the soaked tuber was air-dried until all the excess solution in the tuber surface was removed. Then, the tubers were placed in a plastic tray and kept in the dark room.

### Bio-Metric observation

**Days to the first emergence:** The total days required to induce the emergence of the first sprout were taken as days to the first emergence. For this, potato tubers from each treatment combination were observed each morning to ensure the emergence of any sprouts. Only the sprout that reached a length of 2mm was counted as the first sprout from that particular tuber.

**Breaking of dormancy:** Breaking of dormancy is considered by the number of days elapsing from the treatment until 80% of the tuber has at least one sprout equal to or longer than 2mm (Van Ittersum and Struik, 1992). Here, a tuber from each treatment combination was inspected individually for producing the sprout of at least 2mm; once 80% of the tuber under observation had a sprout of at-least 2mm, then breaking of dormancy was calculated.

**Sprouting length:** The sprout's length was measured using a scale equipped with millimeter reading for earlier data recording days. As the sprout length increased, a scale provided with a centimetre reading was used. The average sprout length was measured regularly at an interval of 7 days upto 49 days of the experiment, starting from the first sprout initiation on the tuber.

**Sprouting density:** The total number of sprouts per tuber was counted, and the average sprouting density was calculated. The tuber of each treatment combination was observed closely at an interval of 7 days. Those sprouts longer than 2mm from a particular tuber were counted, and sprouting density was determined.

### Data analysis technique

The data were collected at an interval of 7 days, and a total of 49 days of data was observed. The statistical analysis of data was done by using statistical packages, namely Microsoft Excel and R-studio. Duncan's Multiple Range Test (DMRT) was used for mean separation and comparison at a 5% significance level.

**Table 1.** Treatment details used in the study.

Treatment number	Name of Treatment
T <sub>1</sub>	Desiree + Control
T <sub>2</sub>	Desiree + Thiourea 1%
T <sub>3</sub>	Desiree + Thiourea 2%
T <sub>4</sub>	Desiree + Thiourea 3%
T <sub>5</sub>	Cardinal + Control
T <sub>6</sub>	Cardinal + Thiourea 1%
T <sub>7</sub>	Cardinal + Thiourea 2%
T <sub>8</sub>	Cardinal + Thiourea 3%

**Table 2.** Days to emergence and breaking of dormancy as influenced by the interaction of variety and different concentration of Thiourea at Dailekh, Nepal (2020).

Treatments	Days to emergence (DTE)	Days to Breaking of Dormancy
Interaction of Two factor		
Desiree*Thiourea 1%	6.33 <sup>e</sup>	10.33 <sup>f</sup>
Desiree*Thiourea 2%	9.33 <sup>d</sup>	13.33 <sup>e</sup>
Desiree*Thiourea 3%	10.33 <sup>d</sup>	15.00 <sup>d</sup>
Desiree* Control	27.67 <sup>b</sup>	32.67 <sup>b</sup>
Cardinal*Thiourea 1%	13.0 <sup>c</sup>	18.66 <sup>c</sup>
Cardinal*Thiourea 2%	12.67 <sup>c</sup>	17.67 <sup>c</sup>
Cardinal*Thiourea 3%	6.67 <sup>e</sup>	13.33 <sup>e</sup>
Cardinal*Control	33.67 <sup>a</sup>	40.67 <sup>a</sup>
LSD (=0.05)	1.271 <sup>***</sup>	1.416 <sup>***</sup>
SEm (±)	0.424	0.472
CV %	4.912	4.05
Grand mean	14.95	20.20

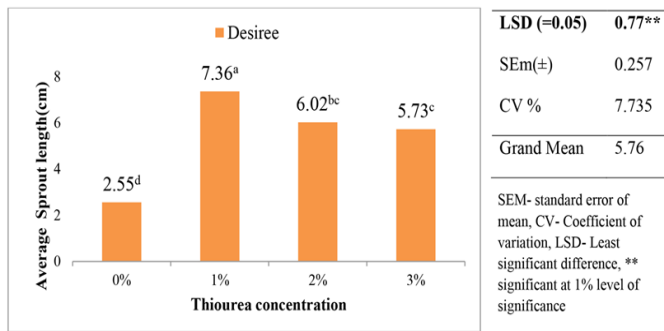
SEm- standard error of the mean, CV- Coefficient of variation, LSD- Least significant difference, \*\*- significant at 1% level of significance, \*\*\*- significant at 0.1% level of significance, common letter(s) within the column indicate non-significant difference based on Duncan Multiple Range Test (DMRT) at 0.05 level of significance.

## RESULTS AND DISCUSSION

### Early sprouting and breaking dormancy

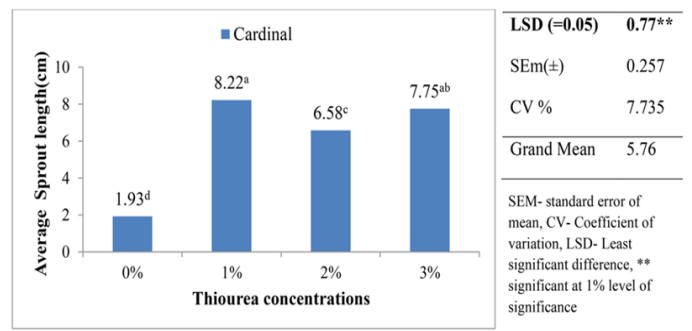
In tubers of Desiree variety treated with Thiourea (1%), sprouting started 6.33 days after treatment, whereas sprouting was started at 28 days for control. Moreover, the breaking of dormancy was achieved at 10.33 days after onset of treatment, which took 32.67 days for control tubers (Table 2). This result is supported by the finding of Bajji *et al.* (2007) where he reported thiourea treated tuber of Desiree showed 80% of sprouting after 6 day of treatment while water treated and control tuber showed slow, delayed and incomplete sprouting within the experiment duration and reached to 80% sprouting at 20 days after treatment. Table 2, shows that Cardinal variety treated with Thiourea (3%) started sprouting at the 6.67<sup>th</sup> day after the treatment, while sprouting on control was initiated at 33.67<sup>th</sup>-day from the onset of treatment. Besides, breaking dormancy was found at 13.33<sup>th</sup> day after the beginning of treatment, which was achieved after 40.67<sup>th</sup> day for control. Furthermore, it was observed that Thiourea at any concentration shortens the dormancy period of tuber as compared to control in both varie-

ties. Result achieved from this research was conformed by Hassani *et al.* (2014) they reported that Thiourea treatment to different variety of potato (Agraria and Burren) started sprouting at 19.13 DAT and breaking of dormancy occurred at 36.75 DAT while in control tuber it took 25.24 days and 54.57 days for sprouting initiation and breaking of dormancy respectively. Therefore, for Desiree tubers, Thiourea (1%) shortens the dormancy period by 22 days compared to control. This result is in accordance with (Bryan, 1989) who, recommended soaking of tuber in 1% aqueous solution of Thiourea for early dormancy breaking of potato varieties. On the other hand, for Cardinal tubers, Thiourea (3%) shortens the dormancy period by 28 days compared to control Tables 2. Moreover, Nasiruddin *et al.* (2016) also reported 36.5 days for dormancy breaking at 3% Thiourea treatment while control took 64.25 days. Therefore, throughout the experiment, we can observe the significant effect of different Thiourea's concentrations on the dormancy breaking of tubers which is supported by Hosseini *et al.* (2011) on early dormancy breaking of potato minituber when treated with Thiourea.



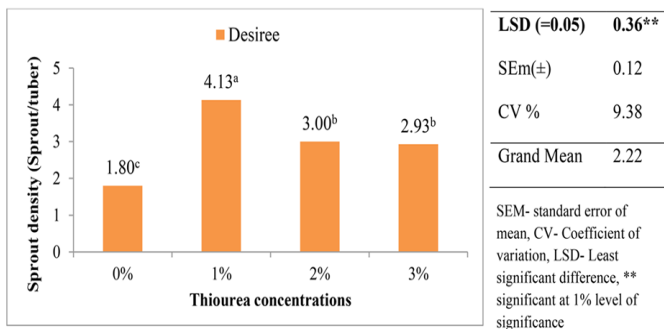
The common letter(s) within column/ bar indicate non-significant difference based on Duncan Multiple Range Test (DMRT) at 0.05 level of significance.

**Figure 1.** Effect of different Thiourea concentration on sprout length (cm) of Desiree potato at 49 days after treatment.



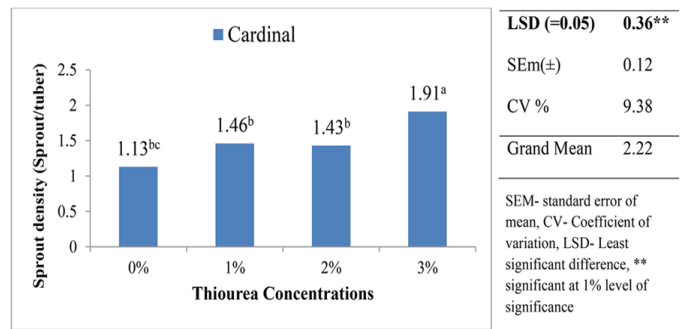
The common letter(s) within column/ bar indicate non-significant difference based on Duncan Multiple Range Test (DMRT) at 0.05 level of significance.

**Figure 2.** Effect of different Thiourea concentration on sprout length (cm) of Cardinal potato at 49 days after treatment.



The common letter(s) within column/ bar indicate non-significant difference based on Duncan Multiple Range Test (DMRT) at 0.05 level of significance.

**Figure 3.** Effect of different Thiourea concentration on sprout density (sprouts/tuber) of Desiree potato at 49 days after treatment.



The common letter(s) within column/ bar indicate non-significant difference based on Duncan Multiple Range Test (DMRT) at 0.05 level of significance.

**Figure 4.** Effect of different thiourea concentration on sprout density (sprout/tuber) of Cardinal potato at 49 days after treatment.

### Sprouting length

For Desiree variety, using Thiourea with 1% concentration produced the longest sprout of 7.36 cm length at 49 DAT, which was significantly higher than other concentrations 0, 2, and 3%, which had sprout of 2.55, 6.02, and 5.72cm, respectively, at 49 DAT as seen in Figure 1. On the other hand, for Cardinal variety, Thiourea(1%) developed the longest sprout of 8.22 cm, which was statistically similar to 3% Thiourea, i.e., 7.75 cm at 49 DAT. Thiourea at a concentration of 2% and control produced shorter sprout of 6.58 cm and 1.92 cm at 49 DAT, respectively shown in Figure 2. Similar kind of result was published by Mani *et al.* (2013) they reported that sprout length of 83mm and 84mm was recorded when tuber was treated with Thiourea at 250mM and 1000mM that was significantly longer than sprout produced at 500mM and 750mM measured 79.61mm and 72.72, respectively. Thus, Thiourea (1% and 3%) was indistinctly superior to other Thiourea concentrations in Cardinal for developing the longest sprouts. While in the case of Desiree, Thiourea (1%) produced the longest sprout than the remaining concentrations, can be seen in Figures 1 and 2. This result was different than those conformed by Hosseini *et al.* (2011) they reported increase in sprout length of tuber as the concentration of Thiourea was increased i.e., treatment of immediately harvested tuber with 10, 20 and 30 g/l Thiourea treatment produced 8mm, 10mm and 12mm sprouts, respectively. This variation could be due to difference in variety, physiological habits and age of the tuber which need to be further observed. Therefore, 1%

Thiourea have positive and significant increment in the average sprout length of both Cardinal and Desiree varieties tubers.

### Sprouting density

Tubers of Desiree variety treated with Thiourea (1%) produced the most significant number of sprouts, i.e., 4.13 sprouts/tuber which is more than twice of control tubers i.e., 1.80 sprouts/tuber (Figure 3). Similar result was discovered by Mani *et al.* 2 (013), they reported tuber of Spunta variety when treated with Thiourea at 250nM produced 6.5 sprouts/tuber that was double to that produced by control i.e. 3.76 sprouts/tuber. For tubers of Cardinal variety, Thiourea (3%) was found to produce significantly higher sprouting density, i.e., 1.91 sprouts/tuber compared to other concentrations and the lowest sprouts per tuber was developed by control, i.e., 1.13 sprouts/tuber (Figure 4). Hassani *et al.* (2014) reported similar result i.e., potato tubers treated with 3% Thiourea for 3 hour produced 2.03 sprouts/tuber which was significantly greater than 1.41 sprouts/tuber of control. Similar finding was presented by Nasiruddin *et al.* (2016) i.e., 3% Thiourea treated tuber developed 3.5 sprouts/tuber while control produced only 0.5 sprouts/tuber. Thus, treatment of tubers with Thiourea of different concentrations showed a significant increment in sprout number per tuber for both varieties compared to control. Therefore, Desiree and Cardinal Variety of potato, when treated with Thiourea of concentration 1% and 3% respectively, increased the sprouting number per tuber (Figures 3 and 4).

## Conclusion

In conclusion, the effect in dormancy breaking and sprouting behavior of potato tuber was different with various concentration of Thiourea. In case of Desiree variety, among all treatment combination, Thiourea (1%) was seen superior in a various parameter such as the emergence of the first sprout (6.33<sup>th</sup> day), breaking of dormancy (10.33<sup>th</sup> day), sprout length (7.36cm) at 49 DAT and sprout density (4.13 sprouts/tuber) at 49 DAT. Which shows superiority of 1% Thiourea for Desiree. On the other hand, for cardinal variety, Thiourea (1%) was seen superior for a parameter such as a sprout length (8.22cm) which was at par with Thiourea 3% (7.75cm) at 49 DAT. However, the emergence of the first sprout (6.67<sup>th</sup> day), breaking of dormancy (13.33<sup>th</sup> day), and sprout density (1.91 sprouts/tuber) at 49 DAT was found superior at Thiourea (3%). Hence, same concentration of Thiourea may not be effective for breaking dormancy and improving sprouting in tubers of different varieties. This variation could be due to varietal and physiological difference in tubers which should be further studied. Based on this study, it is concluded that a lower concentration of Thiourea, i.e., 1% was effective for dormancy breaking of potato tubers and enhancing sprouting behaviour for Desiree potato variety. While for Cardinal variety, 3% Thiourea was found effective for dormancy breaking and improving sprouting behaviour.

## Abbreviations

CRD	: Completely Randomized Design
DAT	: Days after Treatment
Df	: Degree of Freedom
DMRT	: Duncan's Multiple Range test
g	: Gram
i.e.	: That is
ha	: Hectare
Kg/ha	: Kilogram per hectare
LSD	: Least Significant Difference
Masl	: meter above sea level
mm	: Millimeter
No.	: Number
Ns	: Non-Significant
PMAMP	: Prime Minister Agriculture Modernization Project
SEm	: Standard Error of Mean
°C	: Degree Celsius
%	: Percentage
&	: Ampersand

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## Conflict of Interest

There is no conflict among the authors regarding submission of this manuscript.

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