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Effect of physical and chemical treatments on sprouting of dormant potato tubers

M. Nasiruddin*, R. Khatun, F.M.A. Haydar, A. Imtiaj and M.F. Alam

Department of Botany, University of Rajshahi, Rajshahi-6205, Bangladesh
*Corresponding author: mnuddin@ru.ac.bd

Abstract

This study was undertaken to investigate the effect of chemical and physical treatments for breaking seed dormancy of potato in respect to cultivars. The results showed significant difference ($p<0.05$) for cultivars, and treatments in case of days to sprouting, total number of sprout, sprout length and days to 80% dormancy breaking. Compared to control, application of gibberellic acid reduced the dormant period up to about 13.5 days. Similar trends were also observed for 80% dormancy breaking, total number of sprout and sprout length. Gibberellic acid and thiourea application had spectacular effect on sprouting and recorded on average of 15.25 and 18.75 days, respectively. Among the studied cultivars, Diamond was found most responsive for breaking dormance. The cold soak followed by heat treatment was found less effective for breaking dormance than the other treatments in potato. Therefore, application of gibberellic acid is advisable for increasing days to sprouting, accelerating sprout length and consequently faster tuber dormancy breaking in potato.

Keywords: Dormancy breaking, Potato tuber, Gibberellic acid, Thiourea, Temperature.

INTRODUCTION

The potato (*Solanum tuberosum* L.) belongs to family Solanaceae. It is the third most important food crop in the world after rice and wheat in terms of human consumption. More than a billion people worldwide eat potato, and global total crop production exceeds 374 million metric tons (CIP, 2015). It ranks first among the vegetables in terms of area and production in Bangladesh. It occupies 11, 41,727 acres (4, 62,032 hectares) area of land in Bangladesh and the total production has been estimated to be 89, 50,024 metric tons in 2014 (BBS, 2013-2014).

Dormancy is the physiological state of the tuber in which tubers do not sprout even when placed in ideal germination conditions (Reust, 2002; Sonnewald and Sonnewald, 2014). The dormancy period of potato varies from 2 to 3 months, depending on genotype and conditions of pre-and post harvest. Therefore, it should be evaluated before releasing any variety so that farmers are able to store their produce for a desired period of time under traditional storing conditions or in refrigerated infrastructure. For quality of a particular potato clone, its dormancy period and sprouting behavior are major criteria that should be documented before any promising clone is released (Virtanen *et al.*, 2013). Since the dormance period is difficult to determine, post-harvest dormancy is used for practical purposes, and is defined as the period from dehaulming to the time when 80% of tubers show sprouts at least 2 mm long (Pande *et al.*, 2007).

Lack of good quality seed among the growers is a major problem adversely affects the expansion of potato production in many developing countries (Crissman *et al.*, 1993). One major problem of production of quality potato seed is poor sprouting, due to dormancy, which leads to delayed planting and poor crop emergence and vigor (Wiersema, 1985). Dormancy is one aspect of tuber physiological age that begins with potato tuber initiation. During dormancy, biochemical and physiological processes do occur but they do not trigger immediate morphological changes, yet these processes are relevant for the number of sprouts produced after breaking of the dormancy and for the growth vigor of the seed tuber. After harvest, normal seed tubers show dormancy for about 1−15 weeks, depending on cultivar, tuber size, conditions before harvest and storage conditions. Small tubers, such as mini-tubers, even have longer periods of dormancy (Lommen, 1993) and are more sensitive to adverse conditions during storage (Struik and Lommen, 1999). Use of low quantities of growth promoters like thiourea, rindite, carbon disulphide and bromo-ethane (Bryan, 1989) and gibberellic acid (Carrarera *et al*., 2000 and Demo *et al*., 2004) to promote potato seed sprouting has been suggested.

Exogenous application of chemical and physical, offers economical and safe methods to break potato dormancy. Hence, in this study chemicals and cold shock methods were applied in four popular cultivars of potato to evaluate sprouting behavior of the dormant tubers.

MATERIALS AND METHODS

Tuber selection: The potato *(Solanum tuberosum* L.) tuber of popular important cvs. Granula, Cardinal, Diamond and Asterix were used in this experiment. Tubers were collected from Plant Breeding and Gene Engineering Laboratory Department of Botany University of Rajshahi, Bangladesh.

Materials preparation: Freshly harvested potato tubers were washed and placed in a tray before applying chemical (gibberellic acid and thiourea) treatments.

Gibberellic Acid (GA_3): Samples of 20 potato tubers of each cultivar were prepared according to previous research of Rehman *et al.,* (2001). Briefly, tuber was soaked in 100 ppm GA_3 solution for 1 h. After soaking the tubers were air-dried and were transferred in plastic trays and kept at dark place of room temperature (18-25 °C) for sprouting.

Thiourea (H_2 $NCSNH_2$): Samples of 20 tubers of each cultivar were prepared according to previous research of Hosseini *et al.,* (2011). Briefly, tuber was soaked in 3% aqueous solution of thiourea for 1 h. After soaking the tubers were air-dried and were transferred in plastic trays and kept in dark place at room temperature (18-25 °C) for sprouting.

Cold shock plus heat treatment application on tuber: According to Rehman *et al.,* (2001) the tubers were cleansed and allowed to suberize. They were placed in 4 °C for two weeks, and then were held at 18-25 °C for sprouting.

Control (No treatment): 20 tubers from each cultivar was placed immediately after harvest and washing with distilled water in standard storage conditions as a control treatment without the application of physical and chemical treatments.

Methods for data recording and statistical analysis: The dormant period were considered as the number of days elapsing from the treatment till sprouting and was considered to have ended when 80% of the tubers had at least one sprout equal or longer than 2 mm. Data was recorded for days to sprouting (day), total number of sprouts, sprout length, days to 80% dormancy breaking. PAST Software was used for ANOVA. For mean comparisons, Duncan Multiple Range Test (DMRT) was done following SPSS software.

RESULTS AND DISCUSSION

Days of sprouting (day)

According to Table 1 results on analysis of variance, the trait showed significant difference for treatment, genotype and G×T. The highest days (28.75) in control and the lowest days (15.25) in gibberellic acid were observed for this trait (Table 2). Application of growth regulators and physical treatments reduces the number of days of sprouting. Use of gibberellic acid had most postponement on sprouting as supported by others (Helsinki *et al*., 2002 and Gomez and Martinez, 1999). The varietal difference might be due to their different physiological characteristics.

Table 1: Mean squares for tuber dormancy breaking related traits

Characters	Source				
	Mean sum of squares				
	Replication	Genotype	Treatment	G×T	Error
Degrees of freedom	2	3	3	9	30
Days to sprouting	0.63 ns	368.02**	460.58**	788.23 **	2.26
Total number of sprouts	1.38 ns	123.52**	48.35**	16.85**	0.41
Sprout length (cm)	0.04 ns	57.78**	50.12**	26.29**	0.13
Days to 80% dormancy breaking	6.58 ns	2939**	66.52**	15.07*	2.84

**, ** and ns: Significant at 5% and 1% level of probability and non-significant, respectively*

Total number of sprouts

The results revealed that the use of chemicals and physical soak increased total number of sprouts in the dormant potato (Table 2) and significant difference was observed for the treatment (Table 1). The highest number of sprouts was observed in gibberellic acid followed by temperature and thiourea and was supported by Rehmman *et al*., 2001. The total number of sprouts in Diamont cultivar (13.66) was higher than the other cultivars (Table 3). These differences can occur due to various physiological conditions like seed size as well as available storage nutrient in the seed tubers.

Table 2- Mean comparison of the main effects of growth regulator and cultivars

Experimental Treatment		Days to sprouting	Total number of sprouts	Sprout length (cm)	Days to 80% dormancy breaking
Growth regulators	Control (wash by water)	28.75 d	0.5 a	0.175 a	64.25 d
	Gibberellic acid	15.25 a	9 d	5.23 c	32.5 a
	Thiourea	18.75 b	3.5 b	4.65 c	36.5 b
	Temperature	22.75 c	4.75 c	3.1 b	38.5 c
Cultivars	Granula	14.09 a	1.75 a	1.03 a	42.75 b
	Cardinal	27.75 d	4.75 b	3.53 c	41.75 a
	Diamond	23.75 c	7 c	5.93 d	41.5 a
	Asterix	16.25 b	4.25 b	2.68 b	45.75 c

Mean in each column, followed by similar letter (s) not significantly different at 5% probability level, using DMRT separating for growth stimulants and cultivars

Table 3- Mean comparison of interaction effect of treatment and cultivars

Experimental Treatment		Days to sprouting	Total number of sprouts	Sprout length (cm)	Days to 80% dormancy breaking
Control	Granula	0.33 a	0.33 a	0.22 a	68.66 k
	Cardinal	55 j	0.66 a	0.5 a	64.66 j
	Diamond	50 i	0.66 a	0.21 a	63.01 i
	Asterix	0.33 a	0.33 a	0.33 a	69.66 l
GA_3	Granula	14 c	2.66 b	0.5 a	35.66 e
	Cardinal	16 d	10.66 f	3.4 e	30.66 b
	Diamond	12 b	13.66 g	13.56 i	27.66 a
	Asterix	19 e	7.66 d	2.66 cd	34.66 d
Thiourea	Granula	19 e	0.66 a	1.4 b	36.66 ef
	Cardinal	18 e	2.66 b	5.2 g	36.66 ef
	Diamond	17 de	3.66 b	6.88 h	33.66 c
	Asterix	21 f	5.66 c	4.5 f	37.66 fg
Temperature	Granula	23 g	2.66 b	1.7 b	38.66 g
	Cardinal	22 fg	3.66 b	4.78 fg	36.66 ef
	Diamond	21 f	8.66 e	2.5 c	37.66 fg
	Asterix	25 h	2.66 b	3.2 de	39.66 h

Mean in each column, followed by similar letter (s) not significantly different at 5% probability level, using DMRT

Sprout length

The results showed that the application of growth regulators had significant effect on sprout length in seed tubers (Table 1). The use of chemical and temperature increased sprout length of potato (Tables 2 and 3). The highest sprout length was observed in gibberellic acid. The sprout length in Diamont cultivar (6.88) was higher than the other cultivars (Table 3). This difference might be due to the various physiological habits and treatment effect.

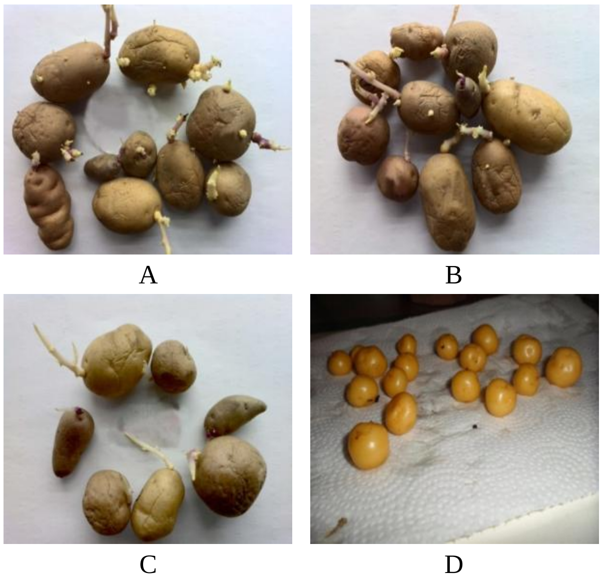

Fig: Effect of gibberellic acid treatment (A), Thiourea treatment (B), Temperature treatment (C) and Control (D) on sprouting of potato tuber.

Days to 80% dormancy breaking

Plant growth regulator caused significant differences in the days to 80% dormancy breaking in comparison to control (Table 2). Gibberellic acid was found better than the other two treatments. The lowest days to 80% dormancy breaking was observed in gibberellic acid (32.5 days) followed by thiourea (36.5 days), temperature (38.5 days) and control (64.25 days) (Table 2). Dogonadze *et al*., (2000) reported that abscisic acid and other ingredients involved in tuber natural dormancy. Application of gibberellic acid on dormant tubers can reduce endogenous abscisic acid of tubers. The reports also state that gibberellic acid causes breakdown of starches and accumulation of renewable sugars in potato tubers which can stimulate the germination and consequently the dormancy breaking (Alexopoulos *et al.*, 2007 and Hemberg 1985). It is also reported that dipping the seeds in gibberellic acid before planting for an hour will break seed dormancy of potato (Rehman *et al*., 2001). However, excessive use of gibberellic acid causes disorders such as stem elongation, excessive growth of the shoots, tuber deformities, and delay in tuber angiogenesis and reduction in root formation (Rezaei *et al*., 1997).

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