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Dormancy Breaking and Effects on Tuber Yield of Potato Subjected to Various Chemicals and Growth Regulators under Greenhouse Conditions

Fazal Rehman*[1], Seung Koo Lee[2], Hyun Soon Kim[3], Jae Heung Jeon[3,] Ji-young Park[3] and Hyouk Joung[3]
Department of Agriculture, Northern Areas Gilgit, Pakistan [2]Department of Horticulture, College of Agriculture and Life Sciences, Seoul National University, Suwon 441-744, Korea,
[3] Plant Cell, Biotechnology Lab, Korea Research Institute of Bioscienc and Biotechnology, Taejon 305-333, Korea

Abstract : This study was conducted to check the effect of various chemicals and growth regulators was checked on dormancy breaking of potato tubers, and also to check the subsequent effects on tuber yield under greenhouse conditions. The chemicals were tested on three potato cultivars having different dormancy release characters. Among the chemicals the tubers treated with rindite exhibited the highest sprouting ratio in all the cultivars. Cultivar Diamont took the least period of time for 50% of tubers to sprout followed by cultivar Atlantic. Highest decay ratio of tubers was observed for cultivar Atlantic and Diamont treated with thio-urea. The tubers treated with thio-urea induced the highest number of sprouts as compare to all other treatments. Significant differences were observed among the treatments and cultivars for various yield characters.

Keywords: Potato (*Solanum tuberosum* L.), Rindite, Gibberellic acid (GA_3), Carbondi sulfide(Cs_2), Thio-urea and dormancy

Introduction

Dormancy of a potato tuber is defined as the physiological state in which autonomous sprout growth will not occur, even when the tuber is placed under ideal conditions for sprout growth (Reust, 1986). The duration of dormancy depends on the genotype, but may also be influenced by the conditions during growth and during storage of the tubers. It is important to know the growth factors influencing dormancy of seed tubers and to be able to predict the duration of dormancy. Dormancy ends when sprout growth can start, but for practical reasons in this study, the presence of at least one sprout per tuber 2 mm long was taken as the indication that dormancy has ended. Microtuber dormancy appears to be correlated with field dormancy duration in a cultivar-specific manner (Leclerc *et al.*, 1995). Recent work has demonstrated that rindite (a 7:3:1 by volume mixture containing ethylene chlorohydrin, 1,2-dichloroethane and carbon tetrachloride) is effective in breaking microtuber dormancy (Kim *et al.*, 1996, 1999). However the mutagenicity, carcinogenicity and high toxicity of rindite components make this mixture unacceptable for routine use. Preliminary results indicated that such dormancy release treatments as thio-urea, GA3, rindite or carbon disulphide applied to microtubers had no significant effect on field tuber production (Kim *et al.*,1996). Numerous chemicals have been tested for their dormancy breaking potential, but generally only a few have shown acceptable results (Burton, 1989,). Most of chemicals has been tested on dormancy release of microtubers, therefore in this study various chemicals and growth regulators were tested on dormancy release of various cultivars having different dormancy release characters and also to check the effect on tuber yield.

Materials and Methods

Chemical treatments and Evaluation: Freshly harvested minitubers of cultivar Atlantic (medium dormancy), Desiree (long dormancy), and Diamont (short dormancy) periods were selected. Following selection, tubers were washed and placed in trays before applying chemical treatments.

Carbon disulfide (Cs_2): Samples of 100 minitubers of each cultivar/treatment were treated at room temperature in 32 x 15 x 19 cm plastic containers with tight fitting lids. Cs_2 was applied in liquid form in 25 ml beakers to give the required concentration of 0.4 ml in the test container. The beakers were placed in the plastic containers where the chemical vaporized. Following treatment tubers were aerated after 72 hrs and placed at constant room temperature in plastic trays for sprouting.

Gibberellic Acid (GA_3): Samples of 100 minitubers of each cultivar/treatment were soaked in 1000 ppm GA_3 solution for 1 hr. After soaking the tubers were transferred in plastic trays and kept in room temperature for sprouting.

Rindite (Ethylene chlorohydrin, 1, 2-dichlrothaneand carbon tetrachloride7:3:1 v/v): Samples of 100 minitubers of each cultivar/treatment were treated at room temperature in 32 x15 x 19 cm plastic containers with tight fitting lids. Rindite was applied in liquid form in 25 ml beakers to give the required concentration of 2 ml in the test container. The beakers were placed in the plastic containers where the chemical vaporized. Following treatment tubers were aerated after 48 hrs and placed at constant room temperature in plastic trays for sprouting.

Thio-urea (H_2 $NCSNH_2$): Samples 100 minitubers of each cultivar/treatment were soaked in 3% aqueous solution for 1 hr. After soaking the tubers were transferred in plastic trays and kept in room temperature for sprouting. The dormant period was 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. Sprouted tubers were counted and separated after every 10 days, and average number of sprouts =2 mm per tuber was recorded one week after the end of dormancy of each treatment. Data was recorded for sprouting % of tubers, decay ratio and number of sprouts/tuber.

Planting of tubers in greenhouse: After breaking dormancy tubers were planted under greenhouse conditions in pots (50 x15cm) to check the plant growth and yield characters of the minitubers treated with different chemicals. The greenhouse was maintained at ambient humidity (RH 60-80%) and day/night temperatures of 24-28 °C during day and 16-20 °C in a 13 hrs photoperiod. Haulms were removed 15 days before harvesting and the crop was harvested 130 days after planting (J.Gopal *et al.*, 1997). The data for various yield characters were recorded immediately after harvesting

Statistical analysis: The experimental unit was pots, 5 tubers were planted per pot with 5 pots per treatment. Pots were arranged in a complete randomized design with three replications of each cultivar. Data for the yield characters was recorded randomly from 5 plants /treatment and means were presented. Treatment effects were compared after analysis of variance. The treatment means were compared using Duncan's multiple range test for significance at a probability of 0.05%.

Results and Discussions

Effect of different chemicals on dormancy release: Dormancy of potato (*Solanumtuberosum* L.) varies among genotypes. Within a genotype, the duration of dormancy may vary between tuber lots of different origin or year. It may also vary within a seed lot of one cultivar from a particular origin or year. Differences in dormancy length among the cultivars treated with different chemicals were clearly observed through out the whole experiment and results are presented in Table I.Tubers treated with 2ml/48 hrs rindite showed the highest sprouting ratio for cultivar Diamont followed by cultivar Desiree (Table 1), while cultivar Atlantic showed the least sprouting ratio during the period of 10 days. Rindite-treated tubers showed the highest sprouting ratio for all the cultivars within 20 days after treatment. Cultivar Diamont showed the highest sprouting ratio during the period of 30 days as compared with other cultivars. Tubers treated with rindite took the minimum period to reach 50% tubers to sprout (Table II). Differences in the dormancy releasing responses treated with various chemicals were clearly observed among cultivars. For cultivar Diamont, the variance of the duration of dormancy within treatments amounted to 15-40 days, for Atlantic was intermediate with 24-40 days and for Desiree was maximum with 24-51 days for 50 % tubers to sprout.
The highest decay ratio was observed for the tubers of cultivars Diamont and Atlantic treated with thio-urea. (Table II). Greater variations were observed for number of sprouts/tuber for all the treatments and cultivars. In cultivar Atlantic the rindite-treated tubers induced the highest number of sprouts/tuber (Table II). The tubers treated with thio-urea and GA_3 induced the same number of sprouts/tuber in cultivar Desiree. While the tubers treated with thio-urea induced the highest number of sprouts in cultivar Diamont. This variation for number of sprouts /tuber may be due to the genetic variation of the different cultivars. It was observed that in all the cultivars the tubers treated with GA_3 produced very thin and elongated sprouts with out a thickened base, while the tubers produced vigorous and flattened in case of the tubers treated with Cs_2, rindite and thio-urea. The present results for sprouts are in agreement with the results of Van Ittersum and Scholtz (1993).
We observed a great significant difference between cultivars for emergence gain (Table III). The rindite-treated tubers showed the highest emergence gain for cultivars Diamont and Desiree while the GA_3 and CS_2 showed the similar emergence gain for cultivar Diamont followed by Cs_2 in cultivar Desiree. The cultivar Atlantic, exhibited similar emergence gain for rindite and thio-urea followed by GA_3 and Cs_2 In this experiment we observed that rindite proved to be the most effective treatment for dormancy breaking and enhanced sprouting in all the cultivars under investigation and the difference for 50% tubers to sprout among the cultivars were minimum irrespective of the natural dormancy period of each cultivar. The present results are in agreement with the results of Mcdonald and Coleman, (1984) and Kim *et al.*, (1999), who found that rindite or bromoethane treatment for 48 hrs and storage at 25°C increased the sprout length and breaking dormancy. The present research thus suggests that 2 ml/48 hrs treatment of rindite would be a proper and optimum dose for the release of dormancy in potato minitubers.

Effect of various chemicals on tuber yield: When producing minitubers, five mutually dependent yield parameters may be manipulated; (1) the number of minitubers per plant (2) the number of minitubers per unit area (3) the average weight of per minituber, (4) the minituber yield per plant and (5) the minituber yield per unit area. Yield pararmeters may be manipulated by crop husbandry during minituber production (lommen & struik, 1992).
The effect of different chemicals on the above described yield parameters of the cultivars under study is presented in (Table IV).

Table 1: Effect of variuos chemicals on dormancy breaking of various potato cultivars, sprouting ratio for minitubers

Cultivar/treatment	Sprouting ratio (%)			
	10 DATb	20 DAT	30 DAT	40 DAT
Altlantic				
Control	0.0±0.0c	0.0±0.0	9.0±9.0	42.0±0.0
CS_2	0.02±0.0	10.3±5.8	78.0±9.9	97.0±2.0
GA_3	0.3±0.3	14.3±2.9	84.0±11.7	98.3±0.3
Rindite	1.3±0.9	15.3±0.9	94.3±1.5	99.0±1.0
Thio-urea	0.0±0.0	3.0±1.1	47.7±4.6	97.3±0.7
Desiree				
Control	0.0±0.0	0.0±0.0	5.0±0.0	32.0±0.0
CS_2	0.0±0.0	12.3±4.9	59.3±25.7	99.3±1.1
GA_3	0.0±0.0	7.0±1.7	54.3±19.3	94.3±9.8
Rindite	3.3±1.5	30.0±9.5	81.6±4.5	97.0±1.7
Thio-urea	0.0±0.0	3.3±1.5	26.6±5.6	98.6±1.5
Diamont				
Control	0.0±0.0	0.0±0.0	30.0±0.0	0.0
CS_2	2.3±0.9	21.3±4.0	98.0±2.0	0.0
GA_3	1.0±0.6	18.6±3.8	99.3±0.3	0.0
Rindite	14.3±5.0	77.3±14.6	99.0±0.6	0.0
Thio-urea	0.0±0.0	4.7±1.2	97.0±0.6	0.0

[a]Sprouting ratio (%) was measured at the interval of 10 days after treatment.
[b]DAT: Days aftertreatment.
[c]Each value indicates the means of three replicates ± SE.

Table 2: Comparison of treatments and cultiv ars for 50% sprouting, decay ratio and number of sprouts/tuber for minitubers

Cultivar/treatment	Days for sprouting	Decay ratio (%)	No. of sprouts/tube
Altlantic			
Control	40	0.0	2.0
CS_2	26	0.7	4.0
GA_3	25	0.7	4.0
Rindite	24	0.7	5.0
Thio-urea	30	2.0	4.0
Desiree			
Control	51	0.0	3.0
CS_2	29	0.7	2.0
GA_3	29	1.3	4.0
Rindite	24	1.3	2.0
Thio-urea	33	0.7	4.0
Diamont			
Control	33	1.0	3.0
CS_2	23	0.3	5.0
GA_3	23	0.3	3.0
Rindite	15	1.0	5.0
Thio-urea	24	2.0	6.0

[a]Decay ratio was measured when 50% of the tubers were sprouted.

Table 3: Comparison for emergence gain between treated and untreated tubers of various cultivars after 50% sprouting of minitubers

Cultivars/treatment	Days for 50% sprouting of minitubers		
	Untreated	Treated	Emergence gain (%)[a]
Altlantic			
CS_2	40	26	35.0
GA_3	40	25	37.5
Rindite	40	24	40.0
Thio-urea	40	30	25.0
Desiree			
CS_2	51	39	23.5
GA_3	51	41	19.6
Rindite	51	34	33.3
Thio-urea	51	47	7.8
Diamont			
CS_2	33	23	30.3
GA_3	33	23	30.3
Rindite	33	15	54.5
Thio-urea	33	24	27.3

[a]Emergence gain: Uintreated control-treated/untreated control X 100

As evident from the results all the treatments produced highest number of tubers/plant as compare to the untreated control in case of cultivar Atlantic. The tubers treated with GA_3 yielded the highest number of tubers/ plant. The GA_3 treated tubers also yielded the highest individual weight of tuber as compare to the other treatments. The tubers treated with rindite and thio-urea yielded the highest number of tubers/pot. All the treatments yielded minimum average weight/plant as compare to the untreated in the case of cultivar Atlantic. Significant differences were observed between the cultivars for the weight of tubers/pot. The tubers treated with Cs_2 yielded the highest weight of tubers/plant. In cultivar Desiree the highest number of tubers/plant were yielded in rindite-treated tubers followed by GA_3, while the highest no of tubers/pot was yielded in CS_2 treatment. The treatment of GA_3 also yielded the highest individual weight and weight of tubers/plant indicating a strong correlation among these parameters. The untreated tubers yielded the highest weight of tubers/pot as compared to other treatments. We observed the similar effects of GA_3 and rindite for cultivar Diamont producing the highest number of tubers/plant. Rindite treatment was also in advance for individual tuber weight and weight of tubers per plant than other treatments.

In our experiment we observed a close relation between the number of tubers, weight of individual and weight of tubers/pot in case of rindite-treated tubers for cultivar Diamont as compared with other treatments and cultivars. Differences in tuber yield and number of tubers/unit area was not very high and significantly differed in few cases. In all over there was a great variation between treatments and cultivars for all of the yield parameters, which may be the result of various genetic and differences among the cultivars.

Table 4: Effect of various chemicals on tuber yield in various cultivars o potato minutubers.

Cultivar/ treatment	Tuber yield				
	No. of tubers/ plant	No. of tubers/ pot	Wt of individual tuber	Wt of tubers/ plant	Wt of tubers/ pot
Altlantic					
Control	6.0c	30.0b	15.6a	73.1a	248.9b
CS_2	7.6b	35.7ab	15.7a	61.6b	271.1a
GA_3	8.7	29.3b	19.3a	71.0a	223.8b
Rindite	6.7c	37.7a	15.8a	68.0a	223.0b
Thio-urea	6.3c	37.7a	13.7a	70.21a	255.4a
Desiree					
Control	6.0a	21.0b	19.4a	54.3b	262.8a
CS_2	5.7a	28.7b	17.8a	68.4ab	261.8a
GA_3	6.7a	24.0b	19.4a	77.8a	219.8b
Rindite	7.0a	28.3a	20.0a	59.9b	244.7b
Thio-urea	6.3a	27.0a	16.7a	58.5b	234.5ab
Diamont					
Control	7.0b	36.0bc	13.7a	75.9a	233.1ab
CS_2	7.3b	32.3c	14.4a	74.0a	216.6b
GA_3	9.0a	40.3ab	15.8a	55.5a	241.2ab
Rindite	8.0ab	41.7a	16.2a	69.2a	296.9a
Thio-urea	7.0b	35.8bc	14.8a	63.7a	233.7ab

[a]Means with the same letter are not significantly different at $P \leq 0.05\%$ according to the Duncan's multiple range test (DMRT)

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