The effect of the weight of potato tuber seeds and the duration of cytokinin application on potato tuber (Solanum tuberosum L.) dormancy release

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Abstract. Potato seeds function as the main production medium in the plant cultivation which requires application of plant growth substances as stimulator of grow. This study aims to determine the effect of tuber weight and cytokinin immersion treatment time on breaking the dormancy period of potato tuber. This research was carried out at the seed warehouse of UPT Benih Induk Hortikultura Kutagadung Berastagi. This research was conducted using factorial completely randomized design, with 2 factors. The first factor, the weight of potato tubers of 4 levels and the second factor, cytokinin immersion time of 5 levels. The results showed that the fastest dormancy breaking was on the 45 DAH immersion i.e. 61.75 days, 12.58 days faster than without immersion, or 6.42 days faster than the 1 DAH immersion treatment. The fastest dormancy breaking is in potato tuber weighing 115-125 g (60.07 days), 13.47 days faster than tuber weighing 25-35 g. The fastest dormancy breaking was at B4W4 treatment (55 days). The number and weight of sprouts increases with increasing immersion time, and with increasing tuber weight.

1. Introduction
Potato seeds function as the main production medium in the plant cultivation. This means that the use of qualified potato tuber seeds plays a very important role on increasing the production and the quality of the plant. The need of potato tuber seeds is still mostly supplied with low quality of the plant. Thus this causes the production by farmers in Indonesia diminishes only 15-17 tons per acre. In comparison to that in Europe, the country can harvest 50 tons per acre [7]. The need of potato tuber seeds now is averagely 108,000 a year on the area of cultivation of the potatoes 72,000 acres. In reality the adversity of the potato tuber seeds which are nationally certified reaches up to only 15 per cent so that there is more demand on the seeds in the country [6]. The production of potatoes is in common higher if they use higher class seeds, but it still depends on the quality of the seeds because the quality much determines the level of production [1]. The system of seedling of the potatoes now is classified into five classes of seeds, those are G0, G1, G2, G3, and G4. Seed classes G0- G3 are source seeds, seed class G4 is spreading seed. The use of seed classes G0 and G1 maintain production increase and the potato tuber production suits which the seeds [4].
Seed indicate an important factor in potato cultivation. That is why, using well-qualified potato seeds can increase the production of the plant [13]. Potato seeds have different weights. The seeds are classified based on the weight into namely, S (10-30 grams), M (31-60 grams), L (61-120 grams), and XL (more than 120 grams). The size of the potato tuber seeds which farmers will use in plant cultivation of potatoes is 30-80 grams/tuber. Meanwhile according to [11], the size of good potato tuber seeds is 30-60 grams/tuber. Basically, any sizes/weights of potato tuber seeds can be used to be seeds. The size which is used to be seeds have to have weight 30-80 grams/tuber. If the weight is less than 30 grams/tuber or even under 20 grams/tuber, the production will not succeed or will be low [2]. Based on Schmidt (2000), the size of the seeds positively correlates with the vigour of the seeds. Relatively heavier seeds tend to have better vigour. Heavier seeds have more nutrient supply compared to those of lower weight seeds. In addition, the embryo of the heavier weight seeds is bigger, too. Substances contained within the potato tuber are namely, carbohydrate, protein, fat and mineral. Those nutrient supplies are needed to be main source of energy for embryo of the tuber while sprouting process lasts [12]. Other than the size of the tuber, another barrier in potato production is that there is dormancy time on potato plant. The duration of this dormancy time of potato tuber seeds is 3-3.5 months. This causes limitation to the availability of potato tuber seeds for the farmers. If the dormancy time can be shortened, it is hoped that the adversity of the potato tuber seeds will be fulfilled. Newly-harvested potatoes are usually kept in storage until their dormancy time ends. The duration of dormancy time is affected by some factors including, the type of cultivar, weather condition, planting place during growing time, age of the plant in growing place, and the condition of the storage [8]. Dormancy time is also inversely proportional to harvesting age of the potatoes. The shorter the harvesting age of the plant, the longer the dormancy time is.

A way to release the dormancy time of plants is by application of plant growth substances as stimulator of growth. The addition of the substances or exogenous hormones will affect the growth of the plant. Cytokinin is one of growth stimulator hormones and it functions in cell fission [10]. Cytokinin is applied to stimulate the formation of buds, to affect cell metabolism, to help in cell fission [5]. This research was conducted using data from research [10], there is the application of cytokinins for breaking dormancy of G1 potato seeds (Solanum tuberosum L.). From the results of this study obtained the results of potato seeds that were soaked for 1 hour in BAP cytokinin (Benzyl amino purine) 100 mgL-1 resulted in faster dormancy break time compared to controls. Based on the facts above, the author is interested to research the effect of the weight of potato tuber and cytokinin application time on dormancy release of potato tuber seeds.

2. Materials and method
The research was conducted at seed Storage UPT. Benih Induk Hortikultura Kutagadung Berastagi, Dinas Tanaman Pangan and Hortikultura, Sumatera Utara. It was conducted on November 2018 to January 2019. The method used in the research was a factorial completely-randomized design, with two factors. The first factor was the weight of the potato tuber seeds, consisting of four levels namely, B1=25-35 grams, B2=55-65 grams, B3=85-95 grams, and B4=115-125 grams. The second factor was the cytokinin application, consisting of five aspects namely, W0=control (without cytokinin application), W1=1 day after harvesting time (DAH), W2=15 days after harvesting time (DAH), W3=30 days after harvesting time (DAH), and W4=45 days after harvesting time (DAH). The application repeated every three times, so that the unit altogether summed up to 45 units of experiment. On every plot of application, there were 10 potato tuber seeds but only 5 samples were used. The potato tuber seeds were Granola L variety that were newly harvested at that time. The potato tuber seeds were soaked for an hour within cytokinin solution as much 100mg/L. The parameters observed were: duration of dormancy release (day/s), number of age bud/sprouts 28 days after plant (bud/s), and size of age bud/sprouts 28 days after plant (gram/s).
3. Result and discussion
The following Table 1 exposes time potato tuber seeds having buds as the result of the application of cytokinin solution and the weight of the seeds.

Table 1. The effect of the weight of potato tuber seeds and the duration of cytokinin application on dormancy release time (day/s)

| Treatment | W0  | W1  | W2  | W3  | W4  | Mean |
|-----------|-----|-----|-----|-----|-----|------|
| B1        | 83.33 a | 73.67 c | 72.00 cd | 69.00 de | 69.67 d | 73.53 a |
| B2        | 79.33 b | 70.00 d | 66.33 ef | 64.67 fg | 63.00 fg | 68.67 b |
| B3        | 69.67 d | 65.67 f | 62.00 gh | 57.67 ij | 59.33 hi | 62.87 c |
| B4        | 65.00 fg | 63.33 fg | 59.33 hi | 57.67 ij | 55.00 j | 60.07 d |
| Mean      | 74.33 a | 68.17 b | 64.92 c | 62.25 cd | 61.75 d |      |

Note: The weight of potato tubers, B1 = 25-35 g, B2 = 55-65 g, B3 = 85-95 g, and B4 = 115-125 g Cytokinin immersion time, W0 = control (without immersion), W1 = 1 day after harvest (DAH), W2 = 15 DAH, W3 = 30 DAH, and W4 = 45 DAH Those numbers followed by the same letters on the same application indicated not significantly different by Duncan’s Range Test at α=5%.

Based on Table 1, it is known that the fastest dormancy release time is on potato tuber seeds weighed 115-125 grams (B4), that is 60.07 days. It is 13.46 days faster than that on potato tuber seeds weighed 25-35 grams (B1), that is 73.53 days. The research resulted in that the more the weight of the potato tuber seeds, the faster the dormancy release time is. This fact is caused by the sufficiency of the energy supply within the tuber to enable germination. The soaking of the potato tuber seeds with cytokinin solution during 45 days after harvesting time (W4) indicates the fastest dormancy release time namely, 61.75 days, 12.58 days faster than that on potato tuber seeds without the application of cytokinin solution (W0) that is, 74.33 days, and 6.42 days faster than that on potato tuber seeds application 1 day after harvesting time (W1) that is, 68.17 days. The research proved that the longer the application after harvesting time, the faster the dormancy release time is. This is related to the physiology process in tuber seeds, while the seeds need time to produce sprouts. Interaction of application which indicated the fastest dormancy release time is B4W4 namely 55.0 days which is unreal different with applications B4W3 and B3W3 namely, 57.67 days. Dormancy release on B4W4 is 28.33 faster than B1W0 namely, 83.33 days.

The following Table 2 serves average number of buds as the result of the application cytokinin solution.

Table 2. The effect of the weight of the potato tuber seeds and duration of applying cytokinin on the number of buds age 28 days (buds)

| Treatment | W0  | W1  | W2  | W3  | W4  | Mean |
|-----------|-----|-----|-----|-----|-----|------|
| B1        | 1.13 | 1.18 | 1.00 | 1.37 | 1.43 | 1.22 d |
| B2        | 1.70 | 1.84 | 1.90 | 1.97 | 2.37 | 1.96 c |
| B3        | 2.67 | 2.84 | 2.73 | 2.99 | 2.86 | 2.82 b |
| B4        | 3.03 | 3.32 | 3.50 | 3.25 | 3.37 | 3.30 a |
| Mean      | 2.13 c | 2.29 bc | 2.28 bc | 2.39 ab | 2.51 a |      |

Note: The weight of potato tubers, B1 = 25-35 g, B2 = 55-65 g, B3 = 85-95 g, and B4 = 115-125 g Cytokinin immersion time, W0 = control (without immersion), W1 = 1 day after harvest (DAH), W2 = 15 DAH, W3 = 30 DAH, and W4 = 45 DAH Those numbers followed by the same letters on the same application indicated not significantly different by Duncan’s Range Test at α=5%.
Based on Table 2 it is known that the weight of the potato tuber seeds 115-125 grams (B4) produced the most buds namely, 3.3 buds; 2.08 more than that on the weight of the potato tuber seeds 25-35 grams (B1) namely, 1.22 buds. The result of the research shows that there are more buds in line with the heavier potato tuber seeds. This fact relates to the sufficiency of the energy supplies contained in the heavier tuber to enable the growing of buds. The soaking of the tuber seeds with cytokinin solution during 45 days after harvesting time (W4) produced more buds namely 2.51 buds; 0.38 more buds than those produced in potato tuber seeds without the application of cytokinin solution (W0) namely, 2.13 buds; and this is 0.22 less bud than those on the potato tuber seeds on the application of soaking for 1 day after harvesting time namely, 2.29 buds. The research proved that there are more buds emerging as a result of the longer application of cytokinin solution after harvesting time.

The following Table 3 indicates average weight of potato buds as the result of the application the weight of the potato tuber seeds and cytokinin solution.

**Table 3.** The effect of the weight of the potato tuber seeds and duration of applying cytokinin on the size of buds aged 28 days after harvesting time (gram/s)

| Treatment | W0  | W1  | W2  | W3  | W4  | Mean |
|-----------|-----|-----|-----|-----|-----|------|
| B1        | 4.79| 9.06| 8.10| 10.54| 9.48| 8.40 d |
| B2        | 8.07| 11.65| 13.00| 15.54| 18.85| 13.42 c |
| B3        | 16.81| 22.13| 25.51| 22.74| 25.37| 22.51 b |
| B4        | 27.46| 23.52| 29.00| 24.14| 32.04| 27.23 a |
| Mean      | 14.28 c| 16.59 bc| 18.90 ab| 18.24 b| 21.44 a|

Note: The weight of potato tubers, B1 = 25-35 g, B2 = 55-65 g, B3 = 85-95g, and B4 = 115-125 g Cytokinin immersion time, W0 = control (without immersion), W1 = 1 day after harvest (DAH), W2 = 15 DAH, W3 = 30 DAH, and W4 = 45 DAH

Those numbers followed by the same letters on the same application indicated not significantly different by Duncan’s Range Test at α=5%.

Based on the Table 3, it is showed that the application of the weight of the tuber 115-125 grams (B4) produces the heaviest buds namely, 27.23 grams; 18.83 grams heavier than those of on the application on potato tuber seeds 25-35 grams (B1) namely, 8.40 grams. The research proved that the size of buds is longer affiliated with the heavier weight of the potato tuber seeds. This is because of the energy supply sufficiency inside the heavier potato tuber seeds to support the growing of buds, and the number of buds growing. The soaking of the potato tuber seeds of 45 days after harvesting time (W4) produced the heaviest weight of buds namely, 21.44 grams; 7.16 grams heavier than those produced by potato tuber seeds without the application of the cytokinin solution (W0) namely, 14.28 grams; 2.31 lighter than those produced by potato tuber seeds with the application of the cytokinin solution during 1 day after harvesting time (W1) namely, 16.59 grams. The result of the study proved that the size of buds is higher in line with the longer soaking after the harvesting time. This is showed by the more buds growing. Interaction of the application producing the heaviest potato buds is 32.04 grams (B4W4), but this is unreal different with the size of buds on interactions of all other applications.

The result of the research indicates that application of the weight of the potato tuber seeds really affects dormancy release time, the number of sprouts, and the size of sprouts. The fastest dormancy release time, the most buds, and the heaviest potato buds are on the weight of the potato tuber seeds 115-125 grams (B4). The size of the tuber is perceived to be positively related to endogenous cytokinin content, and the more energy supply so that the dormancy release time is faster. According to [2] stated that the bigger potato tubers have more nutrient supply (carbohydrate) so that they can have bigger and stronger buds. The sufficiency of energy supply (carbohydrate) enhances translocation of carbohydrate towards the buds to enable their growing bigger so that growth of buds’ vegetative organs can be maximized. This can be observed in the higher number and weight of potato buds on the
higher weight of potato tuber seeds. According to [9], stated that the size of potato tuber seeds really affects parameter of the number of buds.

The result of the study indicates that periods of soaking the potato tuber seeds with cytokinin solution really affects dormancy release time, number of buds, and the size of buds. The soaking of the potato tuber seeds with cytokinin solution 45 days after harvesting time (W4) fastened the dormancy release time 12.58 days compared to the time without soaking the potato tuber seeds with cytokinin solution. This finding is in line with [10] who stated that application of BAP really affects the time when potato buds grow G1. According to [3], explained that effectivity of exogenous cytokinin application is affected by dormancy release time, and it is more effective if applied in the end of dormancy time.

Dormancy time is related to endogenous cytokinin content of the potato tuber seeds. The content of the endogenous cytokinin is affected by the application of the cytokinin. The addition of endogenous cytokinin content of the potato tuber seeds can release dormancy time [14].

Cytokinin is important to release dormancy and to affect better than gibberellin. Exogenous cytokinin affects the increase of endogenous cytokinin in the end of dormancy time [15]. Dormancy release lasts at the same time with the emergence of buds (sprouts). Sprouts emerge because of fastening mobilization of glucose and respiration inside the potato tubers. The potato tuber seeds can be said to have sprouts when the buds reach up to 2 mm [16]. The result of the research indicates that the longest and heaviest potato sprouts exist at the fastest dormancy release time. Dormancy release shows that physiology process lasts maximally in the formation of buds (sprouts) supported by food supply (carbohydrate) sufficiency to help germination.

Dormancy is an aspect of physiology age of potato tuber started by initialization of potato tuber. During dormancy time, biochemical and physiology process actually happens but it does not stimulate direct morphologic changes, but this process is relevant with the number of buds produced after dormancy release time and with the strength of potato tuber seed growth [17].

Interaction of application that resulted in the fastest dormancy release time is application on the weight of potato tuber seeds 115-125 grams with application of cytokinin solution 45 days after harvesting time (B4W4). This proved that by using heavier potato tuber containing more energy and carbohydrate supplies, and with exogenous cytokinin application, the dormancy release time will be faster. The potato buds will grow well as there is the adversity of enough carbohydrate supply in the bigger potato tubers.

4. Conclusion
The higher the weight of the potato tuber, the faster is the dormancy release time and the higher is the number and weight of the potato buds. The fastest dormancy release time is on potato tuber seeds weighed 115-125 grams (B4) that is 60.07 days, the number of buds is 3.3 buds and weighed 27.23 grams. The application of cytokinin significantly affects dormancy release time, the number and weight of sprouts. The highest result achieves in application of cytokinin 45 days after harvesting time (W4) that is, the fastest dormancy release time (61.75 days), the most buds (2.51 buds), and the highest weight of buds (21.44 grams). Interaction of applications producing the highest result is that on potato tuber seeds weighed 115-125 grams with cytokinin soaking 45 days after harvesting time (B4W4) namely, the fastest dormancy release time (55 days), the most buds (3.37 buds) and the highest weight of buds (32.04 grams).

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