Effect of G0 minituberssize and planting distance on G1 *Solanum tuberosum* L. tubers production in Lebanon

ABSTRACT

Plant spacing and seed tuber size are important agronomic management practices in the production of potato. Three weights of G0 potato tubers (W1< 10g; 10g< W2< 20g; 20g< W3< 30g) and two planting distances (D1: 10 cm and D2: 20 cm) with a potato variety Spunta were taken in a study from March to June during the 2022 planting season at the Lebanese Agricultural Research Institute (LARI, Tal Amara), Bekaa, Lebanon. The objective was to observe the effect of G0 tuber weights and planting distance on average weight (AWe), average number (AN), average length (AL) and average width (AW) of G1 potato tuber cultivar Spunta in Lebanon. The largest G0 tubers (20g< W3< 30g) planted at widest distance (D2: 20 cm) yielded the maximumsignificantweight, length and width of 41.75 g 6.63 cm and 3.57 cm respectively of G1 tubers producedwhereas the lowest average in these traits (4.19g, 2.89 cm and 1.49 cm) were obtained in smallest G0 tuber weight (W1< 10g) and closest planting distance (D1: 10 cm). The highest number of G1 tubers(n=24) was obtained with smallest G0 minitubers (W1< 10 g) planted at the closest plant spacing 10 cm, while the lowest (n=12) was obtained in the largest size G0 minituber (20g< W3< 30g) with the closest distance 10cm.To conclude, we outline a protocol to produce potato seeds cultivar Spunta in Lebanon by evaluating the field performance of different size potato minituber and planting distances. Our findings suggest planting G0 minitubers of W< 10 g at spacing distance of 10 cm. This will increase the number of G1 tubers obtained and provide access to broader international markets.

Keywords: Solanum tuberosum L, G0 minituber, *Spunta*, *G1 tuber*.

1. INTRODUCTION

The potato (*Solanum tuberosum* L.) originated from the Andean regions in Peru and Bolivia is one of the main agricultural products in the world with 325.3 million tons production and stands in the fourth place after wheat, rice and corn [1].Potato crop is considered as a high potential food security and profitable crop. It yields high-quality and quantity product per unit input with a shorter crop cycle (mostly <120 days) compared to major cereal crops like maize [2,3].The production of seeds of high quality (genetic purity, hygiene, properphysiological age) is among the most important activities in potato cultivation throughout theworld [4]. So, special attention has been given to tissue culture for potato breeding programs, due to the high number of explants produced from a single mother plant and the adaptation of micro-plants to conditions that favor slow development in orderto conserve virus free genetic material for prolonged time periods [5].

In Lebanon, potato is considered the most important field crop. It is a very important source of food and revenue in rural areas.In 2017, the harvested area estimated at 18,900 ha produced around 425,000tons[6]. Cultivation is mainly concentrated in the Bekaa valley at 900–1000 m above sea level (~70% of total potato cultivated area), and in Akkar plain (~30% of total potato cultivated area)[7]. Potato is cultivated for fresh consumption and processedproducts, with a certain percentage (~37%) kept for export [8]. In Lebanon, *Spunta* is still the preferred variety for consumers over the years[9]. It can be planted in three different seasons.Despite its importance, potato quality and yield can be affected by many factors such as cultivar, plant population, soil type, weather conditions, water management, seed piece size, pests and diseases and many others[10].Even withthe wide range of microclimates suitable for high quality potato seed production, Lebanese farmers faces difficulties finding suitable and available ones. They import around 18000 tons of high-cost tubers every year [6].Some farmers purchase uncertified tuber from local markets or by selection of seeds from yield of previous year causing spread of fungal and viral diseases[11]. Optimizing plant density and G0 tuber size during planting are among the most important agronomic practices of potato seed production as it affects seed cost, plant development, yield, and quality of the crop[12]. Many researches tackled the evaluation of the performance of potato seed tubers[13, 14, 15, 16]but little information exists on the field performance of tubers for the breeder's potato seed production.

In this context, the present study aims at evaluating the field performance of different sizesof G0potato tubers and the effect of planting distanceto produce high-quality and homogeneous certified G1 tubers at acceptable price in the central region of the Bekaaplain in Lebanon.

2. MATERIALS AND METHODS

2.1 Site Characteristics

The experiment was carried out at the Lebanese Agricultural Research Institute (LARI, Tal Amara station, Bekaa, Lebanon) (Figure 1). The site located at 905 m altitude, 33º51.685´ N latitude and 35º59.454´ E longitude.
This region is characterized by typical Mediterranean weather where it is hot and dry from May till October and cold during the remaining period of the year. It has an average rainfall of 592 mm/year.
The soil of the experimental fieldis a mixture of clay (41%), sand (23%) and silt (36%) with 4% of active calcareous. It is rich in available sodium (130 ppm), exchangeable magnesium (301 ppm), calcium (6975 ppm), available nitrogen (34 Kg/ha) and available iron (1.1 ppm) but poor in organic matter (1.4%).

Fig.1 Experimental Field

2.2 Plant Material and Experimental Treatments

Certified mini-tubers (basic seeds G0) of *Spunta*variety produced using*in vitro* techniques at the department of Plant Biotechnology in LARI, were cultivated in Tal Amara station (LARI) at the end of February 2022[17]. Three weights (W1: < 10g; 10g<W2< 20g; 20g<W3< 30g) with two different planting distances (D1: 10 cm and D2: 20 cm) were chosen .The experiment was laid out as a Randomized Complete Block Design(RCBD) in a factorial arrangement and replicated three times per treatmentcombinations (D1W1, D1W2, D1W3, D2W1, D2W2, and D2W3) (Figure 2).The experimental field was divided into three blocks, representing three replications. Each block is subdivided into six plot units.In each plot, 50 G0 minitubers were planted in 5 rows of 10 minitubers each. The minitubers were covered immediately after planting with 2 inches of soil.

Fig. 2 Minitubers Plots

2.3 Crop Management

The field was ploughed 3-4 times to a depth of 25 cm. A combination of nitrogen, phosphorus and potassium were applied before planting using the fertilizer 15-15-15 at a ratio of 225 Kg/1000 m^2. After 30 days of planting, nitrogen (17.5%) and P_2O_5(44%) at a ratio of 50 Kg/1000 m^2 were applied, followed by earthing-up when the plant attained a height of about 15-20 cm from the base. A second earthing-up was done after 20 days of the first earthing up. Water was pumped at a rate of 600 mm/ cultivation season from a reservoir into micro-sprinklersthat spray water on a part of the soil surface above the potato crop.

2.4 Pest management

Protecting the crops from pests and diseases is a crucial step in high-quality potato seed production. The field was netted during the entire growing period to protect the plants from any infestations, especially the aphids that are considered themain viral vectors. Pesticides were applied to crops every 15 days starting from the date of emergence. Arotationof the two insecticides, i.e. chlorpyrophos and deltamethrin, were applied along with the fungicides mefenoxam and mancozeb for early and late blight.

2.5 Harvesting potato seeds crop

The soil was carefully dug at a distance of ~30 cm deep from the plant to locate and pick all G1 tubers using a fork,in order not to bruise or damage the skins. Any injured tubers was eliminated. Then, the produced potatoes were put in plastic bagsand stored at 4^{o}C inorder to keep them dormant during the normal storage season.

2.6 Statistical analysis

Samples of three plants were randomly taken from the middle of each plot (replicate) to reduce the border effect. The mean ± standard deviation of four parameters of G1 tubers was calculated for each treatment, i.e. number per plant (AN), weight (AWe), length (AL) and width (AW). Duncan test was performed to determine the significant difference between the calculated means (SAS).

3. RESULTS

After harvesting, samples were cleaned and the two-way Anova was calculated to find out if the weights of G0 tubers and planting density haveeffect on thefour studied parameters of G1 tubers(number of tubers per plant, average weight, average length, and average width (AN, Awe, Al, AW respectively). In addition, the effect of G0 minituber weights with combined planting density and vice versa was determined(Duplicate information).

3.1 Effect of distance and G0 weights on G1 traits

The highest G1 tubers number (n=24) was obtained for the planting distance D1 and the G0 tubers weight W1 (D1=10 cm and W1< 10 g) while the lowest number of G1 tubers (n=12) was obtained for the Planting distance D1 and W3 (20<W3<30g).
On the other hand, planting at distance D2 (20 cm) and weight W3 was the most remarkable compared to the other combinations (distance and weight) with the highest significant weight, length and width of 41.75 g 6.63 cm and 3.57 cm respectively. The combination D1W1 indicated the lowest average in these traits (4.19g, 2.89 cm and 1.49 cm) as shown in Table 1.

Table 1. Effect of treatments on the AN, AWe, AL and AWof G1tubers produced.

Treatments	AN	AWe	AL	AW
T1(D1W1)	24 ± 9.56a*	4.19 ± 1.47e	2.89 ± 0.23e	1.49 ± 0.21e
T2(D1W2)	14 ± 2.45c	11.26 ± 3.07d	3.93 ± 0.37d	2.20 ± 0.26d
T3(D1W3)	12 ± 3.67c	15.99 ± 2.95c	4.74 ± 0.55c	2.58 ± 0.25c
T4(D2W1)	20.22 ± 1.78ab	29.49 ± 4.83b	5.89 ± 0.37b	3.29 ± 0.27b
T5(D2W2)	15.56 ± 3.16c	32.51 ± 5.99b	6.03 ± 0.71b	3.32 ± 0.35b
T6(D2W3)	15.90 ± 1.96bc	41.76 ± 4.13a	6.63 ± 0.33a	3.57 ± 0.19a

*, Means followed by the same letter are not significantly different according to Duncan's.

3.2 Effect of G0 minituber weightswith combined planting distance on G1 minituber formation

The effect of G0 minituber weight on the G1 tuber production is presented in Table2. A significant ($p<0.0001$) effect of G0 weight tubers was observed on the average number (AN), average length (AL), average width (AW) and average weight (Awe) of G1 tubers produced. G0 tubers weight W1 (<10g) presented the highest ANof G1 tubers produced per plant (n=22.11)and the lowest AWe, AL, and AW, while W3 G0 tubers (20g<W3<30g) yielded the lowest number of G1 tubers (n=13.94) with highest AWe, AL, and AW of 28.88g, 5.69cm, and 3.08cm respectively.

Table 2. Effect of G0 minituber weights with cumulated distance on the AN, AWe, AL and AW of G1 minitubers produced.

	G1 Tuber Characteristics			
G0 Weight	AN	AWe	AL	AW
W1	22.111± 6.95a*	16.84± 13.47c	4.39± 1.57c	2.39± 0.95c
W2	14.78± 2.86b	21.89± 11.87b	4.98± 1.21b	2.76± 0.65b
W3	13.94± 3.48b	28.88± 13.70a	5.69± 1.06a	3.08± 0.55a

W1<10g; 10g< W2 < 20g; 20g <W3 <30g

*, Means followed by the same letter are not significantly different according to Duncan's.

3.3 Effect of planting distance of combined G0 weights on G1 minitubers characteristics

The planting distances used in this study did not induce a significant differencein the number of G1 tubers per plant ($p=0.66$). The average number of tubers varied between 16.66 and 17.22 for D1 (10 cm) and D2 (20 cm) respectively. On the other hand, the planting distance D2 induced a significant difference on the other studied traits. The highest average of the G1 tubers weight (34.59g), tuber length (6.18 cm) and tuber width (3.39 cm) were obtained with the planting distance D2 whereas the planting distance D1 yielded smallest average traits as shown in Table 3.

Table 3. Effect of distance with cumulated weights on the AN, AWe, AL and AW of G1 minitubers produced.

Distance	AN	AWe	AL	AW
D1	16.66± 7.92a*	10.48± 5.53b	3.85± 0.86b	2.09± 0.51b
D2	17.22± 3.15a	34.59± 7.19a	6.18± 0.58a	3.39± 0.30a

D1: 10 cm, D2: 20 cm

*, Means followed by the same letter are not significantly different according to Duncan's.

4. DISCUSSION

Potato is well known for its nutritional importance in Lebanon, but one of its main problems is the high prices of imported seeds. Applying the best agricultural practices(planting density and G0 minituber weights) to produce G1 tubers locally with an acceptable price for farmers can reduce the cost of potato seed.

Generally, average G1 minituber weight, length, width and number responded differently to different G0 minituber weights and variable plant spacing. In this context, the present study showed that G1tuber number increased with decreased G0 seed tuber size where small tuber size yielded the highest G1 tuber number. These results are in accordance with those reported by Roy *etal.* (2015)[18] who reported that the maximum tuber numbers per plant wasobtained with the smallest seed tuber size,but contradicting those of Rojoni *et al.* (2014) [19], and Zkaynak & Samanci (2006)[20] where they reported that tuber numberper plant was increased with increasing seed tuber weight.

In addition, contrary to the present study, Gulluogl &Arıoglu (2009)[21]and Haverkort *et al.* (1991) [22] also indicated that small seeds gave the lowest tuber number per plant, whereas large tubers gave the highest tuber number per plant, the significant difference in tuber number might be due to large seed tuber size attributed high amount of food reserves that produce highest tuber yields. The same information was reported by Rykbost and Charlton (2004) [23] and Karafyllidis et *al.* (1997)[24].

On the other hand, concerning the effect ofG0 tuber weight on G1 tuber weight, the obtained results showed that large G0 seedtuber size resulted in an increase in the average G1 potatoes tuber weight implying that large G0 seed tuber size can provide sufficient nutrients required for growth and development at the initial growth phase as seen by Harnet *et al*. (2014)[25] and Regasa et *al.* (2022)[26]where they showedthat the average tuber weight of potatoes increased with the increase in mother tuber size,but opposing those of Berga *etal.* (1992)[2] that an increase in seed tuber size resulted in decreasing the average tuber weight of potatoes.

In addition, our results indicated that large G0 seed tuber yielded G1 tuber with highest length and width. This might be due to the fact that large-size seed tuber had few sinks available per unit area that resulted in less competition between the individuals at low plant densities. Our results are in line with the findings of Kumar*etal.* (2009) [27] and Regasa *etal.* (2022) [26], who reported that large seed tubers had the potential to produce large tuber yield due to its high content of carbohydrate to feed plants, on the other hand, small seed tubers had no capability of equal competition with other plants for resources and had also little amount of carbohydrate source to support the plant at an earlier growth period.

Moreover, our study showed that wider spacing resulted in an increase in the average tuber weight of potatoes. The increase in plant population and decrease in spacing probably increased the competition between plants, hence, leading to a decrease in the availability of nutrients to each plant and, consequently, resulted in a decline of mean tuber weight. Wider plant spacing permits free growth without any competition for minerals and other requirements[25]. Similar results were obtained by many researchers [12, 21, 28, 29] where higher average weights were observed at wider spacings compared to closer ones.

Concerning the effect of spacing on the average number of G1 tuber, our results showed that spacing had no significant effect on the number as seen by others[10, 30, 31].For instance, Tesfa (2012)[31] and Khalafalla (2001)[10] found that tubers grown at closer plant spacing

efficiently use the soil nutrients and other resources which lead to the production of high marketable tuber numbercompared to wider spacing.
On the other hand, despite the fact that spacing had no significant effect on the number of tubers, large spacing has a significant one on the average length and width of G1 tubers obtained. This may be explained by the fact that more resources where channeled to each individual tuber at low density plantings resulting in a high number of large sized tubers. This is in agreement with many others who concluded that tuber bulking at close spacing results in the formation of small G1 tubers[20, 32, 33, 34]because of availability of growth nutrients.It is important to note that presence of nutrient is a main element that control growth; thus, increase in plant density decreases mean tuber size and increase the competition leading to a highnumber of G1 tubers produced with high stem's numbers.

When relating the effect of distance and weight on G1 trait, we notice that the number of tubers per plant was the highest in smallest minituber size with closest planting distance (D1W1); whereasthe highest average tuber weight, length and width were recorded for plants grown on D2W3 treatment combinations. This could be related to the fact that large seed tuber sizes and wider plant spacing had less resource competitions and received more nutrient resources compared to other treatments. Our results are in accordance with those of Hossain *et al.*, and Dagne *etal*., who reported that the G1 tuber weight was the highest in the larger size minituber planted at wider distances due to the presence of more reserve food which caused increase in mean tuber weight[35, 36].

5. CONCLUSION

In general, potato seed production was affected by minituber size and planting distance. Larger size of minituber produced tubers with large weight and size when it was planted in greater distance. But, the higher seed yield potential was found in smaller sized minituber with closer planting distance. So, it can be concluded based on the yield, that smallweight minituber with 10 cm planting distance may be used for cost effective production of breeders' seeds of potato.

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