Basic Seed Potato First Generation Production under Egyptian Conditions

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ABSTRACT

Aeroponically produced minituber (G0) was studied for basic potato first generation (G1) production under Egyptian conditions. The study contained three factors i.e., two sizes of seeded minituber (smaller or larger than 15 mm), three varieties (Cara, Lady Rosetta and Hermes) and three plant spacing (10, 15 and 20 cm). Obtained results showed significant differences between the tested factors on vegetative growth characters and G1 tuber yield. Larger minituber size produced higher values of stem number, leaf fresh weight, stem fresh weight, leaf and stem dry weight. Cara and Lady Rosetta varieties gave taller plants with higher leaf number and chlorophyll content than Hermes variety. While, Hermes and Cara varieties produced higher stem number than Lady Rosetta. The 15 cm plant spacing gave the highest leaf and stem fresh weight. The highest dry weight was produced in 20 cm plant spacing. Larger minituber size yielded the highest number and weight of G1 tubers. Lady Rosetta and Cara produced higher total yield in the second season. Lady Rosetta gave the highest yield of more than 45 mm size tubers. The highest total tuber number resulted from planting large minitubers in the narrow plant spacing (10 cm) in both seasons. Also, the same treatment gave the highest value of G1 tuber of seed grade (25-35 mm) as number or weight in both seasons. The study recommends the use of large (>15 mm) size aeroponically produced minitubers of the three tested varieties, with 10 cm in row plant spacing for basic seed potatoes first generation production under Egyptian conditions.

Keywords: Potato varieties- Basic seed- Minituber- Aeroponic- Spacing.

INTRODUCTION

Potato is the third consumed food crops worldwide (Devaux et al., 2020). In Egypt, potato represents the largest area of cultivated vegetable crops. Also, potato is considered one of the cash crops where Egypt occupies the fifth place of top exporters of fresh potatoes in the world (FAOSTAT, 2024). However, Egypt is one of the largest importers of seed potatoes mainly from Europe, 110- 150 thousand tons of imported seed potatoes tubers for summer plantation. Potato is mainly vegetatively propagated by tubers which cause accumulation of diseases and degeneration (Struik and Wiersema, 2012). Production of seed potato system depends on production of nuclear stock of plants free from diseases specially virus diseases that are mainly by plant tissue culture techniques (Kawakami et al., 2015). Pre-basic seeds are produced after several subcultures in vitro then semi-in vivo conditions (greenhouses) for potato minituber production then production of basic seeds in open isolated fields (Struik, 2007). The need to local seed potato production program is highly important to fulfil the local growing demand for high quality potato seeds especially under the conditions of lower quality and higher prices of some imported seeds. Continued efforts have been implemented to provide local source for seed potatoes using locally produced minitubers in substrates or by importing from abroad. Since the end of the last century the new technique of production of potato minitubers using aeroponics as a method for producing minitubers from virus free plantlets produced by tissue culture that grabbed the attention of southern developing countries in South America, South East Asia and Africa since this technique allows the production of large number of minitubers which could reduce the required cost and time for subsequent generations of seed potatoes especially in those countries that have not cold isolated area devoted of transmitting viruses insects (Millam and Sharma, 2007; Muthoni et al., 2017; Buckseth et al., 2024; Tiwari et al., 2022; Brocic et al., 2022). Under Egyptian conditions some studies were implemented on pre-basic potato minituber production in substrates (Mohamed et al., 2018, Ezzat and El-Dinary, 2017 and Refaie et al., 2020) and in aeroponic culture system (Khalil and Hamed, 2020; Khalil et al., 2024). It is known there are no conducted studies on first generation of potato basic seeds production specifically that were produced from aeroponically produced minitubers under Egyptian conditions. The current experiment was designed to evaluate the growth of three potato varieties which planted with two minitubers sizes (produced aeroponically) at three plant densities for G1 producing under Egyptian conditions.

MATERIALS AND METHODS

The current study was implemented for two successive seasons 2022/2023 and 2023/2024. In aphid proof net house at Kaha Vegetable Research Farm, Horticulture Research Institute, Qalubia governate, Egypt. The soil was substituted sandy soil. The experiment compared the growth of minitubers (G0) in a split split plot design experiment, two sizes of minitubers less or more than 15 mm placed in the main plots, which subsequently divided into three sub plots, each contained one of the potato varieties (Cara, Hermes and Lady Rosetta), while plant spacings (10, 15 and 20 cm) were assigned in the sub-sub plots. The row width was 75 cm. Drip irrigation was applied. Each treatment consisted of three replications each replicate consisted of 5 meter length row of drip irrigation. Fertilization was applied as 120-75-100 unites of N-P_2O_5- K_2O per feddan (4200 m^2). Planting date was 13 October 2022 and harvest date 31 January 2023 for the first season and 11 October 2023 and harvest date 29 January 2024 for the second season.

Plant emergence data were recorded after 45 days. Vegetative growth data were collected after 75 days where two plants were sampled each replicate. Data of stem length, stem number, leaf number, fresh and dry weight were recorded as well. Also, data on tubers number and weight (fresh and dry) were measured. Chlorophyll reading was measured using SPAD (using TYS-B Chlorophyll meter, China).

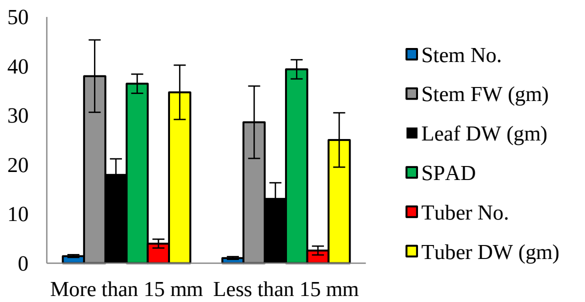
At harvest time, the yield was graded into less than 25 mm, 25-35 mm, 35-45 mm and more than 45 mm. Yield data as number and weight of each grade were recorded as well as total yield per plot and per area unit. Data were subjected to ANOVA according to Sndecor and Cochran (1991) using Statistix 10 software. Means were compared using Tukey HSD test ($P \leq 0.05$).

RESULTS

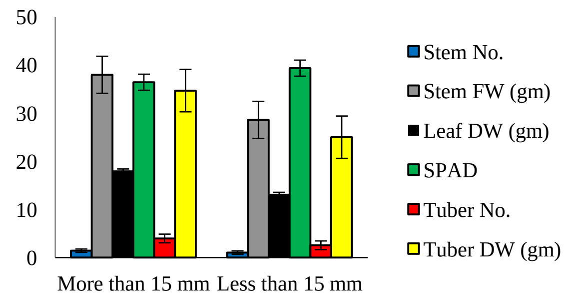
The obtained vegetative growth data after 75 days from planting showed that larger minitubers gave higher significant values for stem number, stem fresh weight, leaf fresh weight, leaf dry weight, tuber number, tuber fresh weight and tuber dry weight with the same trend in both seasons **(Fig.1a and b).** Meanwhile, small minitubers seed size produced higher chlorophyll content (SPAD) values. However, no significant differences between planting with larger or smaller than 15 mm size in plant length and leaf number data after 75 days from planting in both seasons.

Concerning the differences between tested three varieties for vegetative growth data illustrated in **Fig. (2)** showed that Cara and Lady Rosetta produced taller plants, higher leaf number and chlorophyll content than Hermes. However, Hermes and Cara produced higher number of stems than Lady Rosetta. On the other hand, varieties were not significantly different in leaf fresh weight, leaf dry weight, stem fresh weight, stem dry weight, tuber number and tuber fresh weight after 75 days from planting.

Significant differences obtained between the three tested in row plant spacing main effects for leaf fresh weight, leaf weight, stem fresh and dry weigh and SPAD for both seasons **(Fig. 1e-h**). The highest values of stem fresh weight, leaf fresh weight and tuber fresh weight were obtained from 15 cm plant spacing while the highest leaf dry weight values were obtained from 20 cm between plants in both seasons. However, different plant spacing did not enhance significant differences for stem length, stem number, leaf number, tuber dry weight.



a. First season (2022/ 2023)



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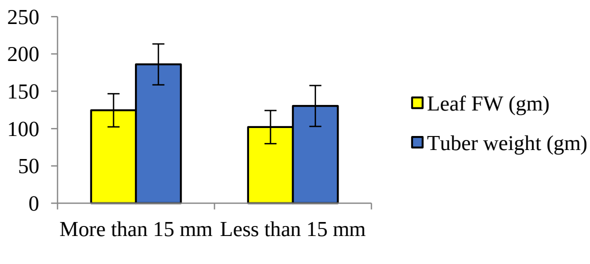

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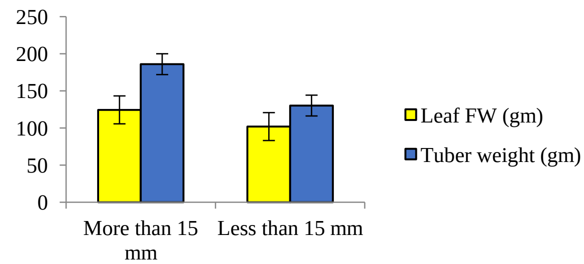

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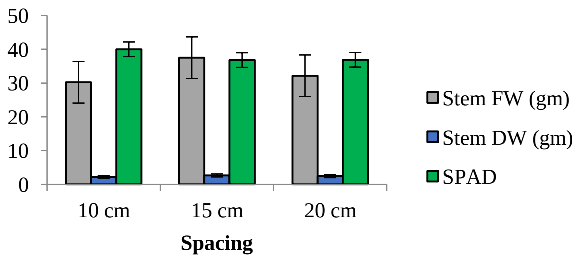

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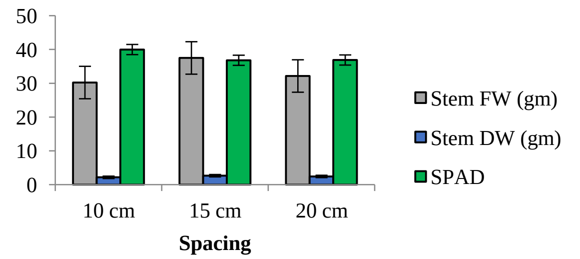

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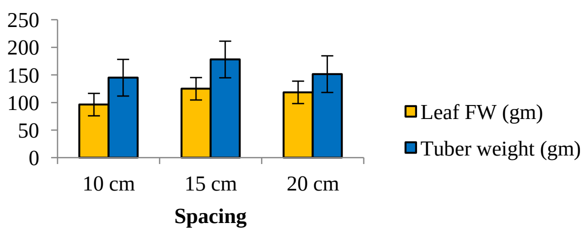
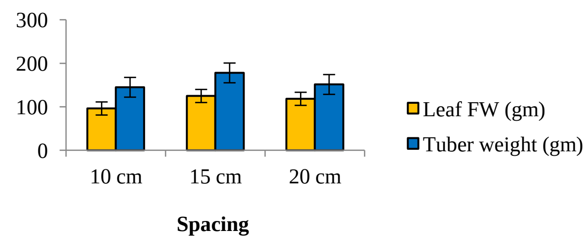
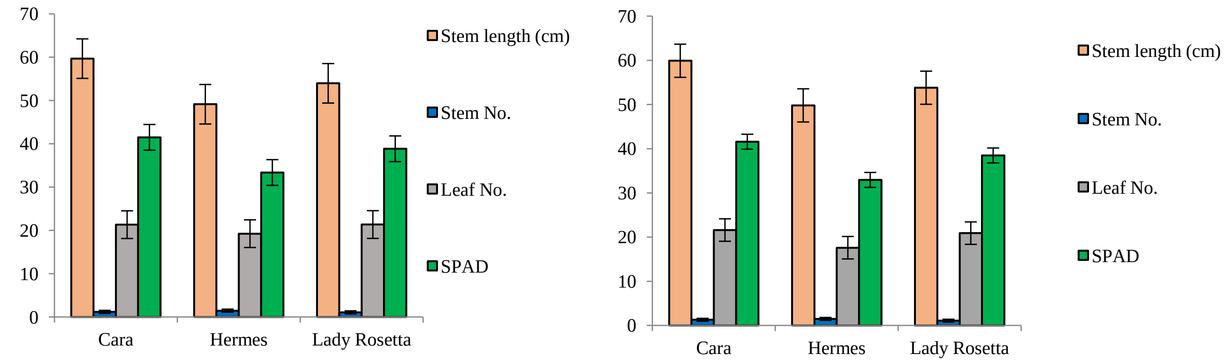


g. First season (2022/ 2023)



h. Second season (2022/ 2023)

Fig (1). Vegetative growth after 75 days in first season (a, c, e and g) and second season (b, d, f and h). Bar indicates HSD (*P* ≤ 0.05).



a. First season (2022/ 2023)   b. Second season (2022/ 2023)

Fig (2). Varieties vegetative growth after 75 days in the first season (a) and the second season (b). Bar indicates HSD ($P \leq 0.05$).

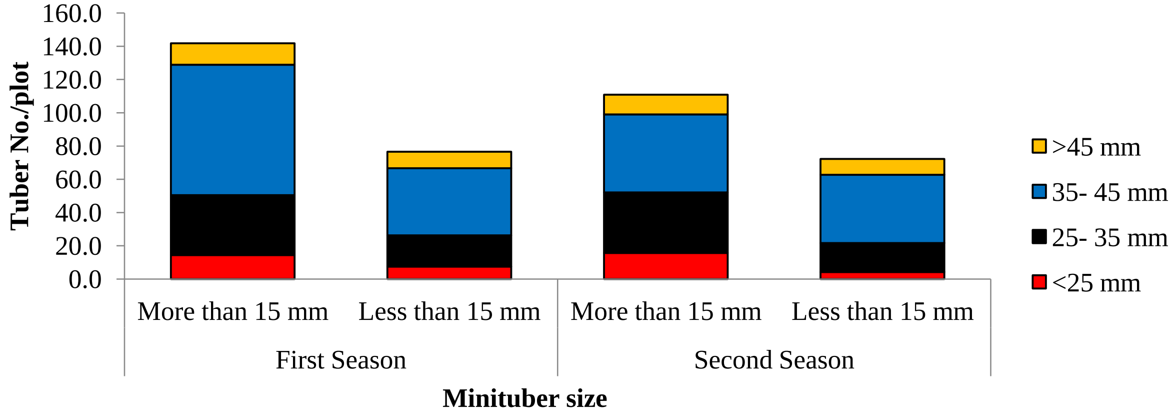
Concerning the interaction between the studied factors on vegetative characters after 75 days; minituber seed size and varieties interactions were significant for stem number, leaf number, leaf fresh weight, stem fresh weight, stem dry weight and SPAD. Also, variety and plant spacing interactions were significant for leaf fresh weight, stem fresh weight, tuber number and tuber fresh weight. Minituber seed size and spacing interactions were significant for stem fresh weight and stem dry weight. Triple interaction among size, varieties and spacing was significant for stem length and stem fresh weight.

Concerning tuber yield, **Fig. (3)** shows the main effects of minituber seed size on tuber yield number and weight per plot at harvest time; planted minituber size more than 15 mm gave higher number of total tuber number of all grades. Although the difference between the two minituber seed sizes for yield of less than 25 mm tuber yield was not significant in both seasons. In the same respect, **Fig. (3b)** illustrates the same trend for tuber yield weight per plot in both seasons.

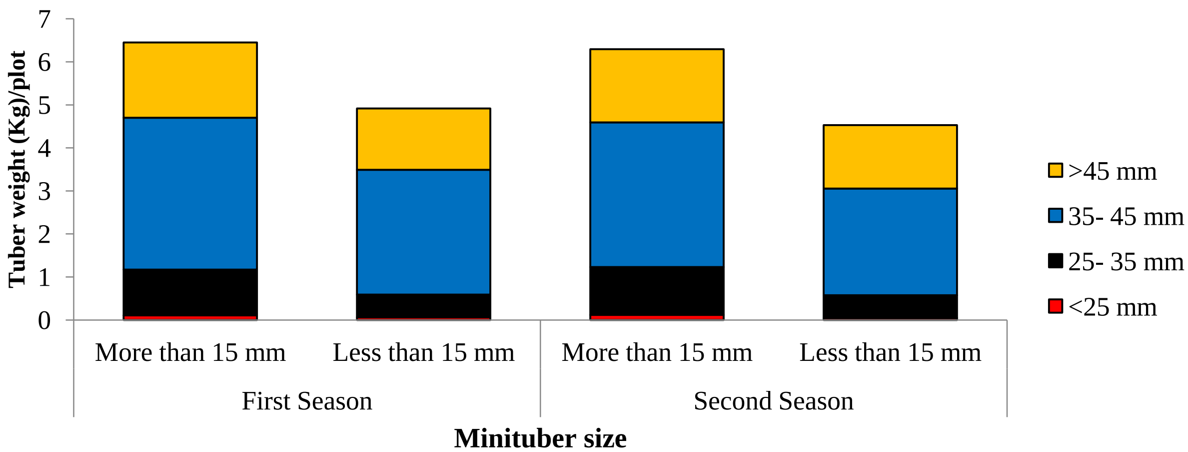
The differences between the three tested varieties in G1 total yield number and weight were not significant in both seasons **(Table 1).** Although, Lady Rosetta and Cara produced significantly higher total yield weight than Hermes in the second season. Also, Lady Rosetta gave the highest number and weight of larger than 45 mm tubers in both seasons and 35-45 mm size in the second season. However, the lowest tuber yield number and weight of 25 and 35 mm tuber size were produced by Lady Rosetta variety during the first and second seasons.

The main effects of the three tested in row plant spacing's (10. 15 and 25 cm) gave significant differences in both seasons (Fig 4). The highest tuber number (172 and 122 tuber/ plot in the first and second seasons respectively). The same was true for all grades (less than 25 mm and seed fraction from 25- 45 mm and > 45mm). Moreover, total tuber weight was higher in the narrow in row plant spacing as total (7.1 and 6.6 Kg/plot in the two seasons respectively). Furthermore, tuber yield for all obtained grades in the narrowest plant spacing (10 cm) was highest followed by 15 and 25 cm plant spacing.

Presented data in **Table (2)** show the effects of interaction between planted minituber size and plant spacing. Planting larger than 15 mm size minituber in the narrow in row plant spacing (10 cm) gave the highest number of total tubers in both seasons. Furthermore, the same treatment gave the highest value of G1 tuber yield of seed grade (25-35 mm) as number per plot (54 and 66 in the first and second season respectively). Also, the same treatment produced the highest value of G1 tuber yield weight of 25-35 mm seed grade i.e., 1.8 and 2.2 ton/fed in the two seasons respectively. However, large minitubers for the wider plant spacing (15 and 20 cm) produced higher tuber weight of more than 45 mm size in both seasons. The difference between size and plant spacing was not significant for total tuber weight in both seasons.



a



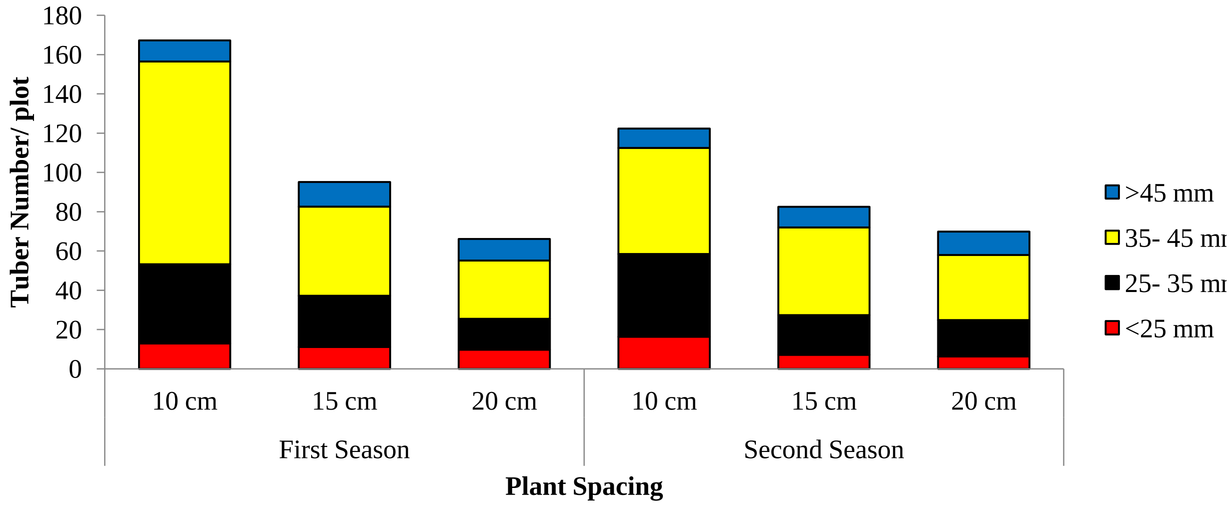
b

Fig. (3). Main effect of minituber size on G1 tuber yield number of different sizes (a) and tuber weight (b) percentage in the first (2022/ 2023) and second (2023/2024) seasons.

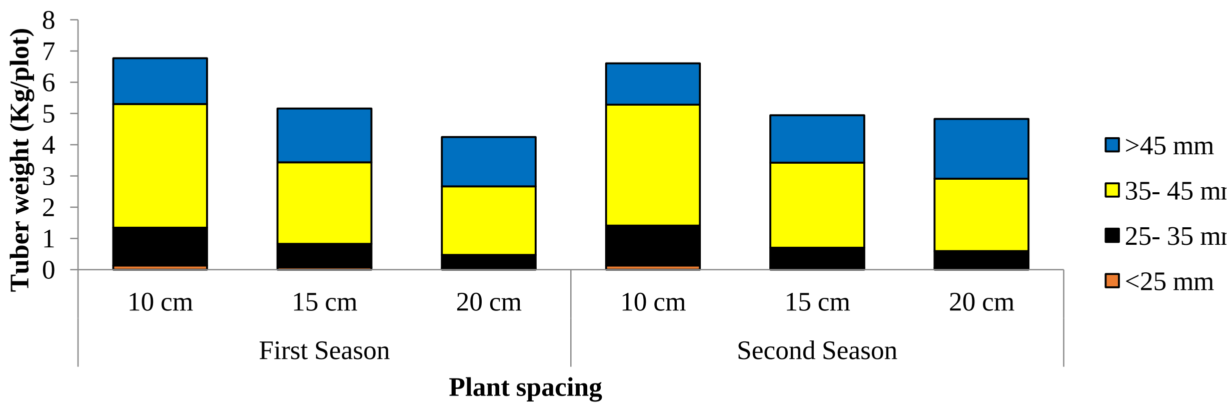
Table (1). Differences between varieties for tubers yield number and weight during first (2022/ 2023) and second (2023/2024) seasons.

Season	Variety	Tuber yield number/plot					Tuber yield weight (g)/plot				
		Total	<25 mm	25-35 mm	35-45 mm	>45 mm	Total	<25 mm	25-35 mm	35-45 mm	>45 mm
First	Cara	137.0 a	13.0 a	29.4 a	83.8 a	10.8 b	5834.1 a	104.8 a	888.6 a	3164.9 b	1675.9 a
	Hermes	101.0 a	13.3 a	30.7 a	49.5 a	7.5 c	5690.6 a	95.0 a	895.3 a	3688.7 a	1011.7 b
	Lady Rosetta	90.8 a	7.7 b	22.2 b	45.0 a	16.0 a	5739.0 a	55.9 b	602.7 b	3003.2 b	2077.3 a
Second	Cara	91.0 a	11.7 a	32.0 a	37.5 b	9.8 b	5700.8 a	110.8 a	1011.9 a	2899.2 b	1679.0 b
	Hermes	93.3 a	11.3 a	28.3 b	48.0 a	5.7 c	4642.7 b	82.6 b	898.2 b	2893.6 b	768.3 c
	Lady Rosetta	90.3 a	6.8 b	20.5 c	46.3 a	16.7 a	5838.1 a	51.6 c	552.6 c	3119.0 a	2114.8 a

*Same letters in the same column in each season are not significantly different according to HSD ($p \leq 0.05$).



a.



b.

Fig (4). Plant spacing differences for seed tuber yield (percentage of each size; a.: number and b.: weight) at harvest time during first (2022/2023) and second (2023/2024) seasons.

Table (2). Effect of interaction between minituber size and plant spacing on G1 yield at harvest time during first (2022/2023) and second (2023/2024) seasons.

Season	Size	spacing (cm)	Tuber yield number/plot Total	<25 mm	25-35 mm	35-45 mm	>45 mm	Tuber yield weight Ton/Feddan Total	<25 mm	25-35 mm	35-45 mm	>45 mm
First	More than 15 mm	10	238.6 a	19.9 a	53.8 a	152.6 a	10.4 bc	8.60 a	0.18 a	1.78 a	5.12 a	1.52 b
		15	116.9 ab	13.2 a	36.7 b	48.4 a	15.6 a	7.50 a	0.11 a	1.21 b	3.8 a	2.36 a
		20	73.0 b	9.1 a	17.4 d	34.3 a	12.8 b	5.53 a	0.07 a	0.59 cd	2.88 a	1.99 a
	Less than 15 mm	10	105.1 b	7.3 a	26.9 c	53.83 a	11.1 bc	7.29 a	0.12 a	0.93 bc	4.47 a	1.76 b
		15	73.3 b	6.0 a	15.6 d	42.3 a	9.4 c	5.78 a	0.06 a	0.48 d	3.75 a	1.50 b
		20	50.6 b	10.3 a	14.1 d	24.9 a	9.2 c	3.97 a	0.03 a	0.37 d	2.03 a	1.54 b
Second	More than 15 mm	10	159.3 a	26.3 a	65.7 a	57.3 a	10.0 b	7.97 a	0.22 a	2.20 a	3.97 a	1.23 b
		15	90.7 b	11.0 b	22.7 b	45.0 c	12.0 ab	6.50 a	0.08 b	0.83 b	3.44 b	1.93 a
		20	82.7 bc	9.7 b	21.0 bc	38.3 d	13.7 a	6.51 a	0.09 b	0.70 bc	3.64 c	2.56 a
	Less than 15 mm	10	85.3 b	6.3 b	18.7 b-d	50.7 b	9.7 b	6.83 a	0.09 b	0.65 bc	4.35 a	1.74 ab
		15	74.3 c	3.3 b	17.7 cd	44.3 c	9.0 b	4.58 a	0.04 c	0.62 bc	2.46 d	1.47 ab
		20	57.0 d	3.0 b	16.0 d	28.0 e	10.0 b	4.30 a	0.03 c	0.51 c	2.03 e	1.73 ab

*Same letters in the same column in each season are not significantly different according to HSD ($p \leq 0.05$).

DISCUSSIONS

The obtained results showed higher foliage growth in larger minituber seed size this could be attributed to the higher initial food reserve in the large minitubers than small ones which enhance faster emergence and plant growth with large ground cover. Besides, larger minitubers enhance bigger root system growth. The bigger growth is reflected in higher values of stem fresh weight, leaf fresh and dry weight **(Fig.1).** The good foliage growth encourages building up higher assimilates which subsequently enhance tuber yield quantity **(Fig.3).** These results are in accordance with those stated by Lommen (1994) that heavier minitubers resulted in regular emergence, faster ground cover and higher harvest index. Furthermore, lighter minitubers resulted in lower sprout and root system growth. Also, Barry et al. (2001) compared between planted minituber sizes (12-15, 15-20, 20-25 or 25-35 mm) they found that increasing planted minituber size resulted in higher ground cover, main stems/m^2, higher total and seed yield and number of seed fraction tubers. Also, Özkaynak and Samanci (2006) mentioned that heavy minitubers gave higher values than light minitubers for tuber yield, tuber weight, tuber number and stem number. Nistor et al. (2011) stated that large minitubers (25-35 mm) gave higher yield than small ones. Dimante and Gaile (2018) reported that plants from lighter minitubers had slower emergence and canopy closure, and less above ground stems. Sadawarti et al. (2017) recorded that germination percentage, compound leaves per plant, plant height and number and weight of tuber were significantly higher in 3-10g of aeroponic minituber. On the other hand, Georgakis et al. (1997) reported that, initial size of mother minitubers have no effect on the distribution of produced tuber yield sizes. In the same line, Dimante and Gaile (2018) mentioned that, the final emergence rate was not significantly affected by the weight class of minitubers.

The differences between varieties were logically expected as the tested varieties have different characteristic and genetic background i.e., the studied varieties have different maturity categories, where Cara is a late variety while Hermes and Lady Rosetta are medium early, in the same respect, potato varieties differences are mentioned in previous literatures (Gopal and Minocha, 1997 and Sumarni, et al. 2016). Also, Sadawarti et al. (2023) observed variability in yield parameters between 17 Indian potato varieties was planted in aeroponic system to produce minitubers.

Increasing plant spacing could cause less competition on soil nutrients and water allowing higher exposure to light which enhance higher photosynthesis and higher assimilates production. In accordance with the obtained results, increasing spaces between plants significantly increased all measured vegetative growth characters (Samy et al., 2014) and increased plant height, number of stems and tubers per plant (Esmaielpour et al., 2011). However, the obtained results gave a higher value for tuber yield as a number and weight in 10 cm in row plant spacing. This could be related to that, increasing plant density (narrow spacing) resulted in increasing the number of plants per area unit with reduction in number and size of tubers per single plant which resulted in increasing the yield per area unit. However, wider spacing and lesser number of plants per area unit resulted in higher number and size of tubers per plant (Svensson, 1962, Smeltzer and Mackay, 1963, Love and Thompson-Johns, 1999, Esmaielpour et al., 2011 and Samy et al. 2014). Also, Georgakis et al. (1997) stated that increasing the minituber planting density resulted in lower percentage of large size tubers while small size tubers increased. Furthermore, Nistor et al. (2011) reported that 8 or 6 minitubers per linear meter gave higher tuber yield than 5 minitubers per linear meter. In addition, Sadawarti et al. (2020) for higher potato seed production (number and weight) recommended minituber planting geometry of 45×10 cm for producing first generational open field. Additionally, narrow in row plant spacing resulted in higher tuber yield form 25-45 mm grade which is preferred in the next basic seed generation plantation to be planted with lower quantity of seed tuber for unite area.

CONCLUSION: The obtained results study recommends for basic seed potato first generation production of the three tested potato varieties (Cara, Lady Rosetta and Hermes) under Egyptian conditions; the use of larger than 15 mm size aeroponically produced minitubers with 10 cm in row plant spacing.

Declaration of Competing Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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الملخص العربى

إنتاج الجيل الأول من تقاوي البطاطس الأساس تحت الظروف المصرية

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تم تقييم انتاج الجيل الأول (G1) من تقاوي البطاطس ما قبل الأساس تحت الظروف المصرية من ميني تيوبر (الجيل الصفري G0) ناتجة من مزارع هوائية. شملت عوامل الدراسة حجمين من أقطار تقاوي الميني تيوبر (أقل أو أكبر من 15 مم) وثلاثة أصناف (كارا وليدي روزيتا وهيرمس) وثلاثة مسافات زراعة (10، 15، 20 سم). أظهرت النتائج اختلافات معنوية بين العوامل المدروسة على النمو الخضري ومحصول درنات الجيل الأول. أعطت الميني تيوبر كبيرة الحجم قيماً أعلى لعدد السيقان والوزن الطازج والجاف للسيقان والأوراق. أعطى صنفي كارا وليدي روزيتا نباتات أطول ذات عدد أكبر من الأوراق ومحتوى أعلى من الكلوروفيل مقارنة بصنف الهيرمس. بينما الصنفين هيرمس وكارا أنتجا عدد أكبر من السيقان عن الصنف ليدي روزيتا. أعطت مسافة الزراعة 15 سم أعلى وزن طازج للأوراق والسيقان. نتج أعلى وزن جاف للسيقان في المسافة بين النباتات 20 سم. أعطت المينى تيوبر ذات الحجم الكبير أعلى محصول درنات جيل الأول. أعطى صنفي الليدي روزيتا والكارا أعلى محصول كلى في الموسم الثاني. أعطى الصنف ليدي روزيتا أعلى محصول من الدرنات ذات أحجام أكبر من 45 مم. نتج أعلى عدد كلى من درنات الجيل الأول من زراعة المينى تيوبر كبيرة الحجم على مسافات 10 سم. كما أعطت نفس المعاملة أعلى عدد ووزن من أحجام التقاوي (25 -35 مم) في كلا الموسمين.

توصى الدراسة باستخدام الميني تيوبر المنتجة من المزارع الهوائية للثلاثة أصناف المختبرة ذات الاحجام أكبر من 15 مم وزراعتها على مسافات 10 سم بين النباتات داخل الخط لإنتاج تقاوي أساس بطاطس الجيل الأول تحت الظروف المصرية.