Original Article

Utilization Of Hydroponic Technique For Potato Mini -Tubers Production

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Abstract

The production of potato seeds in Egypt is the nucleus for providing the import of seeds as potatoes are the fourth most important crop in the world and Egypt imports a large number of potato seeds at high costs. This study aims to optimize the water productivity of the hydroponic and aeroponic systems and increase the potato crop yield and quality. The current experiment was carried out in a greenhouse (1.2 hectares) at the National Company for Protected cultivation, Mohammed Naguib Military Base, Egypt. During the period from 15/2/2019 to 1/6/2019 and 15/9/2019 to 1/1/2020. The experimental layout included some engineering factors of hydroponic and aeroponic systems such as density of plants /per square meter and different nozzles with different discharges for sprinkler and dripper systems. In addition to the determination of water productivity in hydroponic and aeroponic systems. The highest yield production for aeroponic system was at discharge 1.2 lph for micro tuber and mini tuber was as follow; 180 tuber / square meter. aeroponic system was better than the hydroponic system by a percentage of 21% for several mini-tubers per square meter and the yield productivity of the mini-tubers was 93.7%. Aeroponics system gave the highest production at density 100 tuber /m^2 for micro and mini tuber were: 500 tubers/m^2 and 610 tubers/m^2, respectively, and in the hydroponic system, micro tuber and mini tuber were 300 tubers/m^2 and 480 tubers/m^2, respectively.

Keywords: Aeroponics, Hydroponics, Micro tuber, Mini tuber, and Potato.

INTRODUCTION

The need to control environmental factors is one of the most important components of the quality of production, so the specifications for agricultural systems are necessary to facilitate the production process of agricultural transactions and reduce the cost of production and thus achieve continuity of production. Egypt is largely dependent on seed potato imports for its domestic potato production. Because it is the main crop among those producing roots and tubers, and the third most important food crop in the world after rice and wheat. Imports reach roughly 120,000 metric tons for the year **2018/2019**. Seed potato exports to Egypt could reach $15 million annually once market access issues are resolved. , (**Ministerial Decree No. 1202/2018**). Seed potato production is mostly based on in vitro plantlets or micro-tubers, and on the subsequent production of mini-tubers as the first ex-vitro generation **(Ranalli, 1997).** Mini tubers can be produced after acclimatization from plantlets that are planted at high densities in the greenhouse in beds **(Wiersema et al., 1987)** or containers **(Jones, 1988)** using different substrate mixtures, or even in hydroponic culture **(Muro et al., 1997).** Alternatively, soft-less production techniques, such as the Nutrient Film Technique (NFT) and aeroponics have successfully been employed in tuber production, with good prospects for certified seed production (**Boersig and Wagner, 1988)**. The control treatment was constituted by the plant spacing and seed tuber size often used by growers in Huambo (plant spacing of 20 cm with seed tuber size of 28-35 mm) (**Fernando et al. 2016)** All production of seed potato mini-tubers is planted in pots/boxes in agricultural substrates, with low yields, on average 3 to 7 units per plant (Daniels et al. 2000). In addition to low multiplication, the high use of labor and plant health problems linked to substrate reuse impact negatively the traditional production of seed potato mini- tubers. Recently, the use of hydroponic systems is becoming one of the main strategies for producing seed potatoes. In contrast, Aeroponics is a modern technique for growing agricultural plants by providing a nutrient solution in the air without soil. Plant roots receive a nutrient spray mist from an atomizing nozzle (**Lakhiar et al., 2018).** Improved food production spaces and water-saving methods under soilless culture **(Sardare and Admane, 2013; Gruda, 2019**), the aeroponics system stands out since it can achieve yields of up to 49 mini-tubers per plant, besides the repeated harvesting of tubers, which facilitates the standardization and marketing planning **(Ritter et al. 2001).** For potato production, a normal greenhouse structure should provide a safe environment with minimal investments. This approach will allow us to reduce production costs, and plants should be protected from adverse factors and pests by a controlled climate **(Riggio et al., 2019).**

This study aimed to optimize the water productivity of the hydroponic system and aeroponic, as well as, increase the potato crop yield and its quality and produce mini tubers potatoes locally rather than import them at high financial study.

2-MATERIALS AND METHODS

Experimental layouts and procedures are described in Fig. (1), where, this study was carried out in the greenhouse, at the National Company for Protected Agriculture, Mohammed Najib agricultural Base, Egypt. The latitude and longitude of the experiment site were ($30^{\circ}43'35''$ N, and $29^{\circ}19'15''$ E, respectively with an altitude equal to 5.48km). During the period from 15/2/2019 to 1/6/2019 and 15/9/2019 to 1/1/2020.Using three cultivars of potato (Solanum Tuberosum L.) CVS. Spunta, lady rosetta and Hermes were planted in the high-technology greenhouse and its area was 1.2 hectares. (115m * 105m), consisting of black linoleum, white linoleum, concrete molds, an irrigation unit for every system, and potato seedlings that are made from tissue transplantation. The agriculture Environment media consisted of perlite, peat moss and foam (1:1:1).

1- Irrigation systems description:

Irrigation network as shown in fig (1).Two irrigation systems are used in these experiments (spray and drip) are three different discharges of nozzles were used for every system and this discharge were calculated according to the water requirements of the potato crop:

a- Spraying system; three different discharges and their types: (rotor spray, micro spray, and multi-stream sprayer) were used at: 1.8 l/h, 2. l/h, and 2.2 l/h at 2 bar operating pressure.

b- Dripping system; three different discharges were used at: 1.2 l/h, 1.7 l/h, and 2.3 l/h at different spacings 10, 15, and 20 cm at 1 bar operating pressure.

2- Irrigation scheduling:

a- Scheduling for drip irrigation:

- 1 min on / 60 min. off (10 cycles)/ day;
- 3 min on / 60 min. off (10 cycles)/day;
- 5 min on / 60 min. off (10 cycles)/day;

b- Scheduling for spray irrigation:

- 10 sec on / 20 min. off (10 cycles)/day;
- 15 sec on / 20 min. off (10 cycles)/day;
- 20 sec on / 20 min. off (10 cycles)/day.

3- Plant propagation part: Striped potato seedlings produced by tissue cultivation (Spunta, Herms and lady rosetta) planted on plastic boxes packed with a mixture of peat moss, perlite, and foam (1:1:1) in both hydroponic and aeroponic systems.

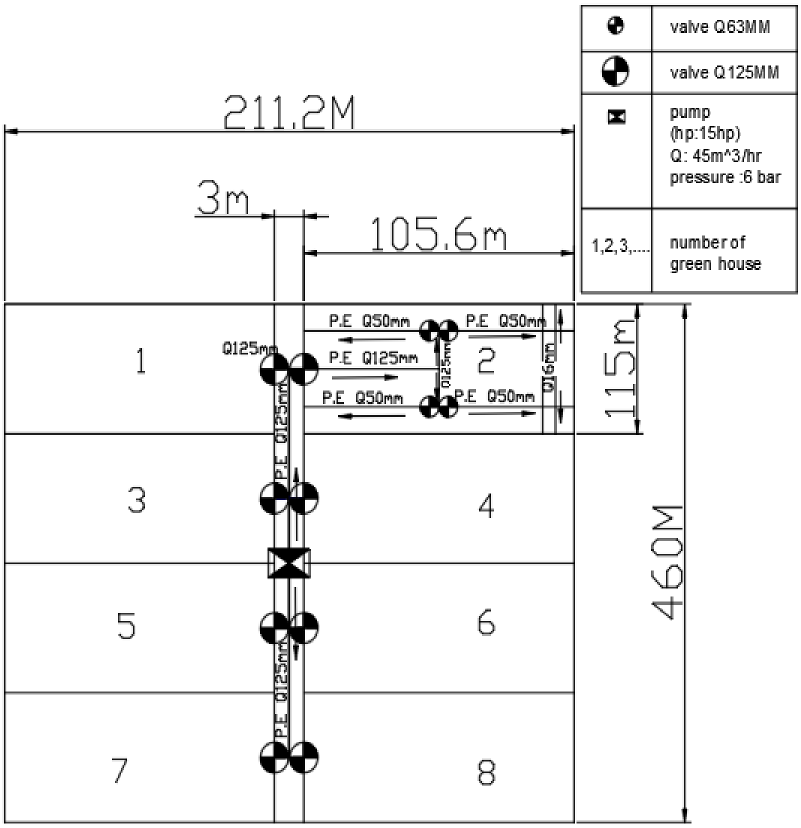

Fig (1): Experimental layout for greenhouse.

4- Density of plants: In this study, three densities of plants were used (60, 80, and 100) plants per square meter.

5- Nutrient solution: The nutrient solution has an EC which does not exceed 2.0 ms/cm. A nutrient solution of EC values between 2.0 and 2.5 dSm^{-1} has been used in potato mini-tuber production. The pH of the nutrient solution does not exceed 7.3; the optimum is 6.5 to 6.8. The nutrient solution is changed every four weeks to replenish the nutrients and maintain the correct pH. **According to Farran and Mingo (2006)**, the following nutrient solution gives satisfactory mini-tuber yield: KNO_3 (0.4 %); KH_2PO_4 (4.4 %), Ca $(NO_3)_2$ (3.1 %); NH_4NO_3 (4.4 %) and $MgSO_4$ (1.5 %), at a pH of 5.7.
The following nutrient solutions have been used with satisfactory results in (Table 1)

Table 1: The nutrient solution that used in the study:

Farran and Mingo-Castel, 2006; Mbiyu et al., 2012	
Nutrient	Concentration (%)
KNO3	0.4
Ca (NO3)2	3.1
NH4NO3	4.4
KH2PO4	4.4
MgSO4	1.5
Ph	5.7

6- Measurements and calculations:

a- Yield productivity parameters:

- Number of tubers/plants;
- Diameter of tuber, cm;
- Weight of tuber, g;
- Total yield per square meter (total weight/m^2)

b- Water productivity: The water productivity was calculated according to **Jensen (1983)** as follows:

WP = Y / W ----------------------------- (1)

WP: Water productivity, kg m^{-3}.
Y: Total yield, kg.
W: Total irrigation water, m^3.

7- Cost analysis:

Annual total cost was calculated according to **(Davies and Richards, 2002)** as follows:
Annual total cost = Total initial costs + Total operational costs.-----(2)
Where;-
Total initial costs, L.E./year = [a] + [b].
- Pumps and installation, L.E [a] + additional infrastructure, L.E [b].
-Total operational costs, L.E./year = [h] + [i] +[s].
- Energy costs per year, L.E/year [h] + water consumption costs per year, L.E/year [i] + maintenance per year [s].
Where;[a]: Pumping cost (L.E./m^3).[i]: Water consumption (m^3/m^2/year).[s]: Maintenance costs, taken as 10% of its initial cost (L.E./year).Years of working life expectancy (20 years).

Statistical analysis for an experiment under study the factors under study are:

1- Irrigation method (I)
- (Spray (for aeroponic system) (I1)
- Drip (for hydroponic system) (I2)

2- Flow rate (Q) for dripping
- 1.2 lph (Q1)
- 1.7 lph (Q2)
- 2.3 lph (Q3)

3- Flow rate (Q) for spray
- 1.8 lph (Q1)
- 2.1 lph (Q2)
- 2.2 lph (Q3)

4- A-Irrigation scheduling (T) for dripping
- 1min on/60min off (10 cycle /day), (T1)
- 3min on/60min off (10 cycle /day), (T2)
- 5min on/60min off (10 cycle /day), (T3)

B- Irrigation scheduling (T) for spraying
- 10 sec on / 20 min. off (10 cycles)/day; (T1)

- 15 sec on / 20 min. off (10 cycles)/day; (T2)
- 20 sec on / 20 min. off (10 cycles)/day; (T3)

5- Plant density (G) , plant / m^2
- 60 (G1)
- 80 (G2)
- 100 (G3)

The treatments were distributed and analyzed using a **completely randomized design (CRD).**

RESULTS AND DISCUSSION

1. Effect of nozzles discharges of sprayer on mini tubers seeds of potato:

Fig. 1 found that when using discharge 1.2 lph was given the highest productivity of 80% for micro-tuber and 100 % for mini –tuber and the number of good tubers was free of mold and fungal and bacterial diseases in tubers and there is no waste of water, compared with other treatment 1.7, and 2.3 lph were given the lower productivity for micro-tuber and mini-tuber cause of increased the moisture content of the soil media (mix of peat-moss, perlite, and foam) In addition, using 2.3 lph found mold and fungal and bacterial diseases, cause of the excessive amount of water.

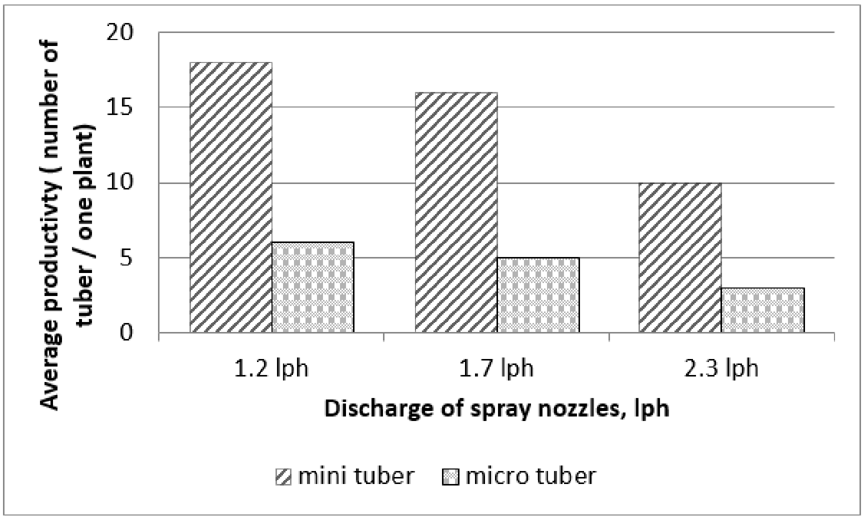

Fig (1): Effect of nozzle discharges of sprinklers on average productivity for micro-tuber and mini-tuber.

2. Effect of using different discharges in the drip system (hydroponic) on productivity:

From Fig. 2 it was found that when using the discharge of 2.2 lph the moisture content of the soil media increased and the number of good tubers was lower compared to the use of discharge 1.8 lph which was given the highest productivity by 60% for micro-tuber and 33 % for mini –tuber and the number of good tubers was free of mold and fungal and bacterial diseases.

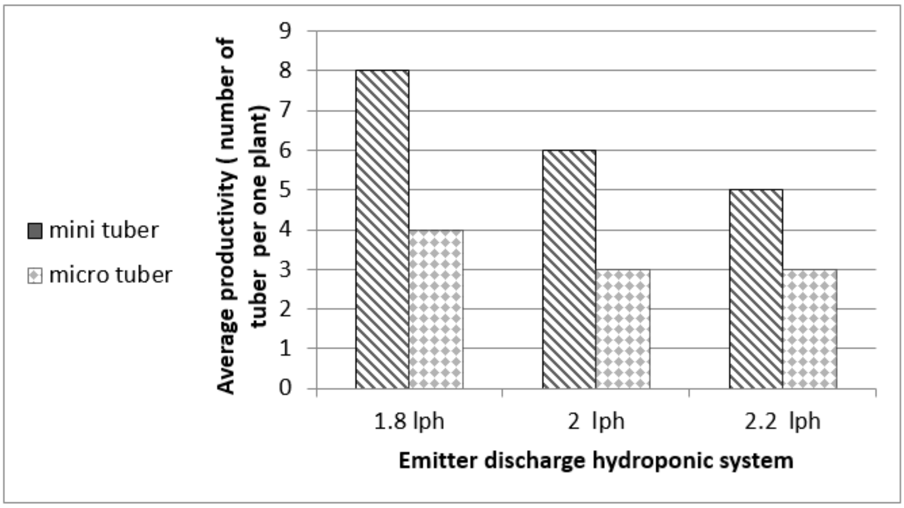

Fig. (2): Effect of nozzles discharges of drip on productivity for micro-tuber and mini-tuber.

3. Effect of Scheduling for drip irrigation on productivity:

From Fig. 3, found that it is at the irrigation period of one minute found that the soil media (mix of peat-moss, perlite, and foam) is somewhat dry which means that the water supply is insufficient, and at a period of 5 minutes the water was increased which caused an increase in the moisture content of the soil media and thus the appearance of mold on some tubers, so at a period of 3 minutes you notice that it is the best productivity compared to the period of one minute and the period of 5 minutes with percentage 100 % for micro-tuber and 75% for mini-tuber because the moisture content of soil media is suitable.

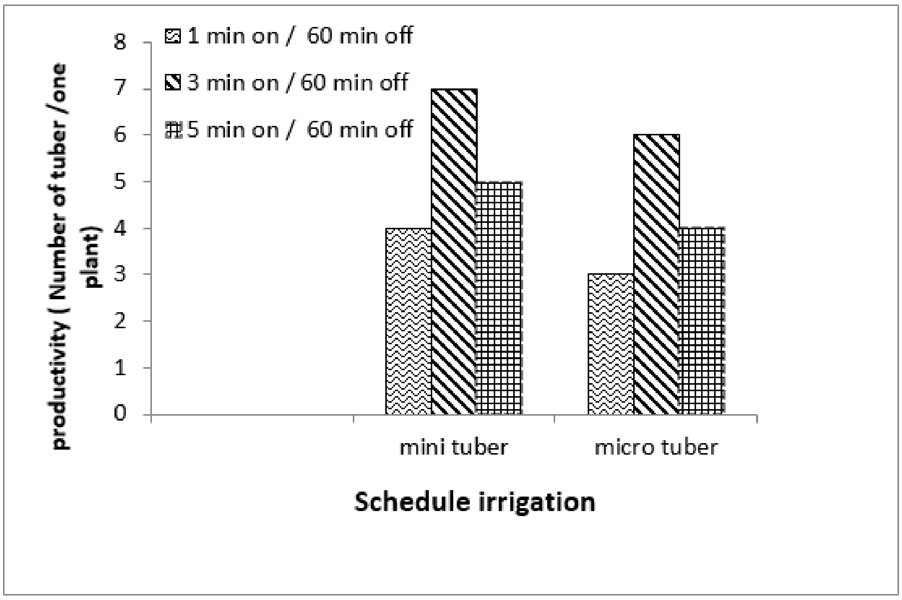

Fig. (3): Effect of different drip time irrigation on productivity.

4. Effect of Scheduling for spraying irrigation on productivity:

From Fig. 4 found that at the irrigation period of 20 seconds, the moisture content of the soil media increased. In addition to increasing water consumption by a greater percentage, which led to the occurrence of mold in the resulting tubers, so the production was less than the period of 10 seconds by a percentage of 50 % for micro-tuber and 28% for mini-tuber.

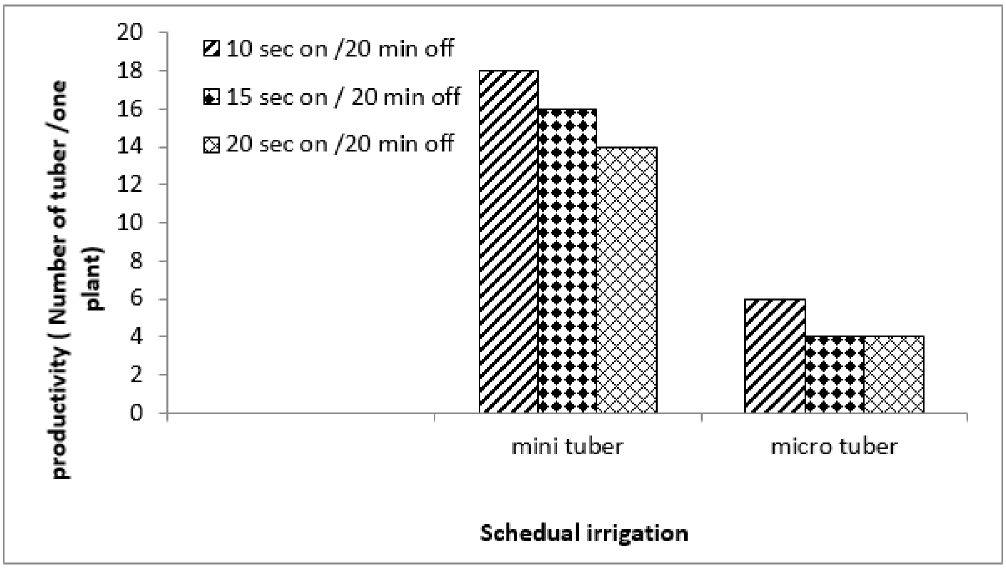

Fig. (4): Effect of different spray time irrigation on productivity

5. Effect of different spacing between plants on productivity in culture hydroponic system

From Fig. 5 we find that at a distance of 15 cm showed the highest productivity for mini tuber and micro tuber as follows: (18 tuber and 6 tuber), respectively due to the number of tubers that were planted . Because it gave the best product in terms of number, size and homogeneity of shape compared with 10 cm and 20 cm treatments.

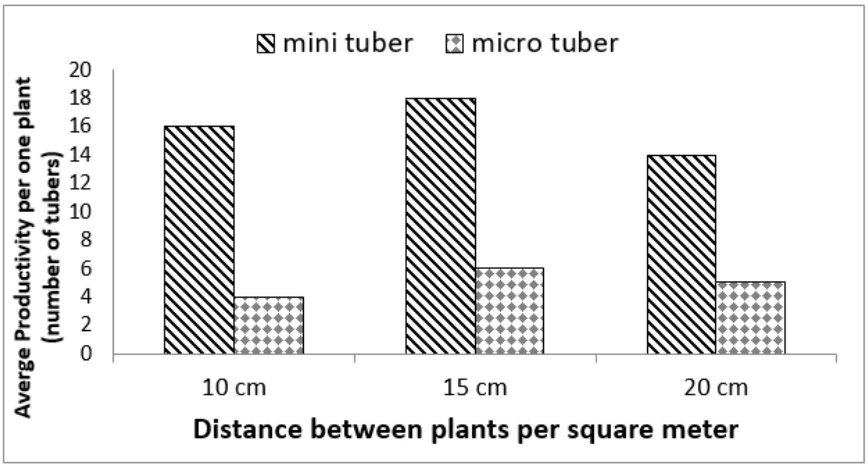

Fig. (5): Effect of different spacing between plants per square meter in hydroponic and aeroponic systems

6. Effect of density of plants per square meter in hydroponic system:

From Fig. 6 found a density of 100 tubers /m^2 gave the best productivity and homogeneity to the number of tubers produced due to the increase in the number of tubers planted per unit per square meter by a percentage 40 % for micro-tuber and 33% for mini tuber also because of the competition of plants, some of them in food and water compared to the density of 60 and 80 tubers per square meter.

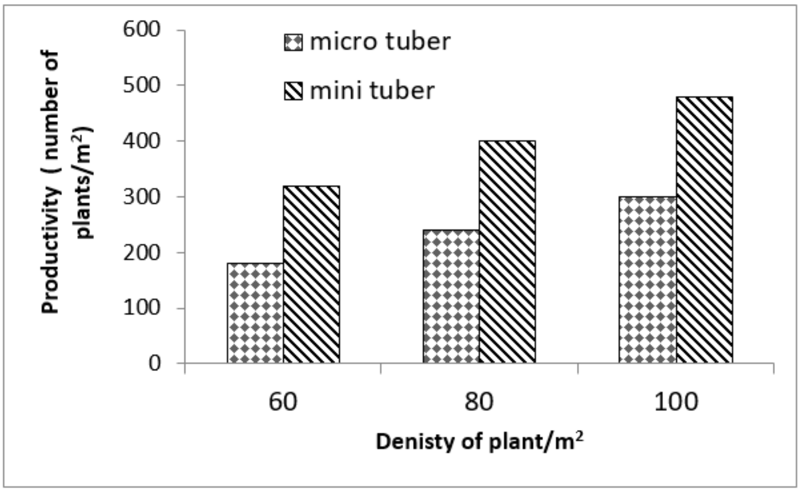

Fig. (6): Effect of density of plants per square meter in hydroponic System.

7. Effect of plants density per square meter in aeroponic system:

From Fig. 8 we find the density of 100 tubers /m^2 gave the best productivity and homogeneity to the number of tubers produced due to the increase in the number of tubers planted per unit per square meter by a percentage 52 % for micro-tuber and 40% for mini tuber also because of the competition of plants, some of them in food and water compared to the density of 60 and 80 tubers /m^2 this according to **(Farran et al, 2006)**.

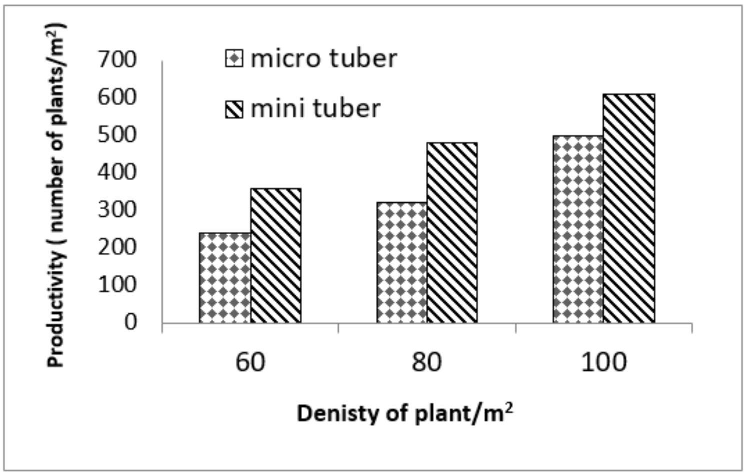

Fig. (7): Effect of density of plants per square meter in aeroponic.

8. Comparison between the productivity of aeroponic and hydroponic systems in water productivity:

The influence of the different cultivation systems on the number and mass of potato mini-tuber in the aeroponic system is presented in the following table:

Table. (2): Comparison between productivity aeroponic and hydroponic systems.

Growing system	Number of micro-tubers/m^2	Number of mini tubers/m^2	Number of micro tubers/m^2	The yield of mini tubers(g)/ m^2	The average number of mini tubers /plants	The average mass of a mini tuber (g)
Hydroponic/ soilless culture	300	480	300	9.6	7	20
Aeroponic	500	610	500	152.6	18	25

Table (2). The previous table found that aeroponic system was better than the hydroponic system by a percentage of 21% for the number of mini-tuber per square meter and yield productivity of mini-tuber at 93.7% this is because in aeroponic system, there is a visually better uniformity water distribution than the hydroponic system.

9. Determination of water productivity in hydroponic and aeroponic systems for the production of micro tuber and mini tubers:

From Fig. 9, the results indicated that when using potato agriculture under aeroponic system gives the least water-consumptive use with high productivity for both micro and mini-tubers Compared to using the hydroponic system because irrigation can be controlled on a crop-by-crop basis. Unlike saturating the crops by flooding them with water, a mist can be administered in very precise amounts and for specific periods, which gives a higher level of control than you would find in a hydroponic system.

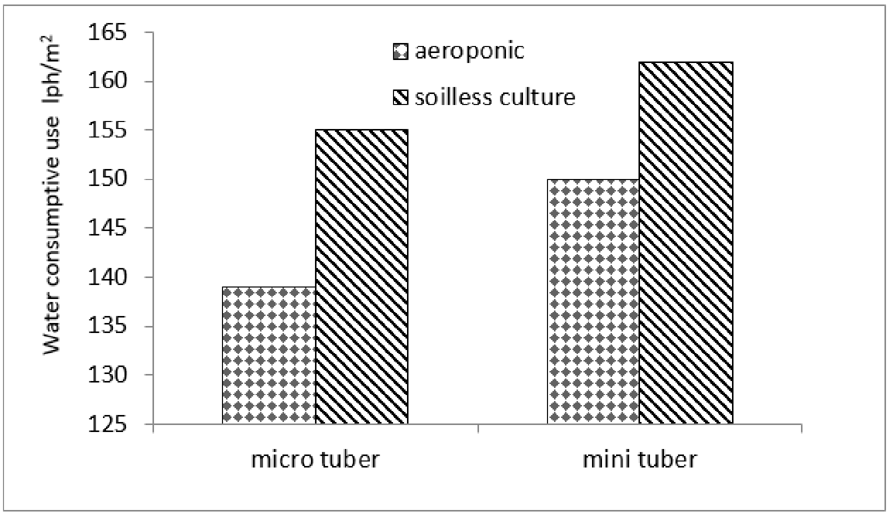

Fig. (9): Effect of different irrigation systems on water consumption.

10. Annual total cost analysis in different irrigation systems:

Table. (3): Annual total cost analysis in different irrigation systems, (L.E m^{-2}).

	Aeroponic system (cost L.E m^{-2})			Soilless culture (hydroponic system)		
	1.2 lph	1.7 lph	2.3 lph	1.8 lph	2.1 lph	2.2 lph
Micro tuber	195	198	205	211	220	235
Mini tuber	203	207	210	260	275	290

From equation 2 and the previous table found that aeroponic gave an average least cost than hydroponic systems per square meter by percentage 11% for micro-tuber and 32.8% for mini-tuber this is meaning aeroponic system was the best because it was the highest productivity and when using aeroponic system gave lower water consumptive use, irrigation period, consumptive energy, compared with hydroponic system.

Statistical analysis

The treatment was distributed and analyzed using **a completely randomized design (CRD)** and the analysis was performed using **SPSS** software. The analysis shows a significant difference between the coefficients, as the result was greater than 0.05.Statistical analysis of yield micro-tuber (kg) for the levels of the main factors:

Treatments	Yield micro (kg)	LSD at 0.05	Significance
I			*
Spray (aeroponic system) (I1)	3.84	0.116977	**a**
Drip (hydroponic system) (I2)	2.69		**b**
Q			*
1.2 lph(Q1)	3.74		**a**
1.7 lph(Q2)	3.24	0.143267	**b**
2.3 lph(Q3)	2.83		**c**
T			*
10 sec on/ 20 min off(T1)	3.69```		
15 sec on/ 20 min off(T2)	3.22	0.143267	**a**
20 sec on/ 20 min off(T3)	2.89		**b**
G			*
100(G1)	4.31		**a**
80(G2)	3.18	0.143267	**b**
60(G3)	2.31		**C**

Statistical analysis of yield mini-tuber (kg) for the levels of the main factors:

Treatments	Yield mini (kg)	LSD at 0.05	Significance
I			*
Spray (aeroponic system)	9.81	0.168	**a**
Drip (hydroponic system)	8.48		**b**
Q			*
1.2 lph	9.93		**a**
1.7 lph	9.01	0.206	**b**
2.3 lph	8.49		**c**
T			*
10 sec on/ 20 min off	9.38		
15 sec on/ 20 min off	9.45	0.2062	**a**
20 sec on/ 20 min off	8.60		**b**
G			*
100	11.41		**a**
80	9.26	0.206	**b**
60	6.77		**C**

Statistical analysis for the experiment found that aeroponic system, Q1, T1 and G1, gave a highly significant comparison with the hydroponic system for micro and mini tubers.

CONCLUSION

The results obtained indicate that the cultivation system exerts a significant influence on the number and the total yield of potato mini-tubers. aeroponic system of cultivation gave the largest number of micro-tuber and mini-tuber per m^2 recorded (500 and 610 tubers) and it was better than hydroponic because in aeroponic system, there is better uniformity because water distribution through root zone by sprayer better than dripper, lower water consumption, the least cost per square meter and the highest productivity.

REFERENCES

1. **Boersig MR, and SA Wagner. (1988)**. Hydroponic system for production of seed tubers. Am Potato J 65:470-471.
2. **Davies, L., and A. Richards. (2002)**. Costing an irrigation System (net margin calculator). State of New South Wales, Department of Primary Industries Agriculture, 112-115.
3. **Farran .I, and A. M. Mingo-Castel. (2006).** Potato mini-tuber production using aeroponics: Effect of plant density and harvesting intervals. Amer J of Potato Res (2006) 83:47-53
4. **Fernando M. de Almeida1, Jorge Arzuaga Sánchez2, Wilfredo Torres de la Noval2 and Juan A. Cabrera Rodríguez. (2016)**. Effect of different plant spacing's and seed tuber sizes on some morpho- Productive Characteristics of Potato in Huambo, Angola Cultivar Tropical. 37, no. 2, pp. 88-95.
5. **Gruda, N. (2019)**. Increasing sustainability of growing media constituents and stand-alone substrates in soilless culture systems. Agronomy 9:298. doi:10.3390/agronomy9060298.
6. **Jensen, M.E., (1983).** Design and operation of farm irrigation systems. Amer. Soc. Agric. Eng. Michigan. USA, p.827.
7. **Jones, E.D. (1988)**. A current assessment of in vitro culture and other rapid multiplication methods in North America and Europe. American Potato Journal 65: 209-220
8. **Lakhiar, I.A., Jianmin, G., Syed, T.N., Chandio, F.A., Buttar, N.A., et al. (2018)**. Monitoring and control systems in agriculture using intelligent sensor techniques: A review of the aeroponic system. Journal of Sensors 2018:ID8672769.
9. **Mbiyu, et al, (2012)**. Use of aeroponics technique for potato (Solanum tuberosum) minitubers production in Kenya. Journal of Horticulture and Forestry Vol. 4(11), pp. 172-177, November 2012.
10. **Ministry of Agriculture and Land Reclamation. Central Administration of Plant Quanta Tine (CAPQ). Statistical Unit and FAS Cairo office research**. **Ministerial Decree No. 1202/2018 (September 12, 2018**). Import phytosanitary requirements and specifications for the importation of seeds potato for growing year (2018/2019).
11. **Muro, J.; V. Diaz; J.L. Goni and C. Lamsfus, (1997)**. Comparison of hydroponic culture and culture in a peat/sand mixture and the influence of nutrient solution and plant density on seed potato yields. Potato Research 40: 431-438**.**

12. **Ranalli, P. (1997)**. Innovative propagation methods in seed tuber multiplication programs. Potato Research 40: 439-453.
13. **Riggio, G., Jones, S.L., and Gibson, K.E. (2019)**. Risk of human pathogen internalization in leafy vegetables during lab-scale hydroponic cultivation. Horticulture 5:25. doi:10.3390/horticulturae5010025.
14. **Ritter, E; B; Angulo P; Riga, C; Herran, J; Rellosoannd M San Jose (2001)**. Comparison of hydroponic and aeroponic cultivation systems for the production of potato mini tubers. Potato Res 44:127–135.
15. **Sardare, M.D., and Admane, S.V. (2013)**. A review on plant without soil-hydroponics. International Journal of Research in Engineering and Technology 2(03):299-304..
16. **Wiersema, S.G., R. Cabello, P. Tovar and J.H. Dodds, (1987)**. Rapid seed multiplication by planting into beds micro tubers and in vitro plants. Potato Research 30:117-120..

إستخدام تقنية الزراعة المائية لإنتاج درنات تقاوي البطاطس المصغرة

1- صابرين علي بكر ، مهندسة زراعية
2- أ.د/ محمود محمد حجازي ، أستاذ الهندسة الزراعية المتفرغ ، كلية الزراعة جامعة عين شمس
3- د/ أسامة محمد أحمد بدير ، أستاذ الهندسة الزراعية المساعد ، كلية الزراعة جامعة عين شمس
4- د/ ياسر عبد الحكيم محمد ، أستاذ مساعد بمركز بحوث الصحراء شعبة البيئة وزراعات المناطق الجافة –قسم الأصول الوراثية – وحدة أقلمة النبات.

الملخص بالعربي

إن مصر اليوم تواجه الكثير من التحديات بسبب نقص كمية المياه ، الزيادة السريعة في النمو السكاني ، التغيرات المناخية ، وتستورد كميات كبيرة من تقاوي البطاطس بأسعار باهظة الثمن هذا الأمر جعلنا نتجه إلي زراعة وإنتاج تقاوي البطاطس محلياً في نظم الزراعة بدون تربة خاصة الزراعة الهوائية والمائية والتي توفر في كمية المياه المستخدمة للري ، مساحة الأرض و تعطي إنتاجية أكبر.

في هذه الدراسة نحاول أن نجد حلولا" لمشاكل نقص المياه وتقليل استيراد تقاوي البطاطس وإنتاجها محلياً .

وتهدف هذه الدراسة إلي :

1. دراسة بعض العوامل الهندسية المؤثرة علي نظام الري والزراعة المائية والهوائية.
2. حساب كفاءة استخدام المياه.
3. مقارنة بين الإنتاج وعدد الدرنات الناتجة في كل نظام.
4. حساب التكاليف الكلية لوحدة المتر المربع.

وقد أجريت التجربة بالشركة الوطنية للزراعات المحمية بقطاع محمد نجيب الزراعي – مصر في الفترة من 2019/2/15 حتي 2019 /6/1 ومن 2019/9/15 حتي 2020/1/1 لدراسة بعض العوامل الهندسية المؤثرة علي نظام الري في الزراعة الهوائية لإنتاج تقاوي البطاطس.
وتم اختيار ثلاثة أنواع من الفوهات ذات تصرفات مختلفة لنظامي الري بالرش والري بالتنقيط .
وتمت الزراعة علي ثلاثة مسافات مختلفة وهم (10 سم ، 15 سم و 20 سم).
تمت الزراعة في كثافات نباتية مختلفة (60 ، 80 و 100 درنة / م^2)

وكانت أفضل النتائج كالتالي:

- وكانت أفضل النتائج المتحصل عليها هي لنظام الزراعة الهوائية عند مسافة 15 سم وتصرف 1.2 لتر/س وعند ضغط تشغيل (2 بار) وعند كثافة 100 نباتية micro-tuber و الصغيرة mini-tuber (610 ، 500) علي التوالي درنة لكل متر مربع. حيث كانت الإنتاجية للدرنات الصغيرة جدا درنة لكل متر مربع وذلك مقارنة بنظام الزراعة المائية.
- وأخيرا تم حساب التكلفة الكلية لنظام الزراعة الهوائية والزراعة بدون تربة (الهيدروبونيك) لوحدة المتر المربع وكانت إجمالي التكلفة 195 جنيه / م^2/ سنة للدرنات الصغيرة جدا micro-tuber و 203 جنيه/ م^2/ للدرنات الصغيرة / سنة لنظام الزراعة الهوائية عند أفضل معاملة 1,2 لتر /س وعند كثافة نباتية 100 درنة /متر مربع و 211 جنيه / م^2 / سنة للدرنات الصغيرة جدا و 260 جنيه / م^2/ عند للدرنات الصغيرة mini-tuber لنظام الهيدروبونيك عند 1,8 لتر / س عند كثافة نباتية 100 درنة / متر مربع.