RESPONSE OF GROWTH, PRODUCTIVITY AND ECONOMIC POTENTIAL OF CULTIVATED PUMPKIN PLANTS SUBSTRATE CULTURE

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Abstract

Growth, productivity and quality of pumpkin plants (*Cucurbita maxima*), in three substrates (mixture of peat moss and perlite (50%: 50% v/v), mixture of sand and rice husk (50% : 50% v/v) and Sand) were tested during 2015 and 2016 seasons. Economic evaluation of productivity in each tested substrates was measured. Results indicated that, sand enhanced significantly both growth and productivity followed by the mixture of sand and rice husk. However, the lowest growth and productivity were obtained when using the mixture of Peat moss and perlite. Economic evaluation confirmed the value of using sand as agriculture substrate for producing pumpkin plants.

Key words: Pumpkin (*Cucurbita maxima*), substrate cultures, economic evaluation, substrate temperature

INTRODUCTION

Pumpkin is commonly refers to cultivars of any one of the species *Cucurbita pepo*, *Cucurbita mixta*, *Cucurbita maxima* and *Cucurbita moschata* (Rubatzky and Yamaguchi, 1999). In addition, *Cucurbita maxima* is gourd-like squash belongs to genus Cucurbita and the family Cucurbitaceae (Muruganantham *et al.*, 2016).

The nutritional value of pumpkin fruits is high, but varies depending on species and cultivars. The flesh is tasty and valuable containing a lot of biological materials. It contains a lot of mineral materials, vitamins, particularly vitamin "A", pro-vitamin β-carotene, ascorbic acid and vitamins B1, B2, B6 and E. In addition, it contains carbohydrates with high amounts of starch and sugars. Amount of sugars in pumpkins strongly depends on climatic conditions (average amount is 5–6 %). Better understanding of genotype and environment interaction will help to optimize yield and quality of crops.

In Egypt, about 256 feddan was cultivated with pumpkin during the year 2015. This area produces about 1808 ton, with an average production of about 7,100 ton/feddan (bulletin of agricultural economics 2015).

Recently, human population is increasing continuouslycreating an urgent need for higher vegetable production all the year round. Therefore, sustainable development is required to response to this demand (Maloupa, 2000). Such needed sustainability is conjoined with the shortage of water resources and arable lands. So, the sustainability is achieved by adaptation of new agricultural practices such as soilless culture.

Soilless culture covers all methods and systems of production tools using nutritional solution with different substrates that support plants instead of soil (Butt *et al.,* 2004; Sheikh, 2006; Gruda, 2009).

Substrate culture is the cultivation of crops in media except soil. Using both of substrates or soilless culture, as a system to produce horticulture crops, is increasing worldwide. Substrates often increase plant growth and yield in many crops (Raviv *et al*., 2002; Barcelos *et al*., 2016; Gruda, 2009).

Despite these many benefits, there is currently very little information available concerning the influence of substrate type on plant growth and nutrient uptake in many crops. Many artificial media or mixtures between any of these media have been used as substrates for soilless culture, of which the most popular are peat, perlite, vermiculate, sand, and mixtures of the above.

The objectives of this study are:

1-To determine the effect of different type of substrates on growth, yield and quality of pumpkin crop.

2- To test the economic potential of cultivating the pumpkin in substrate culture with special attention for the determination of the most economical substrates among the tested ones.

MATERIALS AND METHODS

Investigation was carried out in Dokki Protected Cultivation Experimental site, Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center (ARC), Ministry of Agriculture and Land Reclamation.

In this study three types of substrate were used as follow:

1- Sand,
2- Mixture of peat moss and perlite and
3- Mixture of sand and Rice husk in proportion of 50%: 50% v/v.

Seedlings of Pumpkin (*Cucurbita maxima*, Baladi Varity) were transplanted, in thirty litter pots filled with the tested substrate, on 1/3/2015 and 10/3/2016.

Nutrient solution for the plants was adapted from Cooper solution (Cooper, 1979) depending on the analysis of the local water (El-Behairy, 1994). The desired initial concentration of the nutrient solution was maintained by suitable dilution of the stock solutions with tap water. Electrical conductivity (EC) of the nutrient solution was maintained between (2–2.2) m. $mhos^{-1}$ and pH maintained between (6 - 6.5).

Data regarding vegetative growth and crop yield were collected as follow: plant height (cm), number of leaves, and Leaf area after 30, 60 and 90 days from transplanting. Moreover, plant dry weights (g) were measured at the end of each growing season. In addition, fruit weight (g/plant) and number were counted all over the season.

Maximum and minimum air temperatures recorded daily using a digital thermometer Art.No.30.5000/30.5002 (Produced by TFA, Germany). The results were calculated and presented as a 10 days average (Figures 1 and 2).

All treatments were arranged in randomized complete blocks with three replications. Obtained data were statistically analyzed using the analysis of variance method. L.S.D. tests at 5% level of probability were used to compare means of the treatments. Finally, economic indicators were used to provide economic and environmental evaluation for this experiment.

RESULTS AND DISCUSSION

Substrate temperature:

Data in Figures (1 and 2) indicated that, the three tested substrates recorded low temperatures comparing to the air temperature during both studied seasons. In addition, it was considerable from the data in Figures (1 and 2) that, sand as a substrate recorded highest temperature followed by mixture of sand and rice husk (50% : 50% v/v). On the other hand, the lowest substrate temperature was found in mixture of Peat moss and perlite. The same temperature profile was confirmed during seasons of 2015 and 2016.

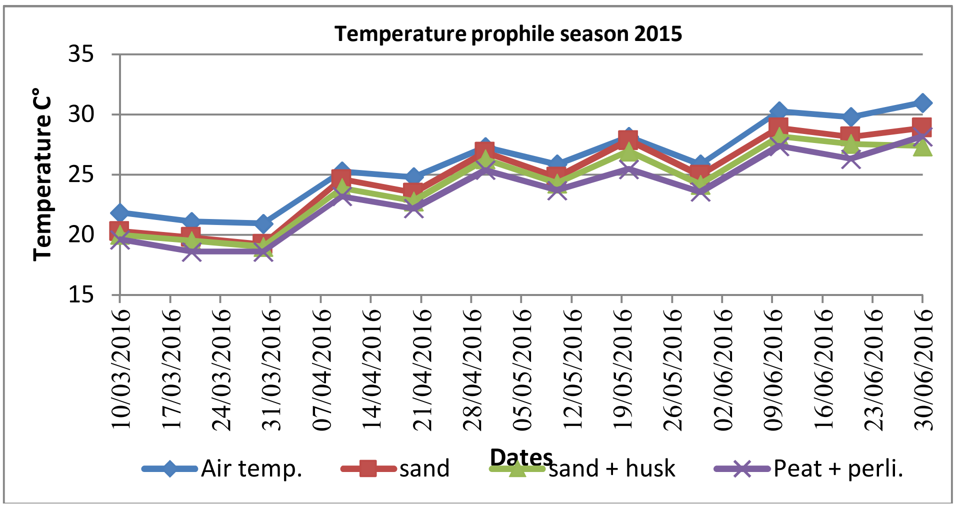

Fig. 1. Air and substrate temperature during 2015.

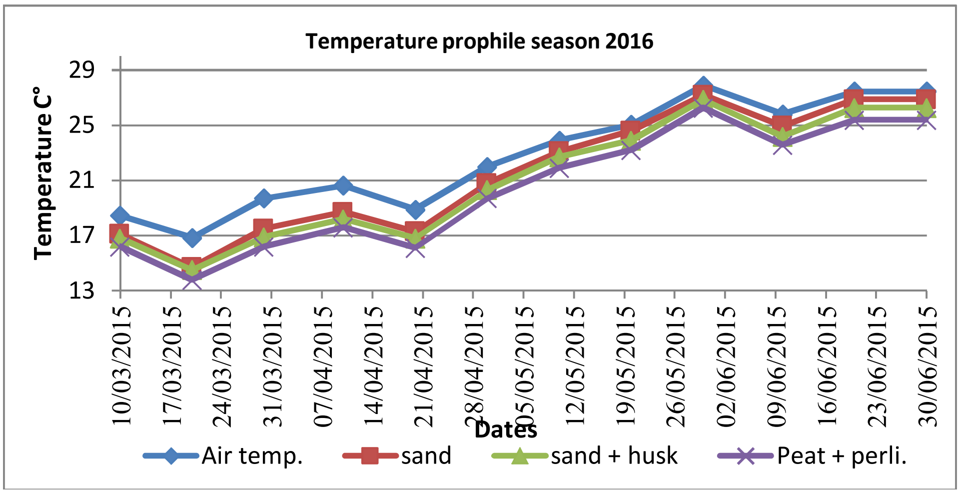

Fig. 2. Air and substrate temperature during 2016.

Plant height:

Data in Table (1) shown the effect of substrate type on plant height after 30, 60 and 90 days from transplanting. Increasing plant height obtained with sand growing media through all experimental periods. Also, the reduction of plant height recorded with Peat + perlite at 30, 60 and 90 days from transplanting. Moreover, the two substrates, sand + husk and Peat + perlite, gave the lowest plant heights, without any significant differences after 60 days. Similar trends were found for both growing seasons. These results are in harmony with Hadda *et al.,* (2003) and Haddad (2007) who mentioned that plants gave faster growth by using sand compared to other substrate.

Number of leaves:

Data in Table (1) indicated that plants cultivated in sand media recorded the highest value of leaves number followed by sand + husk media after 30, 60 and 90 days from transplanting. Low leaves number were observed with plants cultivated in Peat + perlite after 30, 60 and 90 days from transplanting. On the other hand, there were no significant differences between growing media sand + husk and Peat + perlite after 30, 60 and 90 and 60 and 90 days from transplanting at first and second seasons, respectively. These results were true in first and second seasons. The obtained results are not in harmony with Barcelos *et al*. 2016.

Leaf area:

Table (1) showed that leaf area increased when plants cultivated in sand media followed by sand + husk media. Whereas, plants cultivated in Peat + perlite leaf area decreased. The same trend found in both seasons. The obtained results coincided with Radhouani *et al.* 2011.

Table 1. Response of pumpkin plant height, number of leaves and leaf area to cultivated in substrate culture during seasons of 2015 and 2016.

Treatments	Plant height (cm)			Number of leaves			Leaf area		
	First season								
	30	60	90	30	60	90	30	60	90
Peat + perlite	169.0	182.0	189.7	24.7	29.7	31.0	83.3	85.7	84.7
Sand + husk	182.0	196.0	204.0	26.3	30.3	32.0	151.7	154.3	153.3
Sand	199.0	215.0	225.0	30.7	35.7	38.3	184.0	186.7	185.7
L. S. D. at 5%	5.32	15.5	6.91	2.32	1.6	1.53	7.24	6.5	6.50
	Second season								
Peat + perlite	176.0	189.0	194.7	28.0	32.7	34.3	85.0	86.3	85.3
Sand + husk	187.0	202.0	208.7	31.0	33.3	36.0	152.7	155.0	154.3
Sand	205.0	223.0	231.0	34.3	40.0	41.3	185.3	187.0	186.3
L. S. D. at 5%	5.59	11.45	6.26	1.53	2.84	3.74	8.28	6.38	6.15

Dray weight:

Table (2) showed that sand media gave the high value of dray weight followed by sand + husk media, after 30, 60 and 90 days from transplanting. While, Peat + perlite substrate reduced dray weight value at the same days. This trend was true in both growing seasons. The obtained results are not in harmony with Barcelos *et al.,* 2016. He indicated that plants grown in peat had greater dry weight than those grown in other substrates.

Table 2. Response of pumpkin dry weight to cultivated in substrate culture during 2015 and 2016 seasons.

Treatments	Dray weight (g)		
	First season		
	30	60	90
Peat + perlite	114.7	125.7	131.3
Sand + husk	136.3	147.3	153.0
Sand	154.3	168.7	173.0
L. S. D. at 5%	6.69	7.40	5.84
	Second season		
Peat + perlite	116.7	128.0	133.7
Sand + husk	138.7	150.3	156.0
Sand	157.0	172.0	176.3
L. S. D. at 5%	6.65	6.18	3.95

Chemical components of leaf:

Results in Table (3) indicated that there was no significant effect for growing media type on leaf contents (total chlorophyll, total carotenoids and free proline) after 60 days from transplanting. This was held true in both seasons. Although, data in Table (3) showed the leaf contents of N, P and K were affected by type of cultivation media. Plants which cultivated at sand media increased the percentage of N, P and K in leaf. In addition, there were insignificant differences at P and K content in leaf between sand and sand + husk growing media, respectively, in second season. However, growing substrate, Peat + perlite, showed low leaf content of N, P and K. Moreover, in second season, no significant differences noticed between sand + husk and Peat + perlite substrates on percentage of K in leaf.

Table 3. Response of total chlorophyll, carotenoids, free proline, nitrogen, phosphorus and potassium content in pumpkin plants grown in substrate culture at 2015 and 2016 seasons.

Treatments	Total chlorophyll mg/g	Total carotenoids mg/g	Free proline ($\mu g\ g^{-1}$ DW)	N (mg/g)	P (mg/g)	K (mg/g)
	First season					
Peat + perlite	1.35	0.59	23.69	21.17	3.23	28.65
Sand + husk	1.39	0.61	23.92	25.20	4.03	30.09
Sand	1.36	0.59	24.04	28.23	4.53	31.15
L. S. D. at 5%	N.S	N.S	N.S	0.65	0.17	0.34
	Second season					
Peat + perlite	1.41	0.60	23.82	21.4	3.4	28.5
Sand + husk	1.45	0.63	24.27	24.8	3.9	30.0
Sand	1.37	0.61	24.14	27.3	4.3	31.4
L. S. D. at 5%	N.S	N.S	N.S	0.50	0.42	1.55

Yield and its components:

Data in Table (4) presented the effect of tested growing media on yield and its components. It was noticed that all tasted parameters, especially, fruit yield in the two growing seasons were increased with cultivated plants in sand media. Plants cultivated in Peat + perlite media gave the lowest values for those parameters. Similar results were recorded for both seasons. These results are coincided with the finding of Radhouani *et al*. (2011). He found that local grown media (sand) has revealed promising performance: plants grew faster, produced earlier and formed more fruits with marketable yields.

Total yield highest productivity was obtained when plants were cultivated in sand growing media. This could be attributed to the most favorable effect of this treatment on plant growth and uptake of the nutritional elements as mentioned in Table (4).

Table 4. Effect of substrate culture on pumpkin yield and its characteristics during 2015 and 2016 seasons.

Treatments	Fruit length	Fruit diameter	Average fruit weight	Fruit yield (ton/feddan)	T.S.S
	First season				
Peat + perlite	19.50	14.53	3.57	17.66	5.03
Sand + husk	23.57	15.95	4.27	20.50	5.77
Sand	25.50	17.20	4.88	22.73	6.20
L. S. D. at 5%	1.51	1.44	0.34	2.79	0.58
	Second season				
Peat + perlite	19.3	14.6	3.2	17.02	5.23
Sand + husk	24.1	16.3	4.2	20.07	5.90
Sand	25.6	17.6	4.8	22.18	6.17
L. S. D. at 5%	2.24	0.98	0.77	1.41	0.51

Economic evaluation:

Table (5) showed the fixed costs for producing the crop of pumpkin. Investment costs listed as: pump, cable of power, drip irrigation system, pots and timer were 800 pounds, 75 pounds, 250 pounds, 610 pounds, 750 pounds and 120, pounds, respectively.

The total fixed costs were 2605 pounds and the percentage of each item was 30.71%, 2.88%, 9.60%, 23.42%, 28.79% and 4.61% of the total costs and at the same order. The table also distributed the cost of each item on its working life years to illustrate the fixed costs of each item per year in the form of installment depreciation, which were 266.67 pounds for the pump, 15 pounds for the power cable, 83.33 pounds for the tank, 203.33 pounds for the irrigation system, 250 pounds for the pots and 40 pounds for the timer. The total installment of depreciation was 858.33 pounds for each year

Table 5. Fixed costs for the cultivation of the pumpkin crop using different substrate type at 2015 and 2016 seasons.

Items	Investment cost (pound)	Investment cost total (%)	Working life	Cost/year (installment depreciation)	Investment costs yearly total (%)
Pump	800	30.7	3	266.67	31.1
Power cord	75	2.9	5	15.00	1.7
Tanks	250	9.6	3	83.33	9.7
Drip irrigation system	610	23.4	3	203.33	23.7
Pots	750	28.8	3	250.00	29.1
Timer	120	4.6	3	40.00	4.7
Total fixed costs	2605	100.0	---	858.33	100.0

Data in Table (6) showed the variable costs of pumpkin crop. The variable costs items were seed, nutrient solution, substrates (sand, peat moss and perlite, and sand + husk) power, insecticides, workers, harvest and interest of capital 10%, where each item costs 20 pounds, 240 pounds, (100 pounds, 1840 pounds and 75 pounds) 50 pounds, 40 pounds, 200 pounds, 75 pounds and (70 pounds, 246.5 pounds and 70 pounds) respectively. The total operating costs were (730 pounds, 2218.5 pounds and 630 pounds) The percentage of variable costs in ascending order were presented in Table (6).

Table 6. Variable costs for the cultivation of the pumpkin crop using different type's substrate type at 2015 and 2016 seasons.

Items	Costs					
	Peat + perlite	%	Sand + husk	%	Sand	%
Seed	20	0.9	20	3.2	20	2.7
Nutrient solution	240	10.8	240	38.1	240	32.9
substrate	1840	82.9	75	11.9	100	13.7
Power	50	2.3	50	7.9	50	6.8
Insecticides	40	1.8	40	6.3	40	5.5
Workers	200	9.0	200	31.7	200	27.4
Harvest	75	3.4	75	11.9	75	10.3
Interest at the capital 10%	246.5	11.1	70	11.1	70	9.6
Total costs	2218.5	100.0	630	100.0	730	100.0

As showed in Table (7) in the first season the amount of production after 5% losses from sand, peat moss + perlite and sand + husk were 1900, 1425 and 1140 Kg/feddan, respectively, and the total revenue of each item was 4750, 3562.5 and 2850 pounds at the same order. While net return reached about 2527.67 pound for sand, 1340.17 pounds for peat moss + perlite and 627.67 pounds for sand + husk. The rate of return for each pound on sand, peat moss + perlite and sand + husk were 1.85, 11.43, 0.46, respectively. At the same time the rate of return on invested pound were 113.74, 701.52 and 28.24 at the same order.

In the second season, the situation changed where the amount of production after 5% losses from sand decreased to about 1852.5 Kg/ feddan, also, peat moss + perlite decreased to 1306.25 Kg/ feddan comparing with the first season. At the same time the amount of production after losses 5% from "sand + husk" increased to 1187.5 Kg/ feddan. Consequently, the total revenue for the three items sand, "peat moss + perlite and sand + husk reached about 4631.2, 3265.6 and 2968.75 pounds respectively, and net return was 2408.92, 1043.29 and 746.42 pounds at the same order. The rate of return for each pound for sand, peat moss + perlite and sand + husk reached about 1.77, 11.43 and 0.46, respectively, main while the rate of return on the pound invested was 108.40, 46.95 and 33.59 at the same order.

Table 7. Total revenue and net return productivity of pumpkin crop at 2015 and 2016 seasons.

Items	Plant life	production quantity /kg/feddan	Losses 5%	After the amount of production losses	price/Revenues	Total cost	Net return	The rate of return for each pound	The rate of return on the pound invested
First season									
Sand	March 15 to July 15	2000	100	1900	4750	2222.33	2527.67	1.85	113.74
Peat moss + perlite		1500	75	1425	3562.5		1340.17	11.43	701.52
Sand + husk		1200	60	1140	2850		627.67	0.46	28.24
Second season									
Sand	March 15 to July 15	1950	97.5	1852.5	4631.2	2222.33	2408.92	1.77	108.40
Peat moss + perlite		1375	68.7	1306.25	3265.6		1043.29	11.43	46.95
Sand+husk		1250	62.5	1187.5	2968.75		746.42	0.46	33.59

CONCLUSION

Sand was the highest substrate to save temperature compared to other studied substrates. However, mixture of peat moss + perlite was the lowest substrate temperature. Moreover, cultivating pumpkin plants in sand substrate enhanced generally vegetative growth and yield and its components. In addition, sand substrate was the ranked first in enhanced the nitrogen, phosphorus and potassium contents. Finally, ability of sand substrate to increase the growth and productivity of pumpkin plants was assured through the economic study. Whereas, sand substrate presented the highest net return, highest rate of return for each pound and highest rate of return for each invested pound.

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إستجابه النمو والإنتاجية والتقييم الإقتصادي لنباتات القرع العسلي للزراعة بنظام البيئات

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المعمل المركزي للمناخ الزراعي-مركز البحوث الزراعية

يعتبر محصول القرع العسلي (*Cucurbita maxima*) أحد أشهر نباتات العائلة القرعية. وبالرغم من ذلك فإنه لم يلق الأهتمام الكافي لدراسه مدي نجاحه في النمو وكمية الإنتاج في حال زراعته بنظام الزراعة في البيئات.

أجريت هذه التجربة خلال موسمي ٢٠١٥ و٢٠١٦ بموقع المعمل المركزي للمناخ الزراعي-الجيزة-مصر لدراسة إستجابه نمو، إنتاجية وجودة محصول القرع العسلي للزراعه بنظام البيئات. بالإضافة إلي عمل تقييم إقتصادي للنتائج المتحصل عليها، للوقوف علي أفضل البيئات من حيث الربحية. استخدام ثلاثة بيئات لزراعة القرع العسلي كما يلي: (١) الرمل – (٢) خليط من الرمل وسرسة الأرز بنسبه ٥٠% :٥٠% حجماً – (٣) بيت موس وبيرليت بنسبه ٥٠% :٥٠% حجماً.

أوضحت النتائج حدوث زيادة معنوية في كل من نمو وإنتاجية محصول القرع العسلي المنزرع في بيئة الرمل يلية في الترتيب نباتات القرع العسلي المنزرعة في بيئة خليط من الرمل وسرسه الأرز. بينما تم تسجيل أقل القيم المعنوية للنمو والإنتاجية في النباتات المنزرعة في بيئة خليط من البيت موس والبيرليت.

هذا وقد أكدت نتائج التقييم الإقتصادي المردود الإقتصادي المرتفع لزراعة نباتات القرع العسلي في بيئة الرمل.