Middle East Journal of Agriculture Research
Volume: 11 | Issue: 04| Oct. – Dec.| 2022

EISSN: 2706-7955 ISSN: 2077-4605
DOI: 10.36632/mejar/2022.11.4.90
Journal homepage: www.curresweb.com
Pages: 1334-1345

Effect of Substrate Type and Fertilizing Management Programs on Yield and Nitrate Content of Both Molokhia and Spinach Grown on Rooftops in Egypt

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Received: 25 Oct. 2022 **Accepted:** 10 Dec. 2022 **Published:** 25 Dec. 2022

ABSTRACT

leafy vegetables like molokhia and spinach are very popular vegetable crops for egyptian and known for it's high values in vitamins and nutients. For that, two experiments have been conducted (one experiment for molokhia and the second one for spinach) to invistigate the effect of substrate type and fertilizing management programs on yield and nitrate content of both molokhia and spinach grown on rooftops in Egypt. The two experiments have been conducted in the rooftop garden of Central Laboratory for Agricultural Climate (CLAC), Agriculture Research Center, Ministry of Agriculture and Land Reclamation, Dokki, Giza, Egypt, during seasons of 2020 and 2021; summer seasons for molokhia and winter seasons for spinach. Two factors have been tested in both experiments; first factor was substrate type (50% perlite: 50% peat moss "S1" and 80% sand: 20% compost "S2") and the second factor was the fertilizing management programs (chemical nutrient solution whole season "CNS", chemical nutrient solution then compost tea for 5 days before harvest "CNS+5", chemical nutrient solution then compost tea for 10 days before harvest "CNS+10" and organic nutrient solution whole season “compost tea”"CT"). Results indicated the following: regarding the effect of substrate type, S1 could be cosidered the more suitable substrate for producing both molokhia and spinach with high yield and growth parameters. Regarding the effect of fertilizing management programs, CNS recorded higher yield and growth parmeters followed by CNS+5. On the other hand, CNS+5 recorded lower nitrate values than CNS. From the above mentioned results it could be sumarize that inspite of CNS recorded the highist yield values but if we put nitrate content in consideration, the interaction between S1 and CNS+5 could be the most suitable formula between substrate type and fertilizing management programs for producing both molokhia and spinach with high yield and lower nitrate accumaltion than using the standerd chemical solution only the whole production season.

Keywords: Molokhia, Spinach, rooftop gardens, fertilizing programs, substrates.

1. Introduction

Rooftop garden as one of urban cultivation methods can contribute to food security, food consumption, diet composition, food diversity and nutritional status through increased direct access to locally produced food, increased freshness and diversity of available food, and job creation. Rooftop garden allow the possibility to use vacant spaces on roofs to provide simple jobs and increase income for different groups of urban dwellers, whether they are poor, landless, homemakers, retirees, or wealthy (FAO, 2012).

Leafy vegetables are important crops in human diet and play a great role in the nutrients and minerals supply. Yield and nutrition values of these crops were affected by the agricultural practices. One of these leading factors is fertilization. A wrong fertilization for leafy vegetables can produce a nitrate excess in the leaves. Nitrate itself non-toxic, but its metabolites may produce a number of negative health effects (Santamaria, 2006).

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Molokhia (*Corchorus olitorius*) is highly nutritious plant that originated in Egypt, but has since spread throughout the Mediterranean and Middle Eastern region, and is just beginning to appear in western markets, particularly exotic import stores. Both leaves and young pods are edible and somewhat mucilaginous. They can be used in a wide variety of cooked dishes as well as eaten raw in salads or smoothies. There are more than 30 vitamins, minerals, and trace minerals in molokhia, as well as certain organic compounds that significantly contribute to human health. Some of the most prominent nutritional components of molokhia include fiber, potassium, iron, calcium, magnesium, phosphorous, and selenium, as well as vitamin C, E, K, B_6, A, and niacin. It also contains certain antioxidant carotenes and antioxidant elements, making a well-rounded and highly beneficial addition to human diet (Holm *et al.,* 1997; Abul-Soud and Mancy, 2015).

Spinach (*Spinacia oleracea* L.) is an annual leafy popular winter vegetable crop grown in Egypt. Spinach is one of the most important and nutritious leafy vegetable that eaten raw or cooked. It's considered as one of healthy vegetable crops for human consumption. Spinach is rich in B6, riboflavin, folate, niacin, soluble dietary fiber, omega-3 and minerals. Spinach is also rich with iron; its use prevents some diseases like osteoporosis, anemia that results of iron deficiency (Toledo *et al*., 2003 and Patricia, 2014). The disadvantage of spinach it's capable to accumulate some unfavorable compounds like nitrate with a high quantity (Wang *et al.,* 2002 and Jaworska, 2005). These compounds unfavorable for their hazard effect on human health (Salunkhe and Kadam, 1998). Moreover, Dehkharghanian *et al*.و (2010) mentioned that spinach has been likewise recognized as one of the vegetables having innately high nitrate fixation and its petioles have a few fold higher concentration than its leaf blades.

Nitrate is essential to life but a nuisance and possibly a hazard. Nitrate can be changed into nitrite by microbes requiring oxygen. This can happen in the soil, in water and in our bodies. When that happen in our bodies we have to consider two problems methaemoglobinaemia or the blue syndrome and stomach cancer. NO_3 - ions in the soil usually complexes with the production of some pesticides degradation like amino compounds to produce nitrosamine compounds were carcinogenic to human and animals (FAO, 2000).

Therefore, the objective of this work is to investigate the effect of substrate type and fertilizing management programs on yield and nitrate content of both molokhia and spinach grown on rooftops in Egypt

2. Materials and Methods

The work of this study was consisted of two experiments, the two experiments have been conducted at the rooftop garden of the Central Laboratory for Agricultural Climate (CLAC), Agriculture Research Center (ARC), Dokki, Giza, Egypt, during seasons of 2020 and 2021.

Plant material and date of cultivation

First experiment

- Molokhia (*Corchorus olitorius*).
- Cultivated with direct seeds in the first of May 2020 and 2021 respectively in bed system that placed on rooftop.

Second experiment

- Spinach (*Spinacia oleracea*).
- Cultivated with direct seeds in the middle of October 2020 and 2021 respectively in bed system that placed on rooftop.

Description of bed system

The bed system used in both experiments was described by Metwally, (2015) as follow; bed system consisted of wooden table (100cm length, 100cm width, and 10cm depth) and height of table legs was about 60cm from roof floor. The entire depth of the tables have been padded with black polyethylene sheets 0.7mm in thickness and equipped with drainage tube in one side, under this tube, a plastic tank have been put under each table to collect the excess irrigation water. The entire depth of the previous described beds has been filled with 100L of substrate.

Treatments

Two factors have been tested in both experiments in relation to growth and production of molokhia and spinach . The tested factors were as follow:

Factor (A): type of substrate

1. 50% perlite: 50% peat moss **(S1)**.
2. 80% sand: 20% compost **(S2)**.

Factor (B): fertilizing management programs.

1. Chemical nutrient solution whole season(**CNS**).
2. Chemical nutrient solution then compost tea for 5 days before harvest **(CNS+5)**.
3. Chemical nutrient solution then compost tea for 10 days before harvest (**CNS+10**).
4. Organic nutrient solution whole season "compost tea" **(CT**).

Table 1: Substrates physical properties.

Substrate type	Physical properties			
	B.D (Kg/m^3)	T.P.S %	W.H.C %	A.P %
50% perlite: 50% peat moss (S1).	0.140	65.2	52.8	12.5
80% sand: 20% compost (S2).	1.44	35.6	27.5	8.1

Bulk density (B.D). Total pore space (T.P.S).Water holding capacity (W.H.C).Air porosity (A.P).

Table 2: Composition of chemical nutrient solution and compost tea.

Type of nutrient solution	Macro nutrients (ppm)					Micro nutrients (ppm)						
	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Pb	Cd
Compost tea	83	70	140	50	16	0.63	0.02	0.02	0.02	0.11	0.01	n.d
Chemical	200	45	350	180	50	3.00	1.00	0.06	0.10	0.25	0.16	0.01

In both experiments, a drip irrigation system have been used to deliver irrigation water and fertilizers to beds then a slope about 1% have been made for collecting the drained water and fertilizers and return it back to the catchment tank under tables through drainage tube. In addition, the electrical conductivity (EC) for chemical nutrient solution and compost tea were adjusted at the range of 1.8 - 2.0 m. $mhos^2$ using a digital EC meter.

Measurements

Different measurments have been recorded in both experiments as follow:

- Plant height (cm).
- Number of leaves /plant.
- Fresh weight (g/plant).
- Dry weight (g/plant).
- Yield (kg/m^2).
- Nitrate content in leaves (ppm).
- Chlorophyll content in leaves (SPAD).
- Nitrogen percentage in leaves (%).
- Phosphorus percentage in leaves (%).
- Potassium percentage in leaves (%).

Nitrogen, phosphorus and potassium % in leaves were measured using methods described by A.O.A.C., (1990). Nitrate was determined according to Chapman and Pratt, (1982).

Experimental design and statistical analysis

Both experiments were arranged in split plot design with three replicates. The type of the substrates was arranged in the main plots, while fertilizing management programs were arranged in sub plots. Data were statistically analyzed using the analysis of variance method one way ANOVA with SAS package software version 6 (SAS Institute, 1990). The Dunkun's test was used to compare among means.

3. Results

3.1. Molokhia experiment

Table (3) illustrates the effect of substrate type and fertilizing management programs on plant height and number of leaves of molokhia grown on rooftops.

Regarding the effect of substrate type on plant height and number of leaves of molokhia, data in both seasons indicated that S1 recorded higher values than S2 with significant difference between both of them.

Regarding the effect of fertilizing management programs on plant height and number of leaves, data from first season illustrated that CNS recorded the highest plant height values followed by CNS+5, then CNS+10 and finally CT recorded the lowest values. There were no significant differences among CNS, CNS+5, and CNS+10. But there was significant difference between (CNS, CNS+5, CNS+10) and CT. Similar trend was observed in the second season except that the difference between CNS and CNS+5 was significant.

Regarding the effect of interaction between substrate type and fertilizing management programs on both plant height and number of leaves of molokhia, data collected from both seasons illustrated that (S1&CNS) recorded the highest values followed by (S1&CNS+5) without significant difference between them. On the other hand, (S2&CT) recorded the lowest values.

Table 3: Effect of substrate type and fertilizing management programs on plant height and number of leaves of molokhia grown on rooftops during summer seasons of 2020 and 2021.

Sub.	First season (2020)					Second season (2021)				
	Fertilizing management programs									
	CNS	**CNS+5**	**CNS+10**	**CT**	**Mean**	**CNS**	**CNS+5**	**CNS+10**	**CT**	**Mean**
					Plant height (cm)					
S1	39.3 a	37.8 ab	36.9 ab	31.7d	**36.4 A**	37.5 a	36.7 ab	35.2bc	28.7d	**34.5 A**
S2	35.2bc	33.2cd	32.9 cd	26.5e	**31.9 B**	35.0 bc	33.3c	33.4c	26.6e	**32.1 B**
Mean	**37.3 A**	**35.5 A**	**34.9A**	**29.1B**		**36.3 A**	**35.0 B**	**34.3 B**	**27.7 C**	
					No. of leaves /plant					
S1	14.0 a	13.3 ab	12.7b	9.3 d	**12.3 A**	13.7 a	13.3 a	12.3b	9.7cd	**12.3 A**
S2	12.7b	12.7b	11.0 c	8.0e	**11.1 B**	12.3b	12.1b	10.7c	9.3d	**11.2B**
Mean	**13.3 A**	**12.8 A**	**12.2 A**	**8.7 B**		**13.4 A**	**12.5 A**	**11.2A**	**7.8B**	

Table (4) illustrates the effect of substrate type and fertilizing management programs on fresh and dry weights of molokhia grown on rooftops.

Regarding the effect of substrate type on both fresh and dry weights per plant, data collected from both seasons indicated that S1 recorded higher values than S2, and there was significant difference between both of them.

Regarding the effect of fertilizing management programs on fresh weight, data from both seasons showed that the highest values were obtained from CNS followed by CNS+5, CNS+10 and CT respectively. Furthermore, differences among treatments were significant except between CNS+5 and CNS+10.

Concerning the effect on dry weight, data from first season indicated that CNS recorded the highest values followed by CNS+5, CNS+10 respectively, and then CT recorded the lowest values. Moreover, data showed that there were no significant differences among (CNS, CNS+5 and CNS+10). On the other hand, the difference between (CNS, CNS+5, CNS+10) and CT was significant. Similar trends were observed in the second season.

Regarding the effect of interaction on fresh weight, data from first season clarified that (S1&CNS) recorded the highest values followed by (S1&CNS+5) with significant difference between both of them. On the contrary, (S2&CT) recorded the lowest values. Similar trend was observed in the second season.

Concerning the effect on dry weight, data from both seasons indicated that, (S1&CNS) recorded the highest values followed by (S1&CNS+5) without significant difference between both of them. On the other hand, (S2&CT) recorded the lowest dry weight values.

Table 4: Effect of substrate type and fertilizing management programs on fresh and dry weights of molokhia grown on rooftops during summer seasons of 2020 and 2021.

Sub.	First season (2020)					Second season (2021)				
	Fertilizing management programs									
	CNS	CNS+5	CNS+10	CT	Mean	CNS	CNS+5	CNS+10	CT	Mean
	Fresh weight (g/plant)									
S1	28.1 a	26.7 b	26.0 bc	22.9 e	**25.9 A**	30.4 a	28.2 b	27.3b	23.2d	**27.3 A**
S2	25.cd	23.9de	23.8de	21.0 f	**23.4 B**	27.9 b	25.9 c	24.9 c	22.7 d	**25.4 B**
Mean	**26.6 A**	**25.3 B**	**24.9 B**	**21.9 C**		**29.2 A**	**27.6 B**	**26.1 B**	**22.9 C**	
	Dry weight (g/plant)									
S1	4.82 a	4.79 a	4.78 ab	4.66 b	**4.76A**	5.78 a	5.67 a	5.64 a	5.23b	**5.58A**
S2	4.39 c	4.38 c	4.36 c	4.16 d	**4.32B**	5.20 b	5.14 b	5.01c	4.83c	**5.04B**
Mean	**4.61A**	**4.59A**	**4.57A**	**4.41B**		**5.49A**	**5.40A**	**5.32A**	**5.03B**	

Table (5) illustrates the effect of substrate type and fertilizing management programs on yield per m^2 of molokhia grown on rooftops.

Regarding the effect of substrate type, from both seasons showed that S1 recorded higher yield values than S2, and the difference between both of them was significant.

Regarding the effect of fertilizing management, data from first season showed that the highest yield values were obtained from CNS followed by CNS+5, CNS+10 and CT respectively. Furthermore, differences among treatments were significant except the difference between CNS+5 and CNS+10 was not significant. Similar trend was observed in the second season, except there were significant differences among treatments.

Regarding the effect of interaction, data in both seasons indicated that (S1&CNS) recorded the highest yield values followed by (S1&CNS+5). On the other hand, (S2&CT) recorded the lowest yield values.

Table 5: Effect of substrate type and fertilizing management programs on yield of molokhia grown on rooftops during summer seasons of 2020 and 2021.

Sub.	First season (2020)					Second season (2021)				
	Fertilizing management programs									
	CNS	CNS+5	CNS+10	CT	Mean	CNS	CNS+5	CNS+10	CT	Mean
	Yield (kg/m^2)									
S1	3.76 a	3.25 b	3.13 b	2.18de	**3.08 A**	3.95 a	3.76 a	2.70 b	2.26e	**3.17 A**
S2	2.53c	2.**43**c	2.39cd	2.04e	**2.35 B**	2.75 b	2.57bc	2.49 d	2.23e	**2.51 B**
Mean	**3.14 A**	**2.84 B**	**2.76 B**	**2.11 C**		**3.35 A**	**3.16 B**	**2.60C**	**2.25D**	

Table (6) illustrates the effect of substrate type and fertilizing management programs on nitrate and chlorophyll content in leaves of molokhia grown on rooftops.

Regarding the effect of substrate type on nitrate content, data collected from both seasons illustrated that S2 recorded lower values than S1 and the difference between both of them was significant.

Concerning the effect on chlorophyll content, data showed that S1 recorded higher values than S2 with significant difference between both of them.

Regarding the effect of fertilizing management programs on nitrate content, data in both seasons indicated that CT recorded the lowest nitrate content followed by CNS+10, CNS+5 and CNS respectively. Differences among treatments were significant except between CNS+5 and CNS+10.

Concerning the effect on chlorophyll content, data in the both seasons indicated that CNS recorded the highest chlorophyll content followed by CNS+5, CNS+10 and finally CT recorded the lowest values. Moreover, differences among treatments were significant except between CNS+5 and CNS+10.

Regarding the effect of interaction on nitrate content, data in the first season indicated that the lowest nitrate values were recorded in (S2&CT) followed by (S1&CT) with significant difference between both of them. On the contrary, (S1&CNS) recorded the highest nitrate values. The same trend was observed in the second season.

Concerning the effect on chlorophyll content, data collected from first season showed that the highest chlorophyll values were recorded in (S1&CNS), while (S1&CT) recorded the lowest values. Similar trend were observed in the second season except the lowest values recorded by (S2&CT).

Table 6: Effect of substrate type and fertilizing management programs on nitrate and chlorophyll contents in molokhia grown on rooftops during summer seasons of 2020 and 2021.

Sub.	First season (2020)					Second season (2021)				
	Fertilizing management programs									
	CNS	CNS+5	CNS+10	CT	Mean	CNS	CNS+5	CNS+10	CT	Mean
	Nitrate content (ppm)									
S1	957.8 a	862.4b	837.4b	715.0c	**843.2A**	973.2 a	829.0c	818.0cd	697.6e	**829.5A**
S2	943.6 a	752.3c	732.2c	642.8d	**767.7B**	902.2 b	791.7 d	782.6 d	641.2f	**779.4B**
Mean	**950.7 A**	**807.3 B**	**784.8 B**	**678.9C**		**937.7 A**	**810.3 B**	**800.3 B**	**669.4C**	
	Chlorophyll content in leaves (SPAD)									
S1	39.6 a	34.6b	34.4b	29.3 d	**34.5 A**	40.7 a	37.1 b	36.4 b	32.5 cd	**36.7 A**
S2	35.7 b	32.3 c	31.7 c	30.7cd	**32.6 B**	34.7c	33.5cd	32.7cd	31.8e	**33.2 B**
Mean	**37.7 A**	**33.5 B**	**33.0 B**	**30.0 C**		**37.7 A**	**35.3 B**	**34.6 B**	**32.1 C**	

Table (7) illustrates the effect of substrate type and fertilizing management programs on (nitrogen, phosphorus and potassium) % in leaves of molokhia grown on rooftops.

Regarding the effect of substrate type on (nitrogen, phosphorus and potassium) % in leaves, data collected from both seasons indicated that S1 recorded higher values than S2 with significant difference between both of them.

Table 7: Effect of substrate type and fertilizing management programs on (nitrogen, phosphorus and potassium) % in leaves of molokhia grown on rooftops during summer seasons of 2020 and 2021.

Sub.	First season (2020)					Second season (2021)				
	Fertilizing management programs									
	CNS	CNS+5	CNS+10	CT	Mean	CNS	CNS+5	CNS+10	CT	Mean
	Nitrogen %									
S1	3.39 a	3.27 ab	3.03bc	2.43 e	**3.03 A**	3.73 a	3.62 a	3.23 b	2.83 cd	**3.35 A**
S2	2.95 c	2.78 cd	2.71 d	2.42 e	**2.72 B**	3.10bc	3.00bc	2.90bcd	2.73 d	**2.93 B**
Mean	**3.17 A**	**3.03 A**	**2.87 B**	**2.43 C**		**3.42 A**	**3.31 A**	**3.07 B**	**2.78 C**	
	Phosphorus %									
S1	0.85 a	0.79 ab	0.74abc	0.59de	**0.74 A**	0.83 a	0.75bc	0.74 c	0.49 d	**0.70 A**
S2	0.72bc	0.70bcd	0.67 cd	0.53 e	**0.66 B**	0.78 b	0.72 c	0.72 c	0.45 e	**0.67 B**
Mean	**0.79 A**	**0.75 AB**	**0.71 B**	**0.56 C**		**0.81 A**	**0.74 B**	**0.73 B**	**0.47 C**	
	Potassium %									
S1	3.31 a	3.01bc	2.90 cd	2.62ef	**2.96 A**	3.55 a	3.43 ab	3.23 cd	2.70 e	**3.23 A**
S2	3.12 b	2.90 cd	2.79 de	2.50 f	**2.83 B**	3.44 ab	3.30bc	3.08 d	2.42 f	**3.06 B**
Mean	**3.21 A**	**2.96 B**	**2.85 C**	**2.56 D**		**3.50 A**	**3.37 B**	**3.16 C**	**2.56 D**	

Regarding the effect of fertilizing management programs on nitrogen %, data from both seasons showed that CNS recorded the highest values followed by CNS+5 then CNS+10 and finally CT recorded the lowest nitrogen %. There were significant differences among treatments except the difference between CNS and CNS+5.

Concerning the effect of fertilizing management programs on phosphorus %, data in the first seasons illustrated that CNS recorded the highest values followed by CNS+5 then CNS+10 and finally CT recorded the lowest values. There were significant differences among treatments except differences between (CNS and CNS+5) & (CNS+5 and CNS+10) were not significant. Data illustrated similar trend in the second season except that the difference between CNS and CNS+5 was significant.

Concerning the effect of fertilizing management programs on potassium %, data in both seasons indicated that CNS recorded the highest potassium % followed by CNS+5 then CNS+10, while CT recorded the lowest values. Moreover, there were significant differences among treatments.

Regarding the effect of interaction on (nitrogen, phosphorus and potassium) %, in both seasons the highest values were recorded in (S1 & CNS) followed by (S1 & CNS+5) while (S2 & CT) recorded the lowest values.

3.2. Spinach experiment

Table (8) illustrates the effect of substrate type and fertilizing management programs on plant height, number of leaves of spinach grown on rooftops.

Regarding the effect of substrate type, for both plant height and number of leaves data indicated that S1 recorded higher values than S2 and the difference between the two tested substrates was significant in both seasons.

Regarding the effect of fertilizing management programs on plant height, CNS recorded the highest values followed by CNS+5, CNS+10 and CT respectively. There were significant differences among treatments except between CNS and CNS+5. Similar trend was observed in the second season except that the difference between CNS+5 and CNS+10 was not significant.

Concerning the effect on number of leaves, for both seasons, the highest values were recorded by CNS, CNS+5, CNS+10 and CT respectively.

Regarding the effect of interaction between substrate type and fertilizing management, for both plant height and number of leaves, data in both seasons indicated that interaction between S1 and CNS (S1&CNS) recorded the highest values followed by (S1&CNS+5) without significant difference between both of them. In contrary, (S2&CT) recorded the lowest values.

Table 8: Effect of substrate type and fertilizing management programs on plant height and number of leaves of spinach grown on rooftops during winter seasons of 2020 and 2021.

Sub.	First season (2020)					Second season (2021)				
	Fertilizing management programs									
	CNS	**CNS+5**	**CNS+10**	**CT**	**Mean**	**CNS**	**CNS+5**	**CNS+10**	**CT**	**Mean**
					Plant height (cm)					
S1	36.7 a	35.3 ab	33.3 bc	27.0 e	**33.1 A**	38.2 a	35.4 ab	34.1 abc	26.3 de	**33.5 A**
S2	33.6 bc	32.7 cd	30.0 d	23.7 f	**30.0 B**	32.4 bc	31.7 bc	30.4 cd	22.5 e	**29.3 B**
Mean	**35.1 A**	**34.0 A**	**31.7 B**	**25.3 C**		**35.3 A**	**33.6 AB**	**32.3 B**	**24.4 C**	
					No. of leaves /plant					
S1	13.0 a	11.5 ab	11.0 ab	7.5 cd	**10.8 A**	12.8 a	11.9 ab	11.0 abc	8.5 cd	**11.0 A**
S2	11.0 ab	10.5 ab	10.0 bc	6.5 d	**9.5 B**	11.3 ab	9.5 bc	9.5 bc	7.0 d	**9.3 B**
Mean	**12.0 A**	**11.0 AB**	**10.5 B**	**7.0 C**		**12.0 A**	**10.7 B**	**10. 3 B**	**7.8 C**	

Table (9) illustrates the effect of substrate type and fertilizing management programs on fresh and dry weight of spinach grown on rooftops.

Regarding the effect of substrate type, data collected from both seasons indicated that S1 recorded higher values than S2 concerning fresh and dry weight per plant. Moreover, the difference between S1 and S2 was significant.

Regarding the effect of fertilizing management, data collected from both seasons indicated that in fresh and dry weights per plant CNS recorded the highest values followed by CNS+5, then CNS+10 and finally CT recorded the lowest values. Data also showed that there were significant differences among them except between CNS and CNS+5.

Regarding the effect of interaction, data from both seasons indicated that (S1&CNS) recorded the highest values for fresh and dry weights per plant followed by (S1&CNS+5) without significant difference between both of them. On contrary, (S2&CT) recorded the lowest values.

Table 9: Effect of substrate type and fertilizing management programs on fresh and dry weights of spinach grown on rooftops during winter seasons of 2020 and 2021.

Sub.	First season (2020)					Second season (2021)				
	Fertilizing management programs									
	CNS	CNS+5	CNS+10	CT	Mean	CNS	CNS+5	CNS+10	CT	Mean
	Fresh weight (g/plant)									
S1	34.6 a	33.7 ab	30.6 c	26.3 d	**31.3 A**	37.2 a	36.7 a	31.6 b	28.3 c	**33.5 A**
S2	30.8 bc	30.5 c	28.8 cd	23.0 e	**28.3 B**	32.4 b	31.8 b	30.7 b	23.5 d	**29.6 B**
Mean	**32.7 A**	**32.1 A**	**29.7 B**	**24.6 C**		**34.8 A**	**34.3 A**	**31.2 B**	**25.9 C**	
	Dry weight (g/plant)									
S1	5.13 a	5.10 ab	4.10 de	3.47fg	**4.45 A**	5.24 a	5.20 a	4.23 bc	3.90 cd	**4.64 A**
S2	4.64 bc	4.50 cd	3.90 ef	3.30 g	**4.08 B**	4.47 b	4.17 bc	4.07 c	3.53 d	**4.06 B**
Mean	**4.88 A**	**4.80 A**	**4.00 B**	**3.38 C**		**4.85 A**	**4.68 A**	**4.15 B**	**3.72 C**	

Table (10) illustrates the effect of substrate type and fertilizing management programs on yield per m^2 of spinach grown on rooftops.

Regarding the effect of substrate type, data in first season showed that S1 recorded higher values than S2, and there was significant difference between both of them. The same trend was observed in the second season.

Regarding the effect of fertilizing management, data from first season showed that the highest yield values were obtained from CNS followed by CNS+5, CNS+10 and CT respectively. Furthermore, differences among treatments were significant except between CNS and CNS+5. Similar trend was observed in the second season except there was no significant difference between CNS+5 and CNS+10.

Regarding the effect of interaction, in the first season data indicated that both (S1&CNS) and (S1&CNS+5) recorded the highest yield values. Even that (S1&CNS) recorded slightly higher values than (S1&CNS+5) but the difference between both of them was not significant. On the contrary, (S2&CT) recorded the lowest yield values. Similar trends were observed in the second season.

Table 10: Effect of substrate type and fertilizing management programs on yield of spinach grown on rooftops during winter seasons of 2020 and 2021.

Sub.	First season (2020)					Second season (2021)				
	Fertilizing management programs									
	CNS	CNS+5	CNS+10	CT	Mean	CNS	CNS+5	CNS+10	CT	Mean
	Yield (kg/m^2)									
S1	3.48 a	3.40 a	3.13 b	2.56 d	**3.14 A**	3.58 a	3.47 ab	3.19 bc	2.74 d	**3.25 A**
S2	3.04 bc	2.95 bc	2.88 c	2.33 e	**2.80 B**	3.29 ab	3.17 bc	3.09 c	2.29 e	**2.96 B**
Mean	**3.26 A**	**3.18 A**	**3.01 B**	**2.45 C**		**3.43 A**	**3.32 AB**	**3.14 B**	**2.52 C**	

Table (11) illustrates the effect of substrate type and fertilizing management programs on nitrate and chlorophyll content in leaves of spinach grown on rooftops.

Regarding the effect of substrate type on nitrate content in spinach leaves, data from both seasons indicated that S2 recorded lower values than S1 and the difference between both of them was significant.

Concerning chlorophyll content in spinach leaves, data collected from both seasons showed that S1 recorded higher values than S2 with significant difference between both of them.

Regarding the effect of fertilizing management programs on nitrate content, data in both seasons indicated that lowest nitrate values were recorded in CT followed by CNS+10, CNS+5 and finally CNS recorded the highest values. Furthermore, differences among treatments were significant except between CNS+5 and CNS+10.

Concerning the effect on chlorophyll content, data in both seasons showed that the highest chlorophyll values were recorded in CNS, CNS+5, CNS+10 and CT respectively. Moreover, data indicated that there were significant differences among treatments except the difference between CNS and CNS+5 & the difference between CNS+5 and CNS+10 both were not significant.

Regarding the effect of interaction on nitrate content, data in the first season indicated that lowest values were recorded in (S2&CT) followed by (S1&CT) without significant difference between both of them. On the contrary, (S1&CNS) recorded the highest nitrate values. Similar trend was observed in the second season.

Concerning the effect on chlorophyll content, data from first season showed that the highest chlorophyll values were recorded in (S1&CNS) followed by (S1&CNS) and the difference between both of them was significant. On the other hand, (S2&CT) recorded the lowest values. Similar trend was recorded in the second season.

Table 11: Effect of substrate type and fertilizing management programs on nitrate and chlorophyll contents in spinach grown on rooftops during winter seasons of 2020 and 2021.

Sub.	First season (2020)					Second season (2021)				
	Fertilizing management programs									
	CNS	**CNS+5**	**CNS+10**	**CT**	**Mean**	**CNS**	**CNS+5**	**CNS+10**	**CT**	**Mean**
	Nitrate content (ppm)									
S1	954.91 a	703.42 b	703.21 b	622.69 cd	**746.06 A**	1006.52 a	772.75 c	769.02 c	652.33 de	**800.15 A**
S2	892.97 a	665.79bc	637.87bc	571.77 d	**692.10 B**	914.50 b	731.86 cd	675.53 d	598.34 e	**730.06 B**
Mean	**923.94 A**	**684.60 B**	**670.54 B**	**597.23 C**		**960.51 A**	**752.30 B**	**722.27 B**	**625.33 C**	
	Chlorophyll content in leaves (SPAD)									
S1	41.9 a	41.2 ab	40.6 ab	34.5 d	**39.6 A**	43.6 a	42.6 ab	41.0abc	39.1 cd	**41.6 A**
S2	38.5bc	37.7 c	36.4 cd	30.6 e	**35.8 B**	40.3bc	39.3bcd	38.6 cd	37.0 d	**38.8 B**
Mean	**40.2 A**	**39.5 AB**	**38.5 B**	**32.5 C**		**42.0 A**	**41.0 AB**	**39.8 B**	**38.0 C**	

Table (12) illustrates the effect of substrate type and fertilizing management programs on (nitrogen, phosphorus and potassium) % in leaves of spinach grown on rooftops.

Regarding the effect of substrate type on nitrogen % in leaves, data in both seasons clarified that S1 recorded higher values than S2 with significant difference between both of them.

Concerning phosphorus %, data in both seasons indicated that there was no significant difference between both tested substrates.

Concerning potassium %, data in both seasons clarified that S1 recorded higher values than S2 with significant difference between both of them.

Regarding the effect of fertilizing management programs on nitrogen % in leaves, data from both seasons showed that CNS recorded the highest values followed by CNS+5 then CNS+10 and finally CT recorded the lowest values for nitrogen %. There were significant differences among treatments except the difference between CNS and CNS+5.

Concerning phosphorus %, data in the first seasons showed that CNS recorded the highest values followed by CNS+5 then CNS+10 and finally CT recorded the lowest values. There were no significant differences among CNS, CNS+5 and CNS+10. But there was significant difference between (CNS, CNS+5, CNS+10) and CT. Data illustrated similar trend in the second season.

Concerning potassium %, data in both seasons indicated that CNS recorded the highest values followed by CNS+5 then CNS+10, while CT recorded the lowest values. Moreover, there were significant differences among treatments except the difference between CNS+5 and CNS+10.

Regarding the effect of interaction on nitrogen and phosphorus %, in both seasons the highest values were recorded in (S1&CNS) followed by (S1&CNS+5) without significant difference, while (S2&CT) recorded the lowest values.

Concerning potassium %, data from first season illustrated that (S1&CNS) followed by (S2&CNS) without significant difference, while (S2&CT) recorded the lowest values. Similar trend was observed in the second season except (S1&CNS+5) came in the second position instead of (S2&CNS) but the difference still not significant.

Table 12: Effect of substrate type and fertilizing management programs on (nitrogen, phosphorus and potassium) % in leaves of spinach grown on rooftops during winter seasons of 2020 and 2021.

Sub.	First season (2020)					Second season (2021)				
	Fertilizing management programs									
	CNS	CNS+5	CNS+10	CT	Mean	CNS	CNS+5	CNS+10	CT	Mean
					Nitrogen %					
S1	3.01 a	2.97 a	2.81 ab	2.37 cd	**2.79 A**	3.03 a	2.94 ab	2.84 ab	2.46 cd	**2.82 A**
S2	2.73 ab	2.65bc	2.49 c	2.31 d	**2.55 B**	2.67bc	2.64bc	2.44 d	2.23 d	**2.50 B**
Mean	**2.87 A**	**2.81 A**	**2.65 B**	**2.34 C**		**2.85 A**	**2.79 A**	**2.64 B**	**2.34 C**	
					Phosphorus %					
S1	0.80 a	0.79 a	0.78 a	0.64bc	**0.75 A**	0.83 a	0.82 a	0.80 a	0.66bc	**0.78 A**
S2	0.78 a	0.75 a	0.74 ab	0.57 c	**0.71 A**	0.81 a	0.81 a	0.78 ab	0.58 c	**0.74 A**
Mean	**0.79 A**	**0.77 A**	**0.76 A**	**0.60 B**		**0.82 A**	**0.82 A**	**0.79 A**	**0.62 B**	
					Potassium %					
S1	3.15 a	2.96abc	2.91abc	2.50 de	**2.88 A**	3.23 a	3.07 ab	3.04 ab	2.58 cd	**2.98 A**
S2	2.98 ab	2.73bcd	2.65 cd	2.23 e	**2.65 B**	3.03 ab	2.73bc	2.74bc	2.26 d	**2.69 B**
Mean	**3.07 A**	**2.85 B**	**2.78 B**	**2.37 C**		**3.13 A**	**2.90 B**	**2.89 B**	**2.42 C**	

4. Discussion

Regarding the effect of substrate type, the above mentioned results indicated that S1 (50% perlite: 50% peat moss) was more suitable for producing molokhia and spinach than S2 (80% sand: 20% compost); S1 recorded higher yield and higher growth parameters than S2 in both molokhia and spinach. This could be a result of improving the growing conditions in the root zone area that resulted from better physical and chemical properties of S1 than S2 that increased water and nutrients uptake by plant roots. On this point, Lemaire, (1995) mentioned that one of the main factors affecting the growth and production of the plant in substrate culture is the type of substrate itself. Moreover, Maloupa *et al.,* (2001) found that mixed substrates can maintain favorable physical conditions over longer period than the single substrate.

In addition, Fakhri *et al.* (1995) mentioned that for optimum plant growth the substrate must contains adequate easily available water and air. Easily available water is low in perlite. To solve this problem, it is recommended to increase the irrigation frequency, and in this case adding peat moss to perlite increased water availability around root zone. Also, if the aeration and the easily available water are maintained in the appropriate level, the roots grow fast. Also, Vaughn *et al*., (2011) reported that the interest in the use of mixtures of inorganic and organic materials as growing media in soilless culture is increasing. Adding of inorganic substrate such as perlite to organic ones like peat has resulted in a better plant growth and higher yield probably resulted to increase water-holding capacity of inorganic material by adding peat moss, also better aeration of peat due the effect of inorganic substrates which promotes vigorous root growth, which allows better growth of foliage and therefore increases whole yield of plants. Also, Tüzel *et al*. (2001) added that, higher total yield of tomato was obtained from plants grown in mixture of perlite + peat and perlite than from pumice, volcanic ash, pumice + peat and volcanic ash + peat.

Regarding the effect of fertilizing management programs, the above mentioned results illustrated that CNS program recorded the highest yield and growth parameters followed by CNS+5, then CNS+10 and finally CT. this means that the more using inorganic nutrient solution than compost tea in the fertilizing program the more enhanced the yield and growth parameters values in both molokhia and spinach. This could be a results to that compost tea alone didn't supply the plant nutrition requirements and this reflected negatively on growth and production of the plant. Scheuerell and Mahaffee, (2006) reported that compost tea works well with most soilless media and can serve as a preventive measure to suppress pathogens before they cause disease. Compost tea alone is not considered a suitable fertilizer; because it is usually provides minimal nutrient levels. On the other hand, compost tea

enhances microbial activity in root substrate, which helps improve plant growth. Abd El-Aziz, (2003) reported that using compost tea as organic nutrient solution reduced vegetative growth of cantaloupe plants grown in nutrient film technique comparing with inorganic nutrient solution. Moreover, Abou El-Hassan *et al.,* (2008) mentioned that using inorganic nutrient solution gave higher total yield of cantaloupe under nutrient film technique conditions than compost tea as organic source of nutrient solution.

5. Conclusion

Regarding the effect of substrate type, S1 could be cosidered the most suitable substrate for producing both molokhia and spinach with high yield and growth parameters. Regarding the effect of fertilizing management programs, CNS recorded higher yield and growth parmeters followed by CNS+5. On the other hand, CNS+5 recorded lower nitrate values than CNS. From the above mentioned results it could be sumarize that inspite of CNS recorded the highist yield values but if we put nitrate content in consideration, the interaction between S1 and CNS+5 could be the most suitable formula between substrate type and fertilizing management programs for producing both molokhia and spinach with high yield and lower nitrate accumaltion than using the standerd chemical solution only the whole production season.

References

A.O.A.C., 1990. Official Methods of analysis of the association official analytical chemists. 15th ed. Published by the Association of Official Analytical Chemists, Inc. Anlington, Virginia, 22201, U.S.A.

Abd El-Aziz, S.A., 2003. Studies on producing cantaloupe organically by using nutrient film technique (NFT). M. Sc. Thesis. Fac. Agric. Ain Shams Univ., Egypt.

Abou El-Hassan, S., U.A. El-Behairy, S.M. Selim and A.F. Abou- Hadid, 2008. Effect of compost tea as organic nutrient solution for cantaloupe production grown in nutrient film technique. Egypt. J. Hort., 35: 41-58.

Abul-Soud, M. and A. Mancy, 2015. Urban horticulture of molokhia and spinach environmentally via green roof system and vermicomposting outputs., 2(12):1832-1847.

Chapman, H.D. and P.F. Pratt, 1982. Methods of Plant Analysis, I. Methods of Anaylsis for Soil, Plant and Water. Chapman Publishers, Riverside, California, USA.

Dehkharghanian, M., A. Herve and A.V. Mookambeswaran, 2010. Study of flavonoids in aqueous spinach extract using positive electrospray ionization tandem quadrupole mass spectrometry. Food Chem., 121: 863-870.

Fakhri, N.M., E. Maloupa and D. Gerasopoulos, 1995. Effect of substrate and frequency of irrigation on yield and quality of three Gerbera jamesonii cultivars. Acta Hort., 408: 41-45.

FAO (Food and Agriculture Organization), 2000. Guidelines and reference materials on integrated soil and nutrient management andconservation for farmers' field schools. Report AGL/MISC/27/2000. FAO, Rome.

FAO (Food and Agriculture Organization), 2012. Growing greener cities in Africa. First status report on urban and peri-urban horticulture in Africa. ISBN 978-92-5-107286-8.

Holm, L., J. Doll, E. Holm, J.V. Pancho and J.P. Herberger, 1997. World Weeds: Natural Histories and Distribution. New York: Wiley. ISBN 9780471047018.

Jaworska, G., 2005. Content of nitrates, nitrites and oxalates in New Zealand spinach. Food Chem., 89: 235-242.

Lemaire, F., 1995. Physical, chemical and biological properties of growing medium. Acta Hort, 396: 273-284.

Maloupa, E., A. Abou Hadid, M. Prasad and Ch. Kavafakis, 2001. Response of cucumber and tomato plants to different substrates mixtures of pumice in substrate culture. Acta Hort., 559: 593-600.

Metwally, Neveen, 2015. Determination of the most suitable substrate culture system for producing eggplant in rooftop gardens in Egypt. Egypt. J. of appl. Sci., 30(7): 400-411.

Patricia O., 2014. Proximate composition and nutritive value of leafy vegetables consumed in northern côte d'ivoire. European Scientific Journal, 10 (6): 212 – 227.

Salunkhe, D.K. and S.S. Kadam, 1998. Handbook of Vegetable Science and Technology: Production, Composition, Storage and Proc. Marcel dekker, INC, 721.

Santamaria, P., 2006. Nitrate in vegetables: toxicity, content, intake and EC regulation J. Sci. Food Agric., 86:10-17.

SAS Institute, 1990. SAS Procedures Guide. Version 6, third edition. SAS Institute, Cary.

Scheuerell, S.J. and W.F. Mahaffee, 2006. Variability associated with suppression of gray mold (*Botrytis cinerea*) on geranium by foliar applications of non-aerated and aerated compost Teas. Plant Disease, 90:1201-1208.

Toledo, M.E.A., Y. Ueda, Y. Imahori and M. Ayaki, 2003. L-ascorbic acid metabolism in spinach (*Spinacia oleracea* L.) during postharvest storage in light and dark. Postharvest Biol. Terminol., 28: 47-57.

Tüzel, I., Y Tüzel, A. Gül, H. Altunlu and R. Eltez, 2001. Effect of different irrigation schedules, substrates and substrate volumes on fruit quality and yield of greenhouse tomato. Acta Horticulturae, 548: 285–292.

Vaughn, S.F., N.A. Deppe, D.E. Palmquist and M.A. Berhow, 2011. Extracted sweet corn tassels as a renewable alternative to peat in greenhouse substrates. Industrial Crops and Products, 33: 514–517.

Wang, Z.H., Z.Q. Zong, S.X. Li and B.M. Chen, 2002. Nitrate accumulation in vegetables and its residual in vegetable fields. Environ. Sci., 23:79-83.