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Studies on the Fertilizer Requirements of Spinach Plants Growing in Soilless Cultivation

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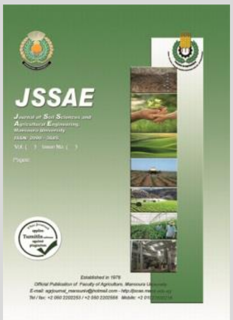

ABSTRACT

This research was conducted at the Faculty of Agriculture, Tanta University, Egypt to determine the effect of different nutrient solution formulations on the growth of spinach grown in two different cultures from the blended substrates. Three different nutrient solutions were used with or without compost tea+ spirolina extract (six treatments). Spinach plants were planted in pots filled with a mixture of substrates (sand + peat moss + perlite) or (vermiculite + peat moss + perlite) in a volume ratio of 1: 2: 1. The results showed that the plant height and plant weight of spinach were significantly affected by different nutrient solution and growth media. The highest values for these parameters were obtained with Cooper's solution and a mixture (vermiculite + peat moss+ perlite) (1: 2: 1), and on the other hand, the lowest values for these parameters were obtained by the mixture of the media (sand - peat - perlite) (1: 2: 1). This mixture of nutrient solution + 50% compost tea + spirulina extract achieved the highest values of elements percentage for spinach. Nutrient uptake was closely related to the dry matter of spinach, where a mixture of (vermiculite + peat moss + perlite) substrates gave the highest values in terms of minerals uptake. Data are tabulated for the N, P, K, Fe, Mn and Zn content in spinach plants at each treatment. The obtained results showed a clear variation in the chemical and physical properties of the different media and nutrient solution after the plants were harvested.

Keywords: Nutrient solution, soilless culture , substrate ,spirulina extract, compost tea.

INTRODUCTION

Growing vegetables using soil presents a host of challenges, such as changing temperatures, ability to retain moisture, available nutrient supply, proper aeration of roots, as well as disease and pest infestation. Soilless production under protected conditions mitigates some of these problems, while giving the grower better control over plant growth and development (Obaid *et al*., 2022). Soilless cultivation represents a viable opportunity for the agricultural production sector, especially in areas characterized by soil degradation and limited water availability. Moreover, this agricultural practice embodies a favorable response towards eco-friendly agriculture and a promising tool in seeing the public challenge in terms of food security. Soilless culture is the most intensive production system for horticultural crops and has been used for several years in the Mediterranean countries (Brun et. al., 2001). Commercial use of soilless culture has been increasing rapidly in Egypt in recent years. At the same time, many scientific researchers, especially in the field of vegetable and ornamental production, have been conducted on soilless culture (EL-Beshbeshy, 2000 a and b; Tüzel *et al*., 2003; EL-Beshbeshy and Sherif 2000, and EL- Beshbeshy, 2005).

So, soilless culture systems can be used in order to prevent negative effects of soil on plants and provide an appropriate culture environment in production (Brun *et al*., 2001), and has been used widely in protected agriculture to improve the growing environment and provide optimal water and nutrient supply for cultivated crops (Vives-Peris *et al*., 2020). Soilless culture can potentially improve cropping systems by optimizing the use of inputs (nutrient, pesticides and water), controlling diseases more efficiently and make it possible to increase crop production regardless of the climatic conditions (Montagne *et al*., 2015). At the same time, the soilless culture has become more aware of the quality, quantity and health of what they have consumed (Savvas *et al*., 2003). Soilless may serve as an alternative planting medium because it reduces incidence associated with soil borne diseases and pests which leads to reduced use of soil fumigant. It improves water use efficiency and fertilizer use due to its high water-holding and cation exchange capacity (Cantliffe *et al*., 2007).

Soilless culture systems (SCS) are currently one of the fastest-growing sectors in horticulture (Savvas *et al*., 2018; Tüzel *et al*., 2021), and can provide important requirements for plant growth with equal growth and yield results compared to field.

The choice of growing medium is the one of the first steps in establishing any soilless culture system. The medium or substrate used in soilless culture is more than simply a means of support for plant. It must provide oxygen, hold water effectively after perfect drainage, Free from pests and pathogens, give a suitable air pore volume and high structural stability in order to produce optimum plant growth. Important considerations for commercial use of the substrates are' the suitability for the intended use, availability and purchase price.

The use of peat as organic substrates are of interest for hydroponic culture, if they possess only little microbial activity, decompose slowly and are available readily at reasonable coast. Peat consists of partially decomposed

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aquatic, marsh, bog, or swamp vegetation. The composition of different peat deposits varies widely, depending upon the vegetative from which it originated, state of decomposition, mineral content, and degree of acidity. Peat culture undoubtedly gives high yields of quality vegetables (Resh, 1991). Seven different media were used to seedling production of tomato, sweet pepper and cucumber, results showed that the heaviest fresh and dry weight of seedling were recorded with the peat moss +vermiculite (Hellal *et al*., (1996). Choi *et al*., (1997) showed that pepper plant growth such as plant height and fresh weight, root medium composed of peat moss and vermiculite (75: 25) showed best results and the other treatments composed of various ratio of peat moss + vermiculite or peat moss + perlite also showed good results. But the treatments composed of various ratio of peat moss + vermiculite + perlite + sand + burnt rice hull (50 :10:5:25) resulted in the lowest plant growth. Therefore, the objective of this work is to study dry matter production and nutrient contents by spinach plants in relation to different nutrient solution formulations and two mixtures of substrate as growth medium.

MATERIALS AND METHODS

The research work was carried out at the soil and water department, Faculty of Agriculture, Tanta University, during the growing season 2019. The research studies comprised of two greenhouse in pots experiment to determine the suitable nutrient solution formulation for spinach (*Spinacia oleracea*) as a leaf vegetable production in soilless cultures by using two mixtures of growth substrates and three kinds of nutrient solutions (Hogland and Arnon. (1938), Hewit. (1966), and Cooper. (1979) with or without spirolina extract and compost tea (organic solution). Sand, peat moss, vermiculite and perilite were used as a feed stock to separately produce two types of mixture growing substrates. The first mixture (M1) preparing in 2 liters plastic pots containing 1:2:1 (v:v:v) sand + peat moss + perlite, while the second mixture (M2)was 1:2:1 (v:v:v) vermiculite + peat moss + perlite. Table 2 shows some characteristics of both mixture growth substrates types used.

Table 1. Some chemical characteristics of two mixture substrates types used in this study

Properties substrates	M1	M2
pH (1:10 substrate: water)	7.07	5.66
EC dS m^{-1} (1:10 substrate: water)	0.27	0.41
Organic matter%	25.21	24.37
Total macronutrients, ppm		
N	135.32	132.22
P	12.8	12
K	119.52	189.24
Available micronutrients, ppm		
Fe	5.02	8
Zn	5.36	3.04
Mn	2.8	6

Where, M1: sand + peat moss + perlite mixed at 1:2:1 (v:v:v), and M2: vermiculite + peat moss + perlite mixed at 1:2:1 (v:v:v).

The three different nutrient solution formulations used in this study with their contents. The formulations which were used include all the nutrient elements necessary for plant vegetation period in Table 3). In this study the above three nutrient solutions were used individually or with organic solution (Spirolina extract and compost tea) the composition of organic solution are present in table (6). The Six studied treatments in this experiment for each crop were as the follows**:**

1: 100% Hoagland (F1).
2: 50% Hoagland+50% compost tea and algae extract (F2)
3: 100% Hewitt (F3).
4: 50% Hewitt +50% compost tea and algae extract (F4)
5: 100% Cooper (F5).
6: 50% Cooper+50% compost tea and algae extract (F6)

Table 2. Nutrient solution formulations which were used in the study

Nutrient	Hoagland & Arnon (1938)	Hewitt (1966)	Cooper (1979)
	mg L^{-1}		
N	210	168	200-236
P	31	41	60
K	234	156	300
Ca	160	160	170-185
Mg	34	36	50
S	64	48	68
Fe	2.5	2.8	12
Cu	0.02	0.064	0.1
Zn	0.05	0.065	0.1
Mn	0.5	0.54	2.0
B	0.5	0.54	0.3
Mo	0.01	0.04	0.2

Table 3. Concentration of some macro and micro nutrients in spirolina extract and compost tea

Nutrient	Spirolina extract	Compost tea
	mg L^{-1}	
N	175.89	162.3
P	52.3	16.5
K	179.7	90.65
Fe	20.47	1.98
Zn	1.0	2.85
Mn	7.96	1.34

The irrigation by nutrient solutions or water was done to the pots when needed to maintain favorable moisture content during the growth period as the follows: The plants were irrigated 3 times a week in the first state by water and then after 13 days it irrigated 3 times a week (two by nutrient solution and one by water). At the end of vegetation period the crop was harvested (55days after sowing). Plant height, fresh weight and dry matter weight were measured to determine the growth performance of spinach plants. The plants were washed with distilled water before drying in an oven at 65º C. N, P, K, Fe, Zn, and Mn contents in the plants were determined, following H_2O_2 and H_2SO_4 digestion. Total nitrogen was determined by the micro-Kjeldahel method, phosphorus was determined calorimetrically using the mixed reagents (reducing agent, metol (P-methyleamino phenosulphate), sodium sulphite, meta-bisulphate and ammonium molybdate) then measured on Spectrophotometer, potassium was determined using the Flamphotometer. zinc, iron, and manganese in the digest were estimated with the help of Atomic Absorption Spectrophotometer. The Duncan's Multiple Range Test was used for statistical analysis according to Snedecor and Cochran, (1971).

RESULTS AND DISCUSSION

1. Plant growth:

Different nutrient solution formulations had obvious effects on spinach yield. In general, all nutrient solution treatments produced significantly higher yields of spinach with M2 than M1 (Table 4). However, the growth and yield values of spinach were significantly higher with the use of 50% spirolina extract and compost tea for all types of nutrient solutions, compared to both nutrient solutions alone. The highest fresh and dry matter yield of spinach was recorded in cooper's solution with M2 media. As to the effect of the various treatment in spinach plant height, measurements of plant height show that early plant growth was slightly faster in second substrate mixture (M2) than other substrate mixture (M1). As can be seen, the maximum values of fresh weight and dry matter of spinach plants were 9.37 g plant^{-1} and 1.36 g plant^{-1} in the M2 + F5 or F6 and M2 + F5, respectively. Among the other treatments the F1 and F2 treatments produced the lowest yield for plants grown in the M1. The differences among various treatments were found to be significant for the two parameters. The effect of application of different nutrient solution with or without organic solution on vigor of plant height on first substrate mixture (M1) was equal to that grown on second substrate mixture (M2). The average values of fresh weight, plant height and dry matter weight of spinach in two substrate mixtures as affected by different nutrient solutions formulas are presented in Table (5). Among the six treatments, the cooper's solution formulate produced the highest fresh weight yield, followed by Hewitt's solution and Hogland's solution formulates. The increased fresh weight of spinach with Cooper's solution is due to its higher nutrient contents. Conventional fertilizers of three nutrient solutions had a lower yield compared to those applied with spirolins + compost tea. Compared to the two mixtures of substrates, higher yields could be achieved when vermiculite was used in the mixture of substrates; the difference was statistically significant Table (6). Positive increases in fresh weight and dry matter in M2 are due to the good composition of the substrate mixture (organic and inorganic substrates) (Ameri *et al*., 2012). Soilless production of leafy vegetables under controlled environments is one of the most appropriate technologies to accomplish human food requirements. This production technology is economically viable to curb food insecurity (Croft *et al*., 2017).

Table 4. Influence of two substrates mixture and nutrient solution formulations on spinach plant growth parameters

Treatments		Fresh weight (g plant^{-1})	dry weight (g plant^{-1})	plant high (cm)
M1	F1	5.17^{ef}	0.38^{f}	8.41^{a}
	F2	4.98^{f}	0.51^{d-f}	8.29^{abc}
	F3	5.46^{def}	0.44^{ef}	8.21^{bcd}
	F4	6.73^{cd}	0.72^{b-e}	8.21^{bcd}
	F5	6.27^{cde}	0.67^{b-f}	7.96^{f}
	F6	7.73^{bc}	0.69^{b-e}	7.95^{f}
M2	F1	6.83^{bcd}	0.96^{b}	8.06^{def}
	F2	6.17^{f}	0.80^{bcd}	8.30^{ab}
	F3	6.66^{cd}	0.86^{c-f}	8.14^{cde}
	F4	8.27^{ab}	0.92^{bc}	8.24^{bc}
	F5	9.37^{a}	1.36^{a}	8.00^{ef}
	F6	9.37^{a}	0.88^{bc}	8.07^{def}
F test		ns	*	**

F1; 100% Hoagland; F2: 50%Hoagland+50%compost tea and algae extract; F3: 100% Hewitt; F4: 50% Hewitt +50%compost tea and algae extract; F5: 100% Cooper; F6 :50% Cooper+50%compost tea and algae extract; M1: mixture substrates sand+ peat + perlite (1:2:1); and M2: mixture substrates vermiculite + peat + perlite (1:2:1).

Table 5. Effect of nutrient solutions on average values of plant growth parameters

Nutrient solution	Fresh weight (g plant^{-1})	Dry weight (g plant^{-1})	Plant high (cm)
F1	6.00^{c}	0.67^{bc}	8.23^{ab}
F2	5.58^{d}	0.65^{bc}	8.29^{a}
F3	6.06^{c}	0.62^{c}	8.17^{b}
F4	7.50^{b}	0.82^{ab}	8.22^{ab}
F5	7.82^{ab}	1.01^{a}	7.98^{c}
F6	8.55^{a}	0.78^{b}	8.01^{c}
F test	**	**	**

Table 6. Substrate mixture effect on vegetative growth characters

Nutrient solution	Fresh weight (g plant^{-1})	Dry weight (g plant^{-1})	Plant high (cm)
M1	6.06^{b}	0.57^{b}	8.17^{a}
M2	7.78^{a}	0.97^{a}	8.14^{a}
F test	*	*	ns

The maximum enhancement in plant height, fresh weight and dry matter under M_2 substrate F_6, F_5 and F_3 treatment could be attributed to better water holding capacity and nutrient availability which in turn promotes better vegetative growth (Chhukit 2009). The addition of a suitable nutrient solution enhanced to obtain the amount of vegetative growth. Where, the plant growth rate decrease or increase for several reason including substrate nutrients contents (Chen *et al*., 2018). On the other hand, the positive effect of inorganic with organic supplement on vegetative growth, it may be because that the availability of nutrients increased the photosynthesis process in plants (Ayesha *et al*., 2011).

Table 7. Dry matter % of spinach under integrated substrate mixture and nutrient solutions

Mixture of Substrate	Nutrient solution	Dry matter (%)
M1	F1	7.35
	F2	10.24
	F3	8.05
	F4	10.69
	F5	10.68
	F6	8.92
M2	F1	14.05
	F2	12.96
	F3	12.91
	F4	11.12
	F5	14.51
	F6	9.39

Results obtained on the effect of different treatments on dry matter percentage are presented in Ttable (7). The result shows that, the positive effect of all treatments in both substrate mixture followed the order F1>F5>F2>F3>F4>F6 in the second mixture. The corresponding treatments in first mixture followed the order: F5>F4>F2>F6>F3>F1.Data in Table (8) reveal that the dry matter percentage in spinach plants was higher in all nutrient solution formulas in the M2 compared with the same nutrient solution in the M1.

Nutrient contents

Tables from 8 to 14 show the effect of different nutrient formulas and two types of substrate mixtures on contents of N, P, K, Fe, Zn and Mn in spinach plant. No constant trend was observed for any concentration elements in both spinach plants may be due to dry matter hence dilution effect. Also Russo (1991) found that concentration of 12 elements in leave and fruit of pepper concentration did not respond to fertilizer treatments or spacing. Regarding the effect of different nutrient solutions formulas on N, P and K concentration in second mixture of substrate N and K concentrate in spinach plant were higher compared with the same solution treatment in the first substrate mixture. On the other hand P concentration was lower in spinach plant which received all nutrient solution in second substrate mixture. It is also evident from Table (9) the results of average values in both M1 and M2 that, the cooper's solution with organic solution F6 resulted in a greater N, P and K concentrations in spinach than in treatments received other nutrient solution formulas. Data in Table (10) show a significant increase of N and K concentration as a result of growing plants in M2 compared with M1.

Table 8. Effect of different treatments on N, P and K concentrations (ppm) in spinach plants

Mixture Substrates	Nutrient solution formulates	Concentrations (ppm)		
		N	P	K
M1	F1	55.17^{e}	54.63^{d}	361.21^{j}
	F2	41.52^{g}	52.05^{de}	436.17^{h}
	F3	34.27^{h}	42.95^{f}	389.85^{i}
	F4	46.04^{f}	58.84^{c}	388.80^{i}
	F5	53.31^{e}	53.57^{d}	443.99^{g}
	F6	72.49^{c}	63.20^{b}	525.82^{f}
M2	F1	91.68^{a}	49.19^{e}	682.88^{b}
	F2	81.77^{b}	44.73^{f}	692.47^{a}
	F3	60.33^{d}	44.12^{f}	631.96^{d}
	F4	48.42^{f}	43.18^{f}	586.20^{e}
	F5	62.12^{d}	27.20^{g}	431.72^{h}
	F6	73.39^{c}	66.60^{a}	667.68^{c}
F test		**	**	**

Generally, data in Tables (11) indicated that N, P and K uptake by spinach plant were significantly affected by different nutrient solution formulas in two types of substrate mixtures. In first substrate mixture, the most effective treatment was observed in treatment which received cooper's nutrient solution with or without organic solution, this treatment increased N, P and K uptake over all other treatments. With regard to second substrate mixture the N, P and K uptake by spinach plant, the highest values were recorded in treatment which received Hogland's solution with or without organic solution. It is also evident from the results that the M1 resulted in a greater N, P and K uptake in most cases than in those of first mixture of M2. It should be noted that the uptake of N, p and K in the second substrate (M2) was generally more than double that of the first substrate mixture. This shows clearly the importance of vermiculite substrate as a growth substrate in soilless cultures of the first substrate mixture (M1)

Table 9. Effect of different nutrient solution treatments on average values of N, P and K concentration in spinach plants

Nutrient solution	Concentrations (ppm)		
	N	P	K
F1	73.43^{a}	51.91^{b}	522.04^{c}
F2	61.65^{b}	48.39^{c}	564.32^{b}
F3	47.30^{d}	43.54^{d}	510.90^{d}
F4	47.23^{d}	51.016^{b}	487.50^{e}
F5	57.72^{c}	40.38^{e}	437.86^{f}
F6	72.94^{a}	64.90_{a}	596.75^{a}
F test	**	**	**

Details and symbols as table (4)

Table 10. Effect of different substrate mixture treatments on N, P and K concentration in spinach plants

Mixture Substrates	Concentrations (ppm)		
	N	P	K
M1	50.47^{b}	54.21^{a}	424.30^{b}
M2	69.62^{a}	45.84^{b}	615.48^{a}
F test	**	**	**

Details and symbols as table (4)

Table 11. Effect of different treatments on N, P and K concentrations (ppm) in spinach plants

Mixture of Substrate	Nutrient solution	g plant^{-1})		
		N	P	K
M1	F1	4.05^{k}	4.01^{f}	26.54^{k}
	F2	4.25^{j}	5.32^{de}	44.66^{h}
	F3	2.75^{L}	3.45^{g}	31.38^{j}
	F4	4.92^{i}	6.28^{bc}	41.56^{i}
	F5	5.69^{g}	5.72^{cd}	47.41^{f}
	F6	6.46^{f}	5.63^{d}	46.90^{g}
M2	F1	12.88^{a}	6.91^{a}	95.94^{a}
	F2	10.59^{b}	5.79^{cd}	89.74^{b}
	F3	7.78^{d}	5.69^{d}	81.58^{c}
	F4	5.38^{h}	4.80^{e}	65.18^{d}
	F5	9.01^{c}	3.94^{fg}	62.64^{e}
	F6	6.89^{e}	6.25^{bc}	62.69^{e}
F test		**	**	**

Regarding micronutrients, Tables (12, 13, and 14) show the effect of different nutrient solutions and two mixture substrates on concentration of Fe, Zn and Mn by spinach plants. As has been presented earlier, no constant trend was observed for concentrations elements in spinach plants may be due to dry matter hence dilution effect. As can be expected, Fe, Zn and Mn concentrations in spinach plants were higher in all treatment in second substrate mixture than the same treatments in first substrate mixture**.** Concerning the effect of nutrient solution formulation on micronutrients content data presented in Table (13) show clearly that nutrient solution formulation F6 increase availability of Zn to spinach. These results may be to raise available nutrients for adsorption by spinach plants (Ebrahimi *et al*., 2012b). On the other hand, nutrient solution formulation F3 increases Mn concentration in spinach than other nutrient solutions. The decrease of Mn concentration in plant may be due to amount of Fe in nutrient solution F6 was high and it competitive restriction of Mn absorption by plant.

Table 12. Effect the interaction between two substrate mixture and different nutrient solution formula on micronutrients concentration in leafy vegetables.

Mixture of Substrate	Nutrient solution	Concentrations (ppm)		
		Fe	Mn	Zn
M1	F1	3.85^{ef}	4.20^{g}	3.76^{e}
	F2	1.71^{i}	4.74^{d}	4.01^{d}
	F3	2.93^{h}	5.14^{c}	4.30^{c}
	F4	5.12^{ab}	6.03^{a}	4.71^{b}
	F5	4.35^{c}	4.33^{fg}	3.64^{e}
	F6	3.67^{fg}	1.84^{i}	4.34^{c}
M2	F1	4.13^{cd}	4.70^{de}	2.87^{f}
	F2	3.64^{fg}	4.91^{cd}	3.78^{e}
	F3	5.32^{a}	5.47^{b}	4.44^{c}
	F4	3.93^{de}	2.59^{h}	2.85^{f}
	F5	3.55^{g}	4.22^{g}	4.07^{d}
	F6	4.94^{b}	4.50^{ef}	5.27^{a}
F test		**	**	**

As to the effect of two types of substrate mixture on the Fe, Zn and Mn concentration in spinach, it can be seen from Table (14) that those elements concentrations were relatively higher in plants grown in second substrate mixtures (M2) in most cases.

Table 13. Effect of different nutrient solution on average values of micronutrients concentration in spinach plants grown in both mixture of substrates

Nutrient solution Treatments	Micronutrient conc. in plants ppm Fe	Mn	Zn
F1	3.99[cd]	4.45[c]	3.31[d]
F2	2.67[e]	4.83[b]	3.89[c]
F3	4.13[c]	5.30[a]	4.37[b]
F4	4.52[a]	4.31[cd]	3.78[c]
F5	3.95[d]	4.27[d]	3.85[c]
F6	4.31[b]	3.17[e]	4.80[a]
F test	**	**	**

Table 14. Effect of two substrate mixture on micronutrients concentration in leafy and fruit vegetables

Substrate mixture	micronutrient conc. in plants ppm Fe	Mn	Zn
M1	3.60[b]	4.38[a]	4.13[a]
M2	4.25[a]	4.40[a]	3.88[b]
F test	**	ns	**

Data from table (14) showed that, under using substrate mixed M2 Fe are available in spinach more than substrate mix M1. Also, M2 record high reading for Mn in spinach.M1 increase Zn concentration in spinach. According to (Benito *et al*., 2005), using organic fertilizer integration with mineral nutrient solution improves the fertilizer capacity. However, the leafy vegetables (spinach) require the balance addition of a suitable nutrient solution to obtain the amount of vegetative growth.

CONCLUSION

The results of this experiment indicate that the type of nutrient solution formulations is very important factor in determining the spinach yield through its effect on dry matter accumulation in the plant. Moreover, solid substrates and growing media are available in Egypt, we have a huge reserve from natural source of sand as solid aggregate hydroponic media Vermiculite and perlite and peat moss can be also manufactured for soilless cultures. Thus, the choice the mixture of substrates in soilless cultures can be used in arid region of the world, such as the developing countries of the Middle East to provide intensive food production (or growing fresh vegetables) in a limited area, where land is non –arable and water is scare, In area where fresh water is not available, soilless cultures can use seawater through desalination.

REFERENCES

Ameri, A., Tehranifar, A., Davarynejad, G., and Shoor, M..The Effects of Substrate and Cultivar in Quality of Strawberry. J. BIOL. ENVIRON. SCI., 2012, 6(17), 181-188.

Ayesha, R.; N. Fatima; M. Ruqayya; H. Faheem; K.M. Qureshi; I.A. Hafiz; K.S. Khan; U. Ali and A. Kamal (2011). Influence of different growth media on the fruit quality and reproductive growth parameters of strawberry (Fragaria × ananassa). J. Med. Plants Res., 5(26): 6224-6232.

Benito M., Masaguer A., De Antonio R., Moliner A. (2005): Use of pruning waste compost as a component in soilless growing media. -Bioresource Technology, 96: 597–603.

Brun R, Sttembrino A, Couve C (2001) Recycling of nutrient Butler JD, Oebker NF. 2006. Hydroponics as a Hobby— Growing Plants Without Soil. Circular 844.Information Office, College of Agriculture, University of Illinois, Urbana, IL 61801.

Cantliffe, D. J.; J.Z. Castellanos and A.V. Paranjpe (2007). Yield and quality of greenhouse-grown strawberries as affected by nitrogen level in coco coir and pine bark media. Proc. Fla. State Hort. Soc., 120:157–161.

Chen, H.M., Ma, J.Y., Wei, J.X., Gong, X., Yu, X.C., Guo, H., Zhao, Y.W., 2018. Biochar increases plant growth and alters microbial communities via regulating the moisture and temperature of green roof substrates. Science of the total Environment. 635, 333-342.

Chhukit K. 2009. Studies on vegetative propagation of Kiwifruit (Actinidiadeliciosa). M.Sc. Thesis. Department of Fruit Science, Dr YS Parmar University of Horticulture and Forestry, Solan, HP.

Chio, j. M.., Ahn, J.W., Hyeong, K. j and. Lee, Y.B. 1997. Effect of medium composition on physical properties of soil and seedling growth of red pepper in plug system. Journal of the Korean society for Horticultureal Science. Dec., 38 (6): 618-824.

Cooper A (1979) The ABC of NFT. Grower Books, London.

Croft, M., Hallett, S., Marshall, M. (2017): Hydroponic production of vegetable Amaranth (Amaranthuscruentus) for improving nutritional security and economic viability in Kenya. – Renewable Agriculture and Food Systems 32(6): 1-10.

Ebrahimi, R. F., Rahdari, P., Vahed, M. S., &Shahinrokhsar, P. (2012b). Rice response to different methods of potassium fertilization in salinity stress condition. International Journal of Agricultural and Crop Science, 4,798-802.

EL-Beshbeshy T.R (2000 a). Interaction effects of phosphorus and silicon on Si and P uptake by corn plants Grown in Hydroponic Split-Root Technique Xth International Colloquium for the Optimization of Plant Nutrition. Plant Nutrition for the next Millennium. April 8-13, Cairo, Egypt., Apr 13, 2000

EL-Beshbeshy T.R (2000 b). Potassium fertilization and growth substrate effects on growth and nutrient content in cucumber plants. Xth International Colloquium for the Optimization of Plant Nutrition. Plant Nutrition for the next Millennium. April 8-13, Cairo, Egypt., Apr 13, 2000

EL-Beshbeshy T.R. and M.A. Shrife (2000). Effect of some growth substrates on the growth and nutrient Uptake of pepper and eggplant. Xth International Colloquium for the Optimization of Plant Nutrition. Plant Nutrition for the next Millennium. April 8-13, 2000 - Cairo, Egypt., Apr 03, 2000.

EL-Beshbeshy T.R (2005). Growth And Nutrient Uptake Of Pepper Plants Grown In Different Substrates As Affected By Phosphorus Levels. 15th International Plant Nutrition Colloquium, September 14-19, 2005,- Beijing, China, Sep 19, 2005.

Hellal, R.M., Shaheen, A.M., Omar, N.M. and Mahmoud, A.R. 1996 Comparative studies on seedling production of some vegetable crops with various agricultural media. Egyptian Journal of horticulture 23 (2): 129-144.

Hewitt, E.J. (1966). Sand and water culture methods used in the study of plant nutrition. 2nd Ed., East Malling: Commonwealth Agricultural Bureaux.

Hoagland, D. R.; Arnon, D. I.1938. The water-culture method for growing plants without soil . http://hdl.handle.net/2027/uc2.ark:/13960/t51g1sb8j

Obaid, A. A., Khalil, N. H., Al-Alawy, H. H., & Fahmi, A. H. (2022). Effect of planting density, foliar spraying and overlapping system on the growth and productivity using soilless culture system. Journal of the Saudi Society of Agricultural Sciences

Resh HM (1991). Hydroponic Food Production: A Definitive Guidebook of Soilless Food Growing Methods, 3rd ed. Woodbridge Press Publishing Co., ISBN 0-88007-171-0, California, 462 pages.

Russo, V. M. (1991). Effect of fertilizer rate, application timing and plant spacing on yield and nutrient content of papper.Journal of plant nutrition, 14(10) 1047-1056.

SAVVAS, D., 2003: Hydroponics: A modern technology supporting the application of integrated crop management in greenhouse. Food, Agriculture & Environment 1, 80-86.

Savvas, D.; Gruda, N. Application of soilless culture technologies in the modern greenhouse industry—A review. Eur. J. Hortic. Sci. 2018, 83, 280–293.

Snedecor, G. W. and W. G. Cochran (1971). Statistical methods 6th ed. Iowa state univ. press

Tüzel, Y., Gül, A., Tüzel, İ.H., Öztekin, G.B., Eltez, R.Z., 2003. Effect Of Renewing The Nutrient Solution On Tomato Plants Grown In NFT. SavremenipovrtarPoljoprivredniFakultet Novi Sad, December 2003:5-8.

Tüzel, Y.; Balliu, A. Advances in liquid -and solid-medium soilless culture systems. In Advances in Horticultural Soilless Culture; Gruda, N.S., Ed.; Burleigh Dodds Science: Cambridge, UK, 2021; ISBN 978 1 78676 292 4. Available online: www.bdspublishing. com (accessed on 10 July 2021).

Vives-Peris, V.; de Ollas, C.; Gómez-Cadenas, A.; Pérez-Clemente, R.M. Root exudates: From plant to rhizosphere and beyond. Plant Cell Rep. 2020, 39, 3–17.

دراسات علي الاحتياجات السمادية لنباتات السبانخ النامية في المزارع اللأرضية

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تم اجراء هذا البحث بكلية الزراعة – جامعه طنطا- مصر لتحديد تأثير المحاليل المغنية المختلفه علي نمو نباتات السبانخ النامية في مخلوط بيئتين مختلفتين حيث استخدمت مع ثلاثة محاليل مغذية مع أو بدون شاي الكمبوست + مستخلص الاسبيرولينا (6 معاملات). تم زراعة نباتات السبانخ في اصص بها خليط مختلف من البيئات مكونه من (رمل + بيتموس+ بيرليت) ، (فيرميكيوليت + بيتموس + بيرلت) بنسبة (1:2:1) علي اساس الحجم. تم قياس طول النبات ، ووزن نباتات السبانخ ومحتواها من العناصر ، حيث كان هناك تاثير معنوي لطول ووزن نباتات السبانخ نتيجة لاستخدام المحاليل المختلفه مع مخلوط البيئتين. تم الحصول علي اعلي قيم لهذه المعاملات مع محلول كوبر ومخلوط البيئة المكونه من (فيرميكيوليت + بيتموس + بيرليت) (1:2:1) ، ومن ناحية اخري اقل قيمة تم الحصول عليها كانت مع استخدام مخلوط البيئة المكونه من (رمل + بيتموس +بيرليت) (1:2:1) مع مخلوط المحاليل المغذية الثلاثه + 50% شاي الكمبوست ومستخلص الاسبيرولينا. وكان محتوي امتصاص العناصر في نباتات السبانخ مرتبط بالمادة الجافه للنباتات حيث أعطي خليط البيئة المكونه من فيرميكيوليت + بيتموس + بيرليت اعلي امتصاص للعناصر الغذائية ، ومن خلال جدولة البيانات الخاصهبكل من عناصر النيتروجين والفوسفور ، البوتاسوم ، الحديد ، الزنك والمنجنيزلكل معاملة اظهرت النتائج التي تم الحصول عليها تباين واضح في الخواص الكيميائية والفيزيائية لمخلوط البيئتين والمحاليل المغذية بعد حصاد النباتات.

الكلمات الافتتاحية : المحلول المغذي ، الزراعة بدون تربة ، مستلخص الاسبيرولينا ، شاي الكمبوست