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Effects of varying N, P and K concentrations on growth, biomass, yield and nutritional quality of zucchini squash grown under open and polyhouse soilless culture

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ABSTRACT

Soilless production of vegetables is rapidly gaining momentum and popularity especially in the peri-urban agricultural space. But this requires suitable technological backstopping in terms of substrate, nutrient management and irrigation scheduling. Open and polyhouse experiments were conducted to study the effect of varying levels of N, P and K on the growth, biomass, yield and nutritional quality of zucchini hybrid 'Champion' under soilless culture. The study was carried out with four different NPK levels and seven replications in a completely randomized design. The results revealed that the nutrient scheduling of 168 ppm N-NO_3, 16 ppm P and 189 ppm K recorded maximum fruit length (24.12cm), fruit girth (44.4mm), fruit weight (335.6g) and yield per plant (5.71 kg) and per hectare (71.39 tonnes) under open-field soilless culture. However, maximum plant height (61.25cm), number of leaves (43.33) and total plant dry biomass (146.8g/plant) of zucchini were recorded with application of 185 ppm N-NO_3, 19 ppm P and 224 ppm K. Between open and polyhouse soilless cultivation of zucchini, highest plant height (80.6cm), number of leaves (47.4), number of fruits (22.3) and total plant dry biomass (184.7g/plant) were recorded with polyhouse conditions. Nevertheless, the highest stem diameter (35.2mm), maximum fruit length (23.2cm), maximum fruit girth (42.9mm), fruit weight (315.4g) and yield per plant (5.27kg) and per hectare (65.8t/ha) were recorded with open-field soilless culture. Zucchini plants raised on Arka Fermented Cocopeat registered higher plant height (54.7cm), stem diameter (35.2mm), number of leaves (39.3), total plant dry biomass (139.8g/plant), number of fruits (16.8), fruit length (23.2cm), fruit girth (42.9mm), fruit weight (315.4g) and yield (5.27kg/plant and 65.8t/ha) compared to soil (3.70 kg/plant and 46.3t/ha). The results established that the growers can increase zucchini yield and fruit quality and advance fruit production (10 days) by changing from soil to soilless culture.

Key words: *Cucurbita pepo*, soilless cultivation, nutrient solutions, arka fermented cocopeat.

INTRODUCTION

Soilless cultivation is becoming more popular in peri-urban agriculture. It is a misapprehension to believe that the issue of feasible land is the key reason growers are drawn to soilless farming (Suvo *et al*., 16). Greater yields and better quality is the main reason for adopting soilless cultivation. This hi-tech soilless farming technology is getting popular in urban and peri-urban spaces for growing vegetables, flowers, and medicinal herbs. Use of soilless media has been shown by various researchers to be effective in terms of production quantity and quality of vegetables and flowers (Rouphael and Colla, 13; Ahmad *et al*., 1; Kalaivanan and Selvakumar, 9). The utmost common inert growing medium is rockwool, very popular in Holland, Poland, Ukraine, Russia, South Korea and Japan. However, in recent times rockwool is becoming environmentally unsafe and is considered as a pollutant. As a suitable substitute, cocopeat is emerging as an effective and environmentally safe alternative. It has been found that plants grown in cocopeat grow upto 50% faster than they would in soil. It also eliminates the need for herbicides and pesticides as cocopeat is free from these problems (Ahmad *et al*., 1).

In the horticulture industry, the attention has usually been on yield. Nevertheless, consumer's interest in the quality of horticultural produces has increased in the recent past and would turn out to be the driving force of the future. It is emphasized that better quality is even more significant than total yield for achieving competitiveness in modern horticulture (Gruda, 6). Notably, soilless culture techniques can increase both yield and product quality. Numerous studies confirm that a soilless substrate enables growers to produce vegetables without quality losses compared to soil cultivation (Gruda, 6). Zucchini squash *cucurbita pepo* L. is one of the most popular summer squashes in Americas and Europe. Like in other gourd vegetables, it also

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belongs in the *Cucurbitaceae*, family of vegetables. Zucchini can reach nearly a meter in length, but is usually harvested at the immature stage (15-25cm length). In a culinary context, zucchini is treated as a vegetable; it is usually cooked and presented as a savory dish or accompaniment. Fresh fruits are rich in vitamin-A; provide about 200 IU per 100 g. In addition, they contain moderate levels of the B-complex group of vitamins like thiamin, pyridoxine, riboflavin and minerals like potassium, iron, manganese, phosphorus, and zinc (Rouphael and Colla, 13). Squashes are generally cultivated in the open where climate, insect and disease pressures create challenging conditions for growers and shippers who produce and market the delicate, immature fruit. Under such circumstances, production of fresh vegetables on soilless culture can be explored.

The soilless culture technique allows the achievement of high yields without jeopardizing quality product. Nevertheless, in comparison with other vegetable crops (cucumber, pepper and tomato); there is a dearth of information comparing yield, nutrient composition and fruit quality of summer squash grown in polyhouse and open soilless culture. In soilless culture, nutrient management can greatly influence plant growth and the quality of the product. Therefore, it is crucial to have a good understanding of the plant's nutritional needs in order to ensure a good yield and to sidestep nutrient wastage. This may cut down the production costs and decrease the risk of water contamination. Therefore, the aim of this study was to determine the effects of varying N, P and K levels in nutrient solution on zucchini squash growth, biomass, yield and nutritional quality under open and polyhouse soilless culture.

MATERIALS AND METHODS

Open and polyhouse soilless culture experiments on zucchini squash hybrid 'Champion' were conducted during the kharif 2016 season at ICAR-Indian Institute of Horticultural Research (ICAR-IIHR), Bengaluru. The experimental site is situated at 13°58" N latitude and 77°29" E longitude with an altitude of 890 m above mean sea level. Arka Fermented Cocopeat was used as substrate for growing zucchini under these experiments and compared with soil. Arka Fermented Cocopeat (AFC) is a substrate obtained through bioconversion of coir pith by the action of a tannase producing fungal inoculum within period of 30 days followed by the enrichment with the Arka Microbial Consortium, a carrier based formulation of N fixing, P & Zn solubilizing and K mobilizing bacterial strains.

The substrate Arka Fermented Cocopeat had the following characteristics: bulk density 0.16 Mg m^{-3}; porosity 67.8%; pH 6.75; electrical conductivity 0.5 dSm^{-1}; total carbon 36.1%; total N 0.98%; total P 0.07%; total K 2.20% and Na 0.35%. Physical and chemical characteristics of the soil were: bulk density 1.28 Mg m^{-3} ; porosity 51.3%; pH 6.97, electrical conductivity 0.26 dSm^{-1}; organic carbon 7.8 g kg^{-1} ; available N 0.13 g kg^{-1}; 18 mg kg^{-1} Olsen's P, ammonium acetate (CH_3COONH_4) extractable nutrients as follow: 0.90 g Ca kg^{-1}, 0.174 g Mg kg^{-1} and 0.15 g K kg^{-1} and DTPA extractable micronutrients as follow: 10.3 mg kg^{-1} Fe, 5.70 mg kg^{-1} Mn, 2.24 mg kg^{-1} Cu and 1.35 mg kg^{-1} Zn. Soil physical and chemical properties were estimated by following standard procedures (Jackson, 8).

Silpaulin grow bags of size 4x1x1feet were filled with 60 kgs of Arka Fermented Cocopeat and two seeds of the zucchini squash F_1 hybrid 'Champion' from company Pahuja Seeds, India were sown directly on to the substrate by following a spacing of 60cm between plants. The grow bags were placed in a temperature and relative humidity controlled polyhouse with fan and pad cooling system. A similar set was also maintained at open field conditions for comparison purposes. Since the growth and yield of zucchini plants that are directly sown on AFC were found to be better than transplanted seedlings, it was decided to dispense with the need of raising protray (53.34 cm (L) × 27.94 cm (W) × 2.7 cm (H) size) based nurseries. Four treatments of different N, P and K levels were randomly executed according to Completely Randomized Design (CRD) with seven replicates. Treatments of the experiment were: T_1- 128 ppm N, 11 ppm P and 120 ppm K, T_2-147 ppm N, 13 ppm P and 155 ppm K, T_3-168 ppm N, 16 ppm P and 189 ppm K and T_4-185 ppm N, 19 ppm P and 224 ppm K. For all treatments, secondary and micronutrients applications were kept unchanged. The nutrient solution was made as per the method described by Hoagland and Arnon (7) with modification necessitated to the experiment. Plants grown in soil and soilless culture were fertilized as per the treatments indicated above. The EC values were kept within the range of 1.2 to 1.6 dSm^{-1}. Nutrient solutions were given @ 200 ml per plant and scheduled three times per week. Apart from meeting the plant water needs irrigation was provided to distribute the nutrient solution uniformly across the growth substrate. The texture and porosity of the growing medium, and the surface area to be wetted were important considerations in deciding the frequency of irrigation. The irrigation water quality is characterized by following standard procedures. The concentrations of ions expressed as mg per liter (mg l^{-1}) were: Cl^- (49.7); Ca^{2+} (52); Mg^{2+} (14); Na^+ (26); K^+ (36); bicarbonate (45). The pH and EC values were 7.04 and 0.87 dS m^{-1}, respectively.

Observations on plant height (cm), stem girth (mm), number of leaves, fresh plant biomass (g/plant), dry plant biomass (g/plant), number of fruits per plant, yield per plant (kg/plant) and yield per hectare (t/ha) were recorded. Harvesting started at 40th days after sowing (40 DAS) in soilless plants and at 51st days after sowing (51 DAS) in plants grown under soil and fruits were successively picked every 3rd day until the final harvest. Fruits were collected, counted and weighed at each harvest to determine total fruit yield, yield per plant and average fruit weight. Every time the dimensions and weights of the plant's fruits were measured. Ten zucchini fruits were randomly selected from each treatment and cut into pieces for nutritional quality analysis. The fruit samples were then dried in an oven at 68°C for analyzing their nutrient contents. The samples were sequentially ground by electrical grinder for further analysis. The nitrogen (N) contents in the fruit samples were analyzed after mineralization with sulfuric acid by Kjeldahl method (Jackson, 8). Phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) were estimated digesting with a triacid mixture (9:4:1 HNO_3: $HClO_4$: H_2SO_4) as described by Jackson (8). The data generated from the experiment were scrutinized using SAS 9.3 statistical package (SAS Institute Inc, 2011). Analysis of variance (ANOVA) was done using SAS PROC ANOVA technique. Means were parted using Fisher's protected least significant difference (LSD) test at a probability level of $p<0.05$

RESULTS AND DISCUSSION

Growth and biomass of zucchini as influenced by nutrient solutions containing varying levels of N, P and K and constant levels of secondary and micro nutrients were recorded and presented in Table 1. Nutrient solutions significantly affected the plant height, leaf numbers and total biomass, while the plant stem girth was not significantly affected with nutrient solutions. The maximum plant height (61.25cm), number of leaves (43.33) and total plant dry biomass (146.8g/plant) of zucchini were recorded with application of 185 ppm N-NO_3, 19 ppm P and 224 ppm K per plant and it was statistically on par with application of 168 ppm N-NO_3, 16 ppm P and 189 ppm K per plant. The above mentioned nutrient scheduling recorded maximum growth and zucchini biomass in protected conditions also. The higher N, P and K concentrations in the nutrient solution recorded considerably higher plant growth, number of leaves and plant biomass than other treatments which supplied lower concentrations of N, P and K. These results come to an understanding with Zekri and Obreza (18) who reported that reduced concentrations of N, P and K may affect plant growth and fruit production due to their effects in many physiological functions of plant growth and development including photosynthesis and carbohydrate production, subsequently, yield and fruits quality will be reduced. Andriolo *et al*., (2) reported that the growth of lettuce was affected by low concentrations of the nutrient solution, probably due to low availability of mineral nutrients.

Zucchini fruit weight and yield was significantly affected with different nutrient solutions (Table 2), while number of fruits, fruit length and girth was not significantly differed with treatments. Among the nutrient solutions, the supply of 168 ppm N-NO_3, 16 ppm P and 189 ppm K per plant recorded maximum fruit length (24.12cm), fruit girth (44.4mm), fruit weight (335.6g) and yield (5.71kg/plant and 71.39 tonnes/ha) under open soilless culture. The higher N, P and K concentrations in the nutrient solution contributed significantly better fruit length, fruit girth, average fruit weight and yield than other treatments which supplied lower levels of N, P and K nutrients.

Table 1. Effect of N, P and K concentrations on growth and biomass of zucchini (Summer Squash) hybrid Champion in soilless culture (Open field conditions).

Treatment (NPK levels)	Plant height (cm)	Stem diameter (mm)	Number of leaves	Dry biomass (g/plant)		
				Plant	Root	Total
T1	50.55^{B}	35.79	35.83^{B}	102.17^{B}	15.33	117.50^{B}
T2	51.48^{AB}	35.56	37.67^{AB}	108.50^{AB}	15.67	124.17^{AB}
T3	55.35^{AB}	34.78	40.17^{AB}	113.35^{AB}	17.68	131.03^{AB}
T4	61.25^{A}	34.69	43.33^{A}	129.42^{A}	17.33	146.75^{A}
SE(d)	4.710	1.230	2.890	11.005	1.152	11.295
LSD at 5%	10.03	NS	6.13	23.3	NS	24.2

Values are the means of seven replicate samples. Means in each column by similar letter are not significantly different at 5% level and values in the same column followed by different letters are significantly different by Duncan's multiple range tests (0.05).

Table 2. Effect of N, P and K concentrations on yield and quality of zucchini (Summer Squash) hybrid Champion in soilless culture (Open field conditions).

Treatment (NPK levels)	Number of fruits	Fruit length (cm)	Fruit girth (mm)	Fruit weight (g/fruit)	Yield (kg/plant)	Yield (t/ha)
T1	16.00	22.47	42.31	306.79[AB]	4.88[B]	61.04[B]
T2	16.50	23.15	42.86	323.69[AB]	5.32[AB]	66.54[AB]
T3	17.05	24.12	44.44	335.61[A]	5.71[A]	71.39[A]
T4	17.45	22.96	42.01	295.38[B]	5.15[B]	64.36[B]
SE(d)	0.581	1.239	1.821	15.197	0.217	2.709
LSD at 5%	NS	NS	NS	32.37	0.462	5.773

Values are the means of seven replicate samples. Means in each column by similar letter are not significantly different at 5% level and values in the same column followed by different letters are significantly different by Duncan's multiple range tests (0.05).

The decline in fruit yields with reduced levels of N, P and K in nutrient solutions has been mainly attributed to a reduction in both the average fruit weight and number of fruits per plant (Rouphael and Colla, 13). The average fruit weight of zucchini increased significantly with application of nutrient solution containing high levels of primary nutrients (N, P and K). Lower levels of N, P and K in nutrient solution reduced the fruit weight. These outcomes are in agreement with Zekri and Obreza (18) who reported that lower levels of N, P and K lead to smaller fruits as the level of plant photosynthetic activity drops abruptly. Total yield, the dry matter content and the titratable acidity in peppers were significantly higher when the full strength nutrient solutions were used compared to reduced strength nutrient solution (Giuffrida and Leonardi, 5).

Between open and polyhouse soilless cultivation of zucchini, maximum plant height (80.6cm), number of leaves (47.4), number of fruits (22.3) and total plant dry biomass (144.7g/plant) were recorded with polyhouse conditions. However, stem diameter (35.2mm), maximum fruit length (23.2cm), fruit girth (42.9mm), fruit weight (315.4g) and yield (5.27kg/plant and 65.8t/ha) were recorded with open conditions. The highest zucchini fruit yield was recorded with the open soilless system compared to the polyhouse system (Table 3). This result finds support in the observations of Qaryouti *et al.* (11) who reported that the use of a simplified open soilless system improved productivity and fruit quality in terms of fruit size, shelf life and firmness of tomato.

The earliness in fruit production was witnessed in the plants grown on cocopeat than on soil (Table 6). The first harvest from the plants grown in cocopeat and soil was done at 40th and 51st days after sowing, respectively. The maximum number of harvests was also recorded in soilless plants (13) than plants raised on soil (9). Delayed fruiting in plants grown under soil resulted in reduction in number of pickings. The use of cocopeat led to the earliest harvests compared to soil due probably to the better availability of nutrients and water and also the prevalence of better minimum temperatures in cocopeat particularly in the early period of plant growth (Rouphael *et al.*, 14). The ambient temperature regime in cocopeat can be attributed to the greater retention of water by the substrate which favours towards better thermal inertia than in the soil substrate. Related findings were witnessed in cucumbers grown in closed soilless culture with both organic and inorganic substrates (Marucci *et al.*, 10).

Table 3. Effect of polyhouse and open field soilless production systems on growth, biomass, fruit quality and yield of zucchini (Summer Squash) hybrid Champion.

Production systems	Growth and biomass						Fruit quality and yield					
	Plant height (cm)	Stem diameter (mm)	Number of leaves	Dry biomass (g/plant)			Number of fruits	Fruit length (cm)	Fruit girth (mm)	Fruit weight (g/fruit)	Yield (kg/ plant)	Yield (t/ha)
				Plant	Root	Total						
Poly house	80.6a	22.3b	47.4a	174.3a	10.4b	184.7a	22.3a	15.4b	27.6b	142.3b	3.19b	39.7b
Open field	54.7b	35.2a	39.3b	123.4b	16.5a	139.8b	16.8b	23.2a	42.9a	315.4a	5.27a	65.8a

Values are the means of seven replicate samples. Means in each column by similar letter are not significantly different at 5% level and values in the same column followed by different letters are significantly different by Duncan's multiple range tests (0.05).

Among soil and cocopeat, zucchini plants grown on Arka Fermented Cocopeat registered maximum plant height (54.7cm), stem diameter (35.2mm), number of leaves (39.3), total plant dry biomass (139.8g/plant), number of fruits (16.8), fruit length (23.2cm), fruit girth (42.9mm), fruit weight (315.4g) and yield (5.27kg/plant and 65.8t/ha) compared to soil (3.70 kg/plant and 46.3t/ha) (Table 4). A study conducted with zucchini squash by Rouphael *et al*. (14) reported that the plants grown in a soilless system exhibited higher yield compared with those grown in soil. Suvo *et al*. (16) reported that the response of zucchini squash on a coconut husk substrate was good due to the adequate availability of oxygen, nutrient and water. Similarly the best results were obtained with rose cultivated on coconut dust due to the higher water holding capacity and cation exchange capacity of coconut dust (Fascella and Zizzo, 4). Related studies conducted on tomato showed that higher yields were obtained in soilless culture with organic and inorganic substrates rather than in a soil culture (Qaryouti *et al*., 11). The results of the experiment with cantaloupe showed that all the soilless culture systems performed better than the soil system and the NFT system resulted in the best vegetative growth, yield and quality compared to the other treatments (Singer *et al*., 15). Tangolar *et al*. (17) reported that the table grape cultivars grown in the soilless culture medium (cocopeat and perlite) achieved higher yield and better qualities than those grown in open and conventional conditions.

Significant differences in the N, P, S, Fe and Zn content of the fruit samples was observed with respect to different nutrient solutions application (Table 5). Among the treatments, the highest N (3.76%), P (0.36%), Ca (0.86%), Mg (0.43%), S (0.56%), Fe (143.5 mg kg^{-1}) and Zn (62.63 mg kg^{-1}) content in zucchini fruits was recorded with application of 168 ppm $N\text{-}NO_3$, 16 ppm P and 189 ppm K. However, the supplying of 185 ppm $N\text{-}NO_3$, 19 ppm P and 224 ppm K per plant recorded maximum K (2.68%), Mn (56.78 mg kg^{-1}) and Cu (5.43 mg kg^{-1}) concentration in fruits and it was statistically on par with application of 168 ppm $N\text{-}NO_3$, 16 ppm P and 189 ppm K per plant. The main nutrients taken up by summer squash fruits were N and K which is consistent with the findings reported for summer squash grown in soil culture (Rouphael *et al*., 14). Apart from N and K, the highest P, Ca, Mg, S, Fe and Zn contents were also found in fruits harvested from soilless culture.

Soilless cultured plants recorded higher uptake of macro (N, P, K, Ca, Mg, and S) and micro (Cu, Mn and Zn) nutrients than those grown in soil (Fig. 1 & 2). However, the iron (Fe) content in fruits was

Table 4. Effect of substrates on growth, biomass, fruit quality and yield of zucchini (Summer Squash) hybrid Champion in Open field conditions.

Substrate	Plant height (cm)	Stem diameter (mm)	Number of leaves	Dry biomass (g/plant)			Number of fruits	Fruit length (cm)	Fruit girth (mm)	Fruit weight (g/fruit)	Yield (kg/ plant)	Yield (t/ha)
				Plant	Root	Total						
AFC*	54.7a	35.2a	39.3a	123.4a	16.5a	139.8a	16.8a	23.2a	42.9a	315.4a	5.27a	65.8a
Soil	51.2a	29.6b	35.3a	113.9a	10b	123.9b	13b	22.4a	39.8a	284.5b	3.70b	46.3b

*Arka Fermented Cocopeat

Values are the means of seven replicate samples. Means in each column by similar letter are not significantly different at 5% level and values in the same column followed by different letters are significantly different by Duncan's multiple range tests (0.05).

Table 5. Macro and micronutrient content of zucchini fruits grown under soilless culture.

Treatment (NPK levels)	Macro nutrient (%)						Micronutrient (mg kg^{-1})			
	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu
T1	2.38^{B}	0.26^{B}	2.54	0.57	0.41	0.40^{B}	94.63^{B}	56.20	60.95^{A}	4.34
T2	3.34^{AB}	0.29^{B}	2.58	0.64	0.43	0.48^{AB}	122.8^{AB}	51.62	49.07^{B}	4.67
T3	3.76^{A}	0.36^{A}	2.63	0.86	0.43	0.56^{A}	143.5^{A}	55.68	62.63^{A}	5.05
T4	3.42^{AB}	0.30^{AB}	2.68	0.73	0.37	0.48^{AB}	101.3^{AB}	56.78	54.43^{AB}	5.43
p-Value	0.0454	0.0223	0.9732	0.4843	0.6576	0.0285	0.0361	0.6490	0.0489	0.5073
SE(d)	0.549	0.027	0.303	0.188	0.053	0.045	20.37	4.431	5.015	0.743
LSD at 5%	1.17	0.057	NS	NS	NS	0.0963	43.39	NS	10.68	NS

Values are the means of seven replicate samples. Means in each column by similar letter are not significantly different at 5% level and values in the same column followed by different letters are significantly different by Duncan's multiple range tests (0.05).

Table 6. Time of zucchini fruits harvest under soil and soilless culture.

Harvest	Soilless	Soil
First	40 DAS*	51 DAS
2	43 DAS	54 DAS
3	46 DAS	57 DAS
4	49 DAS	60 DAS
5	52 DAS	63 DAS
6	55 DAS	66 DAS
7	58 DAS	69 DAS
8	61 DAS	72 DAS
9	64 DAS	75 DAS
10	67 DAS	
11	70 DAS	
12	73 DAS	
13	76 DAS	

*DAS - Days after sowing

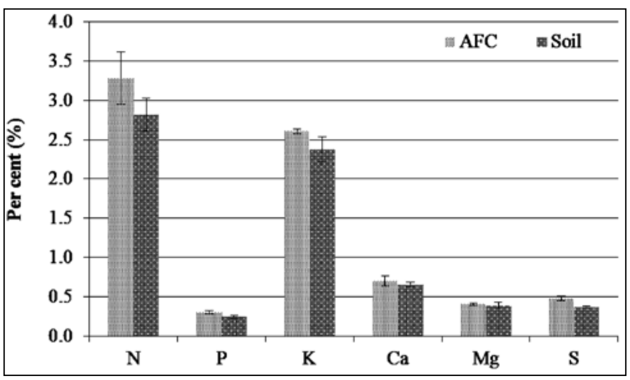

Fig. 1. Effect of substrates on macro nutrient content of zucchini fruits.

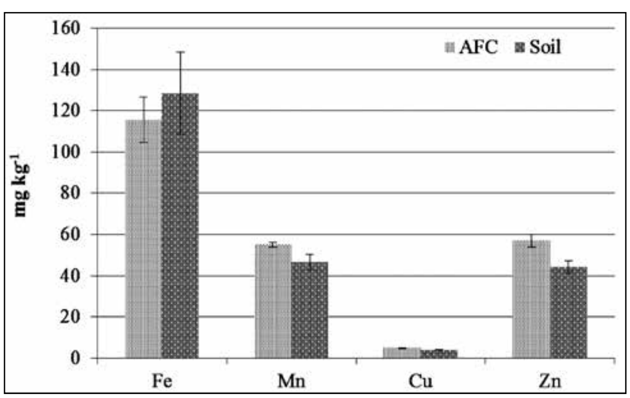

Fig. 2. Effect of substrates on micronutrient contents of zucchini fruits.

found to be greater in plants raised in soil than those grown in soilless culture using Arka Fermented Cocopeat. The higher uptake of most of the macro nutrients by zucchini fruits under soilless culture might be due to an enhanced nutrient availability and uptake in soilless over soil culture (Rouphael *et al*., 14). The micronutrient content (Cu, Mn and Zn) of fruits harvested from plants raised in soilless were higher than the fruits from plants grown on soil. This may possibly be related to the higher micronutrients availability in soilless systems that are assured through better control of pH in the nutrient solution. Similar findings have been reported by Recamales *et al*. (12) that the strawberries cultivated in soil had the low nutritive values than those grown on coconut fibre under soilless culture. Asghari (3) revealed the positive impact of variety of soilless growing media on phytochemical and nutritional composition of strawberries grown in greenhouses.

Considering the results of this study, it can be concluded that the supplying of 168 ppm N-NO_3, 16 ppm P and 189 ppm K per plant may be recommended for realizing maximum zucchini squash yield both under open and polyhouse soilless culture. Further, the substrate plays an important role in soilless production systems and Arka Fermented Cocopeat has emerged as potential substrate for zucchini squash production in open and polyhouse soilless system. Results also indicated that zucchini is found to be one of the best suitable crops for soilless cultivation. Results of the experiment clearly revealed that soilless technique can maximize growth, yield and fruit quality of zucchini squash in comparison with soil culture. Further studies are on to develop a sustainable cropping system for the soilless production of vegetables.

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