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EFFECTS OF SOIL AND CLOSED SOILLESS SYSTEM ON GROWTH, PRODUCTIVITY, FRUIT QUALITY, AND PLANT MINERAL COMPOSITION OF ZUCCHINI SQUASH

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Abstract: Soilless system exhibited higher yield (total and marketable), growth, nutrient accumulation compared with those grown in soil. Among soilless system jute fiber led to higher yield and good fruit quality compare to other substrates. The highest marketable fresh weight was observed in jute fiber, followed by coco fiber while the lowest yield was recorded in soil with a reduction of 22% compared to sales treatments. In soilless culture fruit ascorbic acid and protein content were high with 31 and 71% respectively compared to soil treatment. The concentration of glucose, fructose and sucrose were significantly higher by 25, 32,114% respectively in soilless treatments than in soil. The concentration of N and Mg in leaves, stem, fruits, and flowers were significantly higher in soilless compared to soil. Flowers, leaves, fruit and stem of plants under jute fiber treatments shows highest concentration of K and P was significantly higher in soil than soilless treatments. The micronutrient concentrations (Cu, Fe, Mn, and Zn) of plants grown in soilless treatment were generally higher than those grown on soil in the different plant tissues. The growth, yield, fruit quality and nutrient uptake was much more satisfactory on plant growing under media using jute fiber, than the other media. With controlled nutrient supply, less expense, less labor, no use of pesticides or fertilizer with the controlled environment the use soilless system with jute fiber can be an effective one for growing squash over conventional soil culture. Our results also showed that soilless culture can improve yield (total, marketable fruit) fruit quality of zucchini squash in comparison with soil culture.

Keywords: Soilless culture, Substrate, Yield, Zucchini squash.

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INTRODUCTION

Cultivation of plant without soil, currently practiced all over the world, allows good control over the environment, plant growth, and development (Vanos and Benoit, 1999). The soilless culture technique allows the achievement of high yields and less use of pesticides (Savvas, 2002). The presence of soil born pathogen at the start of the crop cultivation and continuous cultivation of same crop species on the same land represent a limitation of soil based culture. Different research activities and field trials show that hydroponics is an economic, profitable and eco-friendly than the traditional agricultural cultivation. Through soilless cultivation crops grown two times faster and have better nutritive value and it helps to the elimination of the soil borne pests (fungi), diseases, troublesome weeds and also reduction of health risks associated with pest management and soil care (Munoz,2010). Substrates like, oasis cubes, coconut fiber, sphagnum peat moss, rice hulls, sawdust,polyurethane,lava rocks, grow slabs, LECA,claybrick, etc can be used in soilless cultivation of plant (Yeager *et al.,* 2007). Squash is an important vegetable as its fruit, flower, leaves all are the edible part and a good source of nutrient including vitamin C, vitamin A, vitamin B complex, dietary fiber including pectin, iron, and copper. However, Growing zucchini squash hydroponically have become popular over last 20 years. The aim of the study was to compare the soilless culture with conventional soil culture and determine the growth, yield, nutritional values, accumulated nutrition and it's partitioning between leaves, stems, fruit and flowers of zucchini squash and also identifying low cost media based hydroponics system for cultivation of squash.

EXPERIMENTAL

In the presents study, the effect of different media based hydroponics on plant growth and nutritional values were investigated. The experiment was conducted at Biochemistry laboratory, Patuakhali science and technology university, Dumki, Patuakhali, Bangladesh.

Nutrient solution, soilless media and experimental field preparation: The nutrient solution was prepared according to the method described by Hoagland and Arnon (1950) with modification necessitated to the experiment. Non-reactive plastic pot (3litter) was used for nutrient media preparation where jute fiber, coco fiber, cotton was used as substrate All substrates (except soil) were supplied with same nutrient composition. The experimental land was well prepared by ploughing and laddering up to a good tilth.

Plant materials and growth conditions*:* To compare the treatments (substrates) a randomized complete block design with four replicates (ten plants per experimental unit) was used. The hybrid squash seed (South Korea) were surface sterilized by 95% ethanol and imbibed in deionized distilled water overnight. Seedbed was prepared using 50% sand, 25% ash and 25% topsoil (the outmost layer of soil, usually the top 2-8 inches). At the two true leaf stage zucchini plant were transplanted for soil and soilless cultivation. Physical and chemical characteristics of soil were: silt loam (sand 37.5%, silt 52.5%, clay 10%); pH 6.8; EC 0.16 ds/m; 0.658 % organic matter; 0.112 % total N; Available nutrient : 7.79 mg/kg P, 0.06 c mol/kg K, 10 mg/kg S, 0.84 mg/kg Zn , 0.15 mg/kg B. Plant were grown in open place with direct sunlight (11 ± 1 hour's photoperiod) and 21 ±2 °c temperature.

Irrigation and fertigation: For soilless culture, Constant volume of the nutrient solution was maintained by adding deionized distilled water every day. The nutrient level was maintained by adding fresh nutrient solution by every 3 days. The air pump was used for water oxygenation. For conventional soil culture, all weeds and stubble were removed and a basal dose of manure and fertilizers were applied. The land was finally prepared before planting squash seedlings. Well decomposed cow dung at 10 ton/hector was applied during final land preparation. The crop was fertilized with 250 kg urea, 175 kg triple super phosphate (TSP) and 150 kg murate of potash (MP) per hectare.

Biochemical analysis: During growing cycle, the plant height and numbers of leaves were counted at 70 DAT. The fruit was harvested when they reached marketable quality (over 12 cm) where the misshaped, deformed, less than 12 cm fruit were considered as unmarketable. Fruit and flower were collected at 65 DAT oven dried at 80°C for 72 h and ground for the analysis of trace elements. Stems and leaves were collected at 73 DAT and determination of major and trace elements (N, P, K, Ca, Mg, Na, Cu, Fe, Mn and Zn) was done with dry ashing method as described by Karla, (1998). The nitrogen concentration in plant tissues was determined after mineralization with sulfuric acid by "Regular Kjeldahl method" (Bremner, 1965) and convertion factor was used to determine the amount of protein. Zucchini fruit was harvested at 58 DAT, freeze dried (-80°c) and stored at -20°C for Analysis of soluble carbohydrates (glucose, fructose, sucrose, raffinose) and starch contents was determined throughan enzyme-linked spectrophotometric assay as described by Jones *et al*. (1977) including the modification of Antognozzi *et al*. (1996). Ascorbic acid was determined according to the dye method by Ranganna (1977).

Data analysis: Statistical packages SPSS 16 was used for data analysis. Duncan's Multiple Range test was performed at $P \leq 0.05$ on each of the significant variables measured.

RESULTS AND DISCUSSION

Plant height, number of leaves and yield

The plant height and a number of leaves of zucchini squash in jute fiber and coco fiber treatments were significantly higher than for zucchini grown on soil. The highest marketable fresh weight was observed in jute fiber, followed by cocofiber while the lowest yield was recorded on soil with reduction of 22% compare to soilless treatments (Table 1). We could not count the cotton treatment because there was no fruit setting on the plants under this media. It may be related to the physical and chemical properties of substrate and the response of plant was not good because of coloring and toxic chemicals of cotton which changed the character of Hoagland solution and inhabited the nutrient uptake by the plants. The marketable yield on soil treatments was closed to the value reported by Graifenberg *et al.,* (1996) for zucchini squash (11680 g per plant). The above findings may be related to a better temperature regime in jute fiber during the early part of the growing cycle. The better temperature regime in jute fiber was due to the higher water retention of the substrate which leads to a greater thermal inertia than in the other substrates, Similar results were observed in cucumbers grown in aclosed soilless system with organic and inorganic substrates (Marucci *et al*., 2001).

Ascorbic acid content and protein percentage

The highest amount of fruit ascorbic acid content was related to plant under jute media (29.32 mg/100g) when the lowest amount of ascorbic acid recorded on soil with reduction of 31% compare to soilless treatments. On the other hand, fruit and leaves protein percent reduced by 71% and 37% respectively in soil treatments to compare to closed soilless culture (Table 2).

Soluble carbohydrate and starch concentration

The concentration of glucose, fructose and sucrose were significantly higher by 25,32,114 % respectively in soilless treatments than in soil. A significant difference was found between soilless for the main sugars (glucose and fructose) (Table 3). Analysis of sugars in zucchini fruits showed no detectable level of raffinose (Table 3). The concentration of starch in soilless treatments was higher by 137% than in soil culture (Table 3). The qualitative characteristics (soluble sugars, starch, total carbohydrates) varied significantly in relation to the soil and soilless culture. This could be due to a better nutrition control in soilless over conventional culture.

Plant mineral composition

The concentration of N and Mg in leaves, steam, fruits, and flowers were significantly higher in thesoilless plant than in those grown in soil. N concentration highest in plants under coco fiber followed by jute fiber and related to fruit (Table 4). The highest concentration of Mg recorded from leaves of plants under jute fiber treatments (Table 4). The highest concentration of Ca found in leaves related to jute fiber, asignificant amount of Ca also found from aplant of soil (Table 4). Flowers, leaves, fruit and stem of plants under jute fiber treatments shows thehighest concentration of K while alower concentration of K found from aplant of cotton treatments. The concentration of P was significantly higher in soil than soilless treatments.

The dominant nutrients take up by zucchini squash were K and N which is consistent with the result reported for zucchini squash grown in soil culture. The dominant nutrients taken up by zucchini squash were K and N which is consistent with the results reported for zucchini squash grown in soil culture (Huett and Dettman, 1992). In addition, the highest N, P contents were found in fruits, the highest K concentrations occurred in flowers (Table 4), while the highest Mg and Ca concentrations were observed in leaves. The mineral concentration of N in plants organs was close to the values reported for zucchini squash by Villora *et al*. (1998), while the partitioning pattern of nutrient concentration is in agreement with the results obtained by Graifenberg *et al*. (1996) in zucchini plants grown in soil culture. The effects of substrates on Na uptake were significantly different in leaves, fruits, flowers and stems where height amount of Na was recorded from stems of the zucchini plant. The micronutrient concentrations (Cu, Fe, Mn, and Zn) of plants grown in soilless were generally higher than those grown on soil in the different plant tissues. However, micronutrients did not reach a deficiency level (except cotton media) since yields were high and there were no visual deficiency symptoms. Among them, the jute accumulated asignificant amount of micronutrient.

Table 1. Plant height, number of leaves and number of total (T), marketable (M) fruits of zucchini squash grown on four substrates. Values are the mean of four replicate samples in each column, values followed by the same letter do not differ significantly at P=0.05

Substrate	Plant height (cm)	No. of leaves (at 70 DAT)	Fruit (g/plant)		Fruit (g/fruit	
			T	M	T	M
Jute fiber	62.3 [a]	17.75 [a]	2434 [a]	2305 [a]	115 [a]	114.9 [a]
Coco fiber	60.32 [a]	14.25 [b]	2134 [b]	2040 [b]	109 [b]	112.5 [a]
Cotton fiber	36.3 [c]	12.75 [b]	*	*	*	*
Soil	50.9 [b]	9.5 [c]	1699 [c]	1573 [c]	99.5 [c]	86.3 [b]

* no fruit setting

Table 2. Ascorbic acid and protein content of zucchini squash grown on four substrates. Values are the mean of four replicate samples in each column, values followed by the same letter do not differ significantly at P=0.05

Substrate	Fruit ascorbic acid content (mg/100g)	Fruits protein content (%)	Leaves protein content (%)
Jute fiber	29.32 [a]	29.37 [b]	20.6 [a]
Coco fiber	22.25 [b]	31.8 [a]	20.2 [b]
Cotton fiber	*	*	18.75 [c]
Soil	17.62 [c]	17.5 [c]	12.5 [d]

*no fruit setting

Table 3. Soluble carbohydrates and starch concentration in zucchini fruits grown on four substrates. Values are the means of four replicate samples in each column, values followed by the same letter do not differ significantly at P = 0.05

Substrate	Carbohydrates (µg/g of fresh weight)					
	Glucose	Fructose	**Sucrose**	**Raffinose**	**Starch**	**Total**
Jute fiber	5071 [a]	5295 [a]	339 [a]	ND #	1385 [a]	12090 [a]
Coco fiber	4432 [b]	4636 [b]	170 [b]	ND #	1189 [b]	10423 [b]
Cotton fiber	*	*	*	*	*	*
Soil	3575 [c]	3760 [c]	119 [c]	ND #	545 [c]	7999 [c]

*no fruit setting
not detected

Table 4. Major element concentrations and partitioning in plant tissue (leaves, stems, fruits and flowers) of zucchini squash grown on four substrates. Values are the means of four replicate samples. In each column, values followed by the same letter do not differ significantly at P =0.05

Substrate	Major elements (g/kg of dry weight)				
	N	P	K	Ca	Mg
Leaves					
Jute	33.5 a	2.5 b	37.75 a	26.37 a	14.5 a
Coco fiber	32.5 a	2.4 b	27.8 b	21.1 b	13.5 b
Cotton fiber	30.75 a	2.3 b	12.7 c	18.7 c	7.3 d
Soil	20.1 b	3.55 a	37.97 a	23 ab	11.9 c
Stems					
Jute	30.00 a	2.63 c	42.7 a	11.5 ab	9.4 b
Coco fiber	32.25 a	2.8 b	35.7 b	10.2 b	9.5 a
Cotton fiber	14.75 b	2.61 c	27.5 c	10.5 b	3.1 d
Soil	18.25 b	4.7 a	45.5 a	13.25 a	8.1 c
Fruits					
Jute	47.01 b	5.4 b	48.25 a	4.6 a	5.5 b
Coco fiber	51.75 a	5.7 a	44.75 b	4.1 b	5.6 a
Cotton fiber	*	*	*	*	*
Soil	28.25 c	5.8 a	40.7 c	4.2 b	5.1 c
Flowers					
Jute	41.5 a	2.85 b	52.2 a	13.1 a	9.5 a
Coco fiber	35.2 b	2.6 b	43.25 b	9.7 b	8.8 b
Cotton fiber	24.8 c	1.5 c	35.0 c	11.5 a	5.1 d
Soil	28.25 c	4.4 a	49.7 a	13.0 a	5.6 c

* no fruit setting

Table 5. Sodium and trace element concentrations and partitioning in plant tissue (leaves, stems, fruits and flowers) of zucchini squash grown on four substrates. Values are the means of four replicate samples. In each column, values followed by the same letter do not differ significantly at P = 0.05.

Substrate	Trace elements (mg/kg of dry weight)				
	Na	Cu	Fe	Mn	Zn
Leaves					
Jute	317.2 a	8.6 a	57.8 b	289.6 a	87.9 a
Coco fiber	258.8 b	6.5 b	61.7 a	142.3 b	70.3 b
Cotton fiber	160.1 d	2.6 d	21.3 d	35.8 d	29.5 d
Soil	245.6 c	5.3 c	23.6 c	45.9 c	58.4 c
Stems					
Jute	1427 b	12.6 a	69.5 a	101.9 a	28.9 a
Coco fiber	2013.1 a	9.3 b	63.8 b	74.2 b	22.7 c
Cotton fiber	1287 c	5.3 d	33.2 d	34.9 d	15.8 d
Soil	426 d	8.4 c	56.3 c	59.3 c	23.6 b
Fruits					
Jute	103.2 a	9.6 a	63.4 a	49.8 a	70.6 a
Coco fiber	96.8 b	9.3 b	62.5 b	33.5 b	58.3 b
Cotton fiber	*	*	*	*	*
Soil	72.3 c	8.9 c	58.2 c	20.6 c	53.7 c
Flowers					
Jute fiber	120.6 a	9.9 a	77.4 a	172.4 a	108.2 a
Coco fiber	110.7 b	8.3 b	72.8 b	53.6 b	91.6 b
Cotton fiber	60.3 d	4.7 d	45.3 d	22.7 c	52.9 d
Soil	105. 3 c	6.6 c	55.3 c	18.2 d	61.3 c

* no fruit setting

CONCLUSION

The growth, yield, fruit quality and nutrient uptake was much more satisfactory of plant growing under media using jute fiber, than the other media. The result also indicates that the jute fiber may provide adequate oxygen to root than that of cotton and coconut husk. On the other hand, the response of theplant to media using coconut husk was good after the medium with jute fiber. Our results showed that soilless culture can improve yield (total, marketable fruit) fruit quality of zucchini squash in comparison with soil culture. On these types of media based closed container hydroponic technique the loss of nutrient solution is less and this technique does not require pesticide or fertilizer as there was no chance of damage due to soil-borne diseases or pest. And the balance nutrient supply maintained sudden nutrient scarcity. Overall it is an eco-friendly technique for agriculture. So, with the controlled nutrient supply, less expense, less labor, no use of pesticides or fertilizer with controlled environment the use of jute fiber with Hoagland solution can be an effective one for growing squash over conventional soil culture.

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