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EFFECT OF SUBSTRATE MIXTURE AND BIO-STIMULANTS ON GROWTH, FRUITS QUALITY, YIELD AND NUTRIENTS CONCENTRATIONS OF STRAWBERRY PLANTS

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Abstract

Two field experiments were carried out at Modern Agricultural company farm, of PICO Company, Al-Tahrir Directorate, Badr Center, Behaira, during winter seasons of 2015/2016 and 2016/2017. The experiment was to study the effect of different substrate combinations and bio-stimulants on strawberry growth, fruits quality, yield and nutrients concentration under soilless culture system. The trail included 12 growing media in soilless culture system as follow: modern coco peat at ratio 100%, old coco peat + perlite at ratio 1:3 (v/v), old coco peat + sand at ratio 1:3, old coco peat + perlite + sand at ratio 2:2:1, rice straw + perlite at ratio 1:3, rice straw + sand at ratio 1:3, rice straw + perlite + sand at ratio 2:2:1, peat moss + perlite at ratio 1:3, peat moss + sand at ratio 1:3, peat moss + perlite + sand at ratio 2:2:1, old coco peat + sand at ratio 1:1 and rice straw + sand at ratio 1:2 for planting fresh seedling of strawberry. Strawberry foliar in each medium was sprayed three times using 3 bio-stimulants compared with control as follow: amino acids at rate 2ml/l water, seaweed extract at rate 5ml/l water and EM (Biogen: *Azotopacter* sp. + *Azosperillium* sp., Phosphoren: *Bacillus megaterium* and Potassiumag: *Bacillus circulans*, with total bacteria count 106:108) at rate 4ml/l water. A randomize complete block design with two factors was used for analysis all data with three replications for each parameter. The results indicated that the highest value of crown diameter, fruit weight and fruit length was recorded with using modern coco peat as growing medium, whereas the highest plant height and K% was noticed with using rice straw with perlite and sand or with using rice straw with sand only at ratio 1:2. Also, using old coco peat + perlite as growing medium gave a significant increment in marketable fruit yield. Regarding bio-stimulants application, using EM stimulator gave a significant improvement in crown diameter, marketable fruits yield, fruit quality, N% and P% in strawberry leaves followed by seaweed extract.

Key words: Strawberry, Substrate mixture, Amino Acids, Seaweed Extract, EM stimulator, yield, nutrients.

Introduction

Strawberry (*Fragaria* × *ananassa* Duch.) is one of the main export crops, because of its taste, scent and high vitamin content, strawberry is well known all over the world and is a common fruit in food diets. Strawberry is generally grown in soil worldwide. It is a sensitive plant and a number of organisms affect almost all parts including roots, crown, leaves and fruits. The greenhouse production of strawberry has the advantage of increased yield per unit area, early production when market prices are high, relatively easier pest management with reduced use of chemicals, as well as better fruit quality (Cantliffe *et al*., 2007). To reduce the soil pathogens the use of artificial media is gaining popularity and number of soilless substrate can be used to substitute the soil (De-Rijck and Schrevens, 1998). Suitable mixtures of substrate in soilless culture within greenhouse systems prolong harvesting duration of strawberry production and increase in yield (Jafarnia *et al*., 2010). Also, using combinations of soilless substrates (cocopeat + perlite + vermicompost at ratio 2:1:1, cocopeat + perlite + vermicompost at ratio 3:1:1, cocopeat + perlite + vermicompost at ratio 4:0:1, cocopeat + perlite + vermicompost at ratio 4:1:0, cocopeat + perlite + vermicompost at ratio 4:1:1 and cocopeat + perlite + vermicompost at ratio 2:1:2) significantly improved the reproductive growth in strawberry compared to the soil and the substrate combination (cocopeat + perlite + vermicompost, 3:1:1) was found superior among all the treatments (Sharma and Godara, 2017). Material properties of substrate display direct and indirect effects on plant physiology and production (Cantliffe *et al*., 2001). The use of different organic and inorganic substrates

allows the plants to have better nutrient uptake, sufficient growth and development to optimize water and oxygen holding (Albaho *et al*., 2009; Ameri *et al*., 2012). Application of organic materials as substrates for hydroponic culture media was reported by Hesami *et al*., (2012). The appropriate proportion of the substrate in strawberry not only increases the yield potential but also improves the quality of the fruits by accurate control over the supply of water, nutrients, aeration, root temperature and pH (Olympios, 1993; Jensen, 1999).

On the other hand, sub-stances with biological origin have been used to avoid or counteract abiotic or biotic stress in horticulture. Many of these materials are natural products without chemicals or plant growth regulators (Russo and Berlyn, 1991) and according to Crouch *et al*., (1992) can be classified into three major groups on the basis of their source and content: humic substances, hormone containing products and amino-acid containing product. The third group of biostimulants consists of mixtures of peptides and free amino acids which can be obtained by chemical and/or enzymatic hydrolysis of an organic matrix of plant or animal origin and their composition can be highly variable (Maini, 2006). Biostimulants usage has become a common practice in sustainable agriculture, because their application reduces fertilizers and other chemical compound application in agriculture (Russo and Berlyn, 1991). Some studies already investigated positive effects of biostimulants on plants. These studies mostly investigated biostimulant influence on plant growing, rooting, biomass of newly formed roots, early flowering and fruiting (Marfa *et al*., 2008) and thermal stress (Polo *et al*., 2006), but there is a small number of those that had experiments exposed to the relationship between growing media and bio-stimulants in Egypt. Bio-stimulants applications (containing amino-acids of animal origin) gave appositive response in growth and yield of strawberry cultivars (Gilinicki *et al*., 2010; Bogunovic *et al*., 2015). So, this attempt was made to determine the effect of different substrate combination and bio-stimulantson growth, fruit quality, marketable fruits yield and nutrients concentration of strawberry.

Materials and Methods

The experiment was carried out at Modern Agricultural company farm, of PICO Company, Al-Tahrir Directorate, Badr Center, Behaira, during the two successive seasons of 2015/2016 and 2016/2017. The experiment was to study the effect of different substrate cultures and bio-stimulants on strawberry growth, fruits quality, yield and nutrients concentration under soilless culture system. The trail included 12 growing media in soilless culture system as follow:modern coco peat at ratio 100%, old coco peat + perlite at ratio 1:3 (v/v), old coco peat + sand at ratio 1:3, old coco peat + perlite + sand at ratio 2:2:1, rice straw + perlite at ratio 1:3, rice straw + sand at ratio 1:3, rice straw + perlite + sand at ratio 2:2:1, peat moss + perlite at ratio 1:3, peat moss + sand at ratio 1:3, peat moss + perlite + sand at ratio 2:2:1, old coco peat + sand at ratio 1:1 and rice straw + sand at ratio 1:2 for planting fresh seedling of strawberry. Strawberry foliarin each medium was sprayed three times (after one month from transplanting, at flowering stage starting and at fruit set stage starting) using 3 bio-stimulants compared with control (sprayed three times only with water) as follow: amino acids at rate 2ml/l water, seaweed extract at rate 5ml/l water and EM (Biogen: *Azotopacter sp.* + *Azosperillium sp*., Phosphoren: *Bacillus megaterium* and Potassiumag: *Bacillus circulans*, with total bacteria count 106: 108) at rate 4ml/ l water. The plants of strawberry cultivar 'Fortuna' were planted under natural light condition during the first mid of September after treating with Carbendazim and monocrotophos. Holes were made at the bottom of each container to allow the drainage the excess water. The greenhouse with facility of controlling temperature, humidity and light with automation system for irrigation and fertigation was used. The transplanted plants were kept under uniform condition in poly-house during the study period where all the management practices were carried out as per the package of practices. The pH for this experiment maintained from 6.0-6.5 to facilitate the maximum uptake of elements. The Electrical Conductivity (EC) for soilless growing strawberry is maintained below 1.5 mS cm^{-1} for better growth, yield and good quality fruits. The standard and uniform fertilizer solution was used for whole course of investigation. The fertigation system was open drip irrigation with no circulation, using 2 liter/ hour capacity in line lateral drippers installed on each growing bed. A randomize complete block design with two factors was used for analysis all data with three replications for each parameter. Seedling was transplanted in rows of the growing bed, the distance between rows was 0.3 m and the distance between plants in the same row was also 0.3 m. The treatments of this experiment were 48 treatments.

Crown diameter and plant height, the mean of three plants of each plot, at 90 days from transplanting were recorded and also three fruits from each plot randomly sampled at the second harvest to estimate fruit characteristics (fruit weight, fruit length, fruit diameter and fruit TSS%, by using Zeiss laboratory refractometer),

also marketable fruits yield/ 30 m was calculated in the end of season growth. Nitrogen, phosphorus, potassium and calcium percentage of strawberry leaves were determined, 90 days after transplanting (nitrogen content was determined by micro-Kjeldahl method as explained by Hesse, 1971, phosphorus content determined by using spectrophotometer according to Taussky and Shorr, 1952, potassium and calcium content was determined by using absorption flame-photometer according to the method described by Brown and Lilliland, 1946). The treatment means were compared by least significant difference (L.S.D.) test as given by Snedecor and Cochran, (1976) by used M-stat program.

Results

1. Effect of growing media, bio-stimulants and their interactions on strawberry crown diameter:

Data in table 1 showed that the highest crown diameter was recorded with using modern coco peat as growing medium, whereas the lowest crown diameter was achieved with using rice straw + sand at ratio 1:3 followed by old coco peat + sand at ratio 1:1 and peat moss + sand in both seasons, this reduction in crown diameter was significant as compared with using modern coco peat medium in both seasons.

With regard to the effect of bio-stimulants on crown diameter, data indicated that crown diameter was significantly higher with using EM in both seasons as well as seaweed extract in the first season, as compared with control treatment.

The interaction between growing media and bio-stimulants on crown diameter was significant in both seasons (Table 1). In this respect, the highest values of crown diameter were noticed with using the growing media of old coco peat + perlite + sand or rice straw + perlite + sand with EM stimulant in both seasons.

2. Effect of growing media, bio-stimulants and their interactions on marketable fruits yield of strawberry:

As shown in table 2, the results in both seasons indicated that using old coco peat + perlite as growing medium gave a significant increment in marketable fruit yield followed by peat moss + perlite in both seasons, as compared with the other growing media. On the other hand, the worst growing medium at the level of marketable fruits yield was the growing medium of peat moss + sand in both seasons. Generally, using all growing media, except peat moss + sand as well as peat moss + perlite + sand, had a significant increase in marketable fruits yield, as compared with modern coco peat medium in both seasons.

Regarding bio-stimulants effect, there were no significant differences between control treatment and all bio-stimulants in marketable fruits yield in the first season, whereas marketable fruits yield in the second season was significantly higher with using EM stimulant than control treatment.

Table 1: Effect of growing media, some stimulants and their interactionon crown diameter (cm) per plant of strawberry in 2015/ 2016 and 2016-2017 seasons.

Treatment	Stimulants									
	2015/2016 season					2016/ 2017 season				
Growing Media	Control	Amino Acids	Seaweed extract	EM	Mean	Control	Amino Acids	Seaweed extract	EM	Mean
Modern Coco peat	3.73	4.53	4.00	4.93	4.30	5.10	5.93	5.33	6.23	5.65
Old Coco peat +Perlite	3.50	3.23	4.03	5.00	3.94	5.00	5.17	5.07	6.37	5.40
Old Coco peat +Sand (1:3)	3.63	3.37	3.90	5.40	4.07	5.00	4.77	5.23	6.70	5.42
Old Coco peat +Perlite + Sand	3.10	3.30	3.23	5.67	3.82	4.33	4.70	4.70	6.97	5.17
Rice straw + Perlite	4.23	4.10	3.50	4.37	4.05	4.60	5.50	5.83	5.67	5. 40
Rice straw + Sand(1:3)	3.07	3.13	2.93	4.47	3.40	4.03	4.53	4.67	5.77	4.75
Rice straw + Perlite + Sand	3.27	3.60	4.10	5.67	4.16	5.20	5.00	4.87	6.97	5.51
Peat Moss + Perlite	3.67	3.63	3.33	5.03	3.92	4.43	5.03	5.27	6.33	5.27
Peat Moss + Sand	3.03	3.27	3.63	4.73	3.67	4.73	4.67	4.63	6.03	5.02
Peat Moss + Perlite + Sand	4.23	3.30	3.93	4.53	4.00	5.03	4.70	5.83	5.83	5.35
Old Coco peat +Sand (1:1)	3.37	3.30	3.33	4.63	3.66	4.43	4.73	4.97	5.93	5.01
Rice straw + Sand(1:2)	3.30	3.47	5.60	3.93	4.07	6.70	4.87	4.90	5.23	5.42
Mean	3.51	3.52	3.79	4.86		4.88	4.97	5.11	6.17	
LSD at 0.05	G. media (A) = 0.51; Stimulants (B)= 0.26 A × B= 0.92					G. media (A)= 0.53; Stimulants (B)= 0.26 A × B= 0.92				

Table 2: Effect of growing media, some stimulants and their interactionon marketable fruits of strawberry Kg/ 30 m^2 in 2015/2016 and 2016-2017 seasons.

Treatment	Stimulants									
	2015/2016 season					2016/ 2017 season				
Growing Media	Control	Amino Acids	Seaweed extract	EM	Mean	Control	Amino Acids	Seaweed extract	EM	Mean
Modern Coco peat	13.03	13.37	13.40	12.70	13.13	14.43	14.83	14.83	15.37	14.87
Old Coco peat +Perlite	29.70	30.37	30.03	30.40	30.13	31.43	31.83	31.83	32.37	31.87
Old Coco peat +Sand (1:3)	24.03	24.37	24.40	23.70	24.13	25.43	25.83	25.83	26.37	25.87
Old Coco peat +Perlite + Sand	20.03	20.37	20.40	19.70	20.13	21.43	21.83	21.83	22.37	21.87
Rice straw + Perlite	18.63	18.97	19.00	18.30	18.73	20.03	20.43	20.43	20.97	20.47
Rice straw + Sand(1:3)	14.03	14.37	14.40	13.70	14.13	15.43	15.83	15.83	16.37	15.87
Rice straw + Perlite + Sand	17.63	17.97	18.00	17.30	17.73	19.03	19.43	19.43	19.97	19.47
Peat Moss + Perlite	26.03	26.37	26.40	25.70	26.13	27.43	27.83	27.83	28.37	27. 87
Peat Moss + Sand	9.03	9.37	9.40	8.70	9.12	10.43	10.83	10.83	11.37	10.87
Peat Moss + Perlite + Sand	12.03	12.40	12.40	11.70	12.13	13.43	13.83	13.83	14.37	13.87
Old Coco peat +Sand (1:1)	25.63	25.97	26.00	25.30	25.73	27.03	27.43	27.43	27.97	27.47
Rice straw + Sand(1:2)	20.33	20.67	20.70	20.00	20.42	21.73	22.13	22.13	22.67	22.17
Mean	19.17	19.55	19.54	18.93		20.61	21.01	21.01	21.54	
LSD at 0.05	G. media (A) = 0.03; Stimulants (B)= 0.41 A × B= 1.42					G. media (A)= 0.03; Stimulants (B)= 0.45 A × B= 1.56				

The interaction between growing media and bio-stimulants in the two seasons revealed that all bio-stimulant treatments significantly increased the marketable fruits yields with using the growing medium of old coco peat + perlite.

3. Effect of growing media, bio-stimulants and their interactions on plant height of strawberry:

Data in table 3 indicated that using all growing media, except using old coco peat whether + sand (1:1) or + perlite and sand as well as rice straw + sand at both of ratio 1:3 or 1:2, significantly increased plant height, as compared with using modern coco peat in the first season. Generally, the highest value of plant height was recorded with using peat moss + perlite medium in the first season, whereas the lowest value of plant height was with using peat moss + sand. In the second season, except using old

Table 3: Effect of growingmedia, some stimulants and their interactionon plant height (cm) of strawberry in 2015/2016 and 2016-2017 seasons.

Treatment	Stimulants									
	2015/2016 season					2016/ 2017 season				
Growing Media	Control	Amino Acids	Seaweed extract	EM	Mean	Control	Amino Acids	Seaweed extract	EM	Mean
Modern Coco peat	23.00	22.67	21.00	24.33	22.75	17.00	24.33	19.67	24.00	21.25
Old Coco peat +Perlite	28.00	22.33	23.67	27.00	25.25	29.67	23.33	20.33	25.33	24.67
Old Coco peat +Sand (1:3)	21.33	21.00	22.67	22.00	21.75	24.33	25.00	21.33	20.33	22.75
Old Coco peat +Perlite + Sand	25.67	21.67	19.00	28.33	23.67	28.00	17.67	16.33	21.67	20.92
Rice straw + Perlite	24.00	25.00	27.33	27.67	26.00	23.67	25.67	23.00	25.67	24.50
Rice straw + Sand(1:3)	25.67	25.33	24.00	15.67	22.67	28.33	20.67	25.00	20.67	23.67
Rice straw + Perlite + Sand	28.67	27.33	25.33	28.00	27.33	28.33	28.00	21.33	26.67	26.08
Peat Moss + Perlite	29.33	24.33	32.00	25.00	27.67	25.00	22.33	29.33	22.00	24.67
Peat Moss + Sand	21.67	18.00	18.67	23.00	20.33	23.00	21.67	21.33	21.00	21.75
Peat Moss + Perlite + Sand	25.00	27.00	25.33	28.33	26.42	24.33	26.67	26.33	26.33	25.92
Old Coco peat +Sand (1:1)	23.33	25.33	24.00	28.67	25.33	25.33	27.00	22.33	22.67	24.33
Rice straw + Sand(1:2)	22.33	26.67	19.00	20.33	22.08	26.67	25.33	26.00	26.00	26.00
Mean	24.83	23.89	23.50	24.86		25.31	23.97	22.69	23.53	
LSD at 0.05	G. media (A) = 2.05; Stimulants (B)= 1.34 A × B= 4.09					G. media (A)= 2.27; Stimulants (B)= 1.11 A × B= 4.54				

coco peat + perlite + sand, old coco peat + sand (1:3) and peat moss+ sand, using all growing media gave a significant increment in plant height as compared with using modern coco peat medium. Also, the highest plant height was noticed with using rice straw with perlite and sand or with using rice straw with sand only at ratio 1:2, while the lowest plant height was recorded with using modern coco peat and old coco peat + perlite + sand.

Respecting the effect of bio-stimulant on plant height of strawberry, data in the same table indicated that no significant differences were remarked between using all bio-stimulants and control treatment on plant height in the first season. On the contrary, using all bio-stimulant treatments in the second season had a significant decrease in plant height as compared with control treatment.

With respect of the interaction between growing media and bio-stimulants, using peat moss + perlite with seaweed extract in the first season or using old coco peat + perlite without any bio-stimulant in the second season recorded the highest values of plant height.

4. Effect of growing media, bio-stimulants and their interactions on fruits quality of strawberry:

Tables 4,5,6 and 7 show the effects of growing media, bio-stimulants and their interactions on weight, length, diameter and TSS% of strawberry fruits, respectively. In this regard, fruit weight and fruit length of strawberry were significantly higher with using modern coco peat medium than the other media in both seasons, except in the case of using old coco peat + perlite + sand medium in the second season that appeared significant superiority in fruit weight as compared with modern coco peat. On the other hand, using peat moss + perlite + sand in the first season and rice straw + sand at ratio of 1:3 or 1:2 in the second season gave the lowest values of fruit weight, while using old coco peat + sand (1:3) or peat moss + perlite + sand in the first season as well as using peat moss + sand in the second season had the lowest values of fruit length. Also, fruit diameter was significant higher with using rice straw + perlite and peat moss + perlite than using other growing media in the two seasons, whereas using rice straw + sand (1:2) recorded the lowest value of fruit diameter in both seasons. Regarding TSS%, data indicated that the highest values of TSS% were achieved with using old coco peat + sand (1:3) in both seasons as well as with using old coco peat + perlite + sand or using old coco peat + sand (1:1) in the first season, whereas using peat moss + perlite, peat moss + perlite + sand or using rice straw + perlite in both seasons as well as using rice straw + perlite + sand in the first season had lowest values of TSS%.

With regard to the effect of bio-stimulants on fruit quality, data indicated that fruit weight in the first season and fruit length in both seasons were significantly higher with using the all bio-stimulants than control treatment vice versa all bio-stimulants gave significant reduction in fruit weight in the second season as well as TSS% in both seasons, as compared with control. On the other hand, using EM and seaweed extract in the first season significantly increased fruit diameter, as compared with

Table 4: Effect of growingmedia, some stimulants and their interactionon fruit weight (g) of strawberry in 2015/2016 and 2016-2017 seasons.

Treatment	Stimulants									
	2015/2016 season					2016/ 2017 season				
Growing Media	Control	Amino Acids	Seaweed extract	EM	Mean	Control	Amino Acids	Seaweed extract	EM	Mean
Modern Coco peat	23.67	24.83	25.20	23.13	24.21	20.70	22.20	17.37	20.10	20.09
Old Coco peat +Perlite	17.22	23.47	21.47	22.73	21.22	18.30	17.87	18.60	18.07	18.21
Old Coco peat +Sand (1:3)	20.27	24.70	18.60	21.43	21.25	18.07	16.90	15.10	19.93	17.50
Old Coco peat +Perlite + Sand	17.17	21.20	22.20	24.20	21.19	30.07	19.80	16.60	18.23	21.17
Rice straw + Perlite	24.63	21.30	22.40	23.30	22.91	17.60	16.27	15.20	18.03	16.77
Rice straw + Sand(1:3)	22.43	22.27	22.03	23.60	22.58	16.60	15.13	15.23	16.50	15.87
Rice straw + Perlite + Sand	24.67	21.60	21.80	23.00	22.77	18.40	17.07	18.13	18.23	17.96
Peat Moss + Perlite	23.08	23.93	22.60	22.37	22.99	15.93	17.60	16.70	16.93	16.79
Peat Moss + Sand	24.93	22.50	20.80	22.90	22.78	16.50	14.67	17.43	16.10	16.17
Peat Moss + Perlite + Sand	18.00	21.10	21.13	20.90	20.28	16.00	15.10	15.50	17.83	16.11
Old Coco peat +Sand (1:1)	20.10	23.50	21.27	22.00	21.72	17.20	16.97	14.93	18.10	16.80
Rice straw + Sand(1:2)	22.50	20.90	22.80	19.93	21.53	15.87	14.80	14.77	17.57	15.75
Mean	21.56	22.61	21.86	22.46		18.44	17.03	16.30	17.97	
LSD at 0.05	G. media (A) = 0.38; Stimulants (B)= 0.21 A × B= 0.76					G. media (A)= 0.17; Stimulants (B)= 0.15 A × B= 0.34				

Table 5: Effect of growingmedia, some stimulants and their interactionon fruit length (cm) of strawberry in 2015/2016 and 2016-2017 seasons.

Treatment	Stimulants									
	2015/2016 season					2016/ 2017 season				
Growing Media	Control	Amino Acids	Seaweed extract	EM	Mean	Control	Amino Acids	Seaweed extract	EM	Mean
Modern Coco peat	4.65	4.52	5.30	4.80	4.82	5.00	5.10	4.70	5.00	4.95
Old Coco peat +Perlite	3.67	4.53	4.60	5.00	4.45	4.40	4.80	4.90	4.90	4.75
Old Coco peat +Sand (1:3)	4.25	4.52	3.30	4.70	4.19	4.70	4.90	4.70	4.30	4.65
Old Coco peat +Perlite + Sand	3.54	4.65	5.00	5.10	4.57	4.90	4.60	4.80	4.60	4.72
Rice straw + Perlite	4.44	4.30	5.23	4.63	4.65	4.70	4.67	4.60	4.50	4.62
Rice straw + Sand(1:3)	4.18	4.63	4.70	4.70	4.55	3.70	4.40	4.30	4.30	4.17
Rice straw + Perlite + Sand	4.20	4.27	4.60	4.80	4.47	4.70	4.60	4.40	4.40	4.52
Peat Moss + Perlite	3.96	4.90	4.30	4.30	4.36	4.77	4.70	4.90	4.80	4.79
Peat Moss + Sand	4.35	4.80	4.40	4.60	4.54	4.40	3.70	4.50	4.40	4.25
Peat Moss + Perlite + Sand	3.58	4.20	4.70	4.30	4.20	4.20	5.10	4.80	4.80	4.72
Old Coco peat +Sand (1:1)	3.95	4.90	4.40	4.90	4.54	4.50	4.60	4.70	4.83	4.66
Rice straw + Sand(1:2)	3.97	4.30	4.60	5.00	4.47	4.30	4.40	4.50	5.03	4.56
Mean	4.06	4.54	4.59	4.74		4.52	4.63	4.65	4.66	
LSD at 0.05	G. media (A) = 0.08; Stimulants (B)= 0.09 A × B= 0.17					G. media (A)= 0.07; Stimulants (B)= 0.05 A × B= 0.13				

Table 6: Effect of growingmedia, some stimulants and their interactionon fruit diameter (cm) of strawberry in 2015/2016 and 2016-2017 seasons.

Treatment	Stimulants									
	2015/2016 season					2016/ 2017 season				
Growing Media	Control	Amino Acids	Seaweed extract	EM	Mean	Control	Amino Acids	Seaweed extract	EM	Mean
Modern Coco peat	2.80	2.80	3.50	3.00	3.02	2.70	2.70	2.50	2.60	2.62
Old Coco peat +Perlite	2.74	2.85	3.00	2.90	2.87	2.40	2.60	2.57	2.50	2.52
Old Coco peat +Sand (1:3)	2.75	3.01	3.00	3.00	2.94	2.50	2.50	2.20	2.80	2.50
Old Coco peat +Perlite + Sand	2.73	2.90	3.10	3.10	2.96	2.60	2.70	2.30	2.60	2.55
Rice straw + Perlite	3.10	3.00	3.27	3.13	3.12	2.60	2.60	2.80	3.10	2.77
Rice straw + Sand(1:3)	2.83	2.77	3.10	3.20	2.97	2.20	2.50	2.10	2.40	2.30
Rice straw + Perlite + Sand	3.02	2.97	2.80	3.30	3.02	2.70	2.47	2.60	3.00	2.69
Peat Moss + Perlite	2.84	2.90	3.40	3.37	3.13	2.50	2.80	2.50	3.10	2.72
Peat Moss + Sand	2.88	2.70	2.80	3.10	2.87	2.90	2.30	2.30	2.40	2.47
Peat Moss + Perlite + Sand	2.70	2.80	3.10	3.20	2.95	3.30	2.33	2.30	2.60	2.63
Old Coco peat +Sand (1:1)	2.82	2.90	2.90	3.20	2.95	2.60	2.50	2.40	2.53	2.51
Rice straw + Sand(1:2)	2.87	2.60	3.10	2.80	2.84	2.40	2.20	2.20	2.40	2.30
Mean	2.84	2.85	3.09	3.11		2.62	2.52	2.40	2.67	
LSD at 0.05	G. media (A) = 0.08; Stimulants (B)= 0.02 A × B= 0.16					G. media (A)= 0.07; Stimulants (B)= 0.11 A × B= 0.14				

control. Nevertheless, in the second season, there no significant differences were noticed in fruit diameter between control treatment and EM or amino acids treatments, whereas using seaweed extract caused significant reduction in TSS%.

With regard the interaction between growing media and bio-stimulants on fruit characteristics, results showed that using seaweed extract with modern coco peat improved each of fruit weight, fruit length and fruit diameter in the first season. In the second season, the highest value of fruit weight was recorded with using old coco peat + perlite + sand without any bio-stimulant, whereas using amino acids with modern coco peat or with peat moss + perlite + sand showed the highest values of fruit length. Also, the highest fruit diameter was remarked with using peat moss + perlite + sand without

Table 8: Effect of growingmedia, some stimulants and their interactionon nitrogen percentage (%) of strawberry leaves in 2015/ 2016 and 2016-2017 seasons.

Treatment	Stimulants									
	2015/2016 season					2016/ 2017 season				
Growing Media	Control	Amino Acids	Seaweed extract	EM	Mean	Control	Amino Acids	Seaweed extract	EM	Mean
Modern Coco peat	0.42	0.48	0.43	0.51	0.46	2.80	3.10	3.10	3.00	3.00
Old Coco peat +Perlite	0.46	0.84	0.65	0.95	0.72	2.70	3.10	3.00	3.00	2.95
Old Coco peat +Sand (1:3)	0.61	0.64	0.82	0.78	0.71	3.00	3.20	3.11	3.11	3.10
Old Coco peat +Perlite + Sand	0.98	0.56	0.87	0.96	0.84	3.10	3.00	3.20	3.10	3.10
Rice straw + Perlite	0.76	0.58	0.79	0.87	0.75	3.20	3.11	3.00	3.00	3.08
Rice straw + Sand(1:3)	0.54	0.48	0.66	0.65	0.58	3.00	3.20	3.20	3.10	3.12
Rice straw + Perlite + Sand	0.54	0.68	0.65	0.99	0.71	3.10	3.00	3.00	2.90	3.00
Peat Moss + Perlite	0.68	0.74	0.88	0.86	0.79	3.20	3.10	3.10	3.00	3.10
Peat Moss + Sand	0.66	0.64	0.78	0.79	0.72	3.30	3.00	3.00	3.11	3.10
Peat Moss + Perlite + Sand	0.96	0.72	0.86	0.82	0.84	3.00	3.12	3.10	3.12	3.08
Old Coco peat +Sand (1:1)	0.76	0.67	0.89	0.79	0.78	3.00	3.10	3.20	3.10	3.10
Rice straw + Sand(1:2)	0.89	0.54	0.79	0.77	0.75	3.10	3.20	3.11	3.20	3.15
Mean	0.69	0.63	0.76	0.81		3.04	3.10	3.09	3.06	
LSD at 0.05	G. media (A) = 0.03; Stimulants (B)= 0.02 A × B= 0.05					G. media (A)= 0.08; Stimulants (B)= 0.02 A × B= 0.15				

any bio-stimulant. Moreover, using seaweed extract with old coco peat + sand (1:3) as well as using EM with old coco peat + perlite + sand gave the highest values of TSS% in the first season, while using old coco peat + sand (1:3) without any bio-stimulant had the highest value of TSS% in the second season.

5. Effect of growing media, bio-stimulants and their interactions on nitrogen percentage of strawberry leaves:

As shown in table 8, using all growing media, except old coco peat +perlite or rice straw + perlite + sand in the second season, caused significant increase in translocation of N to strawberry leaves in both seasons as compared with using modern coco peat. Generally, using both of old coco peat or peat moss with perlite + sand gave the highest N% in leaves especially in the first season. On the other hand, N% in strawberry leaves did not differences between using modern coco peat and old coco peat + perlite as well as rice straw + perlite + sand in the second season.

Using all bio-stimulants in the second season as well as using EM or seaweed extract in the first season gave a significant increment in N% of strawberry leaves as compared with control, whereas N% in leaves significantly decreased with using amino acids in the first season, as compared with control.

The interaction between growing media and bio-stimulants revealed significant effect in N percentages in strawberry leaves. It was clear that the highest N percentages was recorded with using old coco peat + perlite + sand whether with using EM stimulants or without using any stimulant, old coco peat + perlite as well as rice straw + perlite + sand with using EM stimulant and also with using peat moss + perlite + sand without any stimulant in the first season. In the second season, the best medium that increased N% in leaves was peat moss + sand without any stimulant.

6. Effect of growing media, bio-stimulants and their interactions on phosphorus percentage of strawberry leaves:

Data in table 9 indicated that only using old coco peat + sand at ratio 1:1 or 1:3 in the second season gave a significant enhancement in P% of strawberry leaves, whereas P% in leaves did not affected significantly with using the other growing media in the second season or with using the all growing media in the first season, as compared with using modern coco peat.

Regarding effect of bio-stimulants on P% in strawberry leaves, only using EM or seaweed extract in the second season significantly increased P% in leaves, as compared with control. On the other hand, there no significant differences were noticed between control treatment and all bio-stimulants in the first season as well as amino acids in the second season.

Furthermore, using old coco peat + perlite + sand without any stimulant or using rice straw + sand (1:3) with EM stimulant in the first season as well as using rice straw + sand (1:2) with EM stimulant in the second

Table 9: Effect of growingmedia, some stimulants and their interactionon phosphorus percentage (%) of strawberry leaves in 2015/2016 and 2016-2017 seasons.

Treatment	Stimulants									
	2015/2016 season					2016/ 2017 season				
Growing Media	Control	Amino Acids	Seaweed extract	EM	Mean	Control	Amino Acids	Seaweed extract	EM	Mean
Modern Coco peat	0.16	0.15	0.17	0.19	0.17	0.39	0.39	0.42	0.37	0.39
Old Coco peat +Perlite	0.18	0.14	0.16	0.16	0.16	0.33	0.41	0.39	0.43	0.39
Old Coco peat +Sand (1:3)	0.11	0.18	0.14	0.19	0.15	0.40	0.40	0.43	0.48	0.43
Old Coco peat +Perlite + Sand	0.20	0.19	0.17	0.18	0.18	0.41	0.36	043	0.38	0.39
Rice straw + Perlite	0.15	0.17	0.18	0.19	0.17	0.36	0.38	0.39	0.41	0.38
Rice straw + Sand(1:3)	0.16	0.15	0.19	0.19	0.17	0.40	0.40	0.44	0.43	0.42
Rice straw + Perlite + Sand	0.14	0.18	0.18	0.18	0.17	0.41	0.36	0.43	0.40	0.40
Peat Moss + Perlite	0.18	0.17	0.19	0.19	0.18	0.38	0.40	0.42	0.45	0.41
Peat Moss + Sand	0.19	0.15	0.17	0.15	0.16	0.36	0.38	0.39	0.43	0.39
Peat Moss + Perlite + Sand	0.17	0.18	0.19	0.19	0.18	0.39	0.39	0.41	0.43	0.41
Old Coco peat +Sand (1:1)	0.15	0.19	0.18	0.16	0.17	0.40	0.41	0.48	0.45	0.43
Rice straw + Sand(1:2)	0.18	0.16	0.17	0.18	0.17	0.38	0.36	0.42	0.49	0.41
Mean	0.16	0.17	0.17	0.18		0.38	0.39	0.42	0.43	
LSD at 0.05	G. media (A) = 0.03; Stimulants (B)= 0.02 A × B= 0.05					G. media (A)= 0.03; Stimulants (B)= 0.02 A × B= 0.05				

season gave the highest percentage of phosphorus in strawberry leaves.

7. Effect of growing media, bio-stimulants and their interactions on potassium percentage of strawberry leaves:

Data in table 10 showed that planting strawberry in media of rice straw + perlite, rice straw + sand (1:3) and old coco peat + sand (1:3) in both seasons as well as planting in rice straw + sand (1:2) in the first season or planting in old coco peat + perlite + sand and planting in peat moss + perlite + sand in the second season significantly increased translocation and accumulation of K in leaves, as compared with planting in modern coco peat.

Regarding using bio-stimulants, data indicated that except EM and amino acids stimulants that significantly

Table 10: Effect of growingmedia, some stimulants and their interactionon potassium percentage (%) of strawberry leaves in 2015/2016 and 2016-2017 seasons.

Treatment	Stimulants									
	2015/2016 season					2016/ 2017 season				
Growing Media	Control	Amino Acids	Seaweed extract	EM	Mean	Control	Amino Acids	Seaweed extract	EM	Mean
Modern Coco peat	0.25	0.56	0.26	0.47	0.38	1.98	1.96	2.10	1.98	2.00
Old Coco peat +Perlite	0.30	0.56	0.35	0.43	0.41	2.11	1.98	2.14	1.87	2.02
Old Coco peat +Sand (1:3)	0.13	0.58	0.40	0.63	0.44	2.12	2.11	2.16	1.96	2.09
Old Coco peat +Perlite + Sand	0.20	0.21	0.26	0.43	0.27	2.10	2.21	1.97	1.99	2.07
Rice straw + Perlite	0.56	0.30	0.57	0.48	0.48	2.21	2.00	2.25	2.10	2.14
Rice straw + Sand(1:3)	0.58	0.32	0.47	0.54	0.48	2.11	2.00	2.19	2.15	2.11
Rice straw + Perlite + Sand	0.29	0.30	0.21	0.44	0.31	2.12	1.94	2.11	1.94	2.03
Peat Moss + Perlite	0.22	0.36	0.25	0.45	0.32	2.00	1.86	2.10	1.86	1.95
Peat Moss + Sand	0.11	0.38	0.26	0.56	0.33	1.96	1.88	1.95	1.94	1.93
Peat Moss + Perlite + Sand	0.30	0.34	0.41	0.47	0.38	2.16	1.94	2.18	1.98	2.06
Old Coco peat +Sand (1:1)	0.21	0.37	0.32	0.39	0.32	2.00	2.10	1.89	2.16	2.04
Rice straw + Sand(1:2)	0.31	0.41	0.38	0.71	0.45	1.92	1.77	1.98	1.89	1.90
Mean	0.29	0.39	0.34	0.50		2.01	1.98	2.08	1.98	
LSD at 0.05	G. media (A) = 0.03; Stimulants (B)= 0.02 A × B= 0.05					G. media (A)= 0.03; Stimulants (B)= 0.02 A × B= 0.05				

Table 11: Effect of growingmedia, some stimulants and their interactionon calcium percentage (%) of strawberry leaves in 2015/ 2016 and 2016-2017 seasons.

Treatment	Stimulants									
	2015/2016 season					2016/ 2017 season				
Growing Media	Control	Amino Acids	Seaweed extract	EM	Mean	Control	Amino Acids	Seaweed extract	EM	Mean
Modern Coco peat	1.12	1.00	1.13	0.98	1.06	0.90	0.88	1.20	0.92	0.97
Old Coco peat +Perlite	0.92	0.42	0.89	0.57	0.70	0.98	0.86	1.30	0.86	1.00
Old Coco peat +Sand (1:3)	0.81	0.46	0.45	0.53	0.56	1.10	0.96	1.18	1.10	1.08
Old Coco peat +Perlite + Sand	0.86	0.55	0.77	0.76	0.73	0.90	0.84	1.30	0.94	0.99
Rice straw + Perlite	1.14	0.93	1.00	0.98	1.01	0.78	0.94	0.83	0.91	0.86
Rice straw + Sand(1:3)	1.18	0.21	0.19	0.58	0.54	0.76	0.86	0.79	0.92	0.83
Rice straw + Perlite + Sand	2.10	0.66	1.92	0.64	1.33	1.10	1.00	1.14	1.13	1.09
Peat Moss + Perlite	1.18	0.39	1.01	0.59	0.79	1.00	1.12	1.13	1.39	1.16
Peat Moss + Sand	1.18	0.32	1.16	0.56	0.81	0.96	1.17	0.92	1.19	1.06
Peat Moss + Perlite + Sand	0.53	0.44	0.67	0.66	0.57	0.92	1.19	1.10	1.19	1.10
Old Coco peat +Sand (1:1)	0.48	0.54	0.54	0.67	0.56	1.10	0.99	0.98	1.14	1.05
Rice straw + Sand(1:2)	0.55	0.53	0.69	0.76	0.63	1.11	1.10	1.17	1.18	1.14
Mean	1.00	0.54	0.87	0.69		0.97	0.99	1.09	1.07	
LSD at 0.05	G. media (A) = 0.03; Stimulants (B)= 0.03 A × B= 0.05					G. media (A)= 0.05; Stimulants (B)= 0.04 A × B= 0.11				

decreased K% in leaves in the second season, using all bio-stimulants in the first season and seaweed extract in the second season gave a significant enhancement of K% in leaves, as compared with control.

Also, the highest K% in leaves was remarked with using EM stimulant in medium of rice straw + sand (1:2) in the first season and with using seaweed extract stimulant in medium of rice straw + perlite in the second season.

8. Effect of growing media, bio-stimulants and their interactions on calcium percentage of strawberry leaves:

Data in table 11 indicated that using medium of rice straw + perlite + sand gave a significant excess in Ca% in leaves as compared with using modern coco peat in the first season vice versa Ca % in leaves of strawberry was significantly higher with using medium of modern coco peat than using the other growing media. In the second season, except using medium of rice straw that mixed with perlite or mixed with sand (1:3) as well as using old coco peat that mixed with perlite only or mixed with perlite and sand, using all growing media significantly enhanced translocation and accumulation of Ca in leaves as compared with using medium of modern coco peat. In contrast, using medium of rice straw that mixed with perlite or mixed with sand (1:3) gave a significant reduction of Ca% in leaves as compared with using medium of modern coco peat.

Using all bio-stimulants in the first season gave a significant reduction of Ca% in leaves as compared with control, while using EM and seaweed extract stimulants in the second season significantly increased Ca% in leaves, as compared with control.

Moreover, using medium of rice + perlite + sand without any stimulant in the first season or using medium of peat moss + perlite with EM stimulant in the second season gave the highest values of Ca% in leaves.

Discussion

In the present experiment the combinations of substrate exhibited significant effect on growth parameters, fruits quality, yield and nutrients concentration in strawberry. Among the different combinations of substrates and may cause negative effect on development of strawberry when added to the growing media, whereas the all other combinations of substrate have perhaps created the most appropriate condition for the development of the plant in strawberry. The better results for growth, yield, fruits quality and nutrients concentration with using artificial media may have resulted due to the improvement in root zone environment because of the plant can meet the requirement easily due to appropriate air water relation and nutrient holding capacity. In the same way Olympios, (1993) and Jensen, (1999) mentioned that the appropriate proportion of the substrate in strawberry not only increases the yield potential but also improves the quality of the fruits by accurate control over the supply of water, nutrients, aeration, root temperature and ph. Also, Nourizadeh, (2003) reported that the

improvement of plant growth may be due to suitable conditions in soilless substrate by ventilation and water maintenance. Physiochemical properties of the growing media pose their effect on the plant growth (Wilkerson, 2002), These results also are in agreement with those mentioned by Sharma and Godara, (2017) who reported thatthe substrate combination with coco peat significantly improved the reproductive growth in strawberry. Also, in the analysis of the efficiency of using different combination of substrate the composition of growth media must be taken in consideration (Ingram, 2003). Using coconut coir and compost based growing media may improve the yield and growth parameters of strawberry (Ayesha *et al*., 2011). On the other hand, the negative effect of sand in growing media may be come back to inactive properties of sand that caused easily leaching of many nutrients.

In present study, using EM stimulator gave a significant improvement in crown diameter, marketable fruits yield, fruit quality, N% and P% in strawberry leaves followed by seaweed extract. The responses of plants to bio-stimulants may be related to its effect on sugar metabolism, stimulation of the shikimic acid pathway, or internal hormonal and chemical changes (Thao and Yamakawa, 2009).

The results of present study are in line with the findings of Gilinicki *et al*., (2010) and Bogunovic *et al*., (2015) who reported that Bio-stimulants applications gave appositive response in growth and yield of strawberry cultivars. The positive effect of using EM stimulant maybe attributed to presence of a variety of beneficial microorganisms in the bio-fertilizers which play main role in increasing nutrients absorption by plant and decrease the infection by diseases. These results are in agreement with that found by Shehata and El-Khawas, (2003) and Abou-Aly *et al*., (2006) who reported that bio-fertilizers contain a variety of beneficial microorganisms and enzymes which promote and improve plant growth. Moreover, the increase in growth parameter in plots treated with the bio-fertilizersmay be due to making the major essential macronutrients available to absorption by plants and causes enhancement in plant growth and yield (Han *et al*., 2006).

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