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Response of Growth, Yield and Fruit Quality of Cantaloupe Plants (*Cucumis melo* L.) to Organic and Mineral Fertilization

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ABSTRACT

Two experiments were conducted during successive seasons of 2012/2013 and 2013/2014 under plastic house conditions in a private farm at El-Sadat City, Monofeya Governorate, to study the effect of two levels of organic manure (Nile compost) 2.4 and 3.2 ton/fed. in combination with 3 levels of NPK fertilizers, 50, 75 and 100% of recommended dose on growth, yield and fruit quality of cantaloupe plants. Results strongly showed that the addition of organic manure at a higher level (3.2 ton/fed.) improved plant growth, fruit yield, physical and chemical characters of fruit quality of cantaloupe plants. In the same respect, the highest level of NPK fertilizers (100%) application gave significantly the best growth characters, total fruit yield, physical and chemical quality of cantaloupe fruits. It seems that the percentages of fruit total sugars, TSS and moisture were not affected by NPK application. The interaction between organic manure and NPK fertilizers levels had no significant effect on all studied characters.

Key words: Cantaloupe, Nile compost, NPK fertilizers, Growth, Fruit yield and quality.

Introduction

Cantaloupe fruit is one of the most important and popular fruity vegetables grown in Egypt and it used mainly as a desert and refreshing fruit. It is rich in bioactive compounds such as phenolics, flavonoids and vitamins as well as carbohydrates and minerals (especially potassium). In addition, it is low in fat and calories (about 17 kcal/100g). Furthermore, it has a large amount of dietary fiber (Tamer *et al*., 2010).

Organic farming can provide quality and safety food without adversely affecting the soils health and the environment. However, a concern is whether large-scale organic farming will produce enough food for Egypt's large population. The organic manures were prepared initially from either plant or animal residues. All organic manures improve the behaviors of several elements in soils through that active group (fulvic and humic acids) which have the ability to retain the elements in complex and chelate forms. These materials release the elements over a period of time and are broken down slowly by soil microorganisms. The extent of availability of such nutrients depends on the type of organic materials and microorganisms (Saha *et al.,* 1998). In addition, Ozores-Hampton *et al.* (2011) revealed that organic manure amendments affect soil bulk density, water-holding capacity, soil structure, soil carbon content, macro and micronutrients, pH, soluble salts, cation exchange capacity (CEC), and biological properties (microbial biomass). Also, the use of organic amendments may improve soil quality and enhance the utilization of fertilizer, consequently improving the performance of vegetable crops (Ozores-Hampton, 2012). However, Marculescu *et al*. (2002) concluded that the soil contents of macro and micronutrients, were enhanced by using of organic fertilizers, which play an essential role in the plants growth and development. However, many investigators reported that applying organic fertilizers caused an improve in vegetative growth, yield and fruit quality of fruity vegetable crops. Jimenez *et al*. (1997) found that compost manure application significantly increased vegetative growth parameters of melon plant such as number of leaves/plant, stem length and dry weight as well as fruit yield as compared with control treatment. In the same respect, El-Desuki *et al*. (2000) reported that organic manure addition at higher level (20 m^3/fed.) improved plant growth, NPK content, total yield and fruit quality. Moreover, Jianming *et al*. (2008) reported that the highest vitamin C content in cantaloupe fruits was obtained by using chicken and pigeon manure composts. Also, the P and K mineralization rates increased with increasing amounts of compost added. Furthermore, the nitrate content of fruits was very low compared to that obtained with the inorganic fertilizers (Abou-El-Hassan *et al*., 2002). On the other hand, Sarhan *et al.* (2011) found that crop residues had significant effects on vegetative (shoot) parameters, and substantially improved the quantitative and qualitative traits of squash fruit yield. Other investigators concluded the same results (Melloni *et al.,* 1995; Eissa, 1996 and Pinamontia *et al.,* 1997).

Chemical fertilizers supply major nutrients-period-in quick release forms. Plants obtain fast growth, but long-term benefits are few. Thirty-five percent of inorganic nitrogen and from 15 to 20 percent of the phosphorus and potassium applied to land is lost because farmers apply these inorganic sources in greater amounts than, that could be immediately assimilated by plants or soil. The NPK and other nutrients percentages of matured compost are relatively low, but their benefit lies in the release of nitrogen and phosphorus in the soil at a slow release rate that enabled plants to use them (Martin and Gershuny, 1992).

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On the other hand, organic fertilizer is not immediately available to the plants and nutrients released from organic fertilizer are not enough for plant requirement. So that inorganic fertilizer might be applied with organic fertilizers to supply plants with its needs of the nutrient. Concerning N, P and K fertilization, many investigators reported the importance of N, P and K application to cantaloupe plant. Applications of N, P and K to cantaloupe plants were reported to have a considerable increase in plant growth (El-Desuki *et al*., 2000). Moreover, El-Beheidi *et al*. (1988a) reported that, N application at 180 kg N/fed. led to an increase in vegetative growth of sweet melon plants as compared with 0, 60 and 120 kg N/fed. In addition El-Beheidi *et al*. (1988b) reported that K application had no significant effects on vegetative growth and total yield but improved fruit quality, the best combination treatment for vegetative growth and total fruit yield were 120 or 180 kg N with 72 kg K_2O/fed. Damarany and Farag (1994) found that fruit yield and fruit quality (fruit size, average fruit weight and flesh thickness) were greatest with the intermediate fertilizer application rate (200 N + 210 P_2O_5 + 230 K_2O kg/fed.) as compared with the highest or lowest rate. In addition, Ferrante *et al*. (2008) found that the total fruit yield and fruit nitrogen content linearly increased with increasing N levels. In the same respect, Ng'etich *et al*. (2013) found that the growth and yield of squash plants were significantly affected by nitrogen fertilization. Plants subjected to 160 kg N/ha exhibited increase of about 22.9 - 55.9% in plant height; 28.0 - 29.4% in stem diameter; 26.6 - 39.7% in number of leaves; 61.0 - 204.1% in leaf area and 103.2 - 235.2% in leaf area index compared to the control. Male and female flowers from plants subjected to 120 kg N/ha were more by 13.9 - 30.8% and 7.5 - 63.5%, respectively, in contrast to the control. Biomass yield from 120 and 160 kg N/ha was about 99% higher than the control. Maximum edible fruit yield was realized from plants subjected to 120 kg N/ha which averaged at 11.3 and 86.0% higher than the control and hence can be recommended for improving the production. In the same times, Oloyede and Adebayo (2013) found that the fresh fruit yield was 21 and 7 ton/ha for early and late seasons, respectively. Fruits number/ha were significantly increased from 7000 in control to over 10,000/ha with fertilizer rates between 100 to 250 kg NPK/ha. Increasing fertilizer above 100 kg NPK/ha did not significantly increase the fruit yield. Moreover, Adebayo *et al*. (2014) indicated that the highest values of vegetative growth of watermelon were obtained with NPK fertilizer at rate of 200 kg/ha followed by organomineral fertilizer applied at rate of 2.5 ton/ha compared with control treatment. In contrast the highest fruit yield was obtained from organomineral fertilizer at 2.5 ton/ha followed by NPK.

Materials and Methods

Two experiments were carried out under plastic house conditions at Taba farm, El-Sadat City, Monofeya Governorate, Egypt to study the effect of two levels of organic manure (Nile compost) 2.4 and 3.2 ton/fed. with combination of 3 levels of NPK fertilizers, 50, 75 and 100% of recommended dose (70 + 32 + 30, 105 + 48 + 45 and 140 + 64 + 60 units/fed. as N from ammonium sulphate 20.6% N, P_2O_5 from calcium super phosphate 15.5% P_2O_5 and K_2O from potassium sulphate 48% K_2O, respectively), on growth, fruit yield and fruit quality of cantaloupe plants Galia type 'Arava' cultivar during the two growing seasons of 2012/2013 and 2013/2014.

Nile compost used in this study was obtained from Egyptian Company for Agricultural Residues Utilization (ECARU, www.ecaru.net). Physical and chemical properties of Nile compost are shown in Table (1). The experimental site had a sandy soil texture with pH of 7.6, EC of 1.9 and the organic matter was 0.21% with 14.00, 8.90 and 15.60 mg/100g soil of N, P and K, respectively. Uniform cantaloupe seedlings (30 days old) were transplanted in the first week of November in both seasons of study on one side of drip irrigated ridge at 50 cm apart. The normal agriculture practices for cantaloupe production under plastic house were followed according to the recommendations of Ministry of Agriculture. The organic manure fertilizer rates and phosphorus levels were applied during soil preparation and thoroughly mixed with soil before transplanting. While, nitrogen and potassium fertilizers were divided into 3 equal doses and added in 3 weeks intervals starting after 3 weeks from transplanting date.

The experiment was laid out in a split plot design with three replications. The two compost rates (2.4 and 3.2 ton/fed.) were assigned in the main plots, whereas, the three levels of NPK fertilizers (50, 75 and 100% of recommended dose) were randomly distributed within the subplots. Each subplot contained 24 plants, The subplot size was 4.0 x 3.0 m separated by 1 m width ridge as a border between replicates.

Data record

Vegetative growth: samples of nine plants from each subplot were randomly taken at flowering stage (50 days after transplanting date) and the following vegetative growth characters were recorded: plant length (cm), number of leaves and branches per plant, fresh and dry weight of whole plant and its organs.

*Total yield and fruits quality***:** at harvesting stage cantaloupe fruits were picked weekly throughout the harvesting period, the number of fruits and weight of fruits (kg) per plot as well as fruit length, diameter, average fruit weight and fruit size were determined.

Chemical fruit quality: at harvesting stage random samples of 9 cantaloupe fruits from each subplot were randomly taken and nitrogen percentage in fruits tissue was determined using Kjeldahl method as described by Black (1965). In addition,

protein percentage in fruits was calculated by multiplying nitrogen content by 6.25. Also, ascorbic acid (mg/100g FW), TSS% and fruit moisture% were determined according to AOAC (2000). The percentage of total sugars in fruits tissue were determined according the method described by Dubois *et al.* (1959).

The obtained data of the experiments were subjected to statistical analysis of variance and mean separation was done using LSD test at 5% level of probability according to Gomez and Gomez (1984).

Table 1: Physical and chemical properties of Nile compost used in this study.

Compost properties	Values
Density as wet basis (kg/m^3)	600 - 750
Density as dry basis (kg/m^3)	450 - 560
Moisture content (%)	25 - 30
pH in 1 : 10 extract	5.5 - 7.5
EC in 1 : 10 extract (dS/m)	3.5 - 5.5
Water holding capacity (%)	200 - 300
Organic matter (%)	40 - 45
Organic carbon (%)	23.2 - 26.1
C/N ratio	14.5 : 1 - 16.5 : 1
Total nitrogen (%)	1.4 - 1.8
Phosphorus (%)	0.4 - 0.8
Potassium (%)	0.6 - 1.2
Iron (ppm)	1500 - 2000
Copper (ppm)	160 - 240
Manganese (ppm)	100 - 150
Zinc (ppm)	40 - 80

Source: Egyptian company for agricultural residues utilization (ECARU).

Results and Discussion

Vegetative growth characters

Effect of Nile compost

Data in Table (2) showed clearly that increasing the level of Nile compost from 2.4 to 3.2 ton/fed. improved all vegetative growth characters of cantaloupe plants. A significant increase in the vegetative growth was realized in plant length, number of leaves and shoots per plant as well as fresh and dry weight of whole plants, when Nile compost level increased from 2.4 to 3.2 ton/fed. It could be concluded that, the higher level of organic manure had a positive effect on cantaloupe plant growth. The increment of cantaloupe plant dry weight by application of higher level of Nile compost (3.2 ton/fed.) amounted by 6.48% compared with lower level (2.4 ton/fed.).

The superiority in the vegetative growth by the higher level of organic manure might be attributed to its favorable effect on the physical characters of the soil (Marculescu *et al*., 2002 and Ozores-Hampton *et al.,* 2011) or due to the slow release of nutrients (Eissa, 1996). The obtained results are in good agreement with Jimenez *et al.* (1997); El-Desuki *et al.* (2000); Sarhan *et al.* (2011) and Ozores-Hampton (2012).

Effect of NPK fertilizers

Data shown in Table (2) reported that the vegetative growth characters of cantaloupe plants were increased by increasing NPK level up to 100% (140 N : 64 P_2O_5 : 60 K_2O). Plant length, number of leaves and shoots/plant as well as fresh and dry weight of whole plants were significantly increased by increasing NPK level from 50 to 100%. However, the application of 100% NPK significantly increased all growth characters expressed as number of leaves and shoots/plant, fresh and dry weight of plant compared with the lowest level (50% NPK). The increasing of all vegetative growth characters due to application of the highest level of NPK fertilizers (100%) might be referred to its favorable role in increasing the availability of nutrients to plant absorption and higher photosynthetic activity (Mengel and Kirkby, 1978). Also, may be due to the role of these nutrients in the synthesis of plant proteins, chlorophyll and enzymes (N), root growth, lipids, ATP and ADP formations (P), and activation of enzymes and enhancing of the translocation of assimilates (K) as stated by Devlin and Witham (1986). However, Agba and Enga (2005) reported that there was an increase in growth and yield component of cucumber plants in respond to increase the level of fertilizer application. Many investigators came to similar results (El-Desuki *et al.,* 2000; Ahmed *et al.,* 2007; Ferrante *et al.,* 2008; Ng'etich *et al.,* 2013; Oloyede and Adebayo, 2013 and Adebayo *et al.,* 2014).

Effect of the interaction between Nile compost and NPK fertilizers

The combination effect of Nile compost and NPK fertilizers resulted in higher values of vegetative growth characters of cantaloupe plants as shown in Table (2). The highest values of growth characters were obtained by the combination of a higher level of Nile compost (3.2 ton/fed.) with the highest level of NPK fertilizer (100%). It is cleared

that the interaction effect had no significant differences on plant growth characters. Results might be referred to the complementary effect of Nile compost and NPK fertilizer.

Table 2: Effect of using Nile compost, NPK fertilizers and their interaction on vegetative growth characters of cantaloupe plants (combined data of two seasons).

Fertilizer levels		Plant length (cm)	Number/plant		Fresh weight (g/plant)			Dry weight (g/plant)		
Nile compost	NPK %		Leaves	Shoots	Leaves	Shoots	Whole	Leaves	Shoots	Whole
2.4 ton/fed.	50	132.67	39.67	3.67	100.07	45.53	145.61	18.33	5.19	23.52
	75	138.33	41.67	4.06	104.45	48.10	152.56	20.55	5.43	25.98
	100	142.67	42.67	4.00	104.93	48.18	153.11	19.84	5.44	25.28
Mean		144.22	42.44	4.06	105.71	48.48	145.18	19.72	5.46	25.17
3.2 ton/fed.	50	156	44.33	4.30	108.21	49.59	157.8	21.22	5.65	26.87
	75	157.33	45.00	4.50	112.11	51.72	163.83	20.98	5.74	26.72
	100	178	46.67	5.00	114.96	52.71	167.67	21.49	6.06	27.56
Mean		157.44	44.22	4.46	109.21	50.14	159.34	21.09	5.72	26.80
Average	50	135.5	40.67	3.87	102.26	46.82	149.08	19.44	5.31	24.75
	75	149.33	43.50	4.15	106.57	48.89	155.46	20.53	5.55	26.08
	100	167.67	45.83	4.75	113.54	52.21	165.75	21.24	5.90	27.14
LSD at 5% level	Compost	7.73	1.03	0.05	2.66	0.62	1.76	0.90	0.10	0.63
	NPK	14.31	0.43	0.34	1.77	2.36	4.45	0.59	0.27	1.03
	Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS

50% NPK = 70 : 32 : 30 75 % NPK = 105 : 48 : 45 100% NPK = 140 : 64 : 60.

Total fruit yield and its quality

Effect of Nile compost

Data presented in Table (3) showed that total fruit yield of cantaloupe expressed as number of fruits/plot, weight of fruits/plot (kg), fruit length, diameter (cm), average fruit weight (g) and fruit size (cm^2) were significantly increased by increasing the level of Nile compost from 2.4 to 3.2 ton/fed. The increase in the total fruit yield and fruit characters may be due to favorable effect of Nile compost on the vegetative growth. In addition, due also to the higher percentages of N, P and K uptake by cantaloupe plants received a higher level of Nile compost. Some investigators came to similar results (Melloni *et al.,* 1995; Eissa, 1996; Pinamontia *et al.,* 1997; El-Desuki *et al.,* 2000 and Ozores-Hampton*,* 2012).

Effect of NPK fertilizers

Concerning the effect of different NPK levels, it is cleared from Table (3) that total fruit yield i.e. number of fruits/plot, weight of fruits/plot (kg), fruit length, diameter (cm), average fruit weight (g) and fruit size (cm^2) were significantly increased with increasing the level of NPK application from 50 to 100% level. However, the highest values of physical fruit quality of cantaloupe expressed as fruit length, diameter, weight and size of fruits were significantly recorded by adding the highest level of NPK fertilizers (100%) followed by intermediate level (75%) and then by the lowest level (50%). Whereas, no significant difference was detected between intermediate and the highest NPK levels concerning the average fruit weight. The obtained results may be due to the function of increasing in the vegetative growth, photosynthetic activity, dry matter accumulation and NPK uptake (Abou El-Magd, 1979). These results agreed with those reported by El-Desuki *et al.* (2000); Ahmed *et al*. (2007); Ferrante *et al.* (2008); Ng'etich *et al.* (2013); Oloyede and Adebayo (2013) and Adebayo *et al.* (2014).

Table 3: Effect of using Nile compost, NPK fertilizers and their interaction on total yield and physical fruit characters of cantaloupe plants (combined data of two seasons).

Fertilizer levels		Number of fruits/plot	Weight of fruits/plot (kg)	Fruits			
Nile compost	NPK %			Length (cm)	Diameter (cm)	Average fruit weight (g)	Fruit size (cm^3)
2.4 ton/fed.	50	51.33	10.25	8.78	7.54	199.99	240.00
	75	52.00	10.57	8.95	7.76	201.14	251.67
	100	51.83	10.46	8.98	7.74	202.65	245.00
Mean		51.89	10.46	8.98	7.75	201.50	245.00
3.2 ton/fed.	50	52.50	11.01	9.29	8.00	209.78	255.00
	75	52.50	10.66	9.18	7.98	201.87	250.00
	100	53.34	11.50	9.66	8.11	219.37	260.00
Mean		52.61	11.03	9.30	7.96	210.10	255.56
Average	50	51.67	10.41	8.87	7.65	200.57	245.83
	75	52.17	10.74	9.13	7.87	206.22	250.00
	100	52.92	11.08	9.42	8.04	210.62	255.00
LSD at 5% level	Compost	0.17	0.31	0.19	0.09	5.52	3.47
	NPK	0.54	0.33	0.24	0.11	5.22	2.67
	Interaction	NS	NS	NS	NS	NS	NS

50% NPK = 70 : 32 : 30 75 % NPK = 105 : 48 : 45 100% NPK = 140 : 64 : 60.

Effect of the interaction between Nile compost and NPK fertilizers

The interaction effect between Nile compost levels and NPK fertilizer levels recorded no significant differences on total fruit yield and fruit physical characters as shown in Table (3). Generally it could be declared that using Nile compost at a higher rate with the highest level of NPK fertilizers gave the highest but not significant values of total fruit yield and fruit physical quality of cantaloupe fruits.

Chemical fruit characters

Effect of Nile compost

Data shown in Table (4) indicated that the percentages of nitrogen, protein and fruit moisture as well as vitamin C content were significantly increased with increasing the level of Nile compost manure from 2.4 to 3.2 ton/fed. Whereas, no significant increases were realized on the percentages of total sugars and TSS. These results might be due to the role of organic manure in increasing soil porosity, aeration, water holding capacity and cation exchange capacity (CEC), which encourage the biological activities of soil microorganisms and led to break down of organic matter releasing N, P and K and other nutrients to the soil solution (Ozores-Hampton *et al.,* 2011). As these nutrients are available in the soil solution, absorption would be higher and nutrients uptake might be stimulated. These results agreed with those reported by Melloni *et al.* (1995); Pinamontia *et al.* (1997); Jianming *et al.* (2008); Sarhan *et al.* (2011) and Adebayo *et al.* (2014) they reported that the highest TSS, total sugars, protein, vitamin C and moisture contents in cucurbits fruits were obtained by increasing the levels of compost used.

Effect of NPK fertilizers

The effect of NPK levels on fruit contents of nitrogen, protein and vitamin C showed a significant increase (Table 4). However, the highest level of NPK fertilizers (100%) significantly improved the chemical characters of cantaloupe fruits compared to the intermediate and the lowest levels of NPK (75 and 50%). The highest significant values of nitrogen, protein and vitamin C were recorded with the highest level of NPK fertilizers. While, no significant differences were detected among the levels of NPK fertilizers on the percentages of total sugars, moisture and TSS.

The superiority contents of cantaloupe fruit tissues may be attributed to increase the availability of N, P and K in the soil solution. Consequently absorption would be higher and nutrient accumulation in fruits tissue increased. These results are in good accordance with those of Ferrante *et al.* (2008) and Wang and Sun (2008) on cantaloupe fruits.

Effect of the interaction between Nile compost and NPK fertilizers

The interaction effect between organic manure and mineral fertilizers had no significant differences on the percentages of nitrogen, protein, total sugars, moisture, vitamin C and TSS contents of cantaloupe fruit tissues as shown in Table (4). It is of interest to note that using a higher level of Nile compost (3.2 ton/fed.) with NPK fertilizers at rate of 100% of recommended dose gave the best results of fruit chemical quality.

Table 4: Effect of using Nile compost, NPK fertilizers and their interaction on the chemical fruit characters of cantaloupe plants (combined data of two seasons).

Fertilizer levels		%				Vitamin C (mg/100g F.W)	TSS%
Nile compost	NPK %	N	Protein	Total sugars	Moisture		
2.4 ton/fed.	50	1.143	7.147	11.067	91.247	26.590	11.75
	75	1.163	7.253	11.077	91.593	26.823	11.75
	100	1.147	7.267	11.140	91.453	27.380	11.84
Mean		1.171	7.353	11.112	91.533	27.152	11.80
3.2 ton/fed.	50	1.173	7.313	11.090	91.563	27.667	11.88
	75	1.223	7.647	11.130	91.900	27.487	11.80
	100	1.24	7.720	11.147	92.45	28.487	11.90
Mean		1.192	7.429	11.104	91.869	27.659	11.85
Average	50	1.153	7.200	11.077	91.420	26.707	11.75
	75	1.160	7.290	11.115	91.508	27.523	11.86
	100	1.232	7.683	11.138	92.175	27.987	11.85
LSD at 5% level	Compost	0.010	0.029	NS	0.191	0.348	NS
	NPK	0.041	0.224	NS	NS	0.568	NS
	Interaction	NS	NS	NS	NS	NS	NS

50% NPK = 70 : 32 : 30 *75 % NPK = 105 : 48 : 45* *100% NPK = 140 : 64 : 60.*

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