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Efficiency of Using some Soil Supplements on Sweet Pepper Productivity under Delta Region Conditions

Abd El-Basir, E. A.[1] and W. M. E. Swelam[2]
[1] Self-Pollination Vegetables Crops Research Dept., Hort. Res. Inst., Agric. Res. Center, Giza, Egypt.
[2] Veget. and Flori. Dept. Fac. Agric., Mans. Univ., Egypt.
Corresponding author's: abdelbasir.elsaid@yahoo.com

ABSTRACT

Two investigations were carried out in the open field to study the effects of some soil stimulating supplements, *i.e.,* humic and fulvic acids, zeolite, chicken manure as well as compost on vegetative growth, chemical contents and productivity of sweet pepper plants under drip irrigation system. Results indicated that all applied soil substances significantly enhanced vegetative growth parameters, chemical constituents, endogenous phyto-hormones of leaves, yield and fruit quality compared to the control in both growing seasons of study. Soil applications of either zeolite or compost are the best treatments in enhancing most of the aforementioned parameters. Additionally, our results undoubtedly confirm that the application of zeolite or compost could decrease chemical fertilizers through improving the efficiency of both fertilizers and irrigation water which in turn increase vegetable crops production, minimize economic costs as well as limiting environmental contamination.

Keywords: Sweet pepper – zeolite - compost – organic manure – productivity.

INTRODUCTION

Sweet pepper (*Capsicum annuum* L.) crops are considered one of the most favorable and popular vegetable crops in Egypt, cultivated for both local consumption and exportation. The fruits contain important nutritional compounds as proteins, fats and carbohydrates, minerals and vitamins specially vitamins A and C. Also, fruits are used in various forms such as salads and dry powders of different colors paprika.

There has been an increasing awareness of the undesirable impacts of mineral fertilizers on the environmental balance. One of the modern trends of sustainable agriculture is to use natural and safe materials as soil or foliar applications. Among these materials are zeolite, organic acids (humic and fulvic acids) and organic manures (compost and chicken manure). Zeolite is one of the inclusion compounds (hydrated alumino-silicates); characterized by three-dimensional networks of silicon tetraoxide (SiO_4) and aluminum tetraoxide (AlO_4) tetrahedral linked by the sharing of all oxygen atoms (Reháková *et al.,* 2004). Zeolite is often used in agriculture as soil amendment to provide new substrates for plant growth and yield production due to its higher ability to not only lose water, but also gain it (Mumpton and laroca, 1999), its strong absorption properties, macro and micronutrient contents as well as its higher cation exchange capacity (Manolov *et al.,* 2005).

On the other hand, either humic or fulvic acids are two major components of humic substances. Generally, humic and fulvic acids differ in elemental and functional group contents in addition to the molecular weight. Humic acid is the highest in molecular weight and contain less oxygen-containing functional groups compared to fulvic acid (Weng *et al.,* 2006 and Güngör and Bekbölet, 2010). Humic substances as soil application have direct and indirect effects on plant growth (Chen and Aviad, 1990). The indirect effects include the improvement of soil properties as aeration, aggregation, water holding capacity, permeability, ions transport and availability through pH buffering (Tan, 2003). The direct effects are through the various biochemical effects resulted from maintaining vitamins and amino acids level in plant tissues and accelerating nutrient uptake in response to the uptake of humic substances. Karakurt *et al.* (2009) on pepper plants indicated that application of humic acid had not only positive impacts on growth and fruit quality characteristics, but also influence the quantitative and qualitative of plant. Additionally, fulvic acid accelerates cell division thus stimulates vegetative growth and development as well as increase regulation of plant metabolism to prevent the accumulation of nitrate compounds in plants and increases the resistance to diseases and insects by stimulating tolerance to heat and coldness and many other physical factors (Jackson, 1993). Also, fulvic acid chelates and binds minerals into a bio-available form used by the cells. These trace minerals serve as catalysts to vitamins in the cell. Additionally, fulvic acid is considered one of the most efficient transporters of vitamins into the cell (Williams, 1977). Fulvic acid balances and stimulates cells and creates optimum growth conditions (Poapst and Schnitzer, 1971) through enhancing the permeability of the cell membrane (Christman and Gjessing, 1983).

The benefits of organic composted materials supplements to the soil are widely acknowledged internationally (Lillenberg *et al.,* 2010). Organic manures (chicken and compost) contain high amounts of available essential nutrients which required for plants metabolic processes and growth. Moreover, organic fertilizers play an important role for improving soil physical properties through enhancing biological activity, increasing organic matter content and nutrients supply to plants (Tandy *et al.,* 2009). Organic manures are slow release nitrogen (N) fertilizer where the natural organic materials slowly decomposed by the soil micro-organisms (Rizk, 2001 and El-Gamal and Selim, 2005). Additionally, organic fertilizers are a great source of humus, macro and micro nutrients as well as increase the useful micro-organisms population and activity (El-Gizy, 1994).

This research aimed to evaluate the possible effects of using some safe soil supplements (zeolite, compost, chicken manure, fulvic and humic acids) on improving physiological and metabolic performance of sweet pepper plants under drip irrigation system in Delta region conditions.

MATERIALS AND METHODS

In the two seasons of study, the experiments were conducted in Shabraweysh (a private farm near Mansoura) during the summer seasons of 2015 and 2016. The objective of this research was to study the effect of applying some safe soil supplements (Humic and Fulvic acids, Compost, Chicken manure and Zeolite) on the vegetative growth, chemical contents and productivity parameters of sweet pepper (*Capsicum annum* L.) "Madir" hybrid plants which grown under drip irrigation system in Delta region.

On February during the two seasons of the study, seeds were sown in foam trays filled with vermiculite and peat (1:1) and enriched with different nutrient elements then seedlings were transplanted in the open field on 10th of March in the two seasons. The unit area of the experiment was 32 m^2 (2 drip lines × 20 m long × 0.80 m width). The seedlings were transplanted on one side of drip line at 50 cm apart. All agricultural practices were performed according to the Egyptian Ministry of Agriculture and Land Reclamation recommendations.

Experimental soil analysis:

Some chemical and physical properties of the soil profile of cultivated area (0.0 to 50 cm depth) before transplanting were analyzed as shown in Table 1 according to the method described by Black (1965) and Page *et al.* (1982).

Table 1. Physical and chemical properties of the experimental soil during 2015 and 2016 seasons.

Soil properties		2015	2016
Particle size distribution	Fine sand %	17.12	17.30
	Coarse sand %	8.71	8.90
	Silt %	32.67	32.48
	Clay %	41.50	41.32
	Texture	Clay- loam	Clay-loam
Chemical analysis	pH (in 1:5 soil water suspension extract)	8.0	8.1
	E.C. (dSm^{-1}) in 1:5 soil water extract	1.11	1.13
	Organic matter %	1.44	1.46
	Available P (ppm)	11.72	11.70
	$CaCo_3$	4.50	4.55
	Total N %	0.2	0.3
Soluble anions (meq/L)	HCO^-_3	3.20	3.30
	CO^-_3	0.00	0.00
	SO^-_4	5.12	5.23
Soluble cations (meq/L)	Ca^{++}	4.03	4.03
	Mg^{++}	1.35	1.35
	Na^+	1.20	1.21
	K^+	5.31	5.33
Available micronutrients (ppm)	Fe^{++}	3.60	3.62
	Mn^{++}	1.51	1.50
	Zn^{++}	1.32	1.34
	Cu^{++}	0.51	0.52

Experimental treatments:

The layout of the experiment was randomized complete block design in three replicates. All treatments were applied as soil application at 20 days before transplanting

1) Control (untreated),
2) Chicken manure (10 m^3/fed),
3) Compost (5 ton/fed): obtained from Soil, Water and Environment Research Institute, Agriculture Research Center, Giza, Egypt. The chemical analysis of compost was shown in Table 2.
4) Fulvic Acid (5 kg/fed): commercial product imported from China contain 60 % falvic acid as granules formula,
5) Humic acid (5 kg/fed) Spanish product contain 80 % humic acid and
6) Zeolite (210 kg/fed): natural zeolite granules loaded with micronutrients obtained from Prima Company, Yogyakarta, Indonesia. The chemical analysis of zeolite was shown in Table 3

Table 2. Chemical analysis of compost.

pH	Ec (1:5) ds/m	OM (%)	Organic C (%)	Humidity (%)	Total N (%)	Total K (%)
7.5	3.1	70	33.11	25	1.82	1.25
Total P (%)	C/N ratio	Fe ppm	Mn ppm	Cu ppm	Zn ppm	
1.29	14.1	1019	111	180	280	

Table 3. Chemical composition of zeolite.

Chemical com position	SiO_4	TiO_3	Al_2O_2	Fe_2O_3	Fe O	Mn O	Mg O
	45.50	2.81	13.30	5.40	8.31	0.51	6.30
	Ca O	Na_2O	K_2O	Sr O	P_2O_5	Loss on irrigation	
	9.52	2.83	0.87	0.22	0.67	3.76	
Trace elements (ppm)	Ba	Co	Cr	Se	Cu	Zn	Zr
	10	1.2	35	0.8	19	64	257
	Nb	Ni	Rb	Y			
	13	55	15	22			

Sampling and collecting data:

Vegetative growth: nine plants were randomly taken to measure plant height, leaves and branches number per plant, total fresh and dry weight of plant after 85 days from transplanting.

Chemical contents of leaves: nine plants were randomly taken from each treatment after 85 days from transplanting and the following characteristics were recorded:

1-Minerals content of leaves:

Nitrogen content (N %): was estimated on dry matter according to Piper (1947) using microkjeldahl as described by Horneck and Miller (1998). Phosphorus content (P %) was estimated according to the method of Sandell (1950) and Potassium content (K %) was determined by the flame photometer according to the method described by Horneck and Hanson (1998).

2-Photosynthetic pigments of leaves: carotenoids and total chlorophyll (a+b) were determined colorimetrically in the acetone extract of fresh leaves of sweet pepper leaves after 85 days after transplanting during both seasons by the methods described by Wettstein (1957) and calculated as mg/100g fresh weight.

Endogenous phyto-hormones content of leaves: endogenous indole acetic acid (IAA), gibberellic acid (GA_3), abscisic acid (ABA) and cytokinins in plants were determined by the method of Sadeghian (1971) after 85 days from transplanting.

Productivity parameters: All harvested fruits (at green/yellow stage) from each plot all over the season were used to calculate the following parameters:

Early yield (ton/fed.): Fruit fresh weight of the first two pickings from plants of each plot was recorded as kg/plot, then calculated as ton/fed.

Total fruit yield (ton/fed): calculated according to the following equation:

Total fruit yield (ton/fed) = marketable yield + nonmarketable yield

Samples of twenty marketable fruits were collected from each plot at the middle of harvesting season of each year to determine fruits quality by following parameters: Vitamin C (mg/g fresh weight), titratable acidity (%): estimmated in fresh sweet pepper fruits according to the method described by the AOAC (1990) and total soluble solids (TSS %) measured in fruit juice by the hand refractometer.

Statistical analysis:

All data were subjected to ANOVA at 5 % significance level. Means of treatments were compared Using DMRT (Duncan Multiple Range Test) at 5 % using Co-stat statistical software program (V.6.311).

RESULTS AND DISCUSSION

Vegetative growth:

Data of vegetative growth parameters, *i.e.,* plant height, number of leaves and branches per plant as well as fresh and dry weights of sweet pepper plants as influenced by soil applications are presented in Table (4). Data show that all tested soil supplements (zeolite, compost, chicken manure, fulvic and humic acids) were significantly different in their effects on all the aforementioned vegetative growth characteristics as compared to the control in both seasons of the study. Application of zeolite achieved the highest values of all studied traits followed by compost without significant differences in most cases in both growing seasons.

The simulative effect of zeolite on vegetative growth performance may be due to increasing node number and inter-node length (Zahedi *et al.,* 2009). Also, Zeolite increases water retention capacity as well as the availability of plant nutrition's which in turn enhances plants development and productivity (Ayan *et al.,* 2008). These results are in harmony with Rehakova *et al.* (2004).

Regarding the effects of organic manure (compost), the positive effects on vegetative growth may be attributed to enhancing soil microbial activity and its role in the management of soil fertility under organic application that effect soil dynamics and plant metabolism (Worthington, 2001). In addition, the variation in results between zeolite and compost treatments may be due to their ability of nutrients supplementation which reflected on better vegetative growth performance of sweet pepper plants. Similar results were recorded by Odebonde and Fajinmi (2009) and Atiyeh *et al.* (2002).

Table 4. vegetative growth characters of sweet pepper plants as affected by some soil supplements during summer seasons of 2015 and 2016 after 85 days from transplanting

Treatments	Plant height (cm)		No. of leaves /plant		No. of branches /plant		Fresh weight (gm/plant)		Dry weight (gm/plant)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control (untreated)	57.65^{d}	55.43^{d}	175.0^{d}	167.0^{e}	5.6^{e}	5.6^{d}	565.3^{d}	559.3^{d}	111.43^{c}	109.5^{c}
Chicken manure (10 m^2/fed)	62.76^{c}	60.80^{c}	207.0^{c}	196.6^{d}	7.0^{d}	7.0^{c}	678.6^{c}	670.2^{c}	141.7^{bc}	137.5^{b}
Compost (5 ton/fed)	74.33^{a}	74.00^{a}	275.0^{b}	261.3^{b}	11.3^{b}	11.0^{b}	954.3^{a}	950.0^{a}	199.3^{a}	198.1^{a}
Fulvic Acid (5 kg/f)	67.66^{b}	66.16^{b}	258.6^{b}	252.6^{b}	10.0^{c}	10.0^{b}	8.44.0^{b}	843.6^{b}	202.3^{a}	201.2^{a}
Humic acid (5 kg/f)	63.76^{bc}	63.00^{bc}	229.0^{c}	221.6^{c}	7.3^{d}	7.3^{c}	717.4^{c}	708.9^{c}	143.9^{b}	149.2^{b}
Zeolite (210 kg/fed)	74.00^{a}	74.90^{a}	305.6^{a}	296.3^{a}	13.0^{a}	12.6^{a}	992.4^{a}	982.2^{a}	196.0^{a}	194.9^{a}

Chemical content of leaves:

The chemical constituents of sweet pepper leaves, *i.e.,* N, P, K content, carotenoids and total chlorophyll pigments (a+b) as affected by some soil applications (zeolite, compost, chicken manure, fulvic and humic acids) are shown in Table 5. The obtained results observe that all tested parameters affected by soil treatments as compared with untreated plants. Zeolite application followed by compost recorded the highest values in all studied parameters in both seasons.

The variation in results between zeolite and compost as soil applications in their effects on chemical sweet pepper leaves content may be due to the differences in chemical composition of the two substances, *i.e.,* organic matter and elements percentage as shown in Tables (2 and 3). These results agree with (Anonymous, 2004 and Polat *et al*., 2004). The nutrients gradually released, not only in the first year after application but also in the second or the following years. The most important nutrients necessary for proper growth and development of plants are nitrogen, potassium, calcium and magnesium. They affect not only the size of the crop but also its quality. These results are in harmony with El-Gahdban *et al.* (2002) and Aziz and Iman (2004) on chemical composition and Smedt (2017) on plant photosynthetic pigments.

Previous studies have related compost potential to its content of stable organic matter and nutritive elements (Bevacqua and Mellano, 1994). Also, enhancing macro and micronutrient concentrations by compost application might increase root surface as well as improving metabolites which in turn contribute to the increment of nutrient uptake (Ghallab and El-Gahadban 2004). The results are in harmony with Marzeh *et al.* (2012) on tomato and cucumber indicating that compost application resulted in an increment in vegetative and chemical content parameters over the control plants.

Table 5. Chemical composition of sweet pepper leaves as affected by some soil supplements during summer seasons of 2015 and 2016 after 85 days from transplanting.

Treatments	N (%)		P (%)		K (%)		Carotenoids		Total Chlo.	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control (untreated)	1.05^{d}	1.04^{d}	0.37^{d}	0.36^{c}	1.58^{d}	1.57^{d}	0.251^{e}	0.256^{d}	1.590^{d}	1.585^{d}
Chicken manure (10 m^2/fed)	2.13^{c}	2.12^{cd}	0.47^{c}	0.47^{bc}	1.61^{d}	1.60^{d}	0.286^{d}	0.288^{d}	1.911^{c}	1.893^{cd}
Compost (5 ton/fed)	4.93^{a}	4.86^{a}	0.97^{a}	0.96^{a}	1.97^{b}	1.97^{b}	0.401^{b}	0.408^{ab}	2.267^{ab}	2.269^{ab}
Fulvic Acid (5 kg/f)	3.78^{b}	3.75^{b}	0.67^{b}	0.66^{b}	1.84^{c}	1.83^{c}	0.347^{c}	0.365^{bc}	2.207^{b}	2.183^{bc}
Humic acid (5 kg/f)	2.70^{c}	2.67^{bc}	0.50^{c}	0.51^{bc}	1.81^{c}	1.81^{c}	0.308^{d}	0.307^{cd}	2.084^{bc}	2.066^{bc}
Zeolite (210 kg/fed)	5.10^{a}	5.01^{a}	0.98^{a}	0.99^{a}	2.09^{a}	2.08^{a}	0.442^{a}	0.447^{a}	2.499^{a}	2.559^{a}

Endogenous phyto-hormone contents of leaves:

Data in Table 6 show the endogenous phyto-hormone of leaves on sweet pepper were the content of cytokinins, auxine (indole acetic acid IAA) and gibberellic acid (GA3) expressed in (µg/g F.wt.) as growth promoters hormones and content of abscisic acid (ABA) (µg/g F.wt.) as growth inhibitor phyto-hormone, in two growing seasons of this study.

Data show that the soil supplements (zeolite, compost, chicken manure, fulvic and humic acids) were significantly differed in their effect on most endogenous phyto-hormone contents of leaves in two growing seasons of this research. Also, presented results showed that the significant highest auxin (IAA), Cytokinin and gibberellic acid (GA3) contents were detected in plants treated with zeolite as soil application followed by compost in comparison with other treatments. However, untreated plants recorded the highest values of ABA content in leaves, in both season.

Table 6. Endogenous phyto-hormones of sweet pepper leaves as affected by some soil supplements during summer seasons of 2015 and 2016 after 85 days from transplanting.

Treatments	Abscisic acid (ABA) (µg/g F.wt.)		Cytokinins (µg/g F.wt.)		Auxins (IAA) (µg/g F.wt.)		Gibberellins (GA_3) (µg/g F.wt.)	
	2015	2016	2015	2016	2015	2016	2015	2016
Control (untreated)	8.4^{a}	8.1^{a}	33.9^{d}	33.1^{d}	12.1^{c}	11.4^{c}	27.0^{c}	27.7^{c}
Chicken manure (10 m^2/fed)	5.0^{b}	4.6^{b}	38.3^{d}	37.5^{d}	16.1^{c}	15.4^{c}	32.6^{c}	32.0^{c}
Compost (5 ton/fed)	2.6^{c}	2.7^{bc}	90.0^{b}	89.2^{b}	49.8^{ab}	49.1^{ab}	68.2^{a}	68.8^{a}
Fulvic Acid (5 kg/f)	$3.4b^{c}$	4.0^{bc}	78.4^{c}	77.6^{c}	30.4^{bc}	29.7^{bc}	58.9^{ab}	58.2^{ab}
Humic acid (5 kg/f)	3.6^{bc}	4.4^{bc}	77.2^{c}	76.4^{c}	28.1^{c}	27.3^{c}	51.6^{b}	51.1^{b}
Zeolite (210 kg/fed)	2.0^{c}	2.3^{c}	98.6^{a}	97.7^{a}	60.2^{a}	59.5^{a}	70.5^{a}	70.7^{a}

In this concern, these results being of great important for interpreting the superiority of zeolite/compost in growth and fruit yield under drip irrigation conditions. It was obvious from the same data that, control plants were of the lowest content of the stimulator hormones and of the highest content of the inhibitor one (ABA).Under conditions of this work, the present results were logical since, the same zeolite/compost treatments gave similar effect on vegetative growth parameters, mineral contents, photosynthetic pigments, fruit yield and quality. In addition, it was known that, cytokinins, auxins and gibberlin were stimulator phyto-hormones involve in cell division, elongation and enlargement processes. These results agree with Abd El-Basir (2014) on sweet pepper plants.

Productivity attributes:

Yield and its components considered the mirror of all growth features. The results given in (Table 7) illustrate the response of productivity of sweet pepper plants, *i.e.*, total and early yield, vitamin C content, total soluble solids and titratable acidity to some soil treatments (zeolite, compost, chicken manure, fulvic and humic acids). All applied soil substances gave significant increment in all studied productivity parameters as compared to check plants. Soil application of zeolite recorded the beast values in most traits followed by compost treatment in both seasons.

Such increment in yield and its components of sweet pepper plants may be achieved as a result of adequate supply of macro nutrients (N, P and K) by ziolite application to plants (Table 5). The increment in number of leaves (Table 4) obtained by zeolite increase photosynthetic surfaces and the current of photosynthetic production of more assimilates which cause a significant increment in the productivity traits. These results in harmony with Polat *et al.* (2004),Gul *et al.* (2005), Ozbahce *et al.* (2014) and Mahmoud *et al.* (2017).

Table 7. Yield and its quality parameters of sweet pepper fruits as affected by some soil supplements during summer seasons of 2015 and 2016.

Treatments	Total yield (ton/fed)		Early yield (ton/fed)		Vitamin C (mg/g f.w)		Total soluble solids (TSS %)		Titratable acidity (%)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Control (untreated)	10.758^{e}	10.659^{e}	1.966^{d}	1.940^{d}	49.3^{e}	48.6^{d}	3.83^{c}	3.73^{c}	0.586^{d}	0.585^{e}
Chicken manure (10 m^2/fed)	13.272^{d}	13.296^{d}	3.043^{c}	3.016^{c}	57.2^{d}	56.1^{c}	4.58^{b}	4.48^{b}	0.657^{c}	0.646^{d}
Compost (5 ton/fed)	16.707^{b}	16.714^{b}	4.323^{ab}	4.283^{ab}	70.0^{b}	67.2^{ab}	4.94^{ab}	4.84^{b}	0.857^{a}	0.854^{a}
Fulvic Acid (5 kg/f)	15.476^{c}	15.524^{c}	4.043^{b}	4.176^{ab}	63.6^{c}	62.6^{bc}	4.83^{ab}	4.75^{b}	0.784^{b}	0.786^{b}
Humic acid (5 kg/f)	13.518^{d}	13.352^{d}	3.826^{b}	3.903^{b}	57.7^{d}	58.4^{c}	4.63^{b}	4.70^{b}	0.661^{c}	0.751^{c}
Zeolite (210 kg/fed)	18.766^{a}	18.763^{a}	4.832^{a}	4.776^{a}	72.5^{a}	70.8^{a}	5.24^{a}	5.46^{a}	0.871^{a}	0.867^{a}

Concerning compost effects on fruits quality parameters, this result has the same line with the findings of Santiago *et al.* (2009) and Kashem and Warman (2009). It was found that to maintain the C:N ratio in plants supplied with organic fertilizerers, the extra C may have been used for the production of organic acids like malic and citric acid which are responsible for the fruit acidity. Hence, our obtained results confirmed the previous trails whereas organic fertilizers increased levels of organic acids in sweet pepper fruits.

The improvement of fruit quality may be due to the better growth of plants at different rates of organic fertilizer, which might have favored the production of better quality fruit (Rajbir *et al.*, 2008). Vitamin C levels in vegetables depend on several aspects including plant nutrition, production practice, cultivar and maturity (Antonio *et al.*, 2007). These results agree with Taiwo *et al.* (2007) indicating that compost application at different rates improved vitamin C in fruit.

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كفاءة إستخدام بعض إضافات التربة على إنتاجية الفلفل الحلو تحت ظروف إقليم الدلتا

عبدالبصير السيد عبدالبصير[1] و ولاء محمد السعيد سويلم[2]
[1]قسم بحوث محاصيل الخضر ذاتية التلقيح – معهد بحوث البساتين – مركز البحوث الزراعية – الجيزة – مصر.
[2]قسم الخضر والزينة – كلية الزراعة – جامعة المنصورة – مصر.

اجريت هذة الدراسة تحت ظروف الحقل المكشوف بهدف دراسة تأثير بعض الأضافات الأرضية (أحماض الهيوميك والفلفيك والزيولات والكمبوست وسبلة الدواجن) على النمو الخضري والمحتوى الكيماوي للأوراق والمحصول وجودته لنباتات الفلفل الحلو هجين "مادير". أظهرت النتائج تفوق جميع الإضافات الأرضية على معاملة الكنترول بفروق معنوية فى تحسين صفات النمو الخضري والمحتوى الكيماوي للأوراق والهرمونات النباتية وكذلك المحصول وجودته في موسمي الداسة. كانت الإضافة الأرضية للزيولايت و كذلك الكمبوست الأفضل في تسجيل أعلى القيم. هذا وتؤكد النتائج المتحصل عليها من خلال الدراسة أن اضافة كل من الزيولايت والكمبوست يمكن ان يقلل من الأسمدة الكيماوية من خلال تعظيم الاستفادة من كل من الأسمدة المضافة وكذلك ماء الري والتي تنعكس بدورها على تحسين انتاجية محاصيل الخضر وخفض تكاليف الانتاج تقليل التلوث.