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Effects of Different Organic and Inorganic Fertilizers on Cucumber Yield and Some Soil Properties

[1]Esawy Mahmoud, [1]Nasser Abd EL- Kader, [2]Paul Robin,
[2]Nouraya Akkal-Corfini and [3]Lamyaa Abd El-Rahman

[1]Department of Soil and Water Science, Faculty of Agriculture, Tanta University, Egypt
[2]INRA, UMR1069, Sol Agro et hydrosystème Spatialisation, F-35000 Rennes
[3]Kafr El-Sheikh, Sakha, Agricultural Research Station, Egypt

Abstract: The application of organic wastes combined with or without mineral fertilizer to soil is considered as a good management practices in any agricultural production system because it improves, plant quality and soil fertility. The objective of the present study is to evaluate the effect of three compost types (plant residues, animal residues and mixed) when mixed with mineral nitrogen fertilizers, on cucumber (*Cucumis Sativa*) plants and soil properties. A field experiment was carried out at El-Nataf farm, Sakha, Agricultural Research Station, Kafr El- Sheikh Governorate, Egypt during the two successive summer seasons of 2007 and 2008. The results showed that the mature compost of plant residues was higher in saturation percent and lower in C/N ratio, pH, electrical conductivity and bulk density than the animal and mixed composts. The study demonstrated that the average cumulative cucumber yield was higher with 75% mineral N + 25% organic N treatments compared to other treatments throughout the experiment, especially in the plots treated with plant compost during the two successive summer seasons of 2007 and 2008. The average nitrate of petioles in the plots treated with N 100% organic decreased by 52-69 % compared to 100% mineral N. The average nitrate content of cucumber fruits was only detected in the plots treated with 100% organic N from the composts tested. The nitrogen and phosphorus content of the soil significantly increased, as did the soil organic matter, with the increase of organic nitrogen applied. The experimental results confirmed that the combination of organic and inorganic fertilizers could increase plant growth, yield, quality and soil fertility. It also confirmed that composted organic wastes can be used to substitute for around 25% of chemical nitrogen fertilizers.

Key words: Organic nitrogen · Yield · Combination · Substitute · Plant quality · Cucumber

INTRODUCTION

Large quantities of agricultural residues and animal wastes are produced each year in Egypt. These include about 15 million tons of municipal wastes, 20 million tons of crop residues and 275.5 million m3 of animal manure [1]. Mismanagement of organic wastes, have impacted public health and environment. These organic wastes are rich plant nutrients and through proper management such as composting can be used as a soil conditioner, as well as a nutrient source for plants [2]. Compost addition was found to not only increase crop yield, but also to improve soil fertility in terms of organic C and N content, permeability, plant available water capacity and air-filled porosity [3,4].

In Egypt, the organic matter of cultivated clay soils is between 1.0- 2.5%, while in the calcareous and sandy desert soils, it is usually less than 0.5% under arid and semiarid conditions [5]. In addition, these soils are also low in nitrogen and phosphorus and would benefit with the application of organic matter: 1) improve the soil characteristics; 2) increase soil productivity and 3) organic matter application to these reclaimed soils can reduce the use of chemical fertilizers, which have adverse environmental effects. Riad [6] reported that the required amount of organic matter for the cultivated soils in Egypt corresponds to 170 million tons farm yard manure (FYM).

Fertilizer application rates in intensive agricultural systems have increased dramatically during recent years in Egypt, especially in greenhouse vegetable production

Corresponding Author: Esawy K. Mahmoud, Tanta University, Faculty of Agriculture, Department of Soil And Water Science, Egypt

systems [7]. Because of higher yields and income, use of organic fertilizer and irrigation are increasing, the highest fertilizer inputs can lead to marked deterioration in soil and groundwater quality and the systems are clearly unsustainable [8]. The excess use of nitrogen fertilizers in agriculture can lead to nitrate accumulation into plants. Nitrate accumulation in editable plants is a problem when eaten. Part of the ingested nitrate may be converted to nitrite causing methaemoglobinaemia or even to carcinogenic nitrosamines. Abd El-Hamied [9] reported that, the determination of nitrate and nitrite in food stuffs become increasingly important because of the concern over excessive human dietary intake of these species, causing a health hazard. Gangolli *et al*. [10] reported that, vegetables constitute a major source of nitrate providing more than 85% of the average daily human dietary intake. Abd El-Hamied [9] reported that in leafy, root and fruit vegetables collected from local markets of Upper Egypt leafy vegetables had the highest nitrate content compared to root and fruits vegetables. He also found that nitrite concentration in vegetables under investigation were low in contrast to nitrate content.

Vogtmann *et al*. [11] studied the effect of compost on the yield and quality of some vegetables compared with chemical fertilizers. They found that compost treatments resulted in lower vegetable yields in the first two years, but there were no different after the third year. Kostov *et al*. [12] reported that it was more economical to use composting vegetable residues for greenhouse cucumber production than cattle manure. They also reported that green house cucumbers (*Cucumis Sativus L.*) grown on a medium containing composted vegetables, or vegetable waste with the addition of synthetic nutrients produced fruit 10 to 20 days earlier and had a yield 48 to 79% higher than those grown in soil mixed with cattle manure at a 2:1 ratio (dry weight basis). Roe *et al*. [13] studied green peppers and cucumbers in a sandy soil fertilized with compost or mineral fertilizers. They found that, yields were usually higher when compost was combined with mineral fertilizers. Use of organic manure and chemical fertilization increased soil nutrients and microbial biomass. Application of organic manures significantly increased levels of organic C and N and the formation of water-stable aggregates, as compared with application of chemical fertilizers [14].

The objectives of this study were to assess the effect of three compost types (plant residues, animal residues and mixed plant and animal residues), with or without mineral nitrogen fertilizer, on cucumber (*Cucumis sativa*) plants during the two seasons 2007/2008 and clay soil properties.

MATERIALS AND METHODS

Composting: Six piles were prepared and arranged into windrows using different raw materials from several origins. The approximately dimension of each piles were 3m length, 2.5m width and 1.5m height. Each pile was placed on a 10 cm bed of corn stalks and the entire pile covered with plastic sheet for insulation. The compost piles included two of each type: 1- plant residues (rice straw, corn stalks, empty southern pea pods, cabbage residues and sugar beet leaves) where these materials were chopped into small pieces and then mixed by hand; 2- animal wastes (sheep solid and liquid wastes); 3- two piles were plant/ animal mixture at 1:3 ratio by weight. The moisture content was maintained at 60 % and C/N ratio (30-35) as recommended after corrected by addition mineral nitrogin for all piles, which is considered an optimum for composting [4]. At the end of the composting process (90 days), samples were taken for analysis from each pile (Table 1) and the mature composts used in the cucumber experiment.

Cucumber Experiment: The effect of combination of organic and inorganic nitrogen on cucumber (*Cucumis Saliva*) yield, quality and some soil properties was studied in a field experiment at El-Nataf farm, Sakha, Agricultural Research Station, Kafr El- Sheikh Governorate, Egypt during the two successive summer seasons of 2007 and 2008. The experiment was a completely randomized experimental design with three replicates and the area of each replicate plot was 4m * 5m. The soil in plots was mixed with the various composts based on available N in the compost (recommendation of N fertilizer for cucumber). The soil had a clay texture (63% clay), EC (2.1 dS m^{-1}), bulk density (1.37 g cm^{-3}) and 0.45 g total N kg^{-1}, 0.51 g total P kg^{-1} and 23 mg available N kg^{-1} on a dry weight basis.

Cucumber seedlings with two leaves were transplanted by hand in double rows with 0.9 m row spacing and 0.3 m seedling spacing on September during 2007/2008. Furrow irrigation systems were adopted in the field, based on the conventional schedule. The mineral fertilizer (NH4NO3) was added adjust irrigation. The plants were grown with a 27/19°C day/night temperature regimes. Other aspects of crop management followed conventional practices. Cucumber was starting harvested weekly on December during 2007/2008. Commercial fruits (205-3.0cm in diameter and 13-20 cm long) were picked following conventional harvesting

Table 1: Some chemical composition of the three mature composts

Properties	Units	Mixed	Plant residue	Animal waste
pH		7.66	7.39	7.83
EC	dS m^{-1}	15.90	9.20	16.60
Nitrogen (N)	%	1.70	1.70	1.70
Carbon (C)	%	19.40	17.40	19.50
C/N ratio		27.71	24.86	27.86
Phosphorus	%	0.60	0.50	0.60
Saturation	%	138.90	312.50	122.40
Bulk density	g cm^{-3}	0.63	0.44	0.72

Table 2: Effect of the composts and mineral fertilizer treatments on the average vegetative growth, NO_3 in fruits and petioles and soil pH during the two successive summer seasons of 2007 and 2008

Symbole	Treatment	Fruit kg $plot^{-1}$	Shoot kg $plot^{-1}$ Fresh	Dry	NO_3 mg kg^{-1} Fruit	Petioles	Soil at harvest	EC dSm^{-1}	Soil pH
T1	100% mineral N	112.5	284.0	47.5	92.7	202	2.91	2.15	7.04
T2	75% mineral N + 25% mixed compost	124.3	289.8	48.8	93.7	204	15.02	2.65	7.03
T3	50% mineral N + 50% mixed compost	50.8	143.5	28.5	71.8	108	6.25	2.75	7.09
T4	25% mineral N + 75% mixed compost	39.5	140.0	23.5	56.3	96	4.20	2.95	7.15
T5	100% mixed compost	10.8	128.8	22.0	0.0	72	3.20	2.99	7.41
T6	75% mineral N + 25% plant compost	181.3	368.5	53.8	98.0	260	22.0	2.25	7.14
T7	50% mineral N + 50% plant compost	79.8	224.3	43.0	87.2	228	9.25	2.30	7.24
T8	25% mineral N + 75% plant compost	45.5	222.3	40.3	78.2	168	7.20	2.70	7.23
T9	100% plant compost	37.5	220.0	40.0	0.0	96	3.75	2.80	7.21
T10	75% mineral N + 25% animal compost	117.3	273.3	64.8	98.8	208	17.0	2.45	7.23
T11	50% mineral N + 50% animal compost	24.5	178.3	50.8	60.5	188	7.75	2.80	7.18
T12	25% mineral N + 75% animal compost	11.3	163.3	47.8	23.9	96	5.20	3.00	7.28
T13	100% animal compost	10.5	161.0	23.8	0.0	61	4.42	3.80	7.30
F test		**	**	**	**	**	**		
L.S.D 0.05		1.71	4.95	1.238	1.85	3.96	2.56		

**: Significant between treatments at $p < 0.05$.

practice and weighed from 25 plants in each plot. The treatments used in this experiment are listed in (Table 2). All results were taken on the basis of the average for two successive summer seasons of 2007 and 2008.

Measurements: Shoot fresh and fruit weights were recorded for each plant. Plants were dried at 70°C to become constant weight and this weight was recorded. The dried plant and soil samples were ground and sieved through 2.0 mm mesh. The total N was determined by the kjeldahl method [15]. Nitrogen uptake was calculated as the product of dry matter multiplied by N concentration in shoots. Nitrate was determined in the soil according to Singh [16]. Saturation percentage (%) of compost was determined by adding distilled water at intervals until complete wetting of 100 g of compost [17]. Bulk density of compost was estimated as a ratio between oven dry weights to their volumes as mg m^{-3} as reported by Okalebo *et al*. [18]. Soil pH was measured in 1:2.5 (soil: water) suspension [19] and in a 1:5 ratio (compost: water) suspension for compost. Electrical conductivity (EC) was measured in the compost with a 1:10 (compost: water) ratio. Total organic carbon (TOC) was determined according to Walkley and Black's method as modified by Walkley as Black *et al*. Organic matter (OM) percent was calculated as: OM% = TOC (%) X 1.724. Nitrate was determined in plants according to Singh [16]. Total phosphorus was measured colorimetrically using a spectrophotometer after wet digesting the soil samples in concentrated H_2SO_4 + $HClO_4$ [21].

RESULTS

Chemical Properties of Mature Composts: The compost of plant residues was higher in saturation percent, lower in C/N ratio, pH, EC and bulk density than the animal and mixed composts (Table 1). Based on compost properties, the plant residue compost appears to be the best suited as soil amendment.

Vegetative Growth of the Cucumber Plants: Fertilization had a significant effect on the average fruit, fresh shoot and dry shoot weights of cucumber plants during the two successive summer seasons of 2007 and 2008. (Table 2). Comparing treatments with 100% organic nitrogen (T5, T9 and T13), the highest fruit and dry shoot weights of cucumber were in the plots treated with the plant compost compared to animal and mixed composts. Shoot dry weights with 100% organic nitrogen (T5, T9 and T13) decreased by 15-53% compared to treatment T1 with no compost. Shoot dry weight in 100% compost treatments was lower than in other treatments, especially in the plots treated with mixed compost. Fruit dry weights followed trends similar to shoot dry weights in all treatments (Table 2). The fruit and shoot dry weights in the 75% mineral nitrogen + 25% organic nitrogen treatment were higher than in the other treatments throughout the experiment, especially in the plots treated with plant compost.

N Uptake of the Cucumber Shoots: The average of N uptake by cucumber shoots of N organic 100% treatments decreased by 81% in mixed, 49% in plant and 75% in animal composts compared with 100% N mineral treatment for the two successive summer seasons of 2007 and 2008 (Fig. 1). The highest N uptake was obtained with 75% N mineral + 25% N organic treatments compared with the other treatments for the three compost types (Fig. 1). The N uptake decreased with the increase of organic N applied to clay soil. N uptake was higher in the 75% N mineral + 25% N animal compost treatment than the other treatments. In the experiment the differences in N uptake among N treatments was dependent on both dry matter and N concentrations. The trend of N uptake was similar to the dry weights (Table 2).

Nitrate Accumulation in Cucumber Plants: Fertilization had a significant effect on the average petioles and fruits of cucumber plants for the two successive summer seasons of 2007 and 2008 (Table 2). Nitrate of petioles in the plots treated with 100% compost decreased by 52-69% compared to treatment T1. Nitrate of the fruit followed trends similar to petioles and dry weights in all treatments. Nitrate of the fruits and petioles were greater in the plots treated with 75 % N mineral + 25 % N organic than the other treatments, indicating greater N availability from these treatment than the other treatments. Nitrate of petioles and fruits increased with increase mineral nitrogen when it was applied with composts, indicating that the N availability increased with mineral nitrogen applied. When 100% organic N was applied only, the nitrate content of cucumber fruits was detected in all composts.

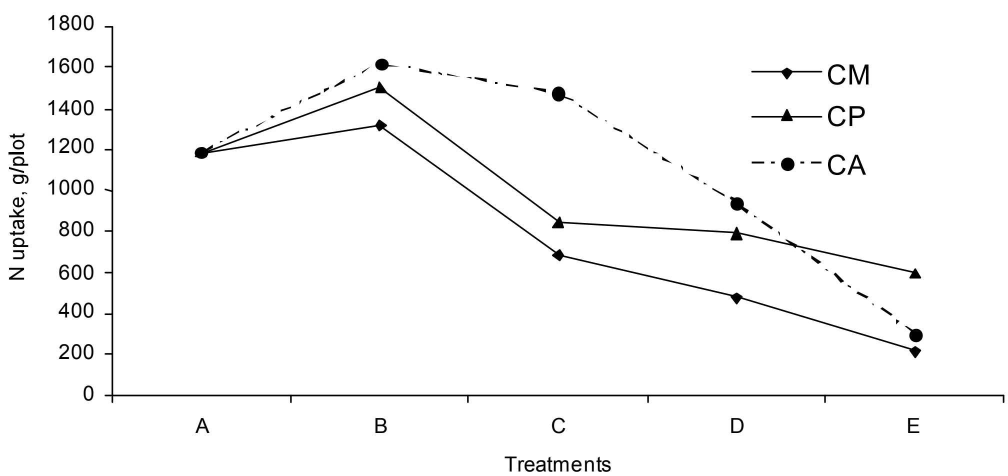

Fig. 1: Effect of the composts and mineral fertilize on the average N uptake of cucumber in the study soil during the two successive summer seasons of 2007 and 2008. A: 100 N mineral + 0 N organic, B: 75 N mineral + 25 N organic, C: 50 N mineral + 50 N organic, D: 25 N mineral + 75 N organic, E: 0 N mineral + 100 N organic

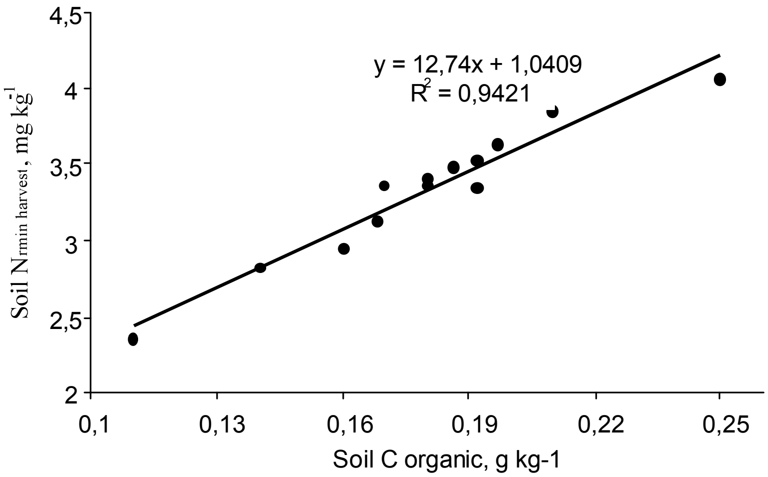

Fig. 2: The relation between soil organic C and soil N remaining in the study soil at harvest

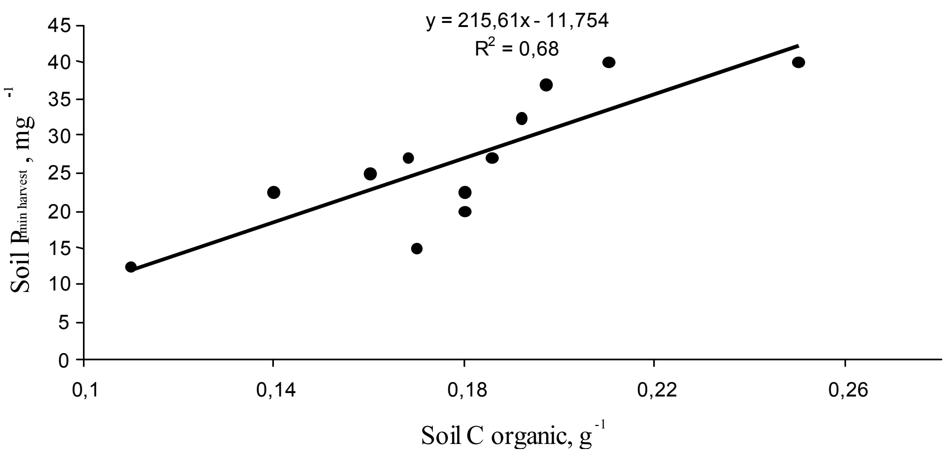

Fig. 3: The relation between soil organic C and soil P remaining in the study soil at harvest

Effect of the Composts and N Mineral Fertilizes on Some Soil Properties: In the plots treated with 100% N organic or combined organic/N mineral fertilizers, EC in the soil was higher than the other treatments throughout the experiment, especially in plots treated with animal compost (Table 2). EC, in the plots treated N organic 100% increased by 28% in mixed, 23% in plant and 43% in animal composts compared with 100% N mineral treatment. In these experiments, EC of the soil increased with the increase soil C organic.The application of composts or interaction between compost and mineral N fertilizers to soil caused a slight increase in soil pH compared with mineral N fertilizer (Table 2). Nitrate of the soil was higher significant in the plots treated with 75 % N mineral + 25 % N organic than the other treatments, indicating higher N availability from these treatment than the other treatments, especially in plots treated with plant compost (Table 2).

The average of the amount of nitrogen and phosphorus left in the soil at harvest with 100% mineral nitrogen treatment were lower than in the other treatments. The nitrogen and phosphorus remained in the soil increased with the increase of organic nitrogen applied as well as soil organic C (Fig. 2, 3).

DISCUSSION

Nitrate Accumulation and N Uptake in Cucumber Plants: Increasing the available nitrogen in the soil by increasing the percentage of mineral N in fertilization led to a clear increase in nitrate accumulation in the plants. Nitrate accumulation in edible plant parts is a problem when eaten. Nitrate content of petioles and fruits in the plots treated with 100% N mineral were higher than N 100% organic. This was attributed to the supply of readily available nitrate from mineral N fertilizers to the plants while, in the organically treated plots, nitrate release was comparatively slow. The nitrate concentrations of petioles and fruits increased with mineral N fertilizers. Similar finding was obtained by Anga [22] who found that nitrate concentration in spinach leaves increased with biofertilizer and N fertilizer combinations. Huang and Lin [23] found that the application of organic combined with chemical fertilizer improved the quality of crops. The mean value of NO_3 mg kg^{-1} dry matter of cucumber fruit collected from 113 plant samples were ranged from 158±21.9 to 175±21.1 NO_3 [24]. ESCF [25] reported that nitrate accumulation of cucumber was between 23-242 mg NO3- per kg dry weight. The maximum acceptable nitrate content of vegetables has been standardized in only a few countries and the recommended limit to 700 mg kg^{-1} fresh product as described by the W.H.O [26]. Cucumber fruits in the presented study approached this slandered.

The increase of N uptake appeared to be more obvious when the compost was mixed with the mineral N fertilizer as compared to the 100% compost or 100% N mineral fertilizer. It can be due either to the effect of compost and mineral N fertilizer on improving soil physical properties, or to a higher mineralization of composts which it due to mineral N inputs. It increased plant availability of macro- and micronutrients which led to high vegetative growth and more absorption of nitrogen (Table 2).

Effect of the Composts and N Mineral Fertilize Treatments on Soil N and P: The nitrogen remained in the soil after harvest increased with the increase of organic nitrogen applied as well as soil organic C. It indicated that the plant uptake was smaller than with mineral N (Fig. 1). It was confirmed by a lower nitrate content of the plants when the percentage of organic N increased.

Vegetative Growth of the Cucumber Plants: Interaction between the compost and mineral N fertilizer is the key objective to solve the conflict between high yields and environmental protection. The fruit and shoot dry weights in the 75% mineral + 25% organic treatment were higher than in the other treatments throughout the experiment. Role of organics in increasing yield of cucumber was attributed to supply of all essential nutrients (Table 1) due to continuous mineralization of organic manures. Our results also showed that the cucumber responded more to plant compost than mixed and animal composts. This because of the fact that the low C/N ratio, phosphorous and EC of the plant compost compared to the other used compost (Table 1). Shoot dry weights of cucumber in the 100% N mineral, 75% N mineral + 25% organic and 50% N mineral + 50% organic treatments were similar to the shoot dry weight of cucumber plants reported in greenhouse experiments with recommended fertilizer N [27]. The application of organic combined with chemical fertilizer improved the yield of crops [23-28]. It also explained that the ratio of nutrients or the rate of their release may not always match the needs of the plant, but the combined use of chemical and organic fertilizers can correct any deficit. The fruits in the 50 % N mineral + 50 % N plant compost decreased by 29 % compared to the N 100% mineral treatment but, the price and quality of these fruits were high and reduced N mineral fertilizers.

CONCLUSION

The excess use of nitrogen fertilizers in agriculture can lead to nitrate accumulation in the plants and groundwater pollution. This study confirmed that the application of compost increased accumulation of organic C, N and phosphorous more than application of N mineral fertilizers. Compost combined with application of N mineral fertilizers was the best management system for increasing soil fertility, cucumber yield and quality and decrease the cost of N mineral fertilizers.

REFERENCES

1. El-Shemy, S. and B. Aly, 1997. Report on agriculture wastes in Egypt. (In. El-Galaa A (Ed.) Organic Agriculture, 308.
2. Smith, S.R., 1992. Sewage sludge and refuse composts as peat alternatives for conditioning impoverished: effects on the growth response and mineral status of petunia grand flora, J. Hort. Sci., 117: 703-706.
3. Mamo, M., C.J. Rosen, T.R. Hallbach and J.F. Moncrief, 1998. Corn yield and nitrogen uptake in sandy soils amended with municipal solid waste compost. J. Pro. Agri., 11: 469-475.
4. Keener, H.M., W.A. Dick and H.A. Hoitmk., 2000. Composting and beneficial utilization of composted by-products materials. In USA. Land application of agricultural, industrial and municipal by-products, SSS a Book series No. 6: 315-341.
5. Abd El-Ghaffar, A.S., 1982. The significance of organic materials to Egyptian agriculture and maintenance of soil productivity. FAO Soil Bulletin, FAO, of U.N. Rome, Italy, 45: 15-20.

6. Riad, A., 1982. Potential of organic matter in Egypt. FAO Soils Bulletin, 45: 22-26.
7. Abd El Hadi, A.H., 2004. County report on Egyptian agriculture. In: Proceeding of the IPI workshop on potassium and fertigation development in West Asia and North Africa.
8. Zhu, J.H., X.L. Li, P. Christie and J.L. Li, 2005. Environmental implications of low nitrogen use efficiency in excessively fertilized hot pepper (*Capsicum frutescens L.*) cropping systems. Agriculture, Ecosystems and Environment, 111: 70-80.
9. Abd El-Hamied, A., 2001. Evaluation of nitrite, nitrate and nitrosamine compounds in Upper Egypt vegetables. Alex. Sci. Exch. J., 22(3): 323-332.
10. Gangolli, S.D., P.A. Brandt, V.J. Ferom, C. Koeman, J.H. Janzowslcy, B. Spiegelhalder, R. Walker and J.S. Sishonk. 1994. Nitrate, nitrite and N-nitroso compounds. Europ. J. Pharmacol., 1: 292.
11. Vogtmann, H., K. Matthies, B. Kehres and A. Meier-Ploeger, 1993. Enhanced food quality: ²Effects of compost on the quality of plant foods. Compost Sci. Util. 1: 82-100. 12. Kostov, O., Y. Tzvetkov, N. Kaloianova. and O. Van Cleemput. 1995. Cucumber cultivation on some wastes during their aerobic composting. Bioresource Technology, 53(3): 237-242.
13. Roe, N.., P.J. Stoffella and D. Graetz, 1997. Composts from various municipal solid waste feedstocks affected vegetable crops. 2: Growth, yields and fruit quality. J. Amer. Soc. Hort. Sci., 122: 433-437.
14. Adrien, N.D., 2006. Mixed paper mill sludge effects on corn yield, nitrogen efficiency and soil properties. Agron. J., 98: 1471-1478.
15. Ahn, Y.S., 1987. Plant analysis for evaluating plant nutrition. In International Training Workshop on soil test and plant analysis. RDA& FFTC/ ASPAC.
16. Singh, I.P., 1988. A rapid method for determination of nitrate in soil and plant extracts. Plant and Soil. 110: 137-139.
17. Rhoades, J.D., 1982. Soluble salts. pp: 167 -179. In A.L. Page (ed). Methods of soil analysis. Part2. Chemical and microbiological properties. Agronomy vol. 9, 2nd ed. American Society of Agronomy, Medison, WJ.
18. Okalebo, J.R., K.W. Gathua and P.L. Woomer, 1993. Laboratory methods of soil and plant analysis: A working manual. TSBF Program, Soil Science Society of East Africa, Technical Publication No. 1, UNESCO, ROSTA, Kenya.
19. Page, A.L., 1982. Methods of Soil Analysis. Part. 2 Chemical and microbiological properties (2nd ed.), Amer. Soc. Agron. Inc. Soil Sci. Soc. Amer. Inc. Madison. Wisconsin U.S.A. properties. Agron. J., 98: 1471-1478.
20. Black, C.A., D.D. Evans, J.L. Wite, L.E. Ensminger and F.E. Clark., 1965. Method of Soil Analysis. Am. Soc. Agron. Inc. Publisher Madison Wisconsin, USA.
21. Cotteine, A., M. Nerloo., G. Velghe and L. Kiekens, 1982. Biological and analytical aspects of soil pollution. Lab. of analytical Agro. State Univ. Ghent-Belgium.
22. Anga, M.A., 2001. Studies on the effect of mineral and biofertilization on yield and quality of spinach. M.Sc. Thesis. Faculty of Agric., Alex. Univ. Vegatable Crops Dept.
23. Huang, S.N. and J.C. Lin, 2001. Current status of organic materials recycling in Southern Taiwan. Soil and Fertilizer Experiment Bulletin, 3: 43-48.
24. Hoaba, V.J.G. and Uittenbogoard, 1994. Chemical composition of various plant species. Dept. of Soil Sci. and Plant watritior. Wageningen Agricultural University. The Netherland.
25. ESCF. 1997. Report of the European Scientific Committee for Food. Luxembourg: office for official publications of the European communities.
26. W.H.O. 1978. Environmental healh criteria 5-Nitrates and N-Nitroso compounds. Geneva, World Health Organization
27. Guo, R., X. Li, P. Christie, Q. Chen and F. Zhang, 2008. Seasonal temperatures have more influence than nitrogen fertilizer rates on cucumber yield and nitrogen uptake in a double cropping system. Environ. Poll., 151: 443-451.
28. Zhang, M. and L. Fang, 2007. Effect of tillage, fertilizer and green manure cropping on soil quality at an abandoned brick making site. Soil and Tillage Research, 93: 87-93.