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INFLUENCE OF GYPSUM AND MANURE ON SOME PROPERTIES OF ALKALI SOIL AND GROWTH OF PEPPER PLANTS

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ABSTRACT: *A pot experiment was conducted to investigate the effect of gypsum (natural chemical amendment) and biogas manure (natural organic fertilizer) and their interaction on plant growth of pepper plants grown on alkali soils, some physical and chemical properties, yield and its components and some vegetative characteristics. The obtained results could be summarized as follows: Application of gypsum from 3, 6 to 9 ton/feddan (corresponding to 50, 100 to 150% of soil gypsum requirements "G.R") caused a decrease in bulk density, pH, electrical conductivity (EC), and exchangeable Na^+ and Mg^{++}, as well as ESP of the alkali soil used. The rate of decrease in each of these parameters was parallel to the application level of gypsum, from 50 to 150% of G.R. While, total porosity, cation exchangeable capacity (CEC) and exchangeable Ca^{++} and K^+ increased above the control. Such increases were more pronounced with 150% G.R. (highest dose) Slight variations in organic matter (O.M.) content were detected due to application of gypsum amendments. Addition of biogas manure (at the rates of 1, 2, & 3 ton/fed.) had a little effect on reducing the values of each of bulk density, pH, EC, Exchangeable cations and ESP. While total porosity, O.M and CEC increased considerably with 3 ton/feddan biogas manure. Coapplication of gypsum and biogas manure, specially at the highest rates of both, showed a positive effect, which was more pronounced in case of EC parameter. Dry matter yield of green pepper, planted in such alkali soil, significantly increased after the soil was treated with gypsum up to 150% of G.R, at the three stages of growth (vegetative, flowering and harvest e.g. 45, 60 & 90 days of planting). Application the increasing rates of biogas manure significantly increased both the dry matter and crop yield of pepper plants grown, each cultivation season. Interaction of gypsum and biogas manure gave a significantly positive effect on plant growth at all levels applied of both amendments. Application of gypsum up to 9 ton/feddan (150% of G.R) significantly increased each of plant height, leaf area, Chlorophylls "a" & "b", total chlorophyll ("a" + "b"), vit. "C", total soluble solids (TSS), number of fruits (pods) per plant, average fruit weight per plant and total yield of green pepper plants in both growth seasons, as compared with the unamended plants. All* *of the studied vegetative characteristics increased progressively with increasing the levels of gypsum as a natural inorganic chemical amendment for alkali soil. Plant height, leaf area, chlorophylls "a" & "b", total chlorophyll ("a" + "b"), vit. "C", TSS, No. of fruits / plant, average fruit weight per plant and total crop yield of pepper plants increased progressively and significantly with increasing the rate of biogas manure up to 3 ton/feddan. Coaddition of gypsum and biogas manure revealed a highly positive effect on all plant characters under study, in the two seasons. The best values for yield and its components were obtained by application of biogas manure at its highest rate, i.e., 3 ton/feddan.*

Key words: *Soil amendments, biogas manure, pepper plants, vegetable crops, alkali soil.*

INTRODUCTION

Green (sweet) pepper (*Capsicum annuum,* L.) is an important vegetable crop through out the world including Egypt. Green pepper are popular food items in the Egyptian diet, as cooked, stuffed and fresh salad. They are excellent sources of vitamins "A" and "C" and are low in caloric value (Shams, 2003 and Ortas *et al.,* 2005).

Saline and alkali soils occupy wide areas scattered all over the world, particularly in arid and semi-arid climate regions. Most of these soils, in Egypt, are located in eastern and western zones of the Nile Delta and are of low crop Productivity. Such soils have complicated problems, mostly related to their high salinity and sodicity levels, which seriously affect plant growth and production, either directly or indirectly. Soil salinity and alkalinity affect several soil physical, chemical and biological properties and availability of plant nutrients.

The main problems of the alkalinity affected soils are their poor physical and chemical properties, i.e., low permeability to water and air due to their high percentage of exchangeable sodium, high pH values and low availability of many nutrients. Food security is one of the most significant aims facing our country, Egypt, nowadays. This can be achieved by raising the efficiency of the presently cultivated soils and reclaiming other new lands. Several inorganic (gypsum) and organic (manure) amendments have been used to improve properties, which are reflected on crop production (El-Gundy, 2005 and El-Shinnawi *et al.,* 2009).

A major aim in agricultural policy of Egypt is to face the excess population pressure and shortage of agricultural area. In Kafer El-Shikh Governorate, the cultivated soils are limited and greatly affected by alkalinity consequently, improving physical, chemical and biological properties of such alkali soil is of utmost importance. Gypsum is usually added to alkali soils for amelioration, by reducing their high exchange able sodium percentages

(ESP). Zein (2000) found that biogas manure play an important role in increasing dry weights of corn and wheat plants also, its positive effect on physical and chemical properties of soil.

Therefore, the main object of the current work is to evaluate the effect of biogas manure (organic fertilizer) and gypsum (inorganic amendments) and their interaction on plant growth, dry weights, some physical and chemical properties, some vegetative characters and crop production of pepper plants and its components grown on alkali soils of Kafr El-Shikh Governorate.

MATERIALS AND METHODS

The present investigation was undertaken to evaluate the effect of organic amendments (biogas manure) and inorganic amendments (gypsum) and their interaction on some physical and chemical properties, plant growth, yield and its components and some vegetative characteristics of pepper planted on alkali soils. Soil surface samples (0 – 15) were taken from the Experimental Farm of Sakha, Kafer El-Shikh Governorate, which represent alkali soils. Soil samples were air-dried, ground, sieved through a 2 mm sieve and good to a unique sample. Some physical and chemical properties of soil were determined according to Black *et al.* (1965) and Jackson (1973), data illustrated in Table (1). Two soil natural conditioners (gypsum and biogas) have different composition and properties were used at f ur rates of application. Organic manure (biogas) was added at the rates of 0, 1, 2 and 3 ton/feddan, gypsum was added at the rates of 0, 3, 6 and 9 ton/feddan which represent 50, 100 and 150% G.R. Peppers (*Capsicum annuum* L.) was chosen as a test plant and grown on alkali soils. Gypsum ($CaSO_4 . 2 H_2O$) which obtained from El-Fayoum region contained 88.6% $CaSO_4$. Some chemical analysis of biogas manure was illustrated in Table (2).

A pot experiment was conducted in 12 replicates for each treatment, 5 kg of soil were packed in plastic pots after thoroughly mixed with calculated amounts of natural amendments of gypsum and water-logged consistently to 120% W.H.C of the soil for leaching period, and biogas manure and wetted for one month. Seeds of sweet pepper were sown in seed bed on the 1st and 5th of January in the first and second seasons, respectively. The seedling were transplanted after 60 days in all pots. The recommend agricultural practices by the Ministry of Agriculture for the region were performed. Soil moisture was maintained at the field capacity in all pots. At vegetative, flowering, fresh and dry weights were recorded while at harvest stage, fresh weight, dry weights beside green bod yield were recorded. Soil of each treatment was subjected to physical and chemical analysis at the end of experiments according to Page *et al.* "Part 1" (1982). Some vegetative characteristics such as plant height, average fruit weight, leaf area, number of fruits/plant, chlorophyll a, b, total chlorophyll a + b, vit. C and total yield and its components were recorded according to A.O.A.C (1965) and Wettstein (1957).

The obtained results were subjected to analysis of variance according to Snedecor and Cochran (1972).

Table (1). Initial physical and chemical properties of the studied alkali soil.

Property		Value
Particle size distribution, %	Sand	16.0
	Silt	27.3
	Clay	56.7
	Texture class	Clay
Field capacity, %		43.50
Bulk density, g/cm^3		1.27
Total porosity, %		52.20
Organic carbon, %		0.53
Total nitrogen, %		0.04
C/N ratio		13.25
Organic matter, %		0.91
pH (1 : 2.5, soil / water suspension)		8.87
Electrical conductivity "EC", dS/m^{-1}		3.92
Available phosphorus, mg/kg soil		10.98
Available potassium, mg/kg soil		512.80
Soluble ions (soil paste extract), meq/l	Ca^{++}	3.50
	Mg^{++}	5.25
	Na^+	30.13
	K^+	0.36
	$CO_3^=$	-
	HCO_3^-	1.50
	Cl^-	34.13
	$SO_4^=$	3.60
Exchangeable cations, meq/100g soil	Ca	12.39
	Mg	10.56
	Na	10.49
	K	1.50
Cation exchange capacity "C.E.C", meq/100g soil		37.94
Exchangeable sodium percentage "E.S.P", %		27.65

Table (2). Some chemical characteristics of the biogas manure used*.

O.C (%)	T.N (%)	C/N ratio	O.M (%)	pH (1 : 5)	T.S (%)	T.P (ppm)	T.K (ppm)	Micro-nutrients, ppm			
								Fe	Zn	Mn	Cu
30.60	1.70	18.00	52.80	6.50	13.30	8600	9100	556	193	264	33

* O.C : Organic carbon T.N : Total nitrogen O.M : Organic matter
T.S : Total solids T.P : Total phosphorus T.K : Total potassium

RESULTS AND DISCUSSION

Because of the similar trends of the results obtained for the two successive experimental growth seasons, we confine our presentation herein to the data of the second season only, to avoid unnecessary repetition. This is applied merely to items "4.1, 4.2 and 4.3", but not to items "4.4 and 4.5" which present the plant characteristics and pepper yield and its components, at the harvest stage, in both growth seasons.

Effect of Gypsum and Biogas Manure on Some Physical and Chemical Properties of the Alkali Soil

Bulk density and total porosity

It is known that bulk density and total porosity are mostly affected by soil texture, structure, swelling and shrinkage and soil moisture content. Total porosity provides a valuable information about soil structure and it is inversely correlated with bulk density. Values of bulk density and total porosity, as affected by application of gypsum and biogas manure to the alkali soil in this study, are shown in Table (3). The data indicated that all treatments affected the soil bulk density and total porosity compared to the untreated soil, where the values of bulk density were reduced as a result of the applied treatments. Regarding the effect of gypsum alone, data indicated that the addition of 3, 6 & 9 ton/feddan (corresponding to 50, 100 and 150% G.R) progressively decreased the soil bulk density, and accordingly increased the total porosity. Data also revealed that, reduction of the bulk density and increase of the total porosity took the following order: 9 > 6 > 3 ton/fed., with the control as a reference. On the other hand, effect of gypsum treatments on the bulk density and total porosity of the soil tested were more pronounced with the highest level, e.g. 150% G.R. This effect may be due to the fact that addition of gypsum to alkali soil increases the ions of soluble and exchangeable Ca^{++} in soil medium, which play a main role in the formation of large stable aggregates. At the same time, the increase of Ca^{++} and the decrease of soluble and exchangeable Na^{+} stimulate the leaching processes. Similar results were obtained by Belal (2004).

Regarding the effect of biogas manure on values of the bulk density and total porosity, data presented in Table (3) denoted that addition of the organic fertilizer (1, 2 and 3 ton/ feddan) decreased the soil bulk density and increased the soil total porosity, compared to the control treatment.

Reduction of the soil bulk density as the result of organic fertilizer addition may be referred to one or both of the two following reasons: (1) density of organic particles is lower than that of the mineral soil ones, (2) organic substances facilitate soil aggregation, thereby increasing the soil porosity or reducing the bulk density. These data are in a good agreement with those obtained by Belal (2004) and El-Shouny *et al.* (2008).

Table (3): Effect of gypsum and biogas manure, as well as their interaction on physical and chemical properties of the soil tested, after harvest of green pepper crop.

Treatment		Bulk density (g/cm^3)	Total porosity (%)	O.M (%)	pH	EC (dSm^{-1})	Exchangeable cations (meq/100 g soil)				CEC (meq/100 g soil)	ESP (%)
Gypsum ton/fed.	Manure ton/fed.						Na^+	K^+	Ca^{++}	Mg^{++}		
0	0.0	1.27	52.10	0.91	8.87	3.92	10.46	1.50	12.39	10.56	37.90	27.60
	1.0	1.27	52.10	0.92	8.85	3.91	10.23	1.58	13.10	10.41	38.10	26.85
	2.0	1.26	52.45	0.95	8.85	3.91	9.41	1.69	14.12	10.00	38.76	24.28
	3.0	1.26	52.45	0.98	8.83	3.90	9.00	1.77	15.66	9.11	39.11	23.01
3 (50% G.R)*	0.0	1.26	52.45	0.90	8.83	3.82	8.22	1.71	16.11	9.05	38.20	21.52
	1.0	1.26	52.45	0.92	8.83	3.80	8.05	1.74	17.72	8.62	38.53	20.90
	2.0	1.24	53.21	0.93	8.82	3.82	7.80	1.82	18.61	7.23	38.71	20.15
	3.0	1.24	53.21	0.95	8.81	3.83	7.67	1.87	19.88	6.12	39.13	19.60
6 (100% G.R)*	0.0	1.23	53.48	0.88	8.62	3.66	5.22	1.76	22.14	6.24	38.74	13.47
	1.0	1.22	53.96	0.89	8.60	3.67	5.00	1.79	23.46	6.11	38.96	12.83
	2.0	1.22	53.96	0.91	8.58	3.68	4.72	1.82	24.32	5.81	39.12	12.06
	3.0	1.20	54.72	0.95	8.55	3.70	4.10	187	25.96	5.63	39.41	10.40
9 (150% G.R)*	0.0	1.20	54.72	0.89	8.35	3.52	4.00	1.86	24.64	5.88	38.98	10.26
	1.0	1.20	54.72	0.90	8.35	3.55	3.82	1.91	25.82	5.52	39.22	9.74
	2.0	1.19	55.09	0.91	8.33	3.57	3.61	1.94	26.97	5.10	39.44	9.15
	3.0	1.18	55.47	0.90	8.28	3.58	3.40	1.98	28.11	4.84	39.82	8.54

* G.R = Gypsum requirements.

The combined effects of the different amelioration treatments (Table 3) showed that, conduction of biogas manure with gypsum, in this experiment, resulted in decreasing the values of soil bulk density and increasing those of soil total porosity rather than the effect of each amendment individually. These results can be explained on the basis that, addition of both organic manure and gypsum together enhances the formation of layer soil aggregates and increases the voids volume which make the leaching process more efficient. Consequently, declination of exchangeable and soluble sodium decreases the dispersion effect of Na^+ and increases the fluculation impact of Ca^{++}. Presence of organic matter in soil acts as cementing materials, thus, both fluculation and cementation help in aggregate formation and increase void ratio. El-Awag *et al.* (1992) found that organic manure decreases the values of soil bulk density and increases those of total porosity Similar results were obtained by El-Gundy (2005) and El-Shouny *et al.* (2008).

Organic matter contents (OM)

Organic matter plays an important role in soils because of its high cation exchange and water holding capacities, as well as its chelation activities, besides being a rich source of various elements. Values of organic matter content, as affected by increasing doses of biogas manure applied to the alkali soil, are presented in Table (3). Data revealed that introduction of biogas manure at the rates of 0, 1, 2 and 3 ton/fed., led to increases in the contents of soil organic matter. Some variations tended to slight decrease in O.M contents were detected due to addition of gypsum, where the interaction gave a positive effect. Similar results were obtained by Belal (2004). El-Sanat (2003) showed that, application of organic manure either alone or combined with gypsum led to a marked increase in soil organic matter in the surface layers of salt affected soils. El-Sedfy (2008) showed that, applying 6 ton organic manure per feddan realized the highest value of organic matter.

Soil pH

Data in Table (3) revealed that, application of gypsum to the alkali soil tested caused a remarkable diminution in soil pH, parallel to the applied level up to 150% of G.R. In this respect, Lindsay and Norvell (1978) reported that, more than one mechanisms is involved in reducing soil pH, as a results of gypsum application. Ca^{++} reacts with bicarbonate to precipitate $CaCO_3$ and release protons (H^+) which decrease the pH. These results are in harmony with those obtained by El-Sanat (2003).

Regarding the effect of biogas manure on soil pH, it could be noticed that, a slight decrease in soil pH occurred after addition of such organic fertilizer, due to the buffering capacity of soil controlling the effect of organic acids produced as metabolites through decomposition of organic matter, as well as, such metabolites are further broken down in soil.

Application of gypsum plus biogas manure at their higher rates induced a positive effect on reducing the soil pH. Data recorded in Table (3), also denote that soluble Ca^{++} increased with increasing the gypsum level applied, as well as, in the treatments of organic fertilizer. This due to that addition of gypsum promotes the availability of Ca^{++} in soil medium, on the other hand, liberation of H^+ as a result of biodegradation of organic fertilizers leads to the formation of carbonic acid (H_2CO_3) which encourages the dissolution of gypsum in soil. These findings are in a good agreement with those reported by Belal (2004) and El-Gundy (2005).

Soil salinity (Electrical conductivity "EC")

Effect of the different amelioration treatments, namely, gypsum and biogas manure, on soil salinity of the alkali soil under study, expressed as electrical conductivity (EC), is declared Table (3). It was shown that, addition of gypsum slightly decreased the EC values of the soil, compared to the control. This was due to that, gypsum allows continuous calcium supply replacing the exchangeable sodium on soil matrix and forming new stable aggregates. Such actions increase hydraulic conductivity and incourage the water to flow down leaching the salts. These results are in agreement with those obtained by El-Sanat (2003) and El-Gundy (2005).

Movement of salts through soil profile depends mainly on soil texture, structure, porosity and permeability. Organic fertilizers greatly affect such soil properties and consequently the salt movement in soil mass. Data in Table (3) showed that, application of the organic fertilizer "biogas manure" alone had a little effect on reducing the EC value of the alkali soil extract. Concerning the interaction of gypsum and organic fertilizer, data showed that, application of biogas manure together with gypsum had a pronounced effect on EC reduction, especially at their higher rates introduced. This can be explained by the role of organic fertilizers in improving the physical and chemical properties of the alkali soil investigated (El-Sanat, 2003, Belal, 2004 and El-Gundy, 2005).

Cation exchange capacity (CEC):

Data in Table (3) emphasized the increase in CEC of the used alkali soil from 37.90 to 38.20, 38.74 and 38.98 meq/100 g soil as a result of adding of 0, 3, 6 and 9 ton gypsum /fed., which represent 0.0, 0.5, 1.0 and 1.5 G.R, respectively. This may be due to that gypsum leads to the formation of aggregates which increase the specific surface of soil. Application of biogas manure at the rates 0, 1, 2 and 3 ton/fed. increased the CEC of the alkali soil, from 37.90 to 38.10, 38.76 and 39.11 meq/100 g soil, respectively. Coapplication of gypsum and manure showed slight decreases of CEC values of the soil, especially at the highest levels of both treatments, i.e. 9 ton gypsum + 3 ton biogas manure/fed. This may be due to the combined effect of gypsum with biogas manure on improving the chemical properties of such sodic soil. Similar results were obtained by El-Sanat (2003), Belal (2004) and El-Gundy (2005).

Exchangeable cations and exchangeable sodium percentage (ESP)

Contents of exchangeable cations appearing in Table (3) indicate that the applied amendments, namely, gypsum and biogas manure, either each alone or both together, promoted the extents of both Ca^{++} and Mg^{++} at the expence of Na^{+} and K^{+} on clay surfaces. Such trend was more pronounced by increasing the levels introduced of either amendment and more by their combinations.

Data in Table (3) pointed out that, treating the employed alkali soil with different rates of gypsum alone as 0, 3, 6 and 9 ton/fed., had a highly diminuting effect on ESP values from 27.60 to 21.52, 13.47 and 10.26%, respectively. This is due to the increased concentration of Ca^{++} in soil solution, replacing the exchangeable Na^{+}. In this respect, it is stated that the use of gypsum as an amendment for alkali soils is oftenly recommended for the purpose of changing a part of the caustic alkaline carbonate into sulfate. Calcium ions affect mainly through their exchange reactions with sodium, whereas acids and acidic compounds act directly through neutralization of

Na_2CO_3 and indirectly via reactions with sodic colloids.

Data presented in Table (3) also showed that, biogas manure addition decreased the ESP values of the alkali soil examined. This reduction can be attributed to the direct and indirect effects of the organic fertilizer through the action of outcome organic acids on neutralization of Na_2CO_3 and improvement of physical conditions of such sodic soil. These results are in agreement with those obtained by Singer *et al.* (1998) and Belal (2004).

Interaction of both gypsum and biogas manure application was found to be more effective than the addition of each individually. Thus, it can be concluded that, addition of manure with gypsum is the most effective practice in reducing ESP values of the alkali soil and consequently improving the chemical properties of such sodic soil (El-Sanat, 2003 and Belal, 2004).

Effect of Gypsum and Biogas Manure on Dry Weight of Pepper Plants Grown on the Alkali Soil

Effect of gypsum as a mineral amendment for the alkali soil, is shown in Table (4). Results declared that the dry matter yield of pepper plants grown on the soil tested, significantly increased with gypsum addition, at the three stages of plant growth (Table 4). Elevating gypsum levels from 50 to 100 and 150% of the gypsum requirements (G.R) had higher positive effects on the obtained dry weight of plants at their three growth stages. Gypsum, as an inorganic ameliorative material allows continuous calcium supply to replace the exchangeable sodium adsorbed on soil matrix and forms new stable aggregates, as well as promotes the availability of Ca^{++} in soil medium. Hence, application of gypsum as an amendment improves physical and chemical properties of the alkali soil, subsequently promotes the plant growth. Application of gypsum to soil until 150% of G.R increased the dry weights of pepper plants at the three stages of growth. The relative increases were 11, 44 and 61% for 3, 6 and 9 ton gypsum /fed., respectively at the first stage, 9, 23 and 71% at the second stage, 35, 64 and 86% at the later stage, respectively. Similar results were obtained by Dora (1996), Belal (2004) and El-Gundy (2005).

Effect of biogas manure applied at different levels (0, 1, 2 and 3 ton/fed.) on the dry matter weight of green pepper plants grown on the alkali soil, at the three stages of growth (vegetative, flowering and harvest), is illustrated in Table (4). The results showed that, application of the organic manure significantly increased the dry matter weight of pepper plants at the three stages of growth. A remarkable increase in dry weight of plants was recorded at 3 ton manure/fed. This is attributed to the favourable effect of biogas manure as a rich natural source of plant nutrients.

Table (4): Effect of gypsum and biogas manure, and their interaction, on dry weights (g / plant) of pepper plants grown on the alkali soil tested.

Treatment		Stage of plant growth			
Gypsum (ton/fed.)	Manure (ton/fed.)	Vegetative	Flowering	Harvest	Mean
0	0	0.36	1.40	3.12	1.63
	1	0.44	1.64	4.2	2.09
	2	0.56	1.82	4.6	2.33
	3	0.60	2.11	4.94	2.55
	Mean	0.49	1.74	4.22	2.15
3	0	0.40	1.52	4.20	2.04
	1	0.52	1.76	4.80	2.36
	2	0.58	2.22	5.12	2.64
	3	0.68	2.40	5.20	2.76
	Mean	0.55	1.975	4.83	2.45
6	0	0.52	1.72	5.12	2.45
	1	0.64	1.91	5.40	2.65
	2	0.68	2.60	5.84	3.04
	3	0.74	2.76	6.12	3.21
	Mean	0.65	2.25	5.62	2.84
9	0	0.58	2.40	5.80	2.93
	1	0.72	2.56	6.12	3.13
	2	0.80	2.80	6.40	3.33
	3	0.82	2.96	6.74	3.51
	Mean	0.73	2.68	6.27	3.23
L.S.D, at 0.05		0.071	0.214	0.357	
L.S.D, at 0.01		0.095	0.289	0.481	

All observations emphasized the beneficial effect of such manure on plant growth, by keeping nutrients in available forms, as well as providing the plants with growth-promoting substances. Organic matter is considered as an important source of macro-and micronutrients. Moreover, organic matter has beneficial effects on chemical, physical and biological properties of soil (El-Shouny *et al.,* 2008 and Faiyad, 2009). Concerning the effect of organic manure levels, Table (4) also showed that, increasing the applied levels of manure up to 3 ton/fed. significantly increased the yield of dry matter of pepper plants at the three stages of growth. The relative increases of plant dry weights were 22, 55 and 67% in the first stage for 1, 2 and 3 ton manure/fed., respectively; in the second stage were 17, 30 and 51.00%, and in the third stage were 37, 47 and 58%, respectively. These results reflect, the importance of introduced organic fertilizer on improvement of physical, chemical and biological properties of the alkali soil tested. Similar results were obtained by Ali (2002), El-Shimi (2004), El-Shouny *et al.* (2008) and Faiyad (2009).

Concerning the coadition of gypsum and organic fertilizer, in the alkali soil examined, Table (4) showed that, such interaction gave a significant positive effect on plant growth at its three stages. The relative increases (%) of the dry matter yield of the different treatments over the control showed that, gypsum additives individually or in combination with manure doses exerted the best results. These results are certainly attributed to the favourable effect of organic fertilizers on physical, chemical, biological and nutritional properties of the soil. Also, gypsum improves soil properties, such as porosity, ESP, pH and also nutrients availability in favour of plant growth. On the other hand, liberation of H^+ as a result of biodegradation of organic fertilizers leads to formation of carbonic acid (H_2CO_3) which encourages the dissolution of gypsum in soil, as a result of reducing soil pH. Similar results were obtained by El-Sanat (2003), El-Gundy (2005) and El-Shinnawi *et al.* (2009).

Vegetative Growth Characteristics of Pepper Plants Grown on the Alkali Soil

The results in Tables (5-8) show the effect of gypsum and biogas manure and their combinations on plant height, leaf area, chlorophylls "a" & "b", as well as their total, crop yield and its components, TSS and vitamin "C", at harvest, in the two growth seasons. Also, see Tables (5-8) in the "Appendix" for the L.S.D. of the statistical analysis of results.

Plant height

It was evident from the results in Table (5) that, plant height gradually increased with increasing the levels of gypsum amendment, as compared with the control treatment in both seasons. The best results, in this respect, were obtained by application of gypsum at the highest rate, i.e., 9 ton/fed. Addition of biogas manure, with its increasing doses, (1, 2 and 3 ton/fed), increased the plant height progressively.

Interaction of gypsum and manure rates (Table 5) showed that there were significant differences among the various interactions on the height of pepper plants. In this respect, plants amended with the highest levels added of both gypsum (9 ton/fed.) and biogas manure (3 ton/fed). exerted the greatest values of plant height in both seasons. The obtained results are in agreement with those reported by El-Mansi *et al.* (1999), Ali (2000) and Shams (2003).

Leaf area

Table (5) shows that increasing the gypsum rates from 3 to 9 ton/fed. significantly increased leaf area of the pepper plants, in both seasons. Application of biogas manure at all levels (1, 2 and 3 ton/fed.) significantly augmented the leaf area of pepper plants grown on the alkali soil of interest. The leaf area per plant increased progressively with increasing the manure dose (Shams, 2003).

Table (5): Effect of gypsum and biogas manure, and their interaction, on plant foliage height and leaf area of pepper plants cultivated in the alkali soil tested, in both cultivation seasons.

Treatment		Plant height (cm.)		Leaf area (m^2)	
Manure (ton/fed.)	Gypsum (ton/fed.)	Season			
		1st	2nd	1st	2nd
0.0	0	23.00	26.00	0.52	0.54
	1	33.67	39.00	0.67	0.64
	2	40.00	41.00	0.78	0.78
	3	41.67	42.67	0.87	0.83
	Mean	34.58	37.17	0.71	0.70
3.0	0	34.00	36.00	0.65	0.64
	1	38.00	38.00	0.70	0.71
	2	40.00	41.00	0.81	0.80
	3	41.33	44.33	0.92	0.88
	Mean	38.33	39.83	0.77	0.76
6.0	0	36.00	38.00	0.71	0.69
	1	40.00	41.00	0.74	0.73
	2	43.00	41.67	0.82	0.83
	3	43.33	45.00	0.96	0.94
	Mean	40.58	41.42	0.81	0.80
9.0	0	37.67	40.00	0.74	0.71
	1	41.67	43.00	0.82	0.85
	2	45.67	43.67	0.88	0.88
	3	49.00	48.00	1.27	0.97
	Mean	43.50	43.67	0.93	0.85
L.S.D, at 0.05		3.483	2.063	0.092	0.038
L.S.D, at 0.01		4.695	2.780	0.124	0.051

Interactions of gypsum and biogas manure on leaf area of pepper plants (Table 5) indicated that all combinations of gypsum and manure levels generally increased the leaf area per plant, as compared with the control treatment, in both seasons of study. Pepper plants treated with both gypsum and biogas manure at 9 and 3 ton/fed., respectively gave the highest values of leaf area per plant in the two seasons.

Effect of organic fertilizers on plant characteristics are attributed to the role of nutrients making up the main components of the organic materials in encouraging plant growth. In addition, the effect of such nutrients on enhancing the assimilation of photosynthetic pigments in plant leaves (Tables 5-8) which is necessary for cell formation and division and consequently promotes plant growth. Moreover, the favourable effect of organic manure on soil physical, chemical and biological properties, which are in turn reflected on the vegetative growth, through the quick release of nutrients in available froms. Organic matter, likewise, creates favourable conditions for the flourishment of plant roots and subsequently better absorption capacity of water and nutrients. (Singer *et al.*, 1998, Hanna and El-Gizy, 1999 and El-Bassiony, 2003).

Chlorophylls "a", "b" and total chlorophyll in pepper leaves

Results in Table (6) represent the effect of gypsum and biogas, as well as their interaction on chemical composition of plant foliage expressed as photosynthetic pigments. Such data declared that contents of chlorophylls "a", "b" and total chlorophyll in pepper plant leaves significantly increased with application of gypsum at the rates of 3 and 6 ton/fed., in the two growth seasons of this study, mostly with no differences between the rates of 6 and 9 ton/fed.

Results illustrated in Table (6) also declare that contents of chlorophylls "a", "b" and total chlorophyll of plant leaves significantly increased with application of biogas manure, at its three levels (1, 2 and 3 ton/fed.), in both season of our study, with the best figures being gained at the rate of 3 ton manure / fed. Combination of both gypsum and biogas manure resulted in significant augmentations of chlorophylls "a", "b" and total chlorophyll contents in plant leaves, compared to the control and the single effect of each of gypsum or biogas. Pepper plants treated with both gypsum and biogas at 9 and 3 ton/fed., respectively gave the highest values of chlorophylls in the two seasons. These results come along with those of El-Mansi *et al.* (1999), Ali (2002) and Shams (2003).

Table (6): Effect of gypsum and biogas manure, and their interaction, on chlorophylls "a", "b" and total chlorophyll in pepper leaves of plants grown on the alkali soil tested, in both cultivation seasons.

Treatment		Chlorophyll "a" (ml/100 g fresh weight)		Chlorophyll "b" (ml/100 g fresh weight)		Total chlorophyll ("a" + "b") (ml/100 g fresh weight)	
Gypsum (ton/fed.)	Manure (ton/fed.)	Season					
		1st	2nd	1st	2nd	1st	2nd
0.0	0.0	24.10	23.34	12.07	13.13	36.17	36.47
	1.0	37.97	36.40	21.27	18.90	59.23	55.30
	2.0	39.70	38.03	21.83	20.90	61.53	58.93
	3.0	40.67	39.80	21.93	21.73	62.60	61.20
	Mean	35.61	34.39	19.28	18.67	54.88	52.98
3.0	0.0	31.93	32.23	16.57	15.93	48.50	48.17
	1.0	47.87	48.37	24.13	24.10	72.67	72.47
	2.0	49.13	49.60	24.73	25.73	73.87	75.33
	3.0	50.37	50.30	26.20	26.73	76.57	77.03
	Mean	44.83	45.13	22.91	23.12	67.90	68.25
6.0	0.0	34.33	34.40	17.37	17.53	51.70	52.93
	1.0	48.27	47.80	24.43	23.43	72.70	71.23
	2.0	50.10	50.10	25.83	24.90	75.93	75.00
	3.0	51.73	51.50	26.80	26.97	78.53	78.47
	Mean	46.11	45.95	23.61	23.21	69.72	69.41
9.0	0.0	35.17	35.97	18.60	18.73	53.77	53.70
	1.0	49.43	48.97	25.77	24.77	75.20	73.73
	2.0	50.47	50.53	26.67	25.73	77.13	66.27
	3.0	55.40	52.00	27.47	27.23	82.70	79.23
	Mean	47.62	46.87	24.63	24.12	72.20	68.23
L.S.D, at 0.05		1.580	1.307	0.980	0.733	1.514	7.652
L.S.D, at 0.01		2.130	1.761	1.321	0.988	2.040	10.316

Total Yield and Its Components of Pepper Crop Cultivated in the Alkali Soil Crop yield and its components

Results presented in Table (7) reveal the effect of gypsum application pepper on crop yield and its components. It was indicated that gypsum addition gave a significant increase of pepper yield per plant, number of fruits per plant and average fruit weight, as compared with the control treatment, in both seasons of the study. Moreover, application of gypsum at its highest level (9 ton/fed.) attained the greatest values of the mentioned characters.

Table (7): Effect of gypsum and biogas manure, and their interaction, on yield and its components of pepper crop cultivated in the alkali soil tested, in both cultivation seasons.

Treatment		Total yield (g / plant)		No. of fruits/plant		Average fruit weight (g)	
Gypsum (ton/fed.)	Manure (ton/fed.)	Season					
		1st	2nd	1st	2nd	1st	2nd
0.0	0.0	102.74	107.86	4.00	4.00	31.24	32.27
	1.0	206.00	219.32	6.33	6.50	48.49	44.30
	2.0	289.61	296.57	8.73	8.63	49.95	47.74
	3.0	309.32	319.14	9.40	9.37	51.37	50.34
	Mean	226.92	235.72	7.12	7.13	45.26	43.66
3.0	0.0	182.27	180.30	6.00	5.33	34.29	35.32
	1.0	223.01	229.10	6.50	6.37	51.30	49.60
	2.0	293.37	306.40	8.83	8.80	53.16	54.88
	3.0	303.10	314.54	9.63	9.63	55.37	56.27
	Mean	250.44	257.59	7.74	7.53	48.53	49.02
6.0	0.0	252.84	260.50	7.33	7.27	43.50	44.27
	1.0	270.60	280.47	7.50	7.77	53.20	54.78
	2.0	361.52	360.53	9.80	9.87	56.12	55.47
	3.0	406.07	409.38	10.33	10.30	58.35	58.33
	Mean	322.76	327.72	8.74	8.80	52.79	53.21
9.0	0.0	274.29	275.53	8.17	7.80	47.17	47.60
	1.0	305.65	306.27	8.63	8.67	54.14	57.13
	2.0	345.78	370.63	10.17	10.27	51.97	60.52
	3.0	442.06	430.15	11.47	11.27	61.21	62.65
	Mean	341.95	345.65	9.61	9.50	53.62	56.98
L.S.D, at 0.05		26.349	8.991	0.795	0.713	4.770	3.154
L.S.D, at 0.01		35.519	12.120	1.071	0.961	6.430	4.252

Regarding the effect of biogas manure on crop yield and its components, results shown in Table (7) declared that, application of the organic fertilizer alone gave a significant increase of the total pepper yield, number of fruits per plant and average fruit weight. Figures of those plant characters achieved elevations by raising the manure dose up to 3 ton/fed, logically due to the encouragement of plant growth, as mentioned before.

Interaction of gypsum and biogas manure on pepper yield and its components (Table 7) revealed that all rates of both amendments gave significant increases in total crop yield, number of fruit per plant and average fruit weight, as compared with the control treatment, in the two seasons. The uppermost results were gained by the treatment of 9 plus 3 ton/fed. of gypsum and biogas, respectively. Similar results were recorded by Ali (2002) and El-Bassiony (2003).

Contents of vitamin "C" and total soluble solids (TSS) in pepper fruits

Results presented in Table (8) indicated that, the gradual levels of added gypsum increased the contents of vit. "C" and total soluble solids (TSS) of the pepper fruits (pods), in both seasons, as compared with the control treatment. Similar results were obtained by Shams (2003).

The effect of biogas manure on vit. "C" and total soluble solids contents (TSS) in pepper fruits is illustrated in Table (8) showed that, increasing the manure rates from 1 to 3 ton / fed. progressively increased the mentioned constituents, in the two growth seasons of the present study.

As for the effect of the exchanging interactions of gypsum and biogas manure on the contents of vit. "C" and TSS in pepper fruits, Table (8) denoted that, all amendment combinations, generally, augmented such constituents. In this respect, interaction of gypsum and biogas at (3 + 1), (6 + 1) and (9 + 1) ton/fed., respectively were the superior treatments, as compared with the other treatments and control, while, the other combinations, i.e. (3 + 2) and (3 + 3), (6 + 2) and (6 + 3) and (9 + 1, 2 and 3) ton/fed. of gypsum and manure, were of insignificant influences on the contents of both vit. "C" and TSS. Moreover, the treatment of 9 + 3 ton/fed. of gypsum and biogas, respectively gave the highest contents of the evaluated characters, in both seasons. These results agree with those reported by Gabr (2000), Singer *et al.* (2001) and Shams (2003).

Table (8): Effect of gypsum and biogas manure, and their interaction, on total soluble solids and vitamin C in plant foliage of pepper plants grown on the alkali soil tested, in both cultivation seasons.

Treatment		TSS %		Vitamin C (mg/100 g f.w.)	
Gypsum (ton/fed.)	Manure (ton/fed.)	Season			
		1st	2nd	1st	2nd
0.0	0.0	3.53	3.50	75.91	74.00
	1.0	6.40	5.80	123.00	127.25
	2.0	7.13	6.47	154.01	150.50
	3.0	8.40	7.40	170.46	165.47
	Mean	6.37	5.79	130.85	129.31
3.0	0.0	5.47	5.40	150.90	149.22
	1.0	6.60	6.80	165.95	160.50
	2.0	7.80	7.40	172.49	166.93
	3.0	8.03	7.80	178.95	175.57
	Mean	6.98	6.85	167.07	163.06
6.0	0.0	7.13	7.10	155.28	155.40
	1.0	7.33	7.40	170.18	167.63
	2.0	8.20	7.60	178.28	174.60
	3.0	8.13	7.80	182.19	177.45
	Mean	7.70	7.48	171.48	168.77
9.0	0.0	7.40	7.38	160.81	160.52
	1.0	8.20	8.10	168.52	173.36
	2.0	8.28	8.21	179.48	180.87
	3.0	8.40	8.32	182.50	181.85
	Mean	8.07	8.00	172.83	174.15
L.S.D, at 0.05		0.508	0.270	4.855	5.605
L.S.D, at 0.01		0.684	0.364	6.544	7.556

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تأثير إضافة الجبس والسماد العضوى على بعض خواص الأرض القلوية ونمو نبات الفلفل

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الملخص العربي

أجريت تجربة أصص على مدار موسمين فى محطة بحوث البساتين بالقناطر الخيرية على محصول الفلفل الأخضر صنف كاليفورنيا وندر لدراسة تأثير الجبس كمحسن غير عضوى والبيوجاز كمحسن عضوى على بعض الخواص الطبيعية والكيميائية للتربة ، نمو النبات والمادة الجافة وبعض الصفات الخضرية والمحصول الكلى الأخضر للفلفل ومكوناته وذلك فى أرض قلوية . ولقد أوضحت النتائج ما يلى :

١-أدت إضافة الجبس إلى الأرض بمعدلات ٣ ، ٦ إلى ٩ طن للفدان (بما يُعادل ٥٠ ، ١٠٠ إلى ١٥٠% من الاحتياجات الجبسية للأرض المختبرة) القلوية إلى انخفاض كلٍ من الكثافة الظاهرية ودرجة pH وملوحة الأرض وكل من الصوديوم والمغنسيوم المتبادلين وكذلك النسبة المئوية للصوديوم المتبادل . وكان معدل النقص متمشياً مع زيادة المستوى المضاف حتى ١٥٠% من الاحتياجات الجبسية . بينما زادت كلٍ من المسامية الكلية وكل من الكالسيوم والبوتاسيوم المتبادلين والسعة التبادلية الكاتيونية ، وبشكلٍ واضح عند إضافة ٩ طن / فدان (١٥٠% من الاحتياجات الجبسية للأرض المختبرة) أما المادة العضوية فكانت الزيادة فيها طفيفة بصفةٍ عامة ، ولكنها كانت أكثر وضوحاً بإضافة سماد البيوجاز مع الجبس .

٢-أدت إضافة سماد البيوجاز إلى الأرض القلوية المختبرة (بمعدلات ١ ، ٢ ، ٣ طن / للفدان) إلى انخفاض طفيف فى ملوحة الأرض . وكان النقص واضحاً فى كلٍ من الكثافة الظاهرية ودرجة الـ pH والنسبة المئوية للصوديوم المتبادل . بينما زادت كل من المسامية الكلية والمادة العضوية والسعة التبادلية الكاتيونية وكل من الكالسيوم والبوتاسيوم المتبادلين .

وكان معدل النقص أو الزيادة واضحاً تماماً عند مستوى ٣ طن / فدان من سماد البيوجاز .

٣-كان لإضافة سماد البيوجاز مع الجبس للأرض القلوية بمستويات عالية نتائج إيجابية فى معدلات النقص أو الزيادة للصفات الفيزيائية أو الكيمائية للأرض تحت الدراسة . وكان واضحاً أن ملوحة الأرض قد تأثرت بالنقصان بطريقة واضحة عند إضافة سماد البيوجاز مع الجبس .

٤-زادت المادة الجافة لنباتات الفلفل المنزرعة فى الأرض القلوية معنوياً مع معاملة الأرض بالجبس خلال مراحل النمو الثلاث (الخضرى ، التزهير ، الحصاد) . وكانت النتائج متزايدة حتى مستوى ١٥٠% من الاحتياجات الجبسية .

٥-أدت إضافة سماد البيوجاز إلى زيادة معنوية فى محصول المادة الجافة لنبات الفلفل عبر مراحل النمو الثلاث فى الأرض القلوية ، وباضطراد مع زيادة مستوى الإضافة حتى ٣ طن / فدان من سماد البيوجاز زادت أوزان المادة الجافة لنبات الفلفل معنوياً .

٦-كان للتداخل بين سماد البيوجاز والجبس تأثيراً إيجابياً ملحوظاً على نمو النبات خلال مراحل نموه الثلاث عند مستويات الإضافة المستخدمة (٣ ، ٦ ، ٩ طن جبس/ فدان + ١ ، ٢ ، ٣ طن سماد البيوجاز / فدان) . وظهرت أحسن النتائج عند إضافة ٩ طن جبس / فدان مع ٣ طن / فدان من سماد البيوجاز ، وكانت هذه الزيادة معنوية .

٧-أدت إضافة الجبس للأرض القلوية حتى معدل ٩ طن / فدان إلى زيادة كلٍ من ارتفاع النبات ومساحة الأوراق ، كلوروفيل "أ" ، "ب" وكلوروفيل "أ" + "ب"، ومحتواه من فيتامين "ج" ، والمواد الصلبة الكلية، وكذلك عدد الثمار (القرون) على كل نبات ، ومتوسط وزن الثمرة ، والمحصول الأخضر الكلى لنباتات الفلفل. وكانت هذه الزيادة معنوية خلال موسمى الزراعة . وزادت قيم كل هذه الصفات المدروسة زيادة واضحة مع زيادة معدل الجبس المضاف .

٨-أوضحت التجارب أن كلاً من ارتفاع النبات ، ومساحة الأوراق ، وكلوروفيل "أ" ، "ب" ، وكلوروفيل "أ" + "ب" ، وفيتامين "ج" والمواد الصلبة الكلية وعدد الثمار على كل نبات ، ومتوسط وزن الثمرة ، والمحصول الكلى للفلفل قد زاد معنوياً وظهرت أفضل النتائج بإضافة سماد البيوجاز بأعلى مستوى تم استخدام (٣ طن / فدان) مع أعلى معدل جبس (٩ طن / فدان) .

وقد أوضحت هذه التجارب أهمية استخدام المصادر الطبيعية ، غير عضوية وعضوية ، فى تحسين خواص الأرض القلوية وإنتاجيتها المحصولية ، مما يُشجع على إجراء المزيد من الدراسات وعلى نطاق حقلى .