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Improvement of calcareous soil chemical properties and its productivity as affected by farming methods and organic manures applications

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ABSTRACT

Organic manures are traditionally used for supplying plant nutrients. Their volume and other operational problems forced the farmers to use inorganic fertilizers. The recycling of organic waste is considered one of the major solutions to get rid of huge piles of wastes. The management of soil organic matter is critical to maintain a sustainable productive organic farming system. They possess many desirable soil properties and exert beneficial effect on the soil characteristics. In this regard, a field experiment was carried out on a calcareous sandy loam soil cultivated with bean (Nubaria 1) at El-Nubaria Agricultural Research Station, El- Behera Governorate during two successive winter seasons of 2012/2013 and 2013 / 2014 to investigate the effect of organic manures (rice straw compost and chicken manure) as organic amendments under farming methods (row and strew) on calcareous soil chemical properties and its productivity. Data indicated that, EC values (dSm^{-1}) and pH values of the studied soil were decreased as a result of using rice straw compost and chicken manure under different cultivation methods. The OM content and cation exchange capacity of the soil after bean harvest were increased by the studied treatments. The high increase was attained by using rice straw compost with row farming method.

Also, results showed that, the treatment with rice straw compost and row farming method resulted increase in the soil content of available N, P, K and Fe, Mn and Zn after harvest of bean. Also, there was a significant increase in N, P and K contents of bean grains with rice straw compost or chicken manure treatments compared with control. The same treatments caused an increase in the concentrations of Fe, Mn and Zn in grains. The bean plant grown under all the studied treatments gave higher yield than the control under calcareous soil conditions and the highest values of straw and grain yields were recorded by using rice straw compost with row cultivation method. As a general, it is concluded that the row cultivation method and the rice straw compost addition had beneficial effect at the different soil properties and crop yield of broad bean plants grown on calcareous soil compared with other treatments under study.

Keywords: Farming method, Calcareous soil, Organic manures, Faba bean.

INTRODUCTION

Most countries have traditionally utilized various kinds of organic materials to maintain or improve fertility and productivity of their agricultural soils. However, several decades ago organic recycling practices in some countries were largely replaced with chemical fertilizers that were applied to high yielding cereal grains that responded best to high level of fertility. Compost utilization as manure is becoming wider spread during recent years as a consequence of the rise in price of conventional fertilizers. Radwan and

Hussein, (1996), Mekki et al., (1999) and El-Kholy and Gomaa,(2000) said that organic fertilizers applications have beneficial effects on growth and yield of some field crops .

Calcareous soils are typical ones in Egypt. The main problems of these soils are related to one or more of the following: high salinity, high pH, lack of adequate texture and structure, very poor in organic matter or biological activities, distractive effect of some macro and micro-nutrients availability. Abd El-Moez et al., (2002) found that, application of composted materials to the saline calcareous soil decreased both EC and pH values. Abd El-Moez and Saleh, (1999) found that, the organic materials have a different effect in modifications of the properties of soil as well as their influence on their nutrition status and soil fertility. Gilley and Risse, (2000) mentioned that long-term annual compost and manure application increase soil organic matter and improved structure. Soil organic matter encourages granulation, increases cation exchange capacity (CEC) and is responsible for adsorbing power of the soils up to 90 %, (Brady and Weil, 2005). Shafeek et al., (2001)and Rizk , (2002) found that the addition of organic matter improves the physical, chemical and biological properties of soils and natural organic material are broken down slowly by soil microorganisms resulting more release of plant available nutrients. Dutta et al., (2003) reported that the use of organic fertilizers together with chemical fertilizers, compared to the addition of organic fertilizers alone, had a higher positive effect on microbial biomass and hence soil health. El-Maaz et al., (2014) concluded that compost application decreased soil pH and EC but increased soil organic matter, cation exchange capacity and the contents of N, P, K, Fe, Mn and Zn. Bokhtiar and Sakurai, (2005) concluded that application of organic manure in combination with chemical fertilizer has been reported to increase absorption of N, P and K in sugarcane leaf tissue in the plant and ratio on crop, compared to chemical fertilizer alone.

Although, the mineral fertilizers application is essential for plant growth, development and yield productivity, using the mineral fertilizers led to an environmental pollution i. e. leaching a considerable amount of nitrogen in ground water especially NO_3^-, increasing nitrate accumulation in plant organs. Abdel-Mouty et al., (2001), Awad, (2002) and EL-Etr et al., (2004) reported that organic fertilizers such as compost is less danger for over fertilizers, it provides a slow release of nutrients as micro-organisms in soil break the organic material down into an inorganic. Compost plays an important role for improving soil physical properties and contains higher levels of relatively available nutrients elements, which are essentially required to plant growth. Paramasivam et al., (2005) reported that concentrations of Zn, Mn and Fe increased with increasing the applied of organic amendment up to 98.8 Mg ha^{-1} irrespective of plant parts. Ali, (2001) showed that DTPA-extractable Fe, Mn and Zn were significantly increased due the application of such compost after either wheat or corn harvesting.

Soil pH has direct impact on ion balance, nutrient availability, and the activities of microscopic organisms in soil and plant growth. Calcareous soils have a wide range of pH due to the type and nature of their constituent, calcium carbonate content and rainfall, and they vary from 7.8 to 8.2. One of

the important roles of pH is controlling nutrient solubility in soil. Solubility of most nutrients usually decreases with increasing pH (Malakouti, 1993). P is an essential element for plant growth. Availability of P is limited in calcareous soils for plants. Different forms of P in combination with calcium exist in calcareous soils. The highest amount of available P is in the pH range of six to seven for the plant. This range of pH is a desirable level for all nutrients (Havlin et al., 2005). Frequent use of large amounts of phosphorous fertilizers in calcareous soils causes accumulation of P in soils but requires a long time for the release of P to soil solution. Applied P in the soil is available for plants only for a short period because it is converted to the insoluble form (Lee, 2001). Acidifying materials can improve availability of nutrients in calcareous soil by decreasing pH. The amount of acidifying materials application for creating plant response depends on calcium carbonate in the soil (Obreza et al., 1993). On the other hand, composts are widely used to improve soil physical properties and valuable source of organic matter. Many of the composts have relatively high pH ranging from seven to eight. High pH of the composts is one problem that limits its usage in alkaline soils.

Yunchen et al., (2009) stated that, organic manures (straw and farmyard manure) significantly influenced soil properties and crop yields. Farmyard manure combined with chemical fertilizer management (M + NP) resulted in higher increase in SOC, available-N and available-P compared with those found under straw manure combined with chemical fertilizer management (S + NP). These results indicate that straw management positively affected soil physical, chemical and biochemical properties as manure treatment in calcareous soil.

Duke, (1981) and Bond et al., (1985) stated that Faba bean (*Vicia fabae L*.) is used as human food in developing countries. It can be used as a green vegetable or dried, fresh or canned in the Middle East, Mediterranean region, China and Ethiopia. Bond et al., (1985) said that Faba bean is considered as a cash crop in Egypt and Sudan. El-Ghandour and Galal , (1997)said that because of the importance of faba bean as food legume for people in Egypt; new areas of reclaimed desert were brought into faba bean cultivation for increasing the production. In this soil, one of the principle production constraints is poor fertility, especially nitrogen deficiency. Therefore, chemical fertilizers are considered a limiting factor, but rarely used on the agricultural systems because of their scarcity and high cost.

This investigation aims to study the effect of farming methods and organic manures for improving the chemical properties and productivity of calcareous soil.

MATERIALS AND METHODS

A field experiment was carried out on a calcareous sandy loam soil cultivated with bean (Nubaria 1) at El-Nubaria Agricultural Research Station, El- Behera Governorate during two successive winter seasons of 2012/2013 and 2013 / 2014 to investigate the effect of organic manures (rice straw

compost and chicken manure) as organic amendments under farming methods (row and strew) on calcareous soil chemical properties and its productivity. This experiment included the following treatments:

A) The cultivation methods which were row and strew methods.

B) Organic manures which were used as rice straw compost and chicken manure.

Two main plots representing method of agriculture treatments. Each main plot contains 6 subplots (3 replicates *2 method of cultivation). Each subplot contains 9 sub-subplots (3 replicates *3 organic manures).The sub-subplot area was 10.5 m^2 (3.5*3 m). Plots replicated three times in Split Split design. Organic amendments application rates were based on the total N content of the materials and followed the recommendations for mineral fertilization of bean plant in new reclaimed soils of Egypt as follows: Broad bean was fertilized by ammonium nitrate (33.5 % N) applied at a rate of 15 kg $Nfed^{-1}$ as soil application in three batches after 15, 30 and 45 days from planting. Ordinary super phosphate (15 % P_2O_5) was applied at rate of 22.5 Kg P_2O_5 fed^{-1}. Potassium sulfates (48.5 % K_2O) were applied at rate of 24 Kg K_2O fed^{-1}. Phosphate and organic manures were added to the soil before planting, while potassium fertilization was carried out after 25 days from planting.

Soil Sampling:

Before planting surface soil sample (0-30) was taken from experimental field, air-dried, ground, sieved through a 2 mm sieve and analyzed for some physical and chemical properties as recorded in Table (1). Disturbed soil samples were taken from the surface layers (0-30) for all plots after harvest for two seasons. The soil samples were air- dried and analyzed for some chemical properties, i.e., soil pH, organic matter and cation exchange capacity according to the methods described by Page et al., (1982). The total soluble salts (EC) were determined in soil paste extract as dSm^{-1}(Jackson, 1973). Particle size distribution was carried out by the pipette method described by Gee and Bauder(1986). The content of available macronutrient (N, P and K) and micronutrients (Fe, Mn and Zn) in soil was determined according to the methods described by Cottenie et al., (1982).

Table (1): Physical and chemical properties of the studied soil before planting

Sand (%)		Silt (%)	Clay (%)	Texture	O.M (%)	$CaCO_3$ (%)	CEC cmol/kg
68.91		16.57	14.52	Sandy Loam	0.87	11.40	29.90
pH (1:2.5)	EC (dSm^{-1})	Available macronutrients (mg/kg)			Available micronutrients (mg/kg)		
		N	P	K	Fe	Mn	Zn
8.15	8.12	39.15	7.90	186.6	3.40	1.64	0.95

Organic manures:

Properties of manures used in this experiment were determined and the obtained data were recorded in Table (2). Manures moisture content was determined by drying at 70 C^0 for 48h., pH was measured in (1:10) manure-

water suspension using electrode pH meter and electrical conductivity (dSm^{-1}) was measured using electrical conductivity bridge, in 1:5 manure - water extraction outlined electrical conductivity according to Jackson, (1973). Manures bulk density (BD) and water holding capacity (WHC) were determined according to Klute, (1986). Manures content of organic carbon was carried out by the method described by Walkely and Black, (1934). Also, manures content of total nitrogen (%) was determined according to the method as described by Page, (1982).

Table (2): Main properties of organic fertilizer used in the experiment

Organic fertilizer	EC (Manure: Water extr.)	pH (Manure: Water sus.)	Bulk density ($g\ m^{-3}$)	Water holding capacity %	O.C %	Total N %	C/N ratio
Rice straw compost	4.99	7.30	0.32	120	18.83	1.39	13.56
Chicken manure	1.81	6.19	0.55	104	20.76	2.11	9.84

Plant analysis:

Sample of dry plant (0.5 g) of each sample was digested using H_2SO_4, $HClO_4$ mixture according to the methods described by Chapman and Pratt, (1961). N, P and K were determined in the digest according to Cottenie et al., (1982). The studied micronutrients Fe, Mn and Zn were determined in the digest using atomic absorption spectrophotometer according to Cottenie et al., (1982). The plant content of N, P, K, Fe, Mn and Zn were determined in plant digestion using the methods described by Cottenie et al., (1982).

Statistical analysis:-

All data obtained from this study combined two seasons were statistically analyzed for analysis of variance (ANOVA) and least significant difference (LSD) at 0.05 probability level was applied to make comparisons among treatment means according to **Gomez and Gomez, (1984).**

RESULTS AND DISCUTION

General view on the experimental soil:-

The experimental soil properties are shown in Table (1) which show that, calcareous soil is characterized by sandy loam texture, with a relatively high $CaCO_3$ (11.40%). The studied soil has pH 8.15 which tends to be alkaline side .EC value is 8.12 dSm^{-1} and tends to be salinity.

Soil chemical properties as affected by different treatments.

Soil pH:

Data presented in Table (3) and Fig. (1) show that soil pH values were decreased by using rice straw compost and chicken manure under different cultivation methods. The production of organic acids (amino acid, glycine, cystein and humic acid) during mineralization (ammonization and ammonification) of organic materials by heterotrophs and nitrification by autotrophs would have caused this decrease in soil pH. Also, data show that

soil pH values were decreased by using rice straw compost compared to other treatments. Similar results are observed by Yunchen et al., (2009).

Soil pH decrease was moaned by using rice straw compost or chicken manure with row cultivation method compared to strew cultivation method. Smiciklas et al., (2002), Pattanayak et al., (2001) and Yaduvanshi, (2001) also observed a decrease in soil pH after the use of organic materials. These results are in agreement with those of Abd El-Moez et al., (2002).

Soil electrical conductivity:

Data in Table (3) and Fig. (1) show that the soil EC (dSm^{-1}) values decreased as a result of the different fertilizer sources under different cultivation methods. These results are in agreement with those of Abd El-Moez et al., (2002) and El-Maaz et al., (2014). The decrease was attained by using rice straw compost or chicken manure with row cultivation method compared to strew cultivation method. Also, data show that soil EC values were decreased by using rice straw compost compared to other treatments. Similar results are observed by Yunchen et al., (2009). From the results it could be concluded that the row method and rice straw compost application led to decrease of EC soil than other treatments. These results are in agreement with Ashour, (2014) who revealed that the application of vermin compost led to decrease of EC soil.

Table (3): Some chemical properties of the studied soil as affected by the studied treatments (Average of two seasons)

Methods of planting	Row				Strew			
Treatments	pH (1:2.5)	EC (dSm^{-1})	O.M %	CEC $Cmolkg^{-1}$	pH (1:2.5)	EC (dSm^{-1})	O.M (%)	CEC $Cmolkg^{-1}$
Control	7.51	7.70	1.13	29.99	7.55	7.42	1.10	29.89
Rice straw compost	7.06	4.02	1.98	32.21	7.14	5.02	1.87	31.05
Chicken manure	7.20	5.03	1.57	30.89	7.25	6.36	1.77	30.55

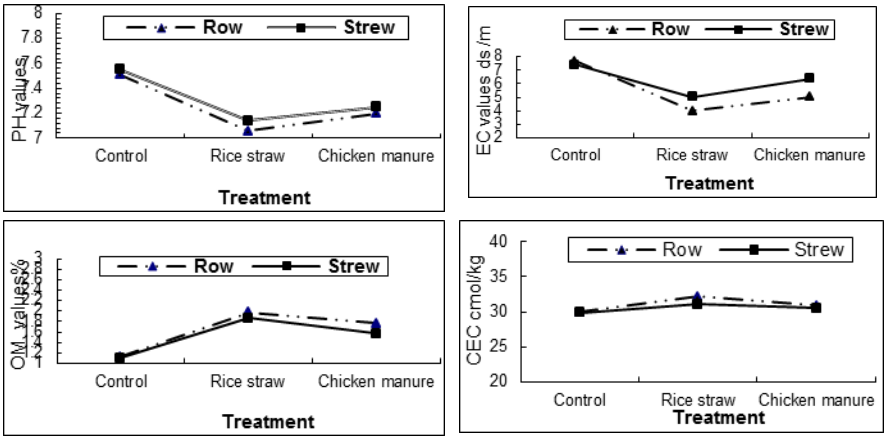

Fig. (1): Effect of different treatments on soil pH, EC, OM, and CEC in calcareous soils.

Soil organic matter and cation exchange capacity:

Data presented in Table (3) and Fig.(1) showed that, the content (%) of O.M was increased by soil treated with rice straw compost and chicken manure under different cultivation methods compared with control. The high increase was attained from rice straw compost especially row cultivation method. These results are in agreement with those of Gilley and Risse, (2000) and El-Maaz et al., (2014) mentioned that long-term annual compost and manure application increase soil organic matter and improved structure.

The cation exchange capacity of the soil as affected by all treatments took the same trend of organic matter and this may be attributed to that soil organic matter encourages granulation, increases cation exchange capacity (CEC) and is responsible up to 90 % adsorbing power of the soils, (Brady and Weil, 2005). The highest value of CEC was found in the treatment of rice straw compost with row cultivation method. These results are in a great harmony with those of El-Maaz et al., (2014).

Available nutrient contents in calcareous soils:

Macronutrient contents in the studied soil:

Data presented in Table (4) and Fig.(2) show the soil content (mg kg^{-1}) of available macronutrients (N, P and K) as affected by rice straw compost and chicken manure under different cultivation methods. The effect of rice straw compost and chicken manure on N, P and K content in soil were significant increase, while the N and P content in soil were no significant as affected by cultivation methods system. This may be attributed to pH decreased as a result of adding organic manures to the soil which is responsible for nutrients availability in soils. Malakouti, (1993) stated that solubility of most nutrients usually decreases with increasing pH. Potassium status of soil was improved significantly when using different cultivation methods after bean crop. El-Maaz et al., (2014) found that there was a general increase in nutrient supplying capacity of soils with addition of compost. These results are in agreement with those of Abdel-Mouty et al., (2001), Awad, (2002) and EL-Etr et al., (2004).

Micronutrients content in the studied soil:

Data presented in Table (5) and Fig.(2) show that there is an increase in soil content (mg kg^{-1}) of available micronutrients (Fe, Mn and Zn) which considered as a result of the used treatments. The high increase was from additions of rice straw compost or chicken manure with row cultivation method. This may be due to the increase of soil organic matter as a result of adding organic manures. The effect of different fertilizers and cultivation methods on available Mn and Zn content in soil were no significantly, while the available of Fe was significant as affected by cultivation methods. These results are in a great harmony with those of Ali ,(2001) and Paramasivam et al., (2005). Similar results were found by Brown and Matt, (2011) who reported that the applied of compost amendment increased available nutrient for Fe, Mn and Zn in comparison to its content in soil.

Table (4): Available content of macro nutrients in the studied soil after bean harvest (Average of two seasons)

Methods of planting	Row			Strew		
Treatments	Macronutrients (mg/kg)			Macronutrients (mg/kg)		
	N	P	K	N	P	K
Control	41.50 b	9.60 a	191.9 c	40.00 a	8.30 b	190.1 c
Rice straw compost	52.00 a	9.95 a	235.0 a	48.19a	8.80 a	221.0 a
Chicken manure	45.00 b	9.85 a	217.8 b	42.95a	8.75 a	211.5 b
LSD. 5%	4.72	ns	5.00	ns	0.30	5.23

Table (5): Available content of micro nutrients in the studied soil after bean harvest (Average of two seasons

Methods of planting	Row			Strew		
Treatments	Micronutrients (mg/kg)			Micronutrients (mg/kg)		
	Fe	Mn	Zn	Fe	Mn	Zn
Control	3.70 b	1.40 a	0.62 b	3.42 c	1.22 c	0.55 c
Rice straw compost	4.08 a	1.82 b	0.80 a	3.98 a	1.55 a	0.72 a
Chicken manure	4.02 a	1.52 a	0.79 a	3.91 b	1.48 a	0.63 b
LSD. 5%	0.21	ns	0.11	1.91	0.01	0.03

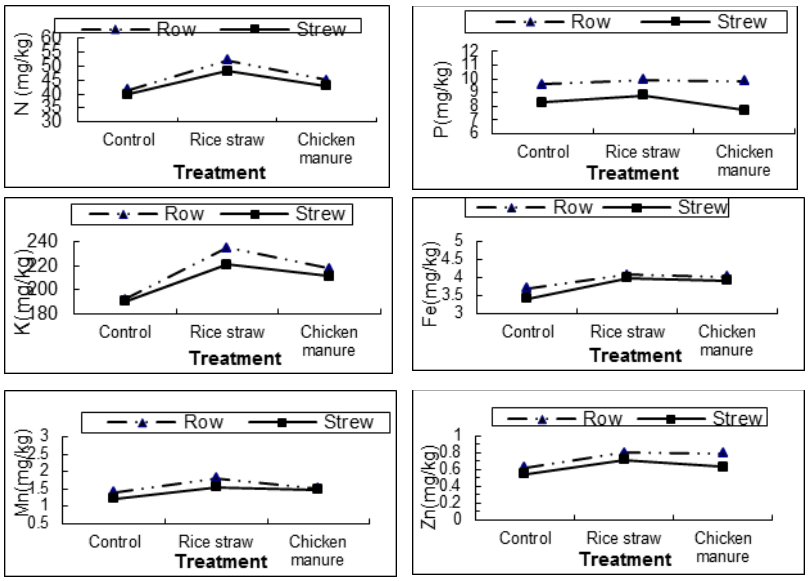

Fig. (2): Effect of different treatments on soil contents of macronutrients (N, P, K) and micronutrients (Fe, Mn, Zn) in calcareous soils.

Macronutrient content in bean grains as affected by the studied treatments:-

Data presented in Table (6) illustrate that the nitrogen concentration (%) in bean grains increased with adding rice straw compost or chicken manure compared to control under different farming methods. The highest value N percentage in grains was 4.12 % attained by treatment of rice straw

compost with row cultivation method. The effect of different fertilizers sources on N, P and K concentration in bean grains were significantly. This effect reflect the increase effect of the used soil amendments on nutrients availability and also to their improve soil physical and chemical properties. Soheil et al., (2012) reported that the applying compost to soil increases N uptake by plant. Similar results were found by El-Maaz et al., (2014).

Table(6): Macronutrient concentration in bean grains (Average of two seasons)

Methods of planting	Row			Strew		
Treatments	Macronutrients (%)			Macronutrients (%)		
	N	P	K	N	P	K
Control	3.88 a	0.43 b	1.67 a	3.42 a	0.40 a	1.61 a
Rice straw compost	4.12 a	0.52 a	1.87 a	3.81 a	0.47 a	1.81 a
Chicken manure	4.02 a	0.45 b	1.79 ab	3.73 a	0.43 a	1.76 a
LSD 5%	ns	0.03	ns	ns	ns	ns

Effect of the studied treatments on micronutrients content in bean grains:-

Data presented in Table (7) show that the effect of different fertilizers sources and different cultivation methods on micronutrients (Fe, Mn and Zn) (mg kg^{-1}) of bean grains were positive effect. The maximum values of Fe 110.52; Mn 65.72 and Zn 18.62 mg kg^{-1} contents in grains as affected soil by rice straw compost and cultivated with row cultivation method than other treatments. The effect of different fertilizers on Fe and Mn content in grains were significantly while the Zn concentration in grains was no significant. These results are in agreement with those of El-Maaz et al., (2014).

Biological, Gain and Strew Yields:-

Results in Table (8) show the effect of applied organic manures and cultivation methods on broad bean productivity under calcareous soil condition. It is clear from Table (8) that the plant grown under the row method gave higher yield than that under strew method one. The row method with rice straw compost proved more efficient for broad bean grain, biological and straw yields than chicken manure and control under strew method. Similar results were obtained by El-Maaz et al., (2010).

Table (7): micronutrients concentration in bean grains (Average of two seasons)

Methods of planting	Row			Strew		
Treatments	Micronutrients (mg/kg)			Micronutrients (mg/kg)		
	Fe	Mn	Zn	Fe	Mn	Zn
Control	93.37 b	49.25 c	13.92 b	92.87 a	45.21 a	12.69 a
Rice straw compost	110.52a	65.72 a	18.62 a	105.22 a	58.19 c	13.58 a
Chicken manure	103.47 ab	57.50 b	14.22 b	98.66 a	53.14 b	12.93 a
LSD 5 %	10.71	4.72	3.46	ns	4.53	ns

Table (8): Broad bean biological, straw and grain yields (kg/fed) as affected by the studied treatments (Average of two seasons)

Treatments	Biological yield			Straw yield			grain yield		
	Agriculture methods		Mean	Agriculture methods		Mean	Agriculture methods		Mean
	Row	Strew		Row	Strew		Row	Strew	
Control	986	930	958	797	773	785	198.0	156.8	172.9
Rice straw compost	2188	2172	2157	1826	1804	1817	362.6	319.2	340.9
Chicken manure	1754	1687	1721	1464	1429	1447	289.8	257.6	273.7
Mean	1643	1581	1612	1362	1336	1349	280.4	244.5	262.5
L.S.D at 0.05	A=5.36 O=6.56 A*O=ns			A=9.39 O=11.51 A*O=ns			A=7.79 O=9.54 A*O=ns		

A=Agriculture methods , O= Organic manures

CONCLUSION

The present investigation has demonstrated the improvement of bean growth and yield by the use of rice straw compost with row cultivation method when they were compared with chicken manure and control (chemical fertilizer) with strew cultivation method.

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تأثير طرق الزراعة و الأسمدة العضوية على الخواص الكيميائية للأرض الجيرية وإنتاجيتها

هـــدي محمـــد رجـــائي محمـــود أحمـــد ،انشـــراح ابـــراهيم محمـــد المعـــاز و محمود عبد الجواد أحمد اسماعيل

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أجريت تجربة حقلية على تربة جيرية بمحطة البحوث الزراعية بالنوبارية – محافظة البحيرة و تم زراعة نبات الفول البلدى (صنف مصرية ١) والذى يتميز بأنه نبات اختياري خلال موسمين زراعيين و متتاليين هما ٢٠١٢ -٢٠١٣، ٢٠١٣- ٢٠١٤ وذلك لدراسة تأثير استخدام نوعين من التسميد العضوى وهما الكمبوست ومخلفات الدجاج كمصلح عضوي تحت نظامين للزراعة هما الزراعة على خطوط والزراعة فى نقر على ارض بلاط على كل من خواص التربة الكيميائية ومحصول الفول البلدى.

أشارت النتائج ان قيم ملوحة التربة و قيم pH قد انخفضت فى حالة اضافة الكمبوست تحت نظام الزراعة على خطوط بالمقارنة بمخلفات الدجاج و طريقة النقر و كان هناك زيادة واضحة فى المادة العضوية والسعة التبادلية الكاتيونية فى حالة اضافة الكمبوست مع الزراعة على خطوط بالمقارنة بمخلفات الدجاج مع الزراعة بطريقة النقر.

أشارت النتائج أيضا الى زيادة محتوى الأرض الجيرية من العناصر الكبرى و الصغرى الميسرة فى حالة اضافة الكمبوست مع الزراعة على خطوط بالمقارنة بمخلفات الدجاج و الكنترول و طرق الزراعة الأخرى. وكذلك زاد محتوى الحبوب من العناصر الكبرى و الصغرى. أيضا وجد ان طريقة الزراعة فى خطوط مع اضافة الكمبوست أعطت أعلى محصول ثم يلية طريقة النقر مع اضافة مخلفات الدجاج.

وبصفة عامة توصى الدراسة باستخدام الكمبوست فى التسميد و الزراعة فى خطوط حيث يقلل من ملوحة التربة و يعمل على تحسين خواص التربه الكيميائية و زيادة محتوى الأرض الجيرية من العناصر الكبرى و الصغرى الميسرة للنبات وبالتالى زيادة المحصول مقارنة بالمعاملات الأخرى تحت الدراسة.