Effect of the manure levels, depth and application methods using subsoil laying machine on the soil salinity and soil pH

Mohammed A. Abdulkareem Shaker H. Aday *Sadiq J. Muhsin
College of Agriculture , University of Basrah

***Corresponding author: E-mail: sadiqar75@gmail.com**

ABSTRACT

A field experiment was carried out in silty loom soil at Al-Hartha Research Station during the corn growing season of 2015. The aim of study was to determine the effect of the added manure (cattle residues) levels (0, 20 and 40 ton ha^{-1}), the depth of manure application (10, 20 and 30 cm), and the method of manure application (mixing with soil and subsoil laying method) on soil salinity and soil pH. The manure was added at certain treatments by using a ditch opener and manure laying machine which was designed and manufactured in the Agriculture Machines and Equipment Dept., Coll. of Agric. Univ. of Basrah in 2015. The field was plowed perpendicularly and the treatments were arranged in RCBD with split-split plot design. Each treatment was 3 replicated using drip irrigation system. Corn (*Zea mays* L.) seeds were planted on the manure rows. All plots received NPK fertilization at the same levels. At the end of growing season, soil samples (0 – 30 cm) were collected to examined soil salinity and soil pH. The results showed that the manure levels had significant effect on soil salinity and pH. Manure level of 40 ton ha^{-1} recorded the lowest values for EC and pH, the values are 4.63 dS m^{-1} and 7.97, respectively compared with the control treatment (0 ton ha^{-1}). The control treatments gave the following values of 6.81 dS m^{-1} and 8.12 for EC and pH, respectively.

The soil EC decreased from 6.13 to 5.48 dS m^{-1} when the added manure depth increased from 10 to 30 cm while the manure depth did not significantly affect the soil pH. The soil EC also decreased when the manure was mixed with soil compared with subsoil manure layer method, it decreased to 5.42 dS m^{-1}

while the subsoil layer gave 6.13 dS m^{-1} whereas, the soil pH was not affected by the manure application methods .The lowest EC value (3.99 dS m^{-1}) was recorded for 40 ton ha^{-1} mixing with soil, while the lowest value for soil pH (7.95) was recorded for 40 ton ha^{-1} manure added at 30 cm.

Key words : organic fertilizer machine, organic residues, EC, pH.

INTRODUCTION

Most of soils in middle and south of Iraq known as poor-structured soil, so ever – degrading physical soil properties and fertility status resulting in poor crop growth and yield. The main reason of such degradation is related to lower organic matter content due to high ambient temperature, low precipitation and low vegetation cover all over the year. Application of organic residues is a common strategy to improve physical properties and supplying nutrients and therefore they affect the soil ecosystem. Regular use of organic residues increases soil organic matter levels, then improves water holding capacity, porosity, bulk density, drainage and tilth (Koenig and Johuson, 1999).

The improvement in the soil structure and lowing the soil bulk density are regarded the main factors in reducing soil EC. Tejada *et al*. (2006) and Al-Deilfi (2013) mentioned that the soil EC decreased when soil was treated with manure compared with soil un-treated. This related to the leaching of the soil salts due to the increase in the soil porosity and the decrease in the soil bulk density. Mahdy (2011) found that when composed manure was added to the soil decreased the soil EC by 50% compared with unfertilized soil, and that was because the manure reduced the soil bulk density which improved soil salinity and sodium leaching ability. Avnimelech and Kocha (1997) and Ganiger *et al*. (2012) mentioned that the application of the manure to the soil decreased the soil pH compared with untreated soil. The reasons were the manure formed organic acids and CO_2 which dissolved in the soil moisture which lead to carbonic acid then reduced pH.

Organic materials always broadcast on the surface and tilled or applied in narrow band on or beneath the soil surface using a common fertilizer spreader or by hand, which often work well for applying small quantities of organic materials with less uniformity and rate control. Furthermore, these conventional methods need higher labor and costs and required more time as well as their roles in the pollution of environment, and the workers may exposure to diseases. According to above problems, ditch opener and organic fertilizer laying machine was designed, manufactured and evaluated in the field. The machine can open ditch to lay the manure in and then buried as subsoil band (layer) or mixed with the soil.

This research was conducted to study the effect of different manure levels, the methods and depth of application of the cattle manure using the manufactured machine on EC and pH of silty loam soil cultivated by corn (*Zea mays* L.).

MATERIALS AND METHDS

The study was carried out in silty loam soil of Al-Hartha Research Station field during the growing season of 2015. physical and chemical properties of soil layer (0 – 30 cm) was analyzed according to Black (1965), Page *et al*. (1982) and Richards (1954). The results are presented in table (1).

Manure was added using a ditch opener and manure laying machine which designed and manufactured in the Agriculture Machines and Equipment Department, College of Agriculture, University of Basrah. The following treatments were used in the research:

(1) – Three levels of manure (0 , 20 and 40 ton ha^{-1}). Which was determined by machine forward speeds, size of manure feeding openers and manure feeding rotational speed.

(2)– Three depths of manure application (0, 20 and 30 cm). The depths were determined (controlled) using tractor hydraulic system.

(3)– Two application methods of manure (mixing and subsoil laying). The manure was mixed with soil using three mixing blades (tines).

Manure (cattle residues) was collected from field beyond Al-Hartha Research Station then composted in a hall of (2×3×0.5 m) diameters for three months at 60% moisture content. The compost dump was manually stirred every 14 days. Then compost air-dried and used in experiment. A sample of composted manure was dried at 50^0 C and analyzed for routine analysis as described by page *et al*. (1982) and presented in table (2).

The field was plowed perpendicularly at 30 cm depth, then divided into three main blocks (levels of manure). Each main block was divided into two sub-main blocks (application methods of manure) while the depth of manure application was carried out as rows of 10 m length within the sub-main blocks. The different treatments were arranged in RCBD with split-split plot design. Each treatment had 3 replications. The experiment was conducted using drip irrigation system. Spanish hybrid variety of maize (*Zea mays* L.) Cadiz was banded on manure rows. All plots received urea (46 % N) at level of 200 kg N ha^{-1}, triple super phosphate (20.21 % P) at level of 130 kg P ha^{-1} and potassium sulfate (43 % K) at level of 100 kg K ha^{-1}. The normal agricultural processes of maize were practiced as usually followed in the commercial production of Al-Hartha region.

Soil samples from the experiment plot were collected for depth of 0 – 30 cm at the end of the growing season (Oct. 10 , 2015). The samples were degraded and sieved by 2mm sieve. Soil EC was measured for extraction 1:1 (soil : water) using conductivity meter while the soil pH was measured for suspended solution 1:1 using pH meter according to methods described in Page *et al* . (1982). All the obtained data were subjected to analysis of variance (ANOVA) and means were compared with Least Significance Difference (LSD) at 5% level of probability (Al-Rawi and Khalaf-Allah , 1980).

Table (1): Basic soil characteristics prior to the experiment

property	Unite	Value
pH		8.13
EC	dS m^{-1}	7.61
Organic matter	g kg^{-1}	6.11
$CaCO_3$	g kg^{-1}	335.10
Available - N	mg kg^{-1}	18.72
Available - P	mg kg^{-1}	16.12
Available - K	mg kg^{-1}	95.34
CEC	Cmol kg^{-1}	25.25
Ca^{++}	mmole L^{-1}	11.13
Mg^{++}	mmole L^{-1}	10.90
Na^{+}	mmole L^{-1}	21.32
K^{+}	mmole L^{-1}	10.60
CO_3^{--}	mmole L^{-1}	0.00
HCO_3^{-}	mmole L^{-1}	9.34
Cl^{-}	mmole L^{-1}	30.15
SO_4^{--}	mmole L^{-1}	19.23
Bulk density	Mg m^{-3}	1.31
Sand	g kg^{-1}	188.87
Silt	g kg^{-1}	590.46
Clay	g kg^{-1}	220.67

Table (2): Some chemical properties of manure used

property	Unite	Value
pH		6.42
EC	dS m^{-1}	13.25
Nitrogen	g kg^{-1}	17.37
Phosphorus	g kg^{-1}	7.16
Potassium	g kg^{-1}	10.44
Organic matter	g kg^{-1}	363.22
Organic carbon	g kg^{-1}	210.69
Bulk density	Mg m^{-3}	0.59
C/N Ratio		12.13
C/P Ratio		29.43

RESULT AND DISCUSSION

(1) soil salinity (EC) :

The results showed that the manure application level significantly affect ($P \leq 0.05$) the soil EC at the end of the corn crop growth season (fig. 1). The soil EC decreased with manure application levels. EC values are 5.87 and 4.63 dS m^{-1} for application levels 20 and 40 ton ha^{-1} , respectively. The percentage of the reduction in the soil EC compared to the control treatment (0 ton ha^{-1}) are 13.80 and 32.01% , respectively. The soil EC for the control treatment is 6.81 dS m^{-1}. The reduction in the soil EC is related to positive effect of the manure on the soil physical properties such as the soil bulk density and the moisture content which improved the soil ability in leaching the salinity down out of the crop roots zone and that resulted in lower soil EC (Aday *et al*. , 2017). This results agreed with that obtained by EL-Shakweer *et al*. (1998), Tejada *et al*. (2006) and Mahdy (2011) who mentioned that when the manure was added to the soil improved the salinity and sodium leaching and that was because the manure reduced the soil bulk density, increased soil porosity and improved soil structure which helps in leaching NaCl down, reduced sodium – exchange percentage and decrease soil salinity. The results were obtained by Aloosy and Al- Ziadi (2011) indicated that the soil salinity decreased within 0 – 30 cm when the manure was used. In this study the soil salinity reduction is significantly related to soil bulk density reduction and soil moisture content increase. The following formula of both respectively $Y= 23.997X – 23.451(R^2 = 0.9486^{**})$, $Y= - 0.2584X + 13.112$ ($R^2 = 0.8723^{**}$). This results revealed that the soil EC can be reduced considerably when the manure is used to improve the soil physical properties. The effect of the manure was more decisive when soil leaching requirement is applied and active drainage system existed in the field of the experiment.

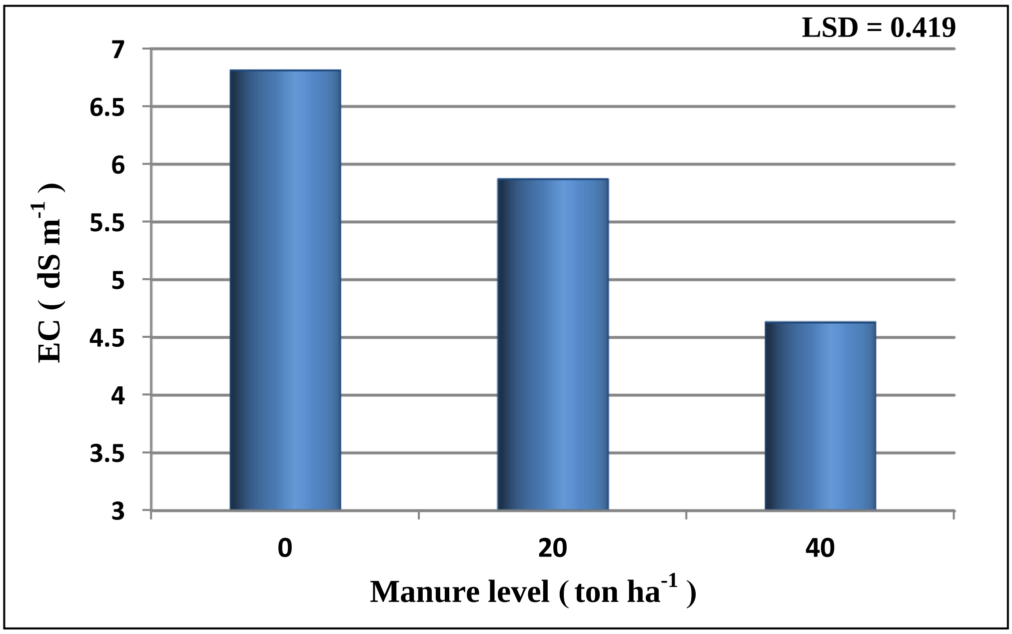

Fig. (1): Influence of manure levels on soil salinity

The depth of the added manure significantly affect in the soil salinity ($P \leq 0.05$), (fig. 2). The soil EC decreased from 6.13 to 5.71 and 5.48 dS m^{-1} when the depth of the added manure increased from 10 to 20 and 30 cm, respectively with significant difference between the values. This would be related to that the deep soil disturbing increased the soil porosity and the manure improved the physical properties such as the soil bulk density and the soil moisture content which pushed the salts down to the lower layers (Aday *et al.* , 2017).

The soil salinity is related to the soil bulk density and the soil moisture content by the following equations: $Y = 17.597X - 15.652$ ($R^2 = 0.7022^{**}$) and $Y = - 0.1644X + 10.441$ ($R^2 = 0.7569^{**}$) respectively. The existence of drainage system helped in washing the salinity to the deeper layers in additional to that the leaching requirement was used which helped in leaching the salts down to the deep layers. Rahmatullah and Gill (2005) mentioned that the salinity decreased when manure was used along the depth of 0 – 100 cm.

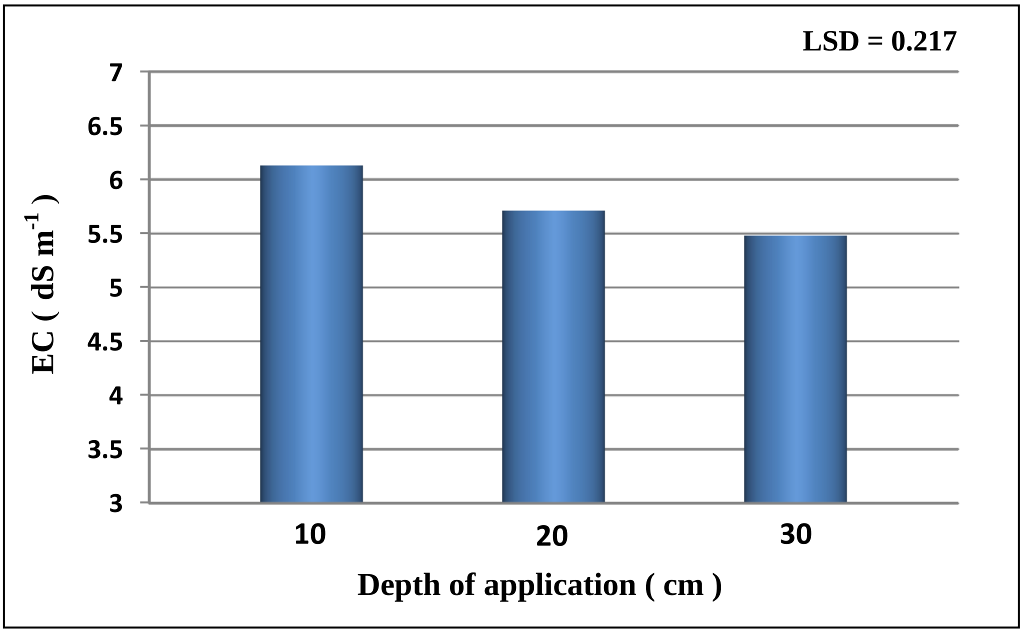

Fig. (2): Influence of depth of manure application on soil salinity

The manure application methods significantly affected the soil salinity ($P \leq 0.05$), (fig. 3). EC of the soil decreased from 6.13 dS m^{-1} for subsoil manure layer (band) to 5.42 dS m^{-1} for soil – manure mixing method. The soil – manure mixing method improved soil structure which increased soil porosity and reduced soil bulk density which facilitated leaching down the soil salts. Soil salinity is related to the soil bulk density and moisture content by the following equations respectively: $Y = 19.329X - 17.822$ ($R^2 = 0.9139^{**}$) and $Y = -0.2213X + 11.988$ ($R^2 = 0.9082^{**}$). Atee *et al*. (2006) and Al-Delfi (2013) found that the addition of the manure to the soil by mixing method reduced EC of the soil through reducing soil bulk density which helped in washing the salts down to the deep soil layers.

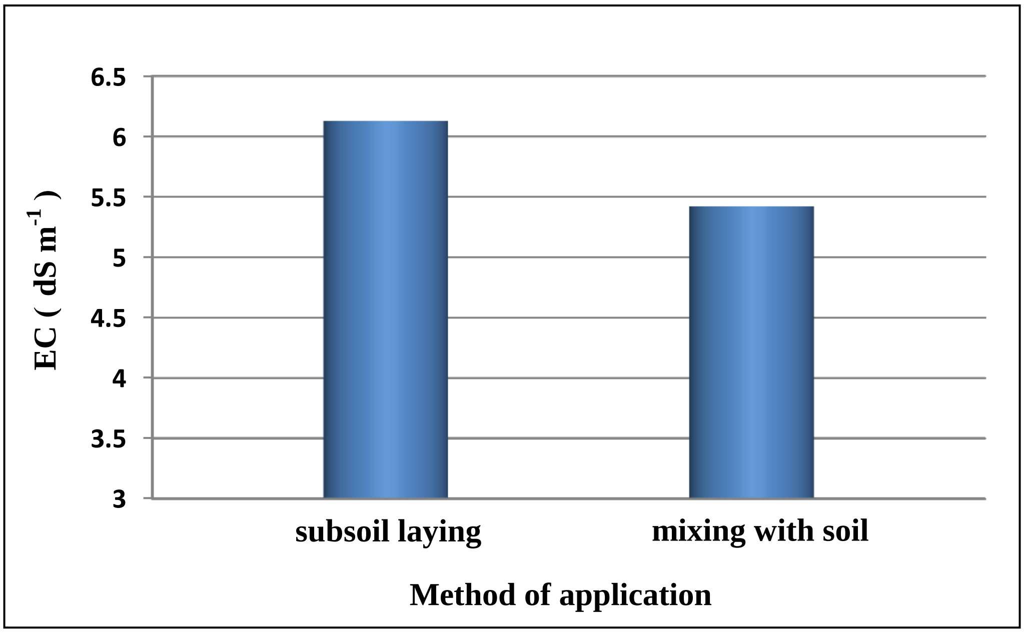

Fig. (3): Influence of method of manure application on soil salinity

The interaction between the manure levels and application methods significantly ($P \leq 0.05$) affected the soil EC (fig. 4). EC of the soil decreased with manure levels for both methods of applications. manure – soil mixing method significantly surpassed subsoil layer method in reducing the soil EC of all manure application levels. The highest EC value recorded for 0 ton ha^{-1} treatment (6.81 dS m^{-1}) while the second highest value was recorded for subsoil layer application of 20 ton ha^{-1} (6.30 dS m^{-1}). These two values are not significantly differed. However, the lowest EC value (3.99 dS m^{-1}) was recorded for 40 ton ha^{-1} which was applied by manure – soil mixing method. The lowest EC value is lower than the above two values by 36.67 and 41.41% , respectively. The manure – soil mixing method and 40 ton ha^{-1} level reduced soil bulk density, increased soil porosity and improved soil water holding capacity which increased the soil leaching ability and that lead to wash the salts downward.

The application of the manure level of 40 ton ha^{-1} as a layer underneath the soil surface gave close value to application level of 20 ton ha^{-1} added by manure – soil mixing methods , there values are 5.27 and 5.44 dS m^{-1}, respectively. This results indicated clearly that soil – manure mixing methods dominated subsoil layer method in improving soil physical properties and reducing soil EC.

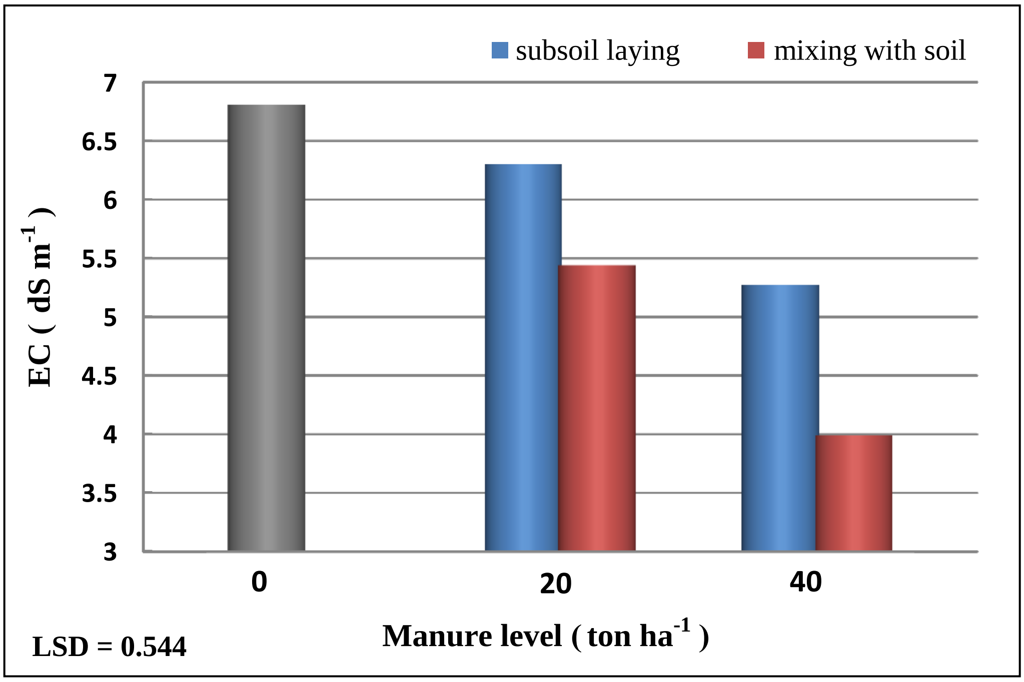

Fig. (4): Influence of manure levels on soil salinity at different application methods

The interaction between the manure application level and depth significantly ($P \leq 0.05$) affected the soil EC (fig. 5). The highest EC value (6.81dS m^{-1}) was recorded for the control treatment (0 ton ha^{-1}), whereas the lowest value (4.14 dS m^{-1}) was recorded for manure level of 40 ton ha^{-1} applied at 30 cm depth. The lowest value significantly differed from the other values except the treatment of 40 ton ha^{-1} at depth of 20 cm. The domination of treatment 40 ton ha^{-1} and depth of 30 cm is related to pushing the salts deeper in the soil far away from crop roots zone.

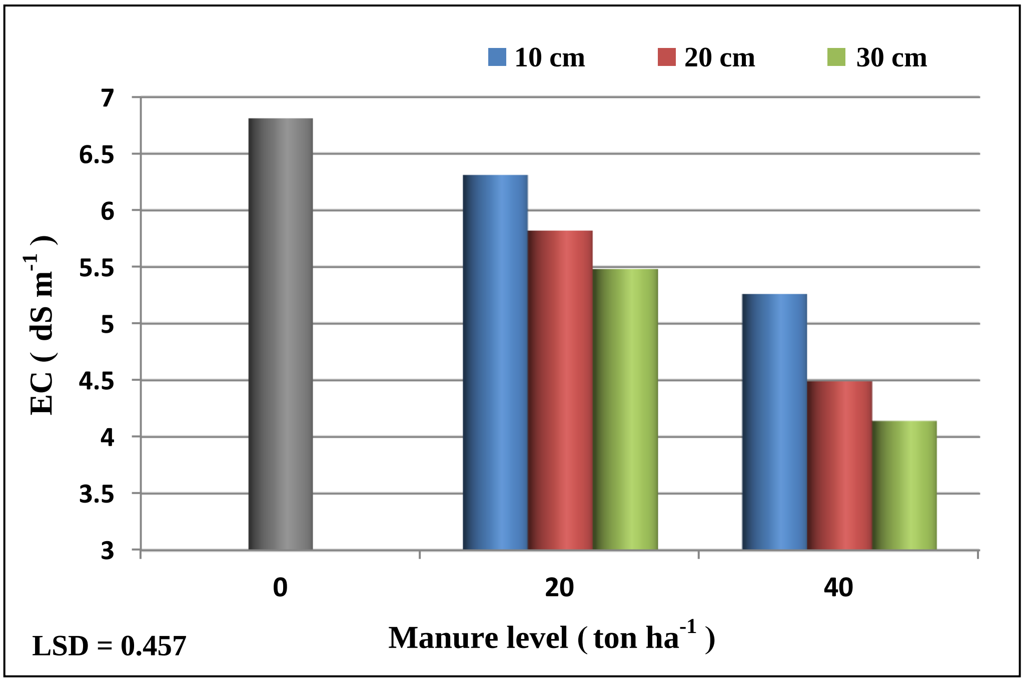

Fig. (5): Influence of manure levels on soil salinity at different depth of application

This study did not show any significant effect for the interaction between the manure application method and the depth of application as well as the interaction between the three factors on the soil EC .

(2) Soil pH:

There is a significant effect ($P \leq 0.05$) for the manure levels on the soil pH at the end of the corn growth season (fig. 6). pH values decreased from 8.12 to 8.08 and 7.97 when the manure application levels increased from 0 (control treatment) to 20 and 40 ton ha^{-1}, respectively. This results is confirmed by Zhao *et al*. (2009) and Zhihui *et al*. (2016) who reported that the soil pH decreased with organic matter of different sources. The organic matter decomposition release CO_2 and other organic acids as well as the soil organisms activities which reduced the soil pH. In additional to that the crop roots release CO_2 which helps in reducing the soil pH.

Ganiger *et al*. (2012) and Mohammed (2013) reported that the soil pH decreased significantly when a manure was added as compared with zero addition. They related the reduction in the soil pH to the manure decomposition which released carbonic acid and the later released 2H and that reduced the soil pH.

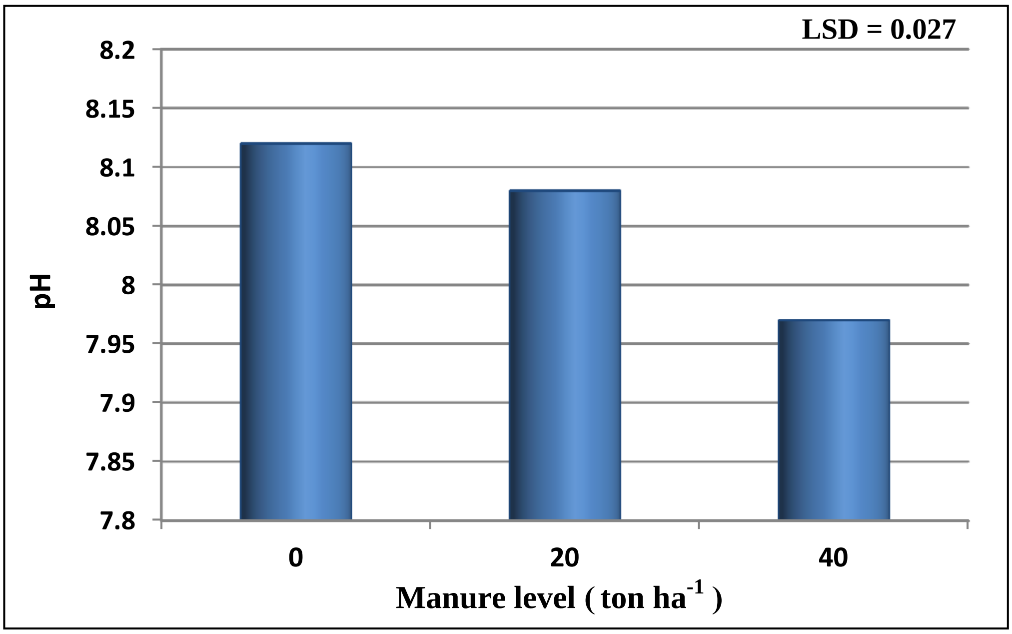

Fig. (6): Influence of manure levels on pH soil

There is a significant effect ($P \leq 0.05$) for the interaction between the manure application levels and depths on the soil pH (fig. 7). The highest value (8.12) of the soil pH was recorded for the control treatment (0 ton ha^{-1}), while the lowest value (7.95) was recorded for 40 ton ha^{-1} and application depth of 30 cm. This was due to the greater amount of added manure which released greater amount of CO_2 and organic acids compared with lower levels as well as this amount of manure distributed along depth 30 cm which cover greater volume of soil.

The study also showed that there is no significant effect for manure application methods, application depths, the interaction between the application method and the application level, the interaction between the application method and the application depth and the interaction between the studied factors on the soil pH. This can be related to the high total value of carbonate (335.10 g kg^{-1}) which inhibited the changes in the soil pH which regulate the soil pH in the alkali range of the soil.

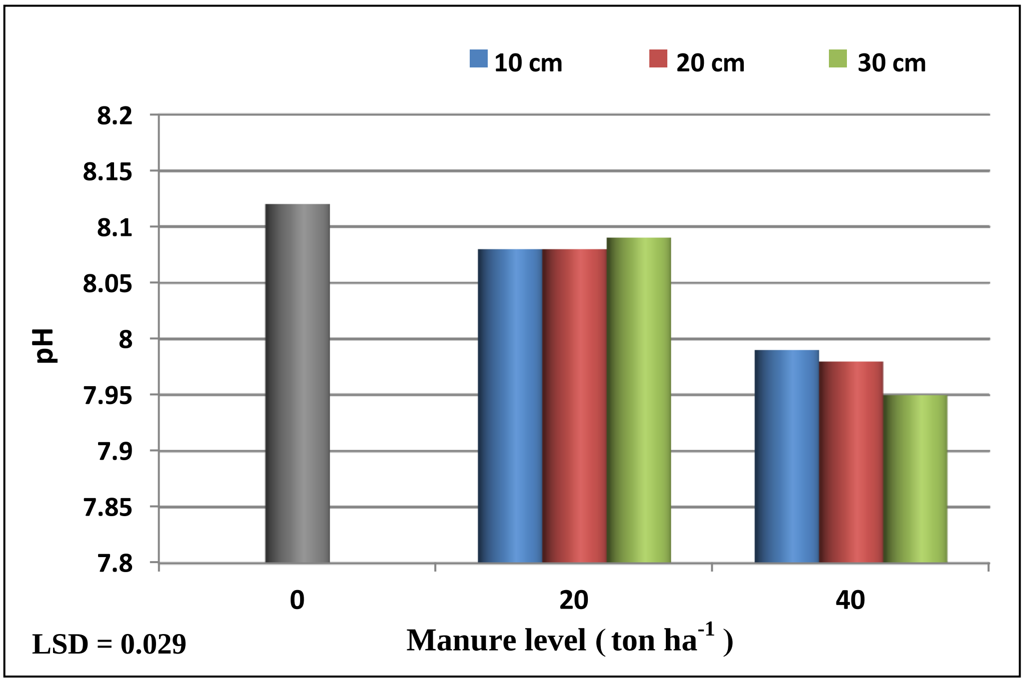

Fig. (7): Influence of manure levels on pH soil at different depth of application

CONCLUSIONS

The following conclusions can be drown from the study :

1- Increasing the amount (level) of the composted cattle residues reduced the soil salinity and pH.

2- Application of the manure deep mixing with the soil increased soil moisture content, improved soil structure which improved soil leaching ability and that resulted in lower soil salinity.

3- Mixing 40 ton ha^{-1} of cattle residues in hectare of soil from the surface to 30 cm depth gave the best results in reducing soil salinity and pH.

REFERENCE

Aday, S.H.; M.A. Abdulkareem and S.J. Muhsin (2017). Effect of the manure levels, depth and the method of applying using ditch opener and manure laying machine on some soil physical properties. Basrah J. Agric. Sci., 30 (1). (in press).

Al-Delfi, H.F. (2013). Role of organic residues in reduce the effect of irrigation water salinity on soil properties and corn (Zea mayes L.) growth. M.Sc. Thesis . College of Agriculture – Univ. of Basrah. Iraq. (in Arabic).

Aloosy, Y.A.M. and H.S.S. Al-Ziadi (2011). The effect of irrigation water quality, organic material and phosphorus on some soil chemical characteristics and yield of cauliflower. The Iraqi J. of Agric. Sci., 42 : 42 – 54. (in Arabic).

Al-Rawi, K.M. and A.M. Khalaf-Allah (1980). Design and analysis of agricultural experiments. Al-Mousel Univ. press. Iraq 488 pp. (in Arabic).

Atee, A.S.; A.A. Thijeel and A.N. Al-Ani (2006). Influence of ground corn cobs on some soil properties 1- chemical and biological. The Iraqi J. of Agric. Sci., 37 (1): 1-16. (in Arabic).

Avnimelech, Y. and M. Kochva (1997). On the agronomic use of municipal solid waste compost : principles and applications. Modern agriculture and nvironment, developments in plant and soil sciences, 71, pp383-393.

Black, C.A. (1965). Methods of soil analysis. Part 1. Physical Properties, Amer. Soc. Agron, Inc. Pub., Madison, Wisconsin, U.S.A. PP: 770.

El-Shakweer, M.H.A.; E.A. El-Sayad and M.S.A. Ejes (1998). Soil and plant analysis as a guide for interpretation of the improvement efficiency of organic conditioners added to different soils in Egypt. Communications in Soil Science and Plant Analysis, 29(11-14) : 2067– 2088.

Ganiger, V.M.; J.C. Mathad; M.B. Madalageri; H.B. Babalad; N.S. Hebsur and B.Y. Nirmala (2012). Effect of organics on the physico-chemical properties of soil after bell pepper cropping under open field condition. Krnataka J. Agric. Sci., 4: 479 - 484.

Koenig, R. and M. Johnson (1999). Selecting and using organic fertilizers. Cooperative Extension. Utah State Univ.

Mahdy, A.M. (2011). Comparative effects of different soil amendments on amelioration of saline-sodic soils . Soil and Water Res., 6 (4): 205-216.

Mohammed, E.J. (2013). Evaluation the effect of organic and mineral fertilization on some soil properties, growth and yield of snake cucumber (*Cucumis mele* Var. flexuosus Nauds). M.Sc. Thesis. College of Agriculture – Univ. of Basrah. Iraq. (in Arabic).

Page, A.L.; R.H. Miller and D.R. Keeney (1982). Methods of soil analysis. Part 2. 2nd ed. ASA Inc. Madison, Wisconsin, U.S.A.

Rahmatullah, N.A. and M.A. Gill (2005). Irrigtion of crops with brackish water using organic amendments. Pak. J. Agric. Sci., 42: 33 - 37 .

Richards, L.A. (1954). Diagnosis and improvement of saline and alkali soils. Agric. Handbook No 60. U.S. Dept . Agric., Washington D.C.

Tejada, M.; C. Garcia; J.L. Gonzalez and M.T. Hernandez (2006). Use of organic amendment as a strategy for saline soil remediation: Influence on the physical, chemical and biological properties of soil. Soil Biology and Biochemistry. 38 (6): 1413-1421.

Zhao, Y.; P. Wang; J.Li; Y. Chen; X. Ying and S. Liu (2009). The effect of two organic manures on soil properties and crop yields on a temperate calcareous soil under a wheat – maize cropping system. Europ. J. of Agro., 31: 36 - 42 .

Zhihui, W.; S. Jianbo; M. Blackwell; L. Haigang; Z. Bingqiang and Y. Huimin (2016). Combined applications of nitrogen and phosphorus fertilizers with manure increase maize yield and nutrient uptake *via* stimulating root growth in a long-term experiment. Pedosphere , 26(1): 62 - 73.

تأثير مستوى وعمق وطريقة اضافة المخلفات العضوية بواسطة آلة وضع السماد العضوي تحت سطح التربة في ملوحة ودرجة تفاعل التربة

محمد عبد الله عبد الكريم   شاكر حنتوش عداي   صادق جبار محسن
كلية الزراعة – جامعة البصرة

المستخلص

نفذت تجربة حقلية في تربة مزيجة غرينية في أحد الحقول التابعة لمحطة ابحاث الهارثة في كلية الزراعة – جامعة البصرة خلال الموسم الزراعي 2015 وذلك لدراسة تأثير مستويات اضافة المخلفات العضوية (0 و 20 و 40 $on\ ha^{-1}$) وعمق اضافة المخلفات العضوية (10 و 20 و 30 cm) وطريقة الاضافة (شريط تحت التربة وخلطا" مع التربة) في ملوحة و pH التربة نهاية موسم النمو لنبات الذرة الصفراء. اضيفت المخلفات العضوية وحسب المعاملات المدروسة باستخدام آلة وضع السماد العضوي في خنادق تحت سطح التربة المصممة والمصنعة في قسم المكائن الزراعية – كلية الزراعة – جامعة البصرة.

حرثت التربة ونعمت ثم أضيفت المخلفات العضوية بواسطة الآلة في خطوط تحت سطح التربة وحسب المعاملات المدروسة وفق ترتيب split-split plot وبتصميم RCBD. اضيفت الاسمدة الكيميائية لكل الوحدات التجريبية بالتساوي . اخذت نماذج التربة للعمق (0 - 30 cm) نهاية موسم النمو وقدر فيها ملوحة التربة و pH التربة. اظهرت نتائج الدراسة ان لمستوى اضافة المخلفات العضوية تأثيرا" معنويا" في كل من ملوحة و pH التربة اذ سجل المستوى 40 $ton\ ha^{-1}$ اقل ملوحة و pH للتربة بلغت 4.63 $dS\ m^{-1}$ و 7.97 على التوالي قياسا" بمعاملة المقارنة (0 $ton\ ha^{-1}$) التي اعطت 6.81 $dS\ m^{-1}$ و 8.12 على التوالي. كما انخفضت ملوحة التربة معنويا" من 6.13 الى 5.48 $dS\ m^{-1}$ عند زيادة عمق اضافة المخلفات العضوية من 10 الى 30 cm في حين لم يؤثر عمق الاضافة معنويا" في pH التربة ، كذلك انخفضت ملوحة التربة معنويا" عند اضافة المخلفات العضوية خلطا" مع التربة اذ بلغت 5.42 $dS\ m^{-1}$ قياسا" بإضافتها كشريط تحت التربة التي اعطت ملوحة تربة مقدارها 6.13 $dS\ m^{-1}$ بينما لم تؤثر طريقة الاضافة في pH التربة. حقق المستوى 40 $ton\ ha^{-1}$ خلطا" مع التربة اقل القيم لملوحة التربة بلغت 3.99 $dS\ m^{-1}$ في حين سجلت اقل القيم لـ pH التربة بلغت 7.95 عند مستوى الاضافة 40 $ton\ ha^{-1}$ بعمق 30 cm.

كلمات مفتاحية : آلة التسميد العضوي ، مخلفات عضوية ، ملوحة التربة ، pH التربة .