International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.9, No.10 pp 38-44, 2016

Effect of different soil conditioners application on some soil characteristics and plant growth IV-Effect of bentonite rates on the some soil chemical properties

***Abd El-Hady M. and Ebtisam I. Eldardiry**

Water Relations and Field Irrigation Dept. National Research Centre, El-Buhouth St., Dokki, Cairo, Egypt

Abstract : This paper investigate the efficacy of the use of bentonite clay as a potential soil conditioner on the some soil chemical properties such as exchangeable sodium percentage (ESP), sodium adsorption ratio (SAR) and electrical conductivity values (EC, dS/m)of coarse textured soils. Field experiment was carried out in Research and Production Station, National research Centre, El-Nobaria, El-Beheara Governorate, Egypt during the season of 2013 on a sandy loam soil. The experimental design was randomized completely block in sex replicates. Barley (*Hardium vulgare* L-Giza 124) followed by Maize (Zea maize L- hybrid 310) were sown. Bentonite was added at rates (0, 2, 4, 6 and 8 %) comparing with farm yard manure (FYM) at 2 % on the half of the plots were treated by 50%, the first one applied before barley and the second one during soil preparation of maize.

The obtained results showed that: ESP values increasing by increasing bentonite application rates to sandy soil in surface layers. Application bentonite at 8% increased ESP by about 98% comparing with untreated one. While 2% bentonite increased ESP by 57% relative to the control and the increase relative to the difference between 8 and 2% bentonite application rate was 41%. ESP values of subsurface soil samples after maize, were highly comparing with surface ones afterbarley crop. SAR values after barley resulted from treated soil by bentonite 2; 8 % and FYM at 2% increased SAR value by about 33, 77; 20 % relative to the control in the first soil depth. Soil salinity (EC, dS/m) revealed that reasonable EC values were obtained through addition of bentonite at different used rates and increased bentonite rates associated with increase in soil EC values. The highest percentage of increase was 21-43, 13-36, 21-43 % relative to the control after maize, while the values were -10, -7; 0, -19; 21, 43 % after barley for the three studied depths after 6, 8 % bentonite. while the FYM had a promotive effect to reduce soil EC which decreased in the examined soil depths in same sequences after maize by about -7, +2, -7; -42, -37, -7%.

The main conclusion is that bentonite play an important role not only increasing soil fine particles but also increase its CEC that play a vital role in soil fertility till 8 % without any risk effect on Soil ESP.

Keywords: bentonite, exchangeable sodium percentage, sodium adsorption ratio,EC.

Introduction

Increasing cultivated lands in Egypt has been a necessity relative to population pressure where coarse textured soils are available, which well known as being droughty, erodible, infertile and non-economical to develop. Agricultural productivity on such soils is hence considerably weak. However they could be as productive as any other soil, if the suitable soil management practices were followed such as addition of soil conditioners and use of the most appropriate irrigation device that minimizes the waste of the precious drop of water[1;2].

Sandy soils are generally regarded as very fragile with respect to agricultural production due to their very low nutrients and organic matter content [3]. **Ebtisam and Abd El-Hady[4]** found that increasing bentonite rates to sandy soil combined with increase in soil moisture content in all studied depths, especially the upper layers till 30 cm. Decline in soil fertility has also been related to the decline of soil nutrients and organic matter. Nevertheless, limited information is available on the fertility status of soils especially with reference to soil-plant relationship, even though analysis of nutrient balance or soil-plant nutrient budget is important and inevitable to assess the sustainability of agricultural ecosystem [5].

It is well recognized that when soils are cleared of their native vegetation and cultivated, chemical degradation of inherent chemical properties occurs. In general, a decline in soil organic matter reduces the soil's capacity to retain exchangeable captions, resulting in accelerated soil acidification and nutrient depletion. The consequent decline in soil fertility can be pronounced in light textured soils, which even in their pristine state can have low levels of fertility. This poor fertility can be further exacerbated by the high temperatures and leaching conditions found in tropical environments[6].

The impact on soil chemical properties following land clearing and continuous cropping can be illustrated by results obtained from [4].To attempt to rescind this degradation and the consequences of nutrient depletion and soil acidification remediation strategies are often implemented. The addition of organic amendments such as manure or compost can be effective but quick decomposed in arid and semiarid condition, seek large quantities and regular additions. However, on coarse textured sandy soils containing low activity clays with limited buffering capacity, increased fine particles such as clay and silt could improve soil physio-chemical characteristics [7].The substitution approach to increasing the retained nutrient properties of the soil has been elucidated in recent studies [8;9] where the addition and incorporation of high-activity clay has been shown to constantly increase the CEC of the soil and provide positive yield interest.

This paper discusses the efficacy of the use of high activity clays, either used alone or in association with other amendments, as a potential soil amendment/ conditioner for increasing the nutrient holding capacity of light textured soils.

Material and Methods

Field experiment was carried out in Research and Production Station, National Research Centre, El-Nubaria, El-Beheara Governorate, Egypt, during the season of 2013 on a sandy loamy soil (23% silt; 8% clay)

Barley (*Hardium vulgare*.L- Giza 124) was sown in the 1st of December and lasted about 145 days followed by maize (*Zea Mays* L-hybride 310) at 5th of April and lasted 109 days. The amount of water applied was based on estimated evapotranspiration (ETo) of the experimental site by sprinkler irrigation. Sprinklers (discharge is 0.95 m^3/h at 2.1 bar) were set up at square design (9x9 m) with 18 % overlapping and its precipitation was 15 mm /h.

Bentonite used in current work is characterized by [4] where it is clay in texture, 4.8 dSm^{-1}, 7.88, 4.6 % and 1.8 % for ECe, pH, $CaCO_3$ and organic matter content. Bentonite application rates were 0, 2, 4, 6 and 8 %, in addition to farm yard manure treatment (FYM) at 2 % on weight basis. Half of the plots were treated by bentonite examined rates in two equal doses (50%), the first one applied before maize and the second one during soil preparation for sowing barley. All fertilizers were applied in recommended.

Some soil properties of the experimental soil before cultivation are mentioned[4]. Three soil depth samples were collected from experimental plots after barley harvested from the surface layers 0-45 cm, 15 each to determine the investigated variables.

The data were subjected to the analysis of variance (ANOVA) appropriate to the randomized complete block design applied after testing the homogeneity of error variances according to the procedure out- lined by [10].

The significant differences (LSD) between treatments were compared with the critical difference at 5% probability level.

Results and discussion

Exchangeable sodium percentage

Data in Fig (1) indicate that exchangeable sodium percentage (ESP)values increasing by increasing bentonite application rates to sandy soil in surface layers. Also, it is worthy to mention that ESP value of control was 1.27 % which doubled to reach 2.51 when soil treated by8 % bentonite after maize. This meant that application bentonite at 8% increased ESP by about 98% comparing with untreated one. While 2% bentonite application rate increased ESP by 57% relative to the control and the increase relative to the difference between 8 and 2% bentonite application rate was 41%. So, it is recommended to reach 8 % without any risk effect on Soil ESP.

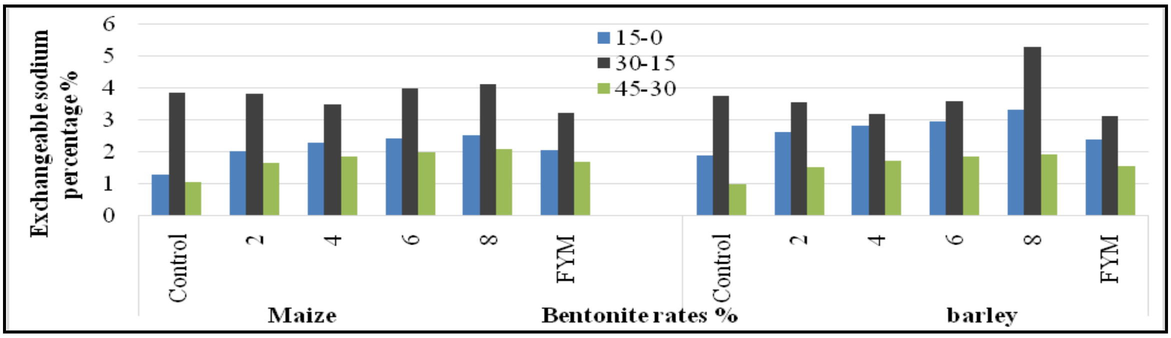

Fig. (1) Effect of bentonite rates and farmyard manure on the soil exchangeable sodium percentage after maize and parley

Whereas the ESP values of subsurface soil samples after maize, were highly comparing with surface ones after same crop. Also, the differences between different bentonite application rates were not significant in the two deepest layers (15-30; 30-45 cm). Same trend was observed after barley, but the values were 77% and 40 % in same previous sequences. Regarding to the FYM effect in comparing to the control plot the rate of increase were 60 and 27% after maize and barley, respectively. However values of ESP increased in surface layers comparing with subsurface ones. Also, one can notice that the differences between ESP values of the subsurface layers were not significant. These results are agreed with those obtained by [11;12]**.** They stated that application bentonite with compost to sandy soil increased significantly total porosity, available water content, soil field capacity, contrary to bulk density and hydraulic conductivity, where their values were significantly decreased.

With respect to the effect of bentonite application with comparing with FYM on the soil sodium adsorption ratio (SAR), Fig. (2) illustrated that values of SAR were very low and there is no harmful effect of sodium in hydrophysical properties. But it could mention that the percentage of change in SAR relative to the application bentonite 2 and 8 %were negatively at 2% with values -4 for the three studied depths. While the 2nd layer was more affected be 8% bentonite and recorded 15 % after maize. Whereas FYM had a promotive effect of bentonite resulted from 8% where negative values were obtained 12, -15; -12 % reduction in SAR after using FYM comparing with untreated after maize.

In the case of the SAR values after barley resulted from treated soil by bentonite 2; 8 % and FYM at 2% increased SAR value by about 33, 77; 20 % relative to the control in the first soil depth. The opposite was true in the case of examined two depth 145-30, and 30-45, except after 8% bentonite where 65 % increased in SAR was recorded.

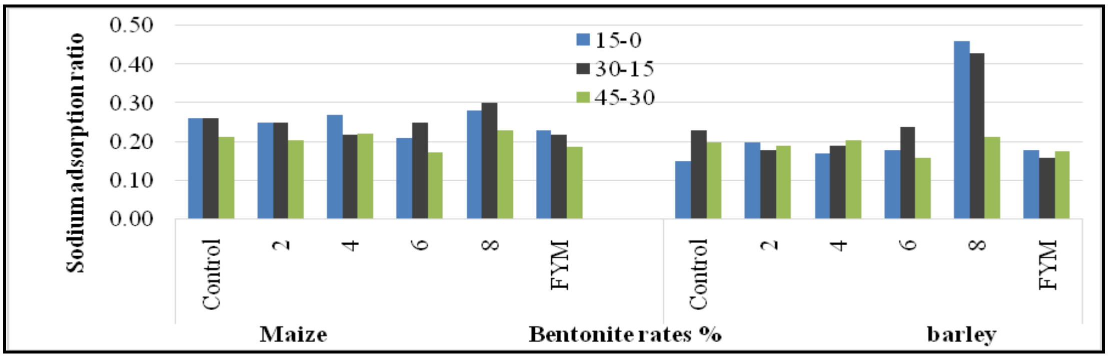

Fig. (2) Effect of bentonite rates and farmyard manure on the soil sodium adsorption ratio after maize and parley

Soil salinity

Soil salinity was expressed in electrical conductivity values (EC) in dS/m, which plotted in (Fig. 3) revealed that reasonable EC values were obtained through addition of bentonite at different used rates. Additionally increased bentonite rates associated with increase in soil EC values. The highest percentage of increase was 21-43, 13-36, 21-43 % relative to the control after maize, while the values were -10, -7; 0, -19; 21, 43 % after barley for the three studied depths after 6, 8 % bentonite. while the FYM had a promotive effect to reduce soil EC which decreased in the examined soil depths in same sequences after maize by about -7, +2, -7; -42, -37, -7%.

According to [13] that 4 dSm^{-1} is the limited value between saline and non-saline soil conditions on the base of yield for most field crops which decreased by about 50 % if EC value increased. Also, it was reported that between 0 – 2 dSm^{-1} salinity effects is negligible.Data in Fig. (3) indicated that the EC values of the collected soil samples after the investigation crops ranged between 1.3 and 2.46 dSm^{-1} wither surface or subsurface after maize or barley under differ shale application rates.

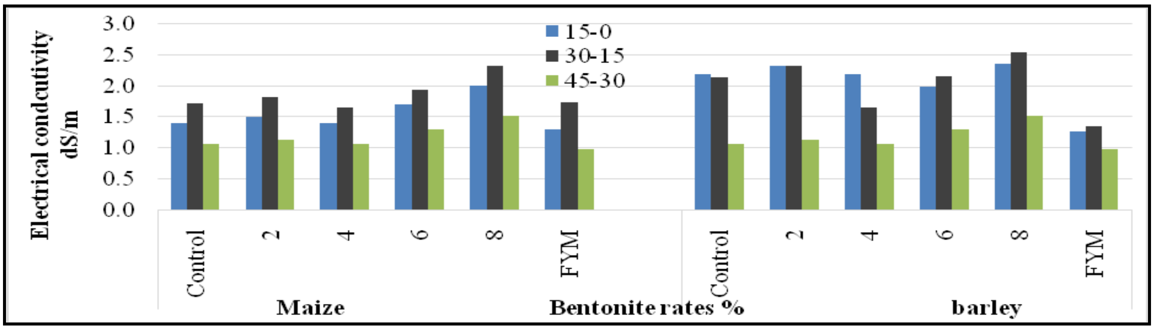

Fig. (3) Effect of bentonite rates and farmyard manure on the soil electrical conductivity after maize and parley

It is clear to note that the main characteristic of sodic soils from the agricultural stand point is that they contain excess of exchangeable sodium to adversely affect the growth of most crop plants[14]. For the purpose of definition, sodic soils are those which have an exchangeable sodium percentage (ESP) of more than 15. Also, it is clear the excess exchangeable sodium has an adverse effect on the physical and nutritional properties of the soil, with resultant reduction in crop growth, significantly or outright. The soils insufficiency appreciable amounts of balanced soluble salts but contain measurable to appreciable quantities of salts adequate of alkaline hydrolysis, e.g. sodium carbonate. The electrical conductivity of saturation soil extracts are, subsequently, as to be inconstant but are often less than 4 dS/m at (salinity limit).

Sodium Adsorption Ratio (SAR) is awidely accepted index for characterizing soil sodicity, which describes the proportion of sodium to calcium and magnesium in soil solution. The formula to calculate SAR is given below, with concentrations expressed in meq/,L analyzed from a saturated paste soil extract (SAR= $\frac{Na}{\sqrt{(Ca+Mg)/2}}$).

Regarding to[14] who gave us a guideline for interpretation the soil chemical properties in the following table (1), it could concluded that there no harmful effect due use of bentonite as a soil conditioner in sandy soil wither in one addition or in annually application to improve soil characteristics and increase its fertility

Table (1) Soil structural condition as affected by changing of soil EC, SAR and ESP%.

Class	EC (dS/m)	SAR (meq/l)	ESP %	Typical soil structural condition*
Normal	< 4.0	< 13	< 15	Flocculated
Saline	> 4.0	< 13	< 15	Flocculated
Sodic	< 4.0	> 13	> 15	Dispersed
Saline-Sodic	> 4.0	> 13	> 15	Flocculated

*Soil structural condition also depends on other factors not included in the NRCS classification system, including soil organic matter, soil texture and EC of irrigation water [14].

Exchangeable Sodium Percentage (ESP)represent the characteristics of soil sodicity. As mentioned above, excess sodium causes poor water movement and poor aeration which reflect quickly in soil productivity. By definition, ESP is the sodium adsorbed on soil particles as a percentage of the Cation Exchange Capacity (CEC), which is used to characterize the sodicity of soils only, whereas SAR is applicable to both soil and soil solution or irrigation water. Also, it could be focus on the use of bentonite play an important role not only increasing soil fine particles but also increase its CEC that play a vital role in soil fertility.

Table (2) Interpretation of exchangeable sodium percentage (ESP) from saturated paste extract.

Parameter	Bentonite%
Maize ESP	0.217
Barley ESP	0.472
Maize SAR	0.103
Barley SAR	0.623
Maize EC	0.450
Barley EC	0.099

Source: Lamondand Whitney[15].

After the kinds and amounts of salts in the soil have been determined by testing, the soil can be properly treated. Reclaiming a salt-affected soil involves leaching, chemical treatment or a combination of both.

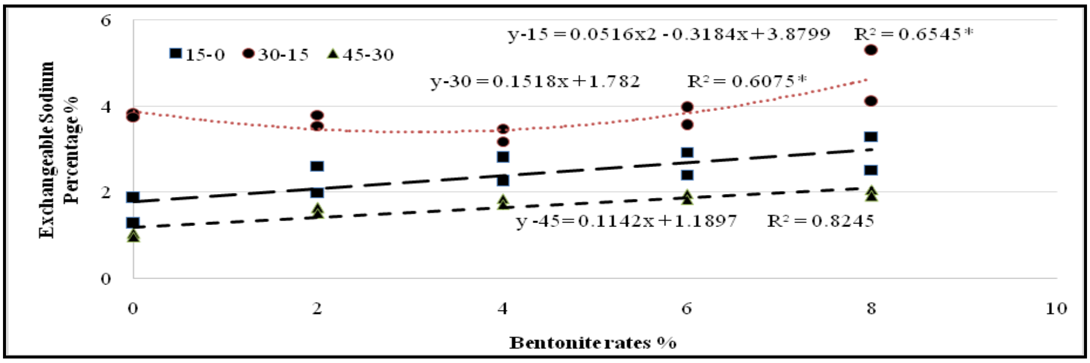

Fig. (4) Regression equations between bentonite rates and the Exchangeable Sodium Percentage %

However, Soil ESP represent Na percentage on the absorbed material, the relation between ESP% and bentonite application rate was very strong especially for the first and the third soil depth, while the regression equation for the second soil depth (15-30 cm) was polynomial one, which means that from bentonite at 4 % the increase in soil ESP is progressively increased. This finding resulted from linear regression equation with high significant value at 1%. To somewhat this figure is sever but still reasonable till ESP less than15%. Also it is clear to mention that ESP represent by the way soil CEC.

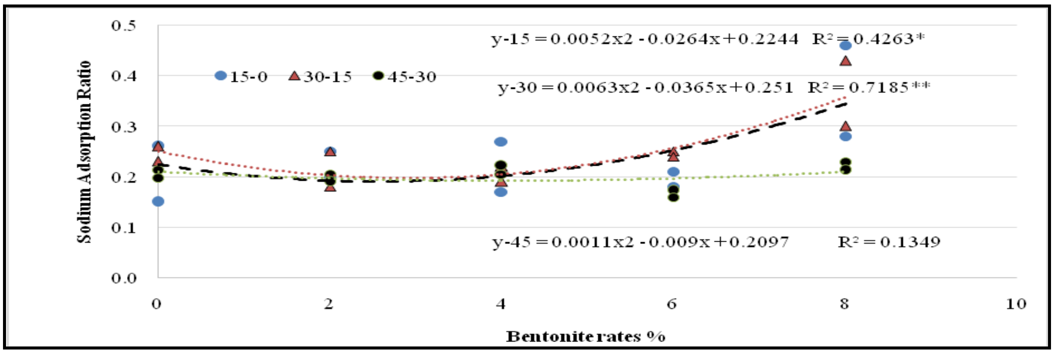

Fig. (5) Regression equations between bentonite rates and Sodium Adsorption ratio

It is clear to mention that bentonite at high rate of application had a promotive effect on the soil SAR that was obtained from polynomial regression equation (Fig. 5), which represent in other way on the soil CEC. Also, at low rates effect of bentonite application to sandy soil was weaks.

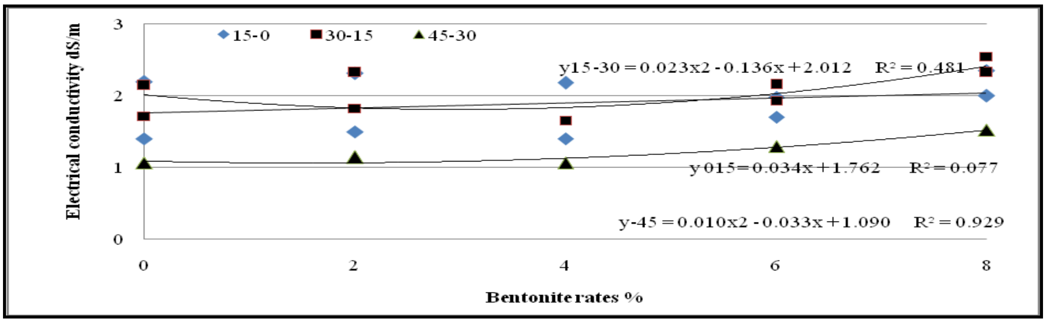

Fig. (6) Regression equations between bentonite rates and the Electrical conductivity

Regarding to the relation between bentonite application rates and soil EC (Fig. 6). Data notice that the relation at the first layer is very weak relative to the soil EC wither bentonite rate increased or not. While in case of the second soil depth was in polynomial and significant at 5%. In third soil depth (30-45 cm) positive relation was obtained in polynomial phase too and could be attributed to the leaching effect of the bentonite salts to the deepest profile layer. this finding was in agreement with reported by[16;17].

Conclusion

In this experiment, bentonite was used as natural soil conditioner and it was the dominant limiting factor for improved soil properties. A considerable part of the effective bentonite application rate was located within the first and second layer (0-30cm) than the last one (> 30 cm), suggesting the importance of dry-wet cycling between soil and applied bentonite that well mixed. Relatively high ratio of the applied bentonite did not fulfill the preferable soil properties strongly suggested the need for proper management for the continuous application of the soil conditioners.

References

1. Abdel-Hady, M.; Ebtisam I. El-Dardiry and M.Y. Tayel 2011. Assessment of some hydrophysical properties for selecting irrigation methods. J. of applied sciences research Journal of Applied Sciences Research, 7(6): 997-1006.
2. Ali, R.R. and M. Abdel-Hady (2011). Use of remote sensing and soils database for sustainable management of irrigation water in desert landforms. International Journal of Environmental Sciences 1(2): 77-84.
3. Boul, S.W., Southard, R.J., Graham, R.C. and McDaniel, P.A. 2003. Soil genesis and classification (5th ed.). Iowa State Press, Ames, Iowa, pp. 494.
4. Ebtisam I. Eldardiry and M.Abd El-Hady, 2015.Effect of different soil conditioners application on some soil characteristics and plant growth. I-Soil moisture distribution, barley yield and water use efficiency. Global Advanced Research Journal of Agricultural Science (ISSN: 2315-5094) Vol. 4(7) pp. 361-367.
5. Vidhaya, T., Viriya, L. and Alan, P. 2004. Nutrient balances and sustainability of sugarcane fields in a mini-watershed agro-ecosystem of Northeast Thailand. Southeast Asian Studies, 41, 473-490.
6. Omotayo, O. E. and K. S. Chukwuka , 2009. Soil fertility restoration techniques in sub-SaharanAfrica using organic resources. African Journal of Agricultural Research Vol. 4 (3), pp. 144-150, March 2009
7. Abdel Hady, M., 2005. Relations between some soil properties and soil moisture constants using path analysis. Egypt.J. Appl. Sci., 20 (5A), 404 – 411.
8. Noble, A.D., Gillman, G.P., and Ruaysoongnern, S. 2000. A cation exchange index for assessing degradation of acid soil by further acidification under permanent agriculture in the tropics. *European Journal of Soil Science* 51: 233-243.
9. Noble, A.D., Gillman, G.P., Nath, S., and Srivastava, R.J. 2001. Changes in the surface charge characteristics of degraded soils in the tropics through the addition of beneficiated bentonite. Australian Journal of Soil Research 39: 991-1001.
10. Dospekhov, B.A. (1984) Field experimentation. Statisti- cal procedures. Mir Publishers, Moscow.
11. Mona A. Osman; Wafaa M. A. Seddik and Gehan H. Youssef (2008). Effect of some organic and natural conditioners addition on physical and chemical properties of soil,nutritional status and zeamaise yield. J. Agric. Sci. Mansoura Univ., 33 (12): 9183 - 9194.
12. Seddikwafaa, M. A. and Liala K. M. Ali (2004). Effect of some natural soil amendments on some soil physical properties, peanut and carrot yields in a sandy soil. Egypt. J. Agric. Res., 82(2): 95-105.
13. US Salinity Laboratory Staff. 1954. Diagnosis and improvement of saline and alkali soils. USDA Agricultural Handbook No. 60. U.S. Government Printing Office. Washington, DC.
14. Horneck, D.S., Ellsworth, J.W., Hopkins, B.G., Sullivan, D.M., Stevens, R.G., 2007. Managing Salt-Affected Soils for Crop Production. PNW 601-E. Oregon State University, University of Idaho, Washington State University.
15. Lamond, R. and D.A. Whitney. 1992. Management of saline and sodic soils. Kansas State University, Department of Agronomy MF-1022.
16. Waskom, R.M., T.A. Bauder, J.G. Davis, and G.E. Cardon. 2010. Diagnosing saline and sodic soil problems. Colorado State University Extension Fact Sheet # 0.521.
17. Abd El-Hady, M., Ebtisam I. Eldardiry 2016. Effect of different soil conditioners application on some soil characteristics and plant growth III- Effect on saturated and unsaturated water flow. International Journal of ChemTech Research. CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN (Online):2455-9555, 9(5):135-143.

*****