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IMPORTANCE OF GYPSUM, ORGANIC MANURE APPLICATION AND NITROGEN, ZINC FERTILIZATION FOR WHEAT CROP IN SALINE SODIC SOILS.

M. S. Genedy*; A. M.G. Ewis** M. M. Sobh** and S. Genaidy*

** Wheat Res. Dept.; F. C.R.I., Agric. Res. Center, Egypt.*

*** Soil &Water Dept. Fac. of Tec. and Development, Zagazig Univ., Egypt.*

**** Soil Fert. and Plant Nnutrition Res.; SWERI, ARC, Egypt.*

ABSTRACT

Two Factorial field experiments on wheat (Var. Msr_2) were conducted during two successive seasons (2015/2016 and 2016/2017).The factors involved gypsum application (none, 100% gypsum requirements) × organic fertilizer rate (none, 20 m^3 fed^{-1}) × nitrogen fertilizer rates (none, 100 kg N fed^{-1}) × zinc fertilizer rates (none, 5 kg Zn fed^{-1}) × 4 replicates. The soils of the experimental locations have been clay loam in texture and the mean values of some properties were EC_e = 6.40 $dS.m^{-1}$, ESP = 18.11 % , pH = 8.30 which reveals higher effects with salinity and sodicity.

The important results could be summarized as follows:

***1**- The addition of gypsum according to soil gypsum requirements (GR) prior wheat cultivation resulted in higher wheat yields as a result of its ameliorative role in soil-pH; soil-EC; soil-ESP and subsequently increasing the availability of some nutrients.*

***2**- Better wheat yields have been obtained by adding organic manure of 20 m^3 fed^{-1} compost, as a result of modifying various soil physico-chemicals characteristics and subsequently increasing most nutrients availability.*

***3**- Nitrogen fertilization with the recommended rate of 100 kg N fed^{-1} (as Ammonium sulfate) led to higher wheat yields as compared to none-fertilized treatment.*

***4**- Zinc sulfate fertilization at rate of 5 kg Zn fed^{-1} for wheat led to better yields; where that response is related to native Zn- unavailability due to higher values of soil-pH and soil- ESP.*

***5**- The significant interaction of those variables on wheat yield and wheat grains-N and Zn concentrations as well as protein content revealed that their use efficiencies have been affected with each other. The co-additions of (GR)×organic manure × N-fertilizer ×Zn fertilizer were*

highly beneficial in improving N and Zn nutrition for wheat yield in such soils.

Keywords: Organic manure, Nitrogen fertilization, gypsum requirements, Zn sulfate, Wheat (Var. Msr_2).

INTRODCTION

Wheat is the most important food crop in Egyptian Agriculture. Wheat higher yield is the major purpose and it is a function of some important variables; i.e. soil salinity and sodicity, irrigation water, plant variety and reclamation as well as fertilization sources. Gypsum is recommended for sodicity reclamation and its application ahead of some crops planting would be better for their productivities. It was indicated that the beneficial effect of gypsum application prior to crops planting in slightly to moderately sodic soil, on yields would be due to amelioration effect brought about i.e. modifying various soil physicochemical characteristics and enhancing N, Ca, Zn and Mn availability to plants (Genaidy, 2011). The remediation of saline soil using chelating agents such as gypsum ($CaSO_4$ $2H_2O$), calcite ($CaCO_3$), calcium chloride ($CaCl_2$) and organic matter (farmyard manure, green manure, organic amendment and municipal solid waste), is a fruitful topic of investigation and can be applied worldwide, being low cost, effective and simple to implement (Mitchell *et al.*, 2000; Hanay *et al*., 2004; Sharma and Minhas, 2005; Tejada *et al.,* 2006 and Mokoi & Verplancke, 2010). The physical, chemical and biological properties of salt affected soil are improved by the application of gypsum and/or FYM as remediation for sustainable land usage and crop productivity, leading to enhanced plant growth and development (Ghafoor *et al*., 2001; Choudhary *et al.,* 2004 and Wong *et al.,* 2009).

Investigation about organic manure indicated some important facts about the role of organic matter as a source of many nutrients i.e. N, P, K, Ca, Fe, Zn, etc. besides its role of increasing the solubility of some nutrients and subsequently their better availability to plants absorption (Genaidy and Hegazy, 2001and Genaidy, 2011).

Nitrogen as a macronutrient is considered a limiting factor in Egyptian soils. In saline-sodic soils, availability and absorption of plant nutrients is severely limited to sustain high crop production due to ion interactions, especially low nitrogen (N) because of its leaching as NO_3, volatilization and de-nitrification losses (Marschner, 2011). Overall, all these factors individually or in combination with each other limit N-use-efficiency (NUE) and the extent of this limitation depends on the

salinity/sodicity levels, crop types and species and soil physicochemical properties (Grattan and Greeve, 1999). Tayebeh (2011), indicated that the different N rates (120, 240 and 360 kg ha^{-1}) had a significant effect on wheat grain yield with increments of (46% at N120, 72% at N240, and 78% at N360) compared to control. The increase in grain yield was due to increase in the yield attribute as the level of nitrogen increased. Also, several studies indicate that N fertilization can increase both wheat grain yield and grain protein content (Subedi *et al.,* 2007; Gorjanovic and Kraljevic-balalic, 2008 and Majid, 2010).

Zinc deficiency is most widespread micronutrient deficiency worldwide (Graham *et al*., 1992 and Welch *et al.,* 1991). Thus, many researches approved crop responses and realizing higher yields by adding the optimum recommended rates as $ZnSO_4.7H_2O$.These responses would be related to Zn-deficiency in such salt-affected soils. Prerna *et al.* (2014) revealed that the Zn increased the contents of N, K, Zn significantly in both grain and straw whereas, phosphorus content was decreased significantly. Also, the comparative reduction in grain and straw yield of wheat as well as contents of P and Zn of grain and straw was less at higher doses of zinc sulfate when the level of ECiw increased in irrigation water. Moreover, Hazardous effects of saline water on wheat can be mitigated to some extent by applying zinc sulfate at the rate of 15 mg Zn kg^{-1} soil.

Accordingly, the objective of this presented research is to indicate the main effects of gypsum application; organic manuring rate (as compost); N-fertilization rate as ammonium sulfate and Zn-fertilization as Zinc sulfate as well as the interaction effects on wheat yield and wheat grains – N, Zn and protein concentration in saline-sodic soils.

MATERIALS AND METHODS

Two factorial field experiments on wheat crop (*Triticum aestivum, L.*) var.Msr_2 have been conducted at Sakha Agric. Res., Station during (2015/2016); (2016/2017) growth seasons, at two different locations, in fulfillment of the purpose of the presented work. The factors involved gypsum application rates (0 and 100% GR) × organic manure (as compost) fertilization rates (0 and 20 m^3 fed^{-1}) × nitrogen fertilization rates (0 and 100 kg N fed^{-1}) × Zinc fertilization rates (0 and 5 kg Zn fed^{-1}) × 4 replicates. The soils of the two experimental locations have the fertility properties as shown in (Table 1), which have been determined according to Richards (1954); Black (1965) and Jackson (1972).

The statistical completely randomized block design with plot area of 6 m^2 was followed. Gypsum and organic manure treatments have been ploughed in soil during tillage processes.

The physico- chemical characteristics of the tested compost have been indicated in (Table 2).Wheat crop (*Triticum aestivum, L.*) var. Msr_2 as high yielding cultivar has been sown on 19/11/2015 and 23/11/2016. Planting irrigation was applied directly after wheat sowing for the two seasons, respectively. Nitrogen fertilization (as ammonium sulfate source) with the afore mentioned rates has been added in two equal doses; the first dose was at mohayah irrigation (30 days after sowing); and the second dose was at the second irrigation, 30 days after the first one; for the two seasons, respectively.

Table (2): Some physico-chemical characteristics of the tested organic manure at the two of experimental locations of the two growth seasons.

Organic manure characteristics	**Location $_1$ (1st season)**	**Location $_2$ (2nd season)**
Moisture content (%)	28.52	29.63
Bulk density (g cm^{-3})	0.402	0.425
Organic matter (OM) %	39.01	43.38
Organic carbon (C) %	22.63	25.16
Total nitrogen (N) %	1.19	1.21
C/N ratio	19.02	20.79
pH (1 : 10 extract)	7.68	7.77
EC_e (1 : 10 extract)	1.63	1.57
Total –P (%)	0.43	0.51
Total –K (%)	1.83	2.68
Total –Zn (mgkg^{-1})	0.87	1.98

Zinc fertilization (as zinc sulfate source) with the above mentioned rates has been added in one addition (with the first N-dose). Irrigation water requirements and irrigation intervals as well as all the agronomic practices, have been applied according to the recommended methods of wheat applied researches. Wheat harvesting has been carried out on 17/5/2016 and on 14/5/2017; for the two seasons, respectively. Wheat yield and yield components have been determined, and wheat-grains have been analyzed for N, Zn concentrations and protein content according to standard methods mentioned by Chapman and Pratt (1961).The statistical field design and analysis of variance have been applied according to Snedecor and Cochran (1971).

RESULTS AND DISCUSSION

I- Effects of the main variables:

1- Gypsum application Effects:

As shown in Table (3); wheat grain and straw yields have been significantly increased by applying the GR treatments, while the increases of grain / straw ratio were nonsignificantly.The parallel increments were (33.9,32.4 and 2.4 %) $_{S1}$ and (35.5, 33.1 and 0.0 %) $_{S2}$ over control treatment ($GR_{0.0}$) and for the two seasons, respectively. These results are in accordance with those obtained by Choudhary *et al.*(2004); Hammad *et al.* (2007) and Wong *et al.* (2009).

With respect to wheat grains- N and Zn concentrations as well as protein content (%), gypsum application increased significantly their values. The obtained increases were (4.6, 16.7, and 5.2 %) $_{S1}$ and (3.5, 17.9 and 4 %) $_{S2}$ over ($GR_{0.0}$) treatments and for the two seasons, respectively. These findings are in harmony with those recorded by Genaidy (2011).

2- *Organic fertilization effectss*:

The same Table (3) indicates that wheat grains and straw yields have been significantly increased by adding organic manure rate of 20 m^3 fed^{-1}. The obtainable increments were (16 and 15.2 %) $_{S1}$ and (17.1 and 15.5 %) $_{S2}$ over control ($OM_{0.0}$) treatment and for the two seasons, respectively. Also the results showed that organic fertilization had no effect on grains / straw ratios for the two seasons. Regarding wheat grains-N Zn concentrations and protein content, organic fertilization resulted in significant increments of (3.3, 7.6 and 3.6 %) $_{S1}$ and (3.5, 6.5 and 4 %) $_{S2}$ over ($OM_{0.0}$) treatments and for the two seasons, respectively. Abou El-Enein *et al.* (2008) obtained similar results.

3- *Nitrogen fertilization effects*:

As shown in the same Table (3), wheat grains and straw yields have been significantly affected by adding the optimum N –fertilization rate of 100 kg N fed^{-1} and there is no significant effects on grains / straw ratios. The gained increases were (19,16.6 and 2.4 %) $_{S1}$ and (20.3,18.5and 0.0 %) $_{S2}$ over the control treatments ($N_{0.0}$) and for the two seasons, respectively. Regarding the wheat N and Zn grains concentrations as well as protein content, nitrogen fertilization gave significant effect with increases of (14.5, 42.2 and 14.9%) $_{S1}$ and (12.5,41.2 and 12.8%) $_{S2}$ over ($N_{0.0}$) treatments and for the two seasons, respectively. These results are in agreement with those realized by Subedi *et al.* (2007); Gorjanovic and Kraljevic-balalic (2008) and Majid (2010).

4- ***Zinc fertilization Effects:***

As shown in the same Table (3), zinc fertilization rate of 5kg fed^{-1} increased wheat grains and straw yields, but grains / straw ratios have been not affected. The significant increases of grains and straw yields were (8.7and 8.8 %) $_{S1}$ and (8.7and 8.1%) $_{S2}$ over the control treatments ($Zn_{0.0}$) and for the two seasons, respectively. With respect to grains-N Zn concentration, and protein percentage, Zn- fertilization resulted in significant increments of (6, 17.4 and 6.1%) $_{S1}$ and (5.7, 15.2 and 5.7%) $_{S2}$ over the ($Zn_{0.0}$) treatments and for the two seasons, respectively. Similar results are in accordance with those stated by Sharaf (2008) and Ali *et al.*(2011) who obtained positive values of wheat yield and nutrient uptake when zinc was applied to the soil. Also, the present results are in agreement with that obtained by Prerna *et al.*(2014) who said that hazardous effects of saline water on wheat can be mitigated to some extent by applying zinc sulfate at the rate of 15 mg Zn kg^{-1} soil.

II- ***Interaction Effects:***

Table (4) reveals the significant interaction (gypsum application × organic fertilization × N fertilization × Zn- fertilization) effects on the wheat characters. With regard to wheat grain and straw yields, the higher values have been resulted by applying the treatments of ($GR \times OM_{20} \times N_{100} \times Zn_5$) and ($GR \times OM_{20} \times N_{100} \times Zn_{0.0}$) with obtainable increases of [(87, 82%) $_{S1}$, (96, 87%) $_{S2}$] $_{gr.y.}$ and [(73, 69%) $_{S1}$, (80, 74%) $_{S2}$] $_{st.\ y.}$ over the control treatments ($GR_{0.0} \times OM_{0.0} \times N_{0.0} \times Zn_{0.0}$) and for the two seasons, respectively. With respect to wheat grains-N Zn concentrations and protein content; the higher values have been obtained by applying of ($GR \times OM_{20} \times N_{100} \times Zn_5$) and ($GR \times OM_{20} \times N_{100} \times Zn_{0.0}$). The parallel increments were [(37, 30%) $_{S1}$, (31, 21%) $_{S2}$] $_{N}$, [(111, 85%) $_{S1}$, (98, 80%) $_{S2}$] $_{Zn}$, and [(37, 30%) $_{S1}$, (31, 21%) $_{S2}$] $_{prot.}$ over the control treatments and for the two seasons, respectively.

***Conclusions*:**

According to the above mentioned results; it could be concluded that:

1- For salt affected soil(saline-sodic soils or sodic) a double purpose could be realized at the same time (a) optimizing soil condition to improve physico-chemical properties and (b) increasing the availability of most nutrients for wheat plants such as nitrogen, zinc, and subsequently better yields. Therefore, the addition of gypsum with 100% (GR) prior wheat

cultivation resulted in higher wheat yield due to reaction in depressing soil-pH, soil-EC, soil-ESP and increasing the availability of most nutrients.

2- Better wheat yield have been obtained by organic manure fertilization (20 m^3.fed^{-1}) as a result of lowering soil-pH, soil-ESP and increasing N and Zn-use efficiency whether from soil or fertilizer sources.

3- Zinc sulfate fertilization of 5 kg Zn $fed.^{-1}$ led to higher wheat yields out of Zn-unavailability due to higher soil-pH and soil-ESP.

4- The significant interactions revealed that the efficiency of gypsum application or zinc sulfate fertilization have been affected with each other and with organic fertilization, that have been increased their efficiencies.

Therefore, the co-addition of the variables resulted in higher values of wheat yield and wheat grains- N Zn as well as protein concentration.

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أهمية إضافة الجبس الزراعي و السماد العضوي مع التسميد المعدني للنيتروجين و الزنك لمحصول القمح بالأراضي الملحية الصودية

محمد سعيد جنيدي * - أشرف محمد جوده عويس - محمود محمد صبح** - سعيد جنيدي*****

* قسم بحوث القمح – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية- مصر

** قسم الأراضي والمياه – كلية التكنولوجيا والتنمية – جامعة الزقازيق- مصر

*** قسم بحوث خصوبة الأراضي وتغذية النبات – معهد بحوث الأراضي والمياه – مركز البحوث الزراعية- مصر .

أقيمت تجربتان عامليتان حقليتان في موسمين متتاليين وبموقعين مختلفين علي محصول القمح [صنف مصر (٢)]٢٠١٥/٢٠١٦، ٢٠١٦/٢٠١٧ بمحطة البحوث الزراعية بسخا بمنطقة شمال الدلتا ، اشتملتا علي دراسة العوامل الأتية: الجبس الزراعي بمعدلي (صفر و الاحتياجات الجبسية للتربة)، التسميد العضوي بمعدلي (صفر –٢٠ م^{3} فدان$^{-1}$) في صورة سماد عضوي مصنع (compost) ، التسميد النيتروجين بمعدلي (صفر – ١٠٠ كجم ن ف$^{-1}$) في صورة كبريتات أمونيوم والتسميد بالزنك بمعدلي (صفر – ٥ كجم ز ف$^{-1}$) في صورة كبريتات زنك . كانت تربة التجربتان ذات قوام طيني طميي (clay loam) و متوسط تركيز الأملاح = ٦,٤ ديسيسيمنز م$^{-1}$ و رقم هيدروجيني = ٨,٣ ونسبة مئوية للصوديوم المتبادل = ١٨,١١ % و الصور الصالحة لعناصر النيتروجين و الزنك هي (٢٠,٥ –٠,٥٣ مللجم كجم $^{-1}$ علي الترتيب).**ويمكن إيجاز النتائج في الأتي :**

١- أدت إضافة الجبس الزراعي بالاحتياجات الجبسية للتربة قبل زراعة القمح إلي زيادة العائد المحصولي و نسبة البروتين في الحبوب وذلك بدرجة معنوية مقارنة بمعاملات المقارنة وذلك لدوره الإصلاحي لبعض الخصائص الكيميائية و الطبيعية لتلك الأراضي.

٢- أدت إضافة السماد العضوي بمعدل ٢٠ م^{3} فدان$^{-1}$ قبل زراعة القمح إلي زيادات معنوية في العائد المحصولي و نسبة البروتين في الحبوب وذلك مقارنة بمعاملات المقارنة وهذا يرجع إلي دوره في تحسين خصائص تلك الأراضي (الكيميائية و البيولوجية) مما أدي إلي زيادة الإمداد و الامتصاص لمعظم العناصر المغذية للنبات.

٣- أدي إضافة التسميد المعدني للنيتروجين بالمعدل المناسب و الموصي به (١٠٠ كجم ن ف$^{-1}$) و كذلك التسميد بالمعدل المناسب للزنك (٥ كجم ز ف$^{-1}$) إلي زيادات معنوية في العائد المحصولي و نسبة البروتين في الحبوب وذلك مقارنة بمعاملات المقارنة.

٤- أدت الإضافات المشتركة من تلك العوامل إلي الحصول على أعلي زيادات معنوية في العائد المحصولي و نسبة البروتين في الحبوب وذلك مقارنة بمعاملات المقارنة.

التوصية :