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EFFECTIVENESS OF APPLYING NATURAL SOIL CONDITIONERS UNDER MOISTURE REGIMES ON SANDY SOIL PROPERTIES AND CEREAL CROPS PRODUCTION

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ABSTRACT

Two experimental sites of arable sandy soil located at Abou Omera Al-Sharkeya village , Baltim district, Kafr El-Sheikh Governorate were chosen. The selected locations represent the conditions of circumstances of northern part of Nile Delta region. Site ١ (fruit field) was devoted for collecting composite surface soil sample for carrying out wheat pot experiment in plastic pots during the growing winter season period ٢٠١٠/٢٠١١. Site ٢ (nearby site ١) was occupied for conducting maize field experiment during growing summer season period ٢٠١١. The main objectives of this investigation were to study and evaluate the effect of natural raw minerals, soil conditioner types, their mixtures and application rates in sandy soil subjected to different irrigation deficits on the following parameters: **(i)** soil properties(chemical, physical, moisture constants and nutritional status after cereal crops harvesting and **(ii)** agronomical production of wheat and maize crops after full maturity in the studied soil under consideration.

Four types of soil conditioners [bentonite , compost , mixture of natural mineral raw materials (MNRM)and their mixtures ١:١:١(w/w)] were applied before cultivation in two recommended application rates low ($R_١$) and high ($R_٢$). Three levels of soil moisture depletion regimes were used (٣٠, ٥٠ and ٧٠ %) from its available water capacity. The N,P,K mineral fertilizers were added according to the recommended doses for sandy soils. Applying natural soil conditioner types, their mixtures and application rates in the studied sandy soil subjected to moisture depletion regime realized improving soil chemical, physical, water holding capacity and macro nutritional status. Soil salinity (soil reaction, electrical conductivity and ionic strength), hazard sodium parameters (soluble sodium percentage and sodium adsorption ratio), soil porosity, available water capacity and phyto – available nutrients were increased. On the other hand, hydraulic conductivity and bulk density were decreased. Generally, high application rate achieved the best values of soil properties in comparison with low application rate. Conditioner mixtures ١:١:١ treatment realized the superiority under wheat pot experiment, meanwhile, compost treatment achieved the best values under maize field experiment. Irrigation after ٥٠ % AWSMD gave moderate values of such properties between wet (٣٠٪ AWSMD) and dry (٧٠٪ AWSMD). Increasing grains, straw, protein, grains weight, harvest index and other yield components significantly for wheat and maize crops, as a result of adding soil conditioners compared with control. Conditioner mixtures ١:١:١ treatment realized the superiority under wheat pot experiment, meanwhile, compost treatment achieved the best values under maize field experiment. Also, high application rate was better than low application rate. Results also indicated that , from view point of water and economic , the highest values of crop yield were obtained from irrigation at ٥٠ % depletion from its available water capacity rather than ٣٠ % and ٧٠ % respectively.

Keywords: Guelph permeameter apparatus; Time Domain Reflectometer (TDR apparatus); Composting; Nutrients – phytoavailability; Sandy soils; Water irrigation management; Soil conditioners; Cutthroat flumes.

INTRODUCTION

Nowadays, the term of « sustainable agriculture » is widely used in world wide, which is keystone of the rational utilization of soils as one of our most important natural resources. It is the important aims of « sustainable agriculture » to protect and maintain of the multifunctions of soils (Varallyay, ٢٠٠٥). For preservation and sustainability the productivity of soil we have to take special regard to sandy soils having unfavorable properties. Sandy soil characterized by less than ١٨ % clay and more than ٦٨ % sand in the first ١٠٠ cm of the soil depth are the poor soils that occur in many parts of the world (van Wambeke,١٩٩٢). There are other problems facing agriculture sector caused by, mainly, inappropriate soil, water and fertile management practices as well as rapid decreasing of agricultural land particularly in Delta soils. Therefore, we have to find rapid solutions to face these problems. Sandy soils hold little water as the large pore spaces allow water to drain freely from soil. The productivity of these soils is limited by low water holding capacities, high infiltration rates, high evaporation, low inherent fertility levels, very low organic matter content and excessive deep percolation losses. Also, the water use efficiency of the crops cultivated in such soil is low.

Tackling these problems can be achieved through applying organic amendments, natural raw minerals and soil conditioners. These materials improve the retentative capacities of these soils and allow plants to get their water requirements and phyto –available nutrients easily.

Cereal crops such as (wheat and maize) are very strategically important crops in Egypt because it's constituent and indispensable part of Egyptian food diet. Generally, there is a great gap between the consumption and production of such crops. On the other hand, it is worthnoting that, the agriculture production in Egypt is mainly depend upon irrigated agriculture. The gap between supplies and demands of water is widening with increasing global population. We are suffering from this trouble, especially when we know that we are under water poverty limit. Because of the water limitation, one of the most important targets in the agriculture sector is how to save irrigation water and increase water use efficiencies. So, new techniques and practices are needed to achieve water save. Estimating irrigation water becomes important for project planning and irrigation management. The over irrigation practiced by the farmers usually leads to low irrigation efficiency. So it is necessary to ascertain to what extent the water in the root zone can be depleted to produce high economic yield with using little water applied . Planning best irrigation regimes is very important for maintaining available irrigation water. The proper water management (irrigation scheduling) not only accurates determination of crop water requirements but also helps to know when and how much water should be applied to get high efficiency of each unit of water. Regulated deficit irrigation is one of such practices. Many studies indicated that the deficit irrigation was a successful technique in crops irrigation, Omran(٢٠٠٥) and Seif *et al*.(٢٠٠٥). The main objectives of this investigation were to study and asses the effect of natural soil conditioner types, their mixtures and application rates in sandy soils subjected to irrigation regimes on:

(i):Soil physico-chemical properties, moisture constants and nutritional status.
(ii):Agronomical production of wheat and maize crops after full maturity.

MATERIALS AND METHODS

Two selected sites represent arable sandy soil located at Abou-Omera Al-Sharkeya village , Baltim district, Kafr El-Sheikh Governorate ٣١° ٣٤ ٤٠,٦ N latitude and ٣١° ١٠ ٥٥,٥ E longitude with an elevation of about ٥ meters above sea level were chosen. Site ١ (fruit field) was devoted for collecting composite surface soil sample for carrying out wheat pot experiment in plastic pots during the growing winter season period ٢٠١٠/٢٠١١. Site ٢ (nearby site ١) was occupied for conducting maize field experiment during growing summer season period ٢٠١١. After wheat and maize plants full maturity, representative composite disturbed soil surface samples were collected, air dried, crumbled by hand, homogenized and finely ground in steel mill to pass through ١٠٠-mesh (٠,١٥ mm opening sieve) and thoroughly mixed.

Generally, soil chemical characterizations of the studied soils before cultivation and directly after cereal crops harvesting as well as properties of the used matured co-compost and irrigation waters were performed using classical methods as reported and explained by Cottenie *et al*.(١٩٨٢); Page *et al*.(١٩٨٢); Carter(١٩٩٣); Rowell (١٩٩٦); Tan(١٩٩٣) and Burt(٢٠٠٤) as tabulated in all Tables in this work. Ionic strength (mmoles $L^{-١}$): was calculated using the following equation as explained by Tan(١٩٩٣).

Ionic strength (mmoles $L^{-١}$) = $½ \sum_{i=١}^{i=n} M_i Z_i^{٢}$

Where: Mi = conc. of ion (i) in mmoles $L^{-١}$ and Zi = charge of ion (i).

Additionally, undisturbed vertical cylindrical volumes of field-moist soil samples were gently obtained using cylindrical sharp edged core samplers for estimating soil physical properties and soil moisture constants using routine work analysis methods as reported and described by Garcia(١٩٧٨); Klute(١٩٨٦); Okalebo *et al*.(١٩٩٣) and Reynolds ١٩٩٣(a,b). Soil moisture constants (field capacity, permanent wilting point and available water capacity) were measured and calculated by means of pressure cooker and pressure membrane apparatus for measuring moisture contents at pressures of ٠,٣٣ and ١٥ bar according to Garcia(١٩٧٨) and reported by Klute(١٩٨٦). Bulk and particle (real) densities were estimated as described by Blake and While, field saturated hydraulic conductivity *in situ* was determined using constant head well permeameter method employing Guelph permeameter apparatus as mentioned by Reynolds(١٩٩٣b). All soil obtained values were calculated on oven dry weight basis ١٠٥ C ° for ٢٤ hours. Some chemical properties of the different irrigation water sources under consideration during the carrying out of pot and field experiment periods are listed in Table (٣).The suitable experimental design was selected for both pot- and field experiments. The wheat pot experimental cross-sectional area was ٠,٠٤٥٣ $m^{٢}$, while maize experimental plot area was ٤,٥ $m^{٢}$ (١,٥x٣ m).The experimental design was split-split plot arrangement with three replications. The main plots were devoted to three irrigation treatments as follows: Wet – treatments (light irrigation) after ٣٠ % AWSMD from soil available water capacity; Medium – treatments (moderate irrigation) after ٥٠ % AWSMD from soil available water capacity (٥٠٪ AWSMD)and Dry treatments (heavy irrigation)after ٧٠٪ AWSMD from soil available water capacity (٧٠٪ AWSMD).Wheat and maize plants were exposed to deficit irrigation and started directly after life watering irrigation (El-Mohayaa irrigation) for achieving the selected available soil moisture depletion levels under consideration.Detailed experimental obtained data about irrigation scheduling and the actual seasonal applied water for wheat and maize crops production cultivated in loamy sand soils subjected to soil moisture depletion regimes over the growing winter and summer season periods ٢٠١٠/٢٠١١ and ٢٠١١ are tabulated in Tables(٦ and ٧). The sub –plots were assigned to five types of soil conditioners and their mixtures ١:١:١(w/w). The conditioner treatments (w/w) were applied as follows: Control (without additions); Bentonite at application rates of ٠,٢ % and ٠,٣٪. ; Co-compost at application rates of ٠,٣ % and ٠,٥ %; Mixture of Natural Raw Minerals (MNRM) at application rates of ٠,٢ % and ٠,٣ %; and the mixtures of the three previous conditioners in ١:١:١ ratio at rates of ٠,٢٣٣٪ and ٠,٣٦٧٪. The soil conditioner treatments were randomly distributed in the three main plots.

Table (١): Initiative physico-chemical characteristics of the selected arable experimental sites under consideration located at Abou-Omera Al-Sharkeya village, Baltim district before planting

*** Site(١): Properties of disturbed and undisturbed surface soil(٠-٣٠ cm)just before collection and transportation for wheat crop cultivation in pot-experiment.**

*** Site(٢): Properties of disturbed and undisturbed surface soil just before cultivation of maize crop field –experiment.**

These conditioner types are mixed well with soil during its preparation for cultivating wheat before sowing and incorporated into soil surface before plowing during soil service process and its preparation before maize planting. Sub sub plots were occupied with two application rates as follows: $R_١$ and $R_٢$ were (low) minimum and (high) maximum recommended application rates respectively Mixture Natural Raw Minerals (MNRM) and bentonite were purchased from Al-Ahram company for mining, natural minerals (ores) and fertilizers. These materials are the new products from Al-Ahram Company for improving soil properties and fertility. The chemical analysis of these materials listed in Table (٤). The analytical data of elemental oxides were kindly obtained from Al-Ahram company. These natural minerals were used as soil conditioners for wheat pot – and maize-field experiments.

Seeds of wheat plants (*Triticum aestivum*, Sakha ٩٣ variety) were obtained from Crop Agronomy Research Department, Sakha Agriculture Research Station, Ministry of Agriculture and Land Reclamation.Wheat pot-experiment was conducted on experimental research area of Sakha Agriculture Research Station, Kafr El-Sheikh city. Pot experiment was performed using cylindrical perforated plastic pots having (mean internal diameter ٢٤ cm and height ٢١ cm) under wire proof greenhouse conditions. Pot cross-sectional area was ٠,٠٤٥٣ $m^٢$ and its interval volume ٩,٥٠٤ liters. Composite loamy sand soil was collected and brought from fruit field (Site ١) located at Abou-Omera east village, Baltim district as mentioned before. Each pot contained ١٠ Kg soil on oven dry weight basis , wheat cultivation elongated ١٣٥ days. Throughout the wheat growth period, a freely drained water was collected from each plastic pot and reused again with irrigation water and also whenever it was necessary.

Grains of maize plants (*Zea mays,L*) three cross ٣٢١ variety were obtained from Maize Research Center, Agriculture Research Center, Ministry of Agriculture and Land Reclamation. Maize field- experiment was carried out on cultivated area of Abou-Omera east village (Site ٢), Baltim district during the growing summer season period ٢٠١١elongated ٩٣ days. Total rented area = ٣,٥ kyrat =٦١٢,٥ $m^٢$ and net cultivated area ٤٠٥ $m^٢$ (٩٠ plots). Experimental plot area was ٤,٥ $m^٢$ (١,٥ x ٣) and its weight ١٠٤٦,٢٥ kg loamy sand soil on oven dry weight basis.

Table (٢): Soil moisture constants and its nutritional status of the selected experimental sites under consideration located at Abou-Omera Al-Sharkeya village, Baltim district before planting.

Soil variables	Obtained values	
	Site (١)* Pot-experiment	**Site(٢)** Field-experiment**
Soil moisture constants		
Soil field capacity(S.F.C) %	١٧,٠	١٨,٠
Soil permanent wilting point(P.W.P) %	٨,٥٠	٩,٠٠
Soil available water capacity(A.W.C) %	٨,٥٠	٩,٠٠
Soil nutritional status		
Total organic-C %	٠,١٧٤	٠,٢٣٢
Organic matter(O.M) %	٠,٢٩٨	٠,٤٠٠
Available macro-nutrients		
Available – N(K-sulphate extractable) *m*gkg^{-1} soil	١٨,٢٨	٢١,٥
Available – P($NaHCO_3$ extractable) *m*gkg^{-1} soil	٧,٦٢	٨,٩٠
Available – K(NH_4-acetate extractable) *m*gkg^{-1} soil	٥٠,١٥	٥٣,٥
Available micronutrients		
Available – Fe(DTPA extractable) *m*gkg^{-1} soil	٦,٠٠	٦,٥٠
Available - Mn(DTPA extractable) *m*gkg^{-1} soil	٤,٤٥	٥,٠٠
Available-Zn(DTPA extractable) *m*gkg^{-1} soil	١,٢٠	١,١٠
Available – Cu (DTPA extractable) *m*gkg^{-1} soil	٠,٣٤	٠,٦٦

Notes : See feet notes of Table(١).

Aerobic / Thermophilic co-composting process was carried out at the experimental farm of Soil Improvement and Conservation Research Department, Sakha Agriculture Research Station during the summer growing season elongated five months from May ٢٠١٠ to October ٢٠١٠. Pyramidical piles(heaps) ٢,٥ × ٢,٥ ×١.٥ m were built up under aerobic conditions. Different solid bio-wastes were used as substrates and augmented organically with farmyard manure (١٠ % w/w) as microbial organic activator as well as with urea , super phosphate and potassium sulfate as microbial chemical activators. The other certain additional materials were incorporated into for speeding up the conversion and improving the final product quality and as growth promoting substances, pH buffering agents and as bulking agents . The obtained chemical and physical characteristics of the used matured co-compost after co- composting process are listed in Table (٥). This matured co-compost was used as soil conditioner.

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Table (٤): Chemical analysis of the used natural raw minerals and soil conditioners

Characteristics	Values	
	Bentonite	**MNRM**
Elemental oxides: %		
$SiO_{٢}$	٥٥,٩	٣٩,٣٦
$TiO_{٢}$	٠,٢٠	٠,٨١
$Al_{٢}O_{٣}$	٢٠,٠	٧,٦٨
$Fe_{٢}O_{٣}$	٠,٧٠	٤,٠٥
MnO	٠,٠٠١	٠,٦٧
MgO	٠,٦٥	٣,٢٠
CaO	٢,٧٠	١٥,٠٧
$Na_{٢}O$	١,٧٦	١,٩٥
$K_{٢}O$	٢,٤٠	٣,٩٤
$P_{٢}O_{٥}$	٠,٨٠	٧,٣٣
$SO_{٣}$	-	٥,٨٣
Loss on ignition	١٠,٠	٩,١٤
ECe dS $m^{-١}$ (١:١٠ Bentonite-water extract(w/v)	١,٨٢	
pH (١:٢,٥ bentonite-water suspension (w/v)	٧,١٢	
Total soluble cations ($m$eq $L^{-١}$) (١:٥ extracts)		
$Ca^{+٢}$	٠,٧٩	
$Mg^{+٢}$	٠,٢٧	
Na^{+}	١,٩٥	
K^{+}	٠,٠٢	
Total soluble anions ($m$eq $L^{-١}$) (١:٥ extracts)		
$CO_{٣}^{=}$	-	
$HCO_{٣}^{-}$	٠,٢٤	
Cl^{-}	١,٥٩	
$SO_{٤}^{=}$	١,٠٦	
Cation exchange capacity, cmoles $kg^{-١}$	٥٩,١٣	
Calcium carbonate %	١٤,٢٧	
Particle size distribution %		
Clay fraction	٨٥,٧٥	
Silt fraction	١٠,٥٤	
Sand fraction	٣,٧١	

Notes:

١- MNRM: Mixture of Natural Raw Minerals

٢- The analytical results of the elemental oxides were kindly obtained from Al-Ahram company for mining and natural fertilizers.

Table (٥): Chemical properties of the used co-compost directly after composting process

Characteristics	Values
Dry weight (kg m$^{-٣}$)	٦٥٠,٠
Moisture content (%)	٢٥,٥
Odour and colour	Acceptable and dark
pH (١:١٠ compost-water suspension w/v)	٧,١٦
EC (١:١٠ compost – water extraction w/v)	٥,٢٣
Total soluble salts(soil paste –water extraction ١:١٠)%	٠,٣٣٥
Saturation percentage % (g/١٠٠g	١٧٥,٠
Total soluble salts (compost material)% (g/١٠٠g compost)	٠,٥٨٦
CEC (cmole kg$^{-١}$)	٦٤,٣٤
Total organic – c %	٢٥,٥
Total organic matter %	٤٣,٩٦
C/N ratio	٢١,٩٨
Total macro-nutrients %	
Total – nitrogen %	١,١٦
Total – phosphorus %	٠,٥٣
Total – potassium %	٠,٣٧
Available macro-nutrients (*m*g kg compost)	
Available – N (potassium sulfate)	١٠٠
Available – P (٠,٥ M $NaHCO_٣$- pH ٨,٥)	٥٠
Available – K (ammonium acetate pH ٧)	٨٥
Available micro-nutrients (*m*g kg compost)	
Available – Fe	٤٥٠
Available – Mn	١٠٠
Available – Zn	٣٥
Available – Cu	١٣٥
Total micro-nutrients (*m*g kg compost)	
Total –Fe	٧٥٣
Total – Mn	٣٦١
Total – Zn	٢٩٧
Total – Cu	١٦٨
Available heavy metals (*m*g kg compost)	
Available – cd	١٣,٢
Available – Ni	٦٢,٧
Available – pb	١٢٠

Irrigation water supply:

Irrigation water supply and number of irrigations were limited according to the levels of soil moisture depletion regimes. Consequently, soil moisture content at demand depletion levels determines the timing of irrigation. Soil moisture content directly before irrigation at which calculated applied water must be added immediately for arriving at soil field capacity was measured in *situ* using TDR apparatus (Time Domain Reflectometert). Magnitude of irrigation applied water were calculated using the following soil moisture depletion equation as reported by (Israelson and Hansen, ١٩٦٢) during wheat and maize growing season periods.

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$$Q = \frac{SFC - CMC}{100} \times Bd \times D \times A$$

Where: Q = Quantity of applied water m٣ pot-١ /irrigate for pot-experiment, and m٣ plot-١ /irrigate for field –experiment ;SFC = Soil field capacity (%) in percent by volume; CMC = Soil moisture content just before irrigation using TDR apparatus; Bd = Soil bulk density Mg m-٣ ; D = Soil depth (m), effective root depth or soil depth required to be irrigated; and A = pot or plot experimental area (m٢) that would be irrigated. With respect to maize field water measurements, the magnitude of planting and life watering irrigates were measured and applied using cutthroat flume(٢٠ ×٩٠ cm)according to Early(١٩٧٥).

A common NPK-fertilization was applied to the soil active root zone during the wheat and maize growing seasons according to the recommended doses of Ministry of Agriculture for wheat and maize crops under sandy soil conditions.

At harvesting time after wheat and maize plants full maturity, biomass grains and straw yields were fairly hand pulled and collected from each wheat pot experiment as well as from inner two rows of central area of maize plots. Some agronomical characteristics of these cereal crops and their productions such as (biomass grains, straw, biological yields and weight of ١٠٠٠ wheat grains and ١٠٠ maize grains) as well as yield vegetative features as affected by soil conditioner types, their mixtures and application rates under irrigation deficits in the studied sandy soil were weight, measured, estimated, recorded and calculated some other parameters. Harvest index(%) was calculated as follows:

HI % = biomass grains yield / biological crop yield × ١٠٠

Statistical analysis:

Analysis of variance was done according to (Snedecor and Cochran,١٩٧٦) using the Irristat software, version ٤,١ according to Biometrics Unit,١٩٩٨, IRRI(١٩٩٨).

RESULTS AND DISCUSSION

Effect of applying soil conditioners under irrigation deficits on soil properties after cereal crops harvesting

Chemical characteristics of soil suspensions and extractions:

Concerning the effect of applying natural soil conditioner types, their mixtures(١:١:١) and application rates in sandy soils subjected to soil moisture depletion regimes (٣٠٪, ٥٠ % and ٧٠ %) from their available water capacities after wheat and maize crops harvesting on soil salinity (pH, EC dS m-١, and ionic strength mmole L-١) and hazard sodium parameters (SAR and SSP %) are listed in Tables (٨,١ and ٨,٢). Generally, the analytical chemicals results listed in aforementioned tables illustrate that values of these chemical parameters in the studied soil on the average of other studied parameters (irrigation treatments and conditioner application rates) were markedly increased due to the application of soil conditioner types in comparison with control values (without additions). These increase could be arranged in the following descending order as follow: Mixtures (١:١:١) > MNRM > Bentonite > Compost >> control .

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It is obviously that, the highest values were achieved as a result of mixtures application, meanwhile, the lowest values were obtained by dressing the compost treatment. However, the highest pH values were recorded at MNRM application under wheat pot experiment. Meanwhile, the lowest values of I.S were obtained at the application of bentonite under field-maize experiment.

On the other hand, these studied chemical properties, on the average of the other studied parameters (conditioner types, and their application rates),were markedly increased with increasing the depletion regimes from its soil available water capacity. Where, the highest values of these chemical parameters were achieved under dry treatment (٧٠ % AWSMD), meanwhile, the lowest values were recorded under wet treatment (٣٠ % AWSMD). Medium treatment had the moderate values between wet and dry treatments. The analytical obtained increments could be rearranged in the following ascending order: Wet –treatment (٣٠ % AWSMD) < Medium – treatment (٥٠ % AWSMD) < Dry – treatment (٧٠ % AWSMD). This could be attributed to the dilution effect , since, salt concentration was decreased with increasing irrigation applied water. As delineated in Tables (٨.١ and ٨.٢), obtained values of the studied chemical properties on the average of the other studied parameters (condition treatments and irrigation regime treatments)were higher under high application rate($R_٢$) rather than under low application rate ($R_١$) at the same conditions. Data listed in Table (٨,٢) reveal also that under maize field experiment , the studied chemical properties were increased with adding soil conditioner types and their mixtures (١:١:١) on the overall average of the other studied parameters (irrigation treatments and conditioners application rates) in comparison with their control –values (without additions) at the same conditions. These parameters mannered the following descending order: Mixtures (١:١:١) > MNRM > Bentonite > Co-compost > Control. Generally, the obtained values of chemical properties after wheat crop harvesting were higher than those obtained after maize crop harvesting.

Soil physical properties:

Concerning the effect of natural soil conditioner types, their mixtures ١:١:١ (w/w) and application rates under soil moisture depletion levels from its available water capacity on soil physical properties after wheat and maize crops harvesting are presented in Tables(٩,١ and ٩,٢). Generally, the results collected in Table(٩,١) show that, on average of other studied parameters (irrigation treatments and conditioner application rates), that saturated hydraulic conductivity SHC (m day$^{-١}$) and bulk density D_b(Mg m$^{-٣}$)were markedly decreased as a result of adding soil conditioner types and their mixtures (١:١:١) in the studied soil after wheat crop harvesting in comparison with their control values. The magnitude of these decrements which less the control values were depended upon the types of these conditioners. It is clearly that, the lowest values were achieved and accompanied with applying conditioner mixtures ١:١:١ (w/w) treatment. Meanwhile, the highest values were obtained with the dressing compost conditioner in comparison with their control values. These decrements could be arranged in the following descending order as follows: Mixtures ١:١:١ > MNRM > Bentonite > compost > control. Oppositely, as demonstrated in the above mentioned Table,

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soil porosity values were mannered the opposite trend, where such values were increased over the control –values with adding soil conditioners and had the following sequence:

Mixtures (١:١:١) < MNRM < Bentonite < Compost < Control

Commonly, the obtained values of all studied physical properties on the average of the other studied parameters (conditioner treatments and irrigation treatments) under the high application rate ($R_{٢}$) were lower than those obtained under the low application rate ($R_{١}$). On the other hand, it was clearly apparent that, SHC values were gradually increased with increasing water irrigation deficits. However, D_b and ρ_T had the opposite trend, which decreased with increasing soil moisture depletion levels for its available water capacity. SHC – increments as well as D_b and ρ_T decrements with increasing moisture depletion levels could be arranged in the following descending order as follows:

Wet – treatment (٣٠٪ AWSMD) > Medium – treatment (٥٠٪ AWSMD) > Dry – treatment (٧٠٪ AWSMD)

In respect of maize field experiment, data demonstrated in Table (٩,٢) show on average of irrigation treatments that, application of all natural soil conditioner types and their mixtures (١:١:١) resulted in decreasing saturated hydraulic conductivity and soil bulk density, as well as led to increasing total porosity in comparison with their control values at the same conditions. It was clear that, conditioner mixtures (١:١:١) realized the lowest values of SHC and ρ_T besides the highest values of D_b in comparison with their control values. However, application of co-compost treatment mannered the opposite trend, which gave the highest values of SHC and ρ_T in addition to the lowest values of $D_{b.}$ Generally, it was apparent from the results that, on average of irrigation treatments and conditioner treatments that, adding high application rates lowered gradually SHC and D_b and raised the values of $\rho_{T.}$ In this direction, the low application rates led to the opposite trend. Commonly, analytical data listed in Tables (٩,١ and ٩,٢) illustrate, on average of all other studied parameters(conditioner treatments and application rates) that, SHC and ρ_T values were gradually increased with increasing soil moisture depletion levels from its available water capacity. However, D_b values were decreased with increasing irrigation deficits.

Soil moisture constants:

As concerns, field capacity (SFC %), permanent wilting (PWP %) and available water capacity (AWC%) values of the studied sandy soils which reflect their soil water holding capacity after wheat and maize crops harvesting as affected by soil conditioner types, their mixtures and application rates under soil moisture depletion regimes, are presented in Tables (١٠,١ and ١٠,٢) respectively. The obtained results, demonstrate, on average of the other studied parameters (irrigation treatments and conditioner –application rates) that, these soil moisture constants were obviously increased by applying soil conditioners and their mixtures (١:١:١) in comparison with their control values at the same conditions.

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Generally, these increments over the controls in studied soil after wheat crop harvesting could be arranged in the following sequence as follows:

Mixtures (١:١:١) > MNRM >Bentonite > Compost > Control

Regarding maize field experiment, data listed in Table (١٠,٢) reveal, on average of other studied parameters that, values of soil moisture constants also were increased in comparison with their control values at the same conditions by applying soil conditioner types and their mixtures (١:١:١). These increments of all soil moisture constants in studied soil after maize crop harvesting could be rearranged in the following sequence as follows :

Compost > Mixtures (١:١:١) > MNRM > Bentonite > Control

High conditioners application rate generally was realized higher values than those obtained by low conditioners application rate. As delineated in Table (١٠,١) it was clearly apparent on average of the other studied parameters, that these water properties were gradually decreased with increasing soil moisture depletion levels for its available water capacity. The highest values were achieved under wet – treatment (٣٠٪ AWSMD) while, the lowest values were given by dry – treatment (٧٠٪ AWSMD). Medium – treatment (٥٠٪ AWSMD) recorded the moderate values of these soil moisture constants between wet(٣٠ % AWSMD) and dry(٧٠ % AWSMD)treatments.

Analytical results show that applying conditioner-mixtures (١:١:١) show its superiority over all other conditioner types under wheat –pot experiments. Meanwhile, applying compost treatment show its superiority over all other conditioner types under maize field experiment.

Effect of applying soil conditioners under irrigation deficits on soil macronutrients content:

Concerning residual contents (concentrations) of (N and P) after wheat and maize crops harvesting as affected by soil conditioner types, their mixtures and application rates subjected to irrigation deficits were listed in Table (١١,١). Analytical results listed in this table reveal that, on average of other studied parameters (irrigation treatment and conditioner application rates), that N and P macronutrients content in studied sandy soils were increased by adding soil conditioner types and their mixtures (١:١:١) after wheat and maize crops harvesting in comparison with their control values.

The highest values of residual N and P were achieved and accompanied by mixtures (١:١:١) treatment. Meanwhile, dressing compost treatment gave lower values than those obtained by applying mixtures treatment in comparison with their control after pot wheat experiment at the same conditions.

Oppositely, residual N and P macro nutrients in the studied soil after maize crop harvesting behaved the opposite trend, where, the highest contents of these nutrients were achieved by applying compost treatment. However, the dressing conditioner mixtures gave values lesser than those obtained by adding compost treatment. The lowest values were absolutely obtained in the studied soil by adding bentonite treatment after either wheat or maize crop harvesting. These increments of the residual N and P macronutrients content after wheat crop harvesting could be arranged in the following sequence as follows:

Mixtures treatment > MNRM > Compost > Bentonite > Control. Moreover, on average of other studied parameters, obtained residual values of these macronutrients under high rate realized slightly values higher than those obtained under low application rate for either wheat or maize crops harvesting.

It was clearly apparent as delineated in Table (١١,١) on average of other parameters, that content of macronutrients (N and P)in the studied sandy soil after wheat and maize crops harvesting under medium –treatment (٥٠٪ AWSMD) were realized the highest values then under wet –treatment, while, the lowest values were obtained under dry-treatment. Residual contents of N and P macronutrients after maize crops harvesting could be also arranged in the following descending order: Compost treatment > MNRM > Mixtures > Bentonite > Control. Residual N and P macronutrients in studied sandy soils after wheat and maize crop harvesting could be arranged in the following descending order as: Medium –treatment (٥٠٪AWSMD) > Wet –treatment (٣٠٪ AWSMD) > Dry-treatment (٧٠٪ AWSMD). From the abovementioned results, it could be concluded that, on average other studied parameters, residual N and P macronutrients content in studied soils after crops harvesting means low exhausting nutrients from soils during the growing seasons of wheat and maize crops.

Effect of dressing soil conditioners under moisture depletion regimes on agronomical crops production

Biomass grains and straw yields:

Regarding wheat crop pot experiment after full maturity, data listed in Tables (١٢,١, ١٢,٢ and ١٢,٣) demonstrate, on average other studied parameters (irrigation treatments and conditioner application rates), that application of soil conditioner types and their mixtures (١:١:١) resulted in significantly increasing wheat biomass grains yield, thousand grains weight, harvesting index and biomass straw yield in comparison with their control values at the same conditions.

Moreover, on average of the other studied parameters, the values of these agronomical features under high application rate ($R_{٢}$) were higher than those obtained under low application rate ($R_{١}$). The increments of these agronomical traits could be arranged in the following descending order as: Mixtures (١:١:١) > MNRM > Bentonite > Compost > Control. So, the highest values of these agronomical features in studied sandy soils were achieved and accompanied by applying conditioner – mixtures treatment. Meanwhile, applying compost treatment gave the lowest values. However, the analytical obtained data, on average of the other studied parameters (conditioner treatments and their application rates) reveal that all agronomical features with the exception of harvest index were gradually decreased with increasing soil moisture depletion levels from its available water capacity. The magnitude of these decrements could be arranged in the following descending order as: Wet-treatment (٣٠٪ AWSMD) > Medium –treatment (٥٠٪ AWSMD) > Dry –treatment (٧٠ % AWSMD).

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However, harvest index (%) was slightly increased with increasing irrigation deficits. Therefore, these increments could be arranged in the following sequence as: Dry–treatment (٧٠ % AWSMD) > Medium–treatment (٥٠٪ AWSMD)>Wet-treatment (٣٠٪ AWSMD).

Concerning field maize crop after full maturity, tabulated data show on average other parameters (irrigation treatments and conditioner application rates) that, dressing soil conditioner types and their mixtures ١:١:١ (w/w) led to increasing significantly biomass maize grains yield, hundred grains weight, harvesting index and biomass straw yield in comparison with their control values at the same conditions with the exception of harvest index. Moreover, the values of these agronomical features under high application rate ($R_٢$) gave higher values than those obtained under low application rate ($R_١$) with exception of H.I which behaved the opposite trend i.e. $R_١$ > $R_٢$. On the other hand, the obtained data under wet treatment (٣٠٪ AWSMD) on average of the other studied parameters (conditioners treatment) that compost treatment gave the highest values of these studied parameters except harvest index which had an opposite trend, where the highest values were obtained by adding their mixtures in comparison with compost application. It could be due to increasing straw yield of compost treatment as comparison with under their mixtures treatment. The lowest obtained values were generally recorded under bentonite treatment. However, such parameters under medium and dry treatments behaved the opposite trend in comparison with wet treatment, since the maximum values of biomass grains yield, ١٠٠ grain weight and harvest index were realized under mixtures treatment. Meanwhile, the biomass straw yield under compost treatment was higher than those obtained under mixture treatment. Generally, mean values of these parameters under medium treatment were higher than those obtained under wet and dry treatments and behaved the following order: Medium > Wet > Dry. Such results were obtained by Abdel-Reheem and Hassan (٢٠١١) , they found that the highest values of wheat water productivity and yield were achieved when irrigation at ٥٠ % depletion from available water , compared to ٧٠ % and ٤٠ % depletion in the loamy soils. confirming this conclusion, similar responses of maize crop production under field conditions was also reported by Khalifa (٢٠١٣), who stated that, irrigation at ٥٠ % SMD gave the highest values of yield and its components of maize crop.

Crop yield components:

As regards to wheat and maize crops vegetative features after full maturity as affected by soil conditioner types, their mixtures and application rates subjected to different levels of irrigation deficits were presented in Tables (١٢,٤ and ١٢,٥). Obtained data shown in Table (١٢,٤) reveal on average of the other studied parameters that, the following wheat crop vegetative features (plant height, number of tillers/ spike; number of spikelets/spike; spike length and panicle mean weight were markedly increased as a result of adding soil conditioners and their mixtures ١:١:١ (w/w). These increments could be arranged in the following descending order:

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Mixtures ١:١:١ treatment > MNRM treatment > Bentonite treatment > Compost treatment > Control. Furthermore, the mean values of these crop vegetative features under high application rate (R٢) were higher than those obtained under low application rate (R١) i.e. R٢ > R١. On the other hand, on average of the other parameters, all these features were gradually decreased with increasing soil moisture depletion levels from its available water capacity. Consequently, these obtained decrements could be arranged in the following order as: Dry –treatment (٧٠٪ AWSMD) < Medium –treatment (٥٠٪ AWSMD) < Wet-treatment (٣٠٪ AWSMD).

With respect to maize field crop vegetative features after full maturity, data were listed in Table (١٢,٥). Obtained data show, on average of the other parameters, that some maize crop vegetative features such as plant height, ear weight, and ear length were obviously increased by adding soil conditioners and their mixtures ١:١:١ (w/w). High application rate (R٢) recorded values higher than those obtained by low application rate (R١). So, under field experiment, compost treatment gave the high values in comparison with mixtures treatment at the same conditions, bentonite treatment realized the lowest values. Respecting irrigation regimes under field experiment, data show on average of the other studied parameters that medium –treatment (٥٠٪ AWSMD) gave the highest values followed by wet –treatment (٣٠٪ AWSMD), while, dry –treatment recorded the lowest values.

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فاعلية إضافة محسنات التربة الطبيعية تحت مستويات استنزاف رطوبى على خواص التربة الرملية وانتاجية محاصيل الحبوب

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الهدف من البحث هو دراسة تأثير اضافة محسنات التربة الطبيعية ومخاليطها تحت مستويات من الاجهاد الرطوبى على خواص التربة الرملية وانتاجية بعض محاصيل الحبوب.

لهذا الغرض اقيمت تجربتان في موقعان يمثلان الأراضي الرملية بمصر بقرية ابوعميرة الشرقية، مركز بلطيم، محافظة كفر الشيخ. الموقع الاول حقل فاكهة اخذت منة عينات سطحية مركبة مثارة واخرى غير مثارة، تم دراسة صفاتها الكيميائية والفيزيائية والمائية لإجراء تجربة قصارى لزراعة القمح بمحطة البحوث الزراعية بسخا خلال الموسم الشتوي ٢٠١١/٢٠١٠ استمرت ١٣٥ يوم، والموقع الثاني قريب من الاول تم استخدامه لإجراء تجربة حقلية لزراعة الذرة في الموسم الصيفي ٢٠١١ استمرت ٩٣ يوم. اضيفت الاسمدة الازوتية والفوسفاتية والبوتاسية الموصي بها، واتبع تصميم القطع منشقة المنشقة في ثلاث مكررات(٩٠ وحدة تجريبية).

تضمنت المتغيرات الدراسية: اربعة معاملات للمحسنات الطبيعية (مخلوط خام المعادن الطبيعية، الكمبوست، البنتونيت و مخلوط شامل من هذه المحسنات بنسبة ١:١:١)، معدلين اضافة اعلى واقل من الموصي به، ثلاث مستويات من الاستنزاف الرطوبى من الماء الميسر في التربة (٣٠ % ، ٥٠% ،و٧٠%).

اهم النتائج الدراسية المتحصل عليها يمكن تلخيصها فيما يلى:-

١ - ازدياد قيم صفات الملوحة ورقم تفاعل التربة، التوصيل الكهربى والقوة الايونية لمعلقات ومستخلصات التربة (١:٥) وكذلك قيم محددات ضرر الصوديوم (SAR,SSP%) بعد حصاد القمح والذرة نتيجة لإضافة المحسنات الطبيعية للتربة الرملية كمتوسط لتأثير باقي المتغيرات الدراسية مقارنة بالكنترول. وقد حققت اضافة المخلوط الشامل (١:١:١) اعلى القيم مقارنة بالكمبوست بالتربة بعد حصاد القمح والذرة. وقد سجل معدل الاضافة الثاني قيم اعلى من معدل الاضافة الاول. وازدادت قيم هذه المتغيرات الكيميائية كقيمة متوسطة لتأثير باقي المتغيرات بزيادة مستوى الاستنزاف الرطوبى وقد اعطت المعادلة المعتدلة AWSMD % ٥٠ قيم وسطية بين المعاملة الرطبة AWSMD ٪٣٠، والمعاملة الجافة AWSMD ٪٧٠ .

٢ - تحسن في الخواص الطبيعية للتربة بانخفاض قيم الكثافة الظاهرية والتوصيل الهيدروليكي وبارتفاع قيم المسامية الكلية للتربة مقارنة بالكنترول وتأخذ قيم الانخفاض والزيادة الترتيب التصاعدي التالي:

Mixtures (١:١:١) > MNRM > Compost > Bentonite > Control

وقد حقق معدل الاضافة الاعلى انخفاضا في قيم HC, D_b وارتفاعا في قيم المسامية الكلية مقارنة بمعدل الاضافة الادنى ، وعموما في تجارب الاصص للقمح حققت اضافة المخلوط الشامل افضل تحسن في الخواص الطبيعية في حين ان تجارب الذرة الحقلية حققت اضافة الكمبوست افضل النتائج.

وقد ازدادت قيم الخواص الطبيعية بزيادة مستوى الاجهاد المائي فقد حققت المعاملة المعتدلة AWSMD % ٥٠ قيم وسطية بين المعاملة الرطبة والجافة.

٣ - تحسنت قدرة التربة على الاحتفاظ بالماء متمثلة في زيادة ثوابت رطوبتها الارضية (السعة الحقلية ، نقطة الذبول والماء الميسر) بإضافة المحسنات الطبيعية ، فقد حققت اضافة المخلوط الشامل قيم اعلى لهذه الخواص المائية تحت ظروف تجارب الاصص ، في حين حققت اضافة الكمبوست اعلى القيم تحت ظروف التجارب الحقلية. واظهرت النتائج ايضا زيادة قيم هذه الثوابت عند اضافة المعدل الاعلى مقارنة بالمعدل الادنى. ومن ناحية اخرى انخفضت قيم هذه الثوابت بزيادة مستوى الاستنزاف الرطوبى فلى تجربة الاصص واخذت الاتجاه العكسي في التجارب الحقلية . عموما المعاملة المعتدلة AWSMD % ٥٠ اعطت نتائج وسطية بين المبتلة والجافة.

٤ - زيادة محتوى التربة من العناصر الغذائية الكبرى(النيتروجين والفوسفور) المتبقية بعد حصاد محصولي القمح والذرة مقارنة بالكنترول نتيجة لإضافة المحسنات وقد حقق المخلوط الشامل اعلى تركيز متبقى لهذه العناصر في تجارب الاصص اما تحت ظروف التجارب الحقلية فكانت السيادة لإضافة الكمبوست ، ومعدل الاضافة الاعلى حقق اعلى تركيز متبقى مقارنة بمعدل الاضافة الادنى. معاملة الري المعتدلة ادت الى قيمة وسطية بين الرطبة والجافة.

٥- زيادة معنوية في محصول الحبوب والقش والبروتين ووزن وحدة الحبوب ، دليل الحصاد وكذلك مكونات محصولي القمح والذرة بعد تمام النضج نتيجة لإضافة المحسنات الطبيعية مقارنة بقيم الكنترول. وحقق معدل الاضافة الاعلى افضل من معدل الاضافة الادنى، وكانت افضل معاملة هي المخلوط الشامل تحت ظروف تجربة الاصص ، في حين كانت معاملة الكمبوست لها السيادة تحت ظروف التجارب الحقلية. وعموما المعاملة المعتدلة اعطت نتائج مرضية وسيطة بين المبتلة والجافة

قام بتحكيم البحث

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Table (٦): Irrigation scheduling and actual seasonal applied water at different regular- intervals for wheat crop production cultivated in loamy sand soil under different soil moisture depletion regimes over the growing winter season period ٢٠١٠/٢٠١١.

Notes : ١- Total applied water/season = calculated applied water +planting and life watering irrigations.
٢-Life watering irrigation = El-Mohayaa irrigation

Table (٧): Irrigation scheduling and actual seasonal applied water at different regular - intervals for maize crop production cultivated in loamy sand soil under different soil moisture depletion regimes over the growing summer season period ٢٠١٢.

Irrigation scheduling	Wet – treatment ٣٠ % AWSMD Light irrigation Short- intervals(every day)			Medium– treatment ٥٠ % AWSMD Moderate irrigation Median -intervals(٣ days)			Dry – treatment ٧٠ % AWSMD Heavy irrigation Long -intervals(٨ days)		
	Irrigation date	Applied water		Irrigation date	Applied water		Irrigation date	Applied water	
		$Lplot^{-١}$	$m^{٢}fed^{-١}$		$Lplot^{-١}$	$m^{٢}fed^{-١}$		$Lplot^{-١}$	$m^{٢}fed^{-١}$
Planting irrigation (٦,٤٨ % SMC)	٥/٧/٢٠١٢	٢٤١	٢٢٤,٦	٥/٧/٢٠١٢	٢٤١	٢٢٤,٦	٥/٧/٢٠١٢	٢٤١	٢٢٤,٦
Life watering irrigation (٩,٧٥ % SMC)	١٠/٧/٢٠١٢	١٧٢,٦	١٦١,١٢	١٠/٧/٢٠١٢	١٧٢,٦	١٦١,١٢	١٠/٧/٢٠١٢	١٧٢,٦	١٦١,١٢
Summation		٤١٣,٦	٣٨٥,٧	Summation	٤١٣,٦	٣٨٥,٧	Summation	٤١٣,٦	٣٨٥,٧
Soil moisture content %	١٥,٣٣ %SMC			١٣,٥ % SMC			١١,٧ % SMC		
Regular- intervals	Short- intervals (every day)			Median- intervals(٣ days)			Long- intervals (٨ days)		
First irrigate	١٣/٧/٢٠١٢	٥٦,٥	٥٢,٧٣	١٥/٧/٢٠١٢	٩٤,١٧	٨٧,٨٩	١٨/٧/٢٠١٢	٢٤٤,٨٢	٢٢٨,٥
Final irrigate	٢٧/٩/٢٠١٢	٥٦,٥	٥٢,٧٣	٢٥/٩/٢٠١٢	٩٤,١٧	٨٧,٨٩	٢٠/٩/٢٠١٢	٢٤٤,٨٢	٢٢٨,٥
Number of irrigates	٧٧ irrigates plus planting and life watering irrigations			٢٥ irrigates plus planting and life watering irrigations			٩ irrigates plus planting and life watering irrigations		
Total irrigation period	٨٦ days ٥/٧/٢٠١٢ – ٢٨/٩/٢٠١٢			٨٦ days ٥/٧/٢٠١٢-٢٨/٩/٢٠١٢			٨٦ days ٥/٧/٢٠١٢-٢٨/٩/٢٠١٢		
Maize harvesting time	October ,٥،٢٠١٢			October , ٥, ٢٠١٢			October , ٥, ٢٠١٢		
Maize growing season period	٩٣ days			٩٣ days			٩٣ days		
Calculated applied water /season		٤٣٥١	٤٠٦٠		٢٣٥٤	٢١٩٧		٢٢٠٣	٢٠٥٧
Total applied water /season		٤٧٦٤	٤٤٤٦		٢٧٦٨	٢٥٨٣		٢٦١٧	٢٤٤٢

Notes: Amounts of applied water for planting and life watering irrigations (ml plot$^{-١}$/irrigate) were measured using cutthroat flume (٢٠×٩٠) according to Early(١٩٧٥).

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A common NPK-fertilization was applied to the soil active root zone during - ٥

Table (٨,١): Soil salinity, sodicity and the ionic strength of its extracts after wheat crop harvesting as affected by natural soil conditioner types, their mixtures and application rates under different soil moisture depletion regimes.

Soil conditioner types and their mixtures	Conditioners application rates (w/w)		Soil moisture depletion levels from its available water capacity (AWSM D-levels)														
			Wet- treatment (٣٠ % AWSMD) Light irrigation Short – intervals(٣ days)					Medium - treatment (٥٠ % AWSMD) Moderate irrigation Median-intervals (٦ days)					Dry-treatment (٧٠ % AWSMD) Heavy irrigation Long-intervals (٩ days)				
			١٤,٤٥ % SMC					١٢,٧٥ % SMC					١١,٠٨ % SMC				
			Chemical parameters														
			pH	EC dSm-١	H.S. parameters SAR	SSP %	I.S mmol L-١	pH	EC dSm-١	H.S. parameters SAR	SSP %	I.S mmol L-١	pH	EC dSm-١	H.S. parameters SAR	SSP %	I.S mmol L-١
Control	Without additions		٧,٨٠	٠,٣٢	٢,٨٦	٦٤,٧١	٣,٦٤	٧,٦٠	٠,٣٥	٢,٨٦	٦٣,٣٦	٤,٤٥	٧,٤٠	٠,٤٤	٣,٢٦	٦٣,١٣	٥,٣٦
Bentonite	low	R١	٨,٠٦	٠,٥٨	٣,٧٦	٦٢,٥٠	٨,٦٣	٨,١٢	٠,٦٢	٣,٨٥	٦٢,٦٩	٨,٧٨	٨,٣٠	٠,٧٥	٤,١٤	٦٢,٨٢	٩,٨٨
	high	R٢	٨,٢٠	٠,٦٨	٤,٢٠	٦٤,٧٩	٨,٨٧	٨,١٦	٠,٦٧	٤,٠٤	٦٣,٠١	٩,٦٤	٨,١٤	٠,٨٧	٤,٣٢	٦٣,٤١	١٠,١٢
Mean			٨,١٣	٠,٦٣	٣,٩٨	٦٣,٦٤	٨,٦٠	٨,١٤	٠,٦٤٥	٣,٩٤	٦٢,٨٥	٩,٢١	٨,٢٢	٠,٨١	٤,٢٣	٦٣,١١	١٠,٠٠
Compost	low	R١	٧,٨٣	٠,٥٤	٣,٢٤	٦٠,٠٠	٦,٧٦	٨,١٢	٠,٦٨	٤,٠٤	٦٣,٠١	٧,٦٣	٨,١٠	٠,٧٣	٣,٥١	٦١,٢٠	٨,٢٤
	high	R٢	٨,١٠	٠,٦٩	٤,٦١	٦٣,٥١	٨,٥٢	٨,١٥	٠,٧٢	٣,٧١	٥٨,٩٧	٩,٠٥	٨,٣٠	٠,٨٧	٤,٥٩	٦٣,٤٤	٩,٥٢
Mean			٧,٩٦	٠,٦١	٣,٩٢	٦١,٧٦	٧,٦٤	٨,١٣	٠,٧٠	٣,٨٧	٦٠,٩٩	٨,٣٤	٨,٢٠	٠,٨٠	٤,٠٥	٦٢,٣٢	٨,٨٨
MNRM	low	R١	٨,١٣	٠,٨١	٤,١١	٦١,٤٤	١١,٢٥	٨,٣٠	٠,٧٥	٤,٢٥	٦٢,٩٦	١٢,٥٢	٨,٢٥	٠,٩٢	٤,٧٦	٦٣,٦٤	١٢,٩٥
	high	R٢	٨,٢١	٠,٩٧	٤,٦٣	٦٢,٣٨	١٢,٦٧	٨,١٨	٠,٧٤	٤,٢٤	٦٣,٢٩	١٣,٢٨	٨,٤٠	٠,٩٤	٤,٧٧	٦٣,٣٧	١٤,٧٢
Mean			٨,١٧	٠,٨٩	٤,٣٧	٦١,٩١	١١,٩٦	٨,٢٤	٠,٧٤٥	٤,٢٤	٦٣,١٣	١٢,٩٠	٨,٣٢	٠,٩٣	٤,٧٦٥	٦٣,٥٠	١٣,٨٤
Their mixtures (١:١:١)	low	R١	٨,١٥	٠,٨٦	٤,٥٣	٦٣,٠٤	١١,٥٣	٨,١٥	١,٢٠	٥,٤٧	٦٤,٠٦	١٣,٦٥	٨,٢٠	١,٠١	٥,٠٠	٦٣,٨٩	١٤,٦٦
	high	R٢	٨,١٥	١,١٣	٤,٢٩	٦٣,٦٤	١٣,٣٦	٨,٢٠	١,١٢	٥,١٧	٦٣,٣٣	١٤,٩٥	٨,٢٢	١,٠٧	٥,٠٩	٦٣,٤٨	١٥,٢٨
Mean			٨,١٥	٠,٩٩٥	٤,٤١	٦٣,٣٣	١٢,٤٥	٨,١٧	١,١٦	٥,٣٢	٦٣,٦٩	١٤,٣٠	٨.٢١	١,٠٤	٥,٠٥	٦٣,٦٨	١٤,٩٧
Average	low	R١	٨,٠٤	٠,٦٩٨	٣,٩٠	٦١,٧٤	٩,٥٤	٨,١٧	٠,٨١٣	٤,٤٠	٦٣,١٨	١٠,٦٥	٨,٢١	٠,٨٦	٤,٥٨	٦٣,٤٧	١١,٤٢
	high	R٢	٨,١٧	٠,٨٦٧	٤,٤٣	٦٣,٥٨	١٠,٨٦	٨,١٧	٠,٨١٣	٤,٢٩	٦٢,١٥	١١,٧٣	٨,٢٨	٠,٩٣	٤,٦٩	٦٣,٤٣	١٢,٤٣
Overall mean			٨,١٠٣	٠,٧٨١	٤,١٧	٦٢,٦٦	١٠.١٨	٨,١٧	٠,٨١٣	٤,٣٤٥	٦٢,٦٧	١١,١٩	٨,٢٤	٠,٨٩٥	٤,٦٤	٦٣,٤٥	١١,٩٣

Notes: ١- Each value is a mean of ٣ replications and all obtained values were calculated on oven dry weight basis at ١٠٥ Cº for ٢٤ hours.

٢- Cylindrical plastic pots cross-sectional area (٠,٠٤٥٣ m٢) containing ١٠ kg loamy sand soil on oven dry weight irrigated with tap water

٣-Winter growing season period of wheat crop elongated ١٣٥ days

٤- Analytical data were determined and calculated using ١:٥ soil water extracts (except pH)

٥-Wet – treatment (light irrigation) : ٣٠ % AWSMD for short –intervals (٣ days)and actual seasonal applied water was ١١٠٧,٤ m٣ fed-١(١١,٩٤ Lpot-١)

٦-Medium – treatment(moderate irrigation) : ٥٠ % AWSMD for median –intervals (٦ days)and actual seasonal applied water was ٩٩٨,١ m٣ fed-١(١٠,٧٦ Lpot-١)

٧-Dry – treatment(heavy irrigation):٧٠ % AWSMD for long –intervals (٩ days)and actual seasonal applied water was ٩٧٢,٤ m٣ fed-١(١٠,٤٩L pot-١).

٨- SMC represents soil moisture content (%) directly before irrigation at which calculated water applied must be applied immediately for arriving its field capacity.

Soil conditioner types and their mixtures	Conditioners application rates (w/w)		Soil moisture depletion levels from its available water capacity (AWSM D-levels)														
			Wet- treatment (٣٠ % AWSMD) Light irrigation Short – intervals(every day)					Medium - treatment (٥٠ % AWSMD) Moderate irrigation Median-intervals (٣ days)					Dry-treatment (٧٠ % AWSMD) Heavy irrigation Long-intervals (٨ days)				
			١٥,٣٣ % SMC					١٣,٥ % SMC					١١,٧ % SMC				
			Chemical parameters														
			pH	EC dSm-١	H.S. parameters		**I.S *m*mol L-١**	pH	EC dSm-١	H.S. parameters		**I.S *m*mol L-١**	pH	EC dSm-١	H.S. parameters		**I.S *m*mol L-١**
					SAR	SSP %				SAR	SSP %				SAR	SSP %	
Control	Without additions		٧,٨٤	٠,٣٥	٢,٦٩	٦٤,٥٢	٣,٥٨	٧,٦٤	٠,٣٨	٢,٥٨	٦٢,٥٠	٤,٤٦	٧,٤٢	٠,٤٦	٢,١٧	٥٤,٠٥	٥,٣٥
Bentonite	low	R١	٨,١٠	٠,٦٦	٤,٢٠	٦٥,٦٣	٧,٦٥	٨,٠٠	٠,٦٨	٤,٤٦	٥٨,٤٦	٨,٢٥	٨,١٣	٠,٨٣	٤,٨٠	٦٠,٨٥	٨,٢٦
	high	R٢	٨,٢٤	٠,٦٨	٣,٩٠	٦٤,٥٢	٧,٩٦	٨,٥٠	٠,٧٠	٤,٩١	٧١,٦٨	٩,٣٧	٨,١٤	٠,٩٧	٤,٨٥	٦٢,٠٠	١٠,٠٥
Mean			٨,١٧	٠,٦٧	٤,٠٧	٦٥,٠٧	٧,٨١	٨,٢٥	٠,٦٩	٤,٦٨	٦٥,٠٩	٨,٨١	٨,٢٤	٠,٩٠	٤,٨٣	٦١,٤٣	٩,١٥
Compost	low	R١	٧,٨٠	٠,٥٧	٣,٢٥	٥٩,٥٠	٧,٦٥	٨,١٧	٠,٥٣	٣,٤٤	٥٣,٠٦	٨,٠٠	٧,٨٠	٠,٨٢	٣,٤١	٥٥,٨٠	٩,٠٢
	high	R٢	٨,١٩	٠,٦٩	٤,٢٠	٦٢,٦٣	٨,٣٦	٨,١٩	٠,٦١	٤,٥٦	٥٨,٨٠	٨,٥٨	٨,٥٠	٠,٩٠	٤,٧٢	٦٠,٨١	٩,٦٨
Mean			٧,٩٩	٠,٦٣	٣,٧٣	٦١,٠٦	٨,٠١	٨,١٨	٠,٥٧	٤,٠٠	٥٥,٩٤	٨,٢٩	٨,١٨	٠,٨٦	٤,٠٦	٥٨,٣٠	٩,٣٥

MNRM	low	R١	٨,١٠	٠,٨٥	٤,١٥	٦١,٠٥	١٠,١٣	٨,٢٣	٠,٧٤	٣,٣٨	٥٧,٩٧	١٠,٠٨	٨,٠٥	٠,٩٢	٤,٠٩	٥٩,٧٨	١٠,٦٢
	high	R٢	٨,١٦	٠,٩٧	٤,٣٢	٦٢,٥٠	١٢,٤٥	٨,٢٨	٠,٧٥	٤,٦٦	٦٧,٥٦	١١,٣٦	٨,٥٠	٠,٩٤	٤,٦٦	٦٤,٤٤	١١,٤٠
Mean			٨,١٣	٠,٩١	٤,٢٤	٦١,٧٨	١١,٢٩	٨,٢٥	٠,٧٤٥	٤,٠٢	٦٢,٧٧	١٠,٧٢	٨,٣٠	٠,٩٣	٤,٣٨	٦٢,١١	١١,٠١
Their mixtures (١:١:١)	low	R١	٨,١٨	٠,٨٨	٥,٥١	٦٨,٨٣	١٠,٩٥	٨,١٥	١,٢٠	٥,٨٨	٦٤,٧٩	١١,٥٠	٨,٠٨	١,١١	٤,٣٥	٦٤,٦٢	١٢,٦٥
	high	R٢	٨,٣٥	١,٥٠	٦,٩٩	٦٩,٥٧	١٢,٦٦	٨,٣٩	١,٩٠	٥,٩٢	٦٧.٧٧	١٢,٥٤	٨,٦٠	١,١٧	٥,٤٥	٦٧,٣٣	١٤,٢٤
Mean			٨,٢٦٥	١,١٩	٦,٢٥	٦٩,٢٠	١١,٨١	٨,٢٧	١,٥٥	٥,٩٠	٦٦,٢٨	١٢,٠٢	٨,٣٤	١,١٦	٥,٨٩	٦٥,٩٦	١٣,٤٥
Average	low	R١	٨,٠٥	٠,٧٤	٤,٢٨	٦٣,٧٥	٩,١٠	٨,١٤	٠,٧٩	٤,٢٩	٥٨,٥٧	٩,٤٦	٨,٠٧	٠,٩٠	٤,١٦	٦٠,٢٦	١٠,٣٩
	high	R٢	٨,٢٣	٠,٩٦	٤,٨٥	٦٤,٧٩	١٠,٣٦	٨,٣٣	٠,٩٩	٥,٠١	٦٦,٤٧	١٠,٤٥	٨,٤٥	٠,٩٦	٥,٤٢	٦٣,١٤	١١,٣٤
Overall mean			٨,١٣٩	٠,٨٥	٤,٥٦	٦٤,٢٧	٩,٧٣	٨,٢٣٧	٠,٨٩	٤,٦٥	٦٢,٥٧	٩,٩٦	٨,٢٦٥	٠,٩٦٣	٤,٧٩	٦١,٧٠	١٠,٨٦

Table(٨,٢): Soil salinity, sodicity and the ionic strength of its extracts after maize crop harvesting as affected by natural soil conditioner types , their mixtures and application rates under different soil moisture depletion regimes

Notes: **١-** Each value is a mean of ٣ replications and all obtained values were calculated on oven dry weight basis at ١٠٥ Cº for ٢٤ hours.

٢- Analytical data were determined and calculated using ١:٥ soil water extraction (except pH).

٣- Field plot sectional –area ٤,٥ $m^{٢}$ and its weight ١٠٤٦,٢٥ kg loamy sand soil on oven dry irrigated with drainage water (Kotshner).

٤- Summer growing season period of maize crop elongated ٩٣ days

٥- Wet – treatment (light irrigation): ٣٠ % AWSMD for short –intervals (every day)and actual seasonal applied water was ٤٤٤٦ $m^{٣}$ $fed^{-١}$(٤٧٦٤ $Lplot^{-١}$)

٦- Medium – treatment (moderate irrigation): ٥٠ % AWSMD for median –intervals (٣days)and actual seasonal applied water was ٢٥٨٣ $m^{٣}$ $fed^{-١}$(٢٧٦٨ L $plot^{-١}$)

٧- Dry – treatment (heavy irrigation): ٧٠ % AWSMD for long –intervals (٨ days)and actual seasonal applied water was ٢٤٤٢ $m^{٣}$ $fed^{-١}$(٢٦١٧L $plot^{-١}$).

٨- SMC represents soil moisture content (%) directly before irrigation at which calculated applied water must be done immediately to arrive its field capacity.

Table (٩،١): Saturated hydraulic conductivity, bulk density and total porosity of studied soils after wheat crop harvesting as affected by natural soil conditioner types, their mixtures and application rates under different soil moisture depletion regimes .

Soil conditioner types and their mixtures	Conditioner application rates (w/w)		Soil moisture depletion levels from its available water capacity(AWSMD-levels)								
			Wet - treatment (٣٠ % AWSMD) Light irrigation Short – intervals (٣ days)			Medium - treatment (٥٠ % AWSMD) Moderate irrigation Median – intervals (٦ days)			Dry -treatment (٧٠ % AWSMD) Heavy irrigation Long-intervals (٩ days)		
			١٤,٤٥ % SMC			١٢,٧٥ % SMC			١١,٠٨ % SMC		
			Physical parameters								
			SHC m/day	**D_b Mg /m^٣**	**ρ_T %**	**SHC m/day**	**D_b Mg /m^٣**	**ρ_T %**	**SHC m/day**	**D_b Mg /m^٣**	**ρ_T %**
Control	Without additions		٢,٤٨	١,٥٥	٤١,٥١	٢,٥٤	١,٥٦	٤١,١٣	٢,٤٧	١,٥٧	٤٠,٧
Bentonite	low	R١	٢,٤٣	١,٤٣	٤٦,٠٠	٢,٥٢	١,٤٥	٤٥,٢٨	٢,٥٥	١,٤٢	٤٦,٤٢
	high	R٢	٢,٤١	١,٤٥	٤٥,٢٨	٢,٤٠	١,٤١	٤٦,٧٩	٢,٤٣	١,٤٠	٤٧,١٧
Mean			٢,٤٢	١,٤٤	٤٥,٦٦	٢,٤٦	١,٤٣	٤٦,٠٤	٢,٤٩	١,٤١	٤٦,٧٩
Compost	low	R١	٢,٤٥	١,٤٦	٤٤,٩١	٢,٥١	١,٤٤	٤٥,٦٦	٢,٧١	١,٤٦	٤٤,٩١
	high	R٢	٢,٤٣	١,٤٥	٤٥,٢٨	٢,٤٣	١,٤٢	٤٦,٤٢	٢,٥٣	١,٣٠	٥٠,٩٤
Mean			٢,٤٤	١,٤٥٥	٤٥,٠٩	٢,٤٧	١,٤٣	٤٦,٠٤	٢,٦٢	١,٣٩	٤٧,٩٠
MNRM	low	R١	٢,٤٠	١,٤٤	٤٥,٦٦	٢,٤٠	١,٤٤	٤٥,٦٦	٢,٤١	١,٤٥	٤٥,٢٨
	high	R٢	٢,٣٨	١,٤٣	٤٦,٠٠	٢,٣٦	١,٤٠	٤٧,١٧	٢,٣٧	١,٣٥	٤٩,٠٦
Mean			٢,٣٩	١,٤٣٥	٤٥,٨٥	٢,٣٨	١,٤٢	٤٦,٤٢	٢,٣٩	١,٤٠	٤٧,١٧

Their mixtures (١:١:١)	low	R١	٢,٣٨	١,٤١	٤٦,٧٩	٢,٤٨	١,٤٢	٤٦,٤٢	٢,٤٥	١,٣٦	٤٨,٦٨
	high	R٢	٢,٣٢	١,٣٤	٤٩,٤٣	٢,٣٤	١,٣١	٥٠,٥٧	٢,٣٩	١,٣٢	٥٠,١٩
Mean			٢,٣٥	١,٣٧٥	٤٨,١١	٢,٤١	١,٣٦٥	٤٨,٥٠	٢,٤٢	١,٣٤	٤٩,٤٣
Average	low	R١	٢,٤١	١,٤٣٠	٤٦,٠٤	٢,٤٧	١,٤٣٧	٤٥,٧٧	٢,٥٣	١,٤٢٣	٤٦,٣٠
	high	R٢	٢,٣٨	١,٤٢٣	٤٥,٤٢	٢,٤٤	١,٣٨٥	٤٧,٧٤	٢,٤٣	١,٣٤٣	٤٩,٣٢
Overall mean			٢,٣٩٥	١,٤٢٦	٤٦,٣٣	٢,٤٥٥	١,٤١١	٤٦,٧٥	٢,٤٨	١,٣٨٣	٤٧,٨١

Notes: **١-**Each value is a mean of three replications and the obtained results were calculated on oven dry weight basis at ١٠٥ C° for ٢٤ hours

٢- **SHC** : Soil hydraulic conductivity ; $\mathbf{D_b}$: Soil bulk density and $\boldsymbol{\rho_t}$: Soil porosity in volume percent .

Table (٩،٢): Saturated hydraulic conductivity, bulk density and total porosity of studied soils after maize crop harvesting as affected by natural soil conditioner types, their mixtures and application rates under different soil moisture depletion regimes.

Soil conditioner types and their mixtures	Conditioner application rates (w/w)	Soil moisture depletion levels from its available water capacity(AWSMD-levels)								
		Wet - treatment (٣٠ % AWSMD) Light irrigation Short – intervals (every day)			Medium - treatment (٥٠ % AWSMD) Moderate irrigation Median – intervals (٣days)			Dry -treatment (٧٠ % AWSMD) Heavy irrigation Long-intervals (٨ days)		
		١٥,٣٣ %SMC			١٣,٥ % SMC			١١,٧ % SMC		
		Physical parameters								
		SHC m/day	$\mathbf{D_b}$ **Mg /m٣**	$\boldsymbol{\rho_T}$ **%**	**SHC m/day**	$\mathbf{D_b}$ **Mg /m٣**	$\boldsymbol{\rho_T}$ **%**	**SHC m/day**	$\mathbf{D_b}$ **Mg /m٣**	$\boldsymbol{\rho_T}$ **%**
Control	Without additions	٢,٦٣	١,٥٠	٤٣,٤٠	٢,٦٠	١,٤٨	٤٤,١٥	٢,٥٥	١,٥٢	٤٢,٦٤

Bentonite	low	R١	٢,٦٠	١,٤١	٤٦,٧٩	٢,٨٤	١,٣٥	٤٩,٠٦	٢,٥٥	١,٤٢	٤٦,٤١
	high	R٢	٢,٣٢	١,٣٣	٤٩,٨٠	٢,٣١	١,٣٠	٥٠,٩٤	٢,٤٠	١,٢٢	٥٣,٩٦
Mean			٢,٤٦	١,٣٦٤	٤٨,٣٤	٢,٥٧٥	١,٣٣	٤٩,٨١	٢,٤٧٥	١,٣٢	٥٠,١٩
Compost	low	R١	٢,٨٠	١,٣٨	٤٧,٩٢	٣,٠٠	١,٣٥	٤٩,٥٧	٣,٩٥	١,٣٥	٤٩,٠٦
	high	R٢	٢,٤٢	١,٣٥	٤٩,٠٦	٢,٣٢	١,٣٠	٥٠,٩٤	٣,١٧	١,٢٨	٥١,٧٠
Mean			٢,٦١	١,٣٦٥	٤٨,٥٠	٢,٦٦	١,٣٢٥	٥٠,٠٠	٣,٥٦	١,٣١٥	٥٠,٣٨
MNRM	low	R١	٢,٦٤	١,٤٠	٤٧,١٧	٢,٥٠	١,٢٨	٥١,٧٠	٢,٨٦	١,٣٨	٤٧,٩٢
	high	R٢	٢,٢٠	١,٣٤	٤٩,٤٣	٢,٤٨	١,٤٠	٤٧,١٧	٣,١٠	١,٣٠	٥٠,٩٤
Mean			٢,٤٢	١,٣٧	٤٨,٣٠	٢,٤٩	١,٣٤	٤٩,٤٤	٢,٩٨	١,٣٤	٤٩,٤٣
Their mixtures (١:١:١)	low	R١	٢,٤٤	١,٣٩	٤٧,٥٤	٢,٣٨	١,٣٨	٤٧,٩٢	٢,٣٠	١,٣٧	٤٨,٣٠
	high	R٢	٢,٣٤	١,٣٧	٤٨,٣٠	٢,٣٥	١,٣٥	٤٩,٠٦	٢,٠٠	١,٣٢	٥٠,١٩
Mean			٢,٣٩	١,٣٨	٤٧,٩٢	٢,٣٦٥	١,٣٦٥	٤٨.٤٠	٢,١٥	١,٣٥	٤٩,٠٦
Average	low	R١	٢,٦٢	١,٣٩	٤٧,٥٥	٢,٦٨	١,٣٤	٤٩,٣٤	٢,٩١٥	١,٣٨	٤٧,٩٢
	high	R٢	٢,٣٢	١,٣٥	٤٨,٦٧	٢,٣٦٦	١,٣٤٤	٤٩,٨٣	٢,٦٦٠	١,٢٨	٥١,٧٠
Overall mean			٢,٤٧	١,٣٧١	٤٨,٢٦	٢,٥٢٣	١,٣٤٢	٤٩,٣٦	٢,٧٩	١,٣٣	٤٩,٧٧

Notes:١-Each value is a mean of three replications and the obtained results were calculated on oven dry weight basis at ١٠٥ C° for ٢٤ hours.

٢- SHC : Saturated hydraulic conductivity ; D_b: Soil bulk density and $\boldsymbol{\rho_t}$: Total porosity(in volume percent).

Table(١٠،١): Field capacity, permanent wilting point and available water capacity of studied soils after wheat crop harvesting as affected by natural soil conditioner types, their mixtures and application rates under different soil moisture depletion regimes.

Soil conditioner types and their mixtures	Conditioner application rates (w/w)		Soil moisture depletion levels from its available water capacity(AWSMD-levels)								
			Wet- treatment (٣٠ % AWSMD) Light irrigation Short – intervals (٣ days)			Medium - treatment (٥٠ % AWSMD) Moderate irrigation Median – intervals (٦ days)			Dry - treatment (٧٠ % AWSMD) Heavy irrigation Long- intervals (٩ days)		
			١٤,٤٥ % SMC			١٢,٧٥ % SMC			١١,٠٨ % SMC		
			Soil moisture constants								
			SFC%	**PWP %**	**AWC %**	**SFC%**	**PWP %**	**AWC%**	**SFC%**	**PWP %**	**AWC%**
Control	Without additions		١٧,٠	٨,٥	٨,٥	١٦,٦	٨,٢	٨,٤	١٦,٤	٨,٢	٨,٢
Bentonite	Low	R١	١٧,٧	٨,٧	٩,٠	١٧,٤	٨,٦	٨,٨	١٦,٨	٨,٤	٨,٤
	High	R٢	١٨,٤	٩,٠	٩,٤	١٧,٨	٨,٨	٩,٠	١٧,٣	٨,٥	٨,٨
Mean			١٨,٠٥	٨,٨٥	٩,٢	١٧,٦	٨,٧	٨,٩	١٧,٠٥	٨,٤٥	٨,٦
Compost	Low	R١	١٧,٧	٨,٨	٨,٩	١٧,٣	٨,٥	٨,٨	١٧,٢	٨,٥	٨,٧
	High	R٢	١٨,١	٨,٨	٩,٣	١٨,٥	٨,٩	٩,٦	١٧,٥	٨,٨	٨,٧
Mean			١٧,٩	٨,٨	٩,١	١٧,٩	٨,٧	٩,٢	١٧,٣٥	٨,٦٥	٨,٧
MNRM	Low	R١	١٩,٢	٩,٥	٩,٧	١٨,٥	٩,٢	٩,٣	١٧,٩	٨,٩	٩,٠
	High	R٢	١٩,٥	٩,٨	٩,٧	١٨,٧	٩,٣	٩,٤	١٨,٢	٩,٠	٩,٢

Mean			١٩,٣٥	٩,٦٥	٩,٧	١٨,٦	٩,٢٥	٩,٣٥	١٨,٠٥	٨,٩٥	٩,١
Their mixtures (١:١:١)	Low	R١	١٩,٦	٩,٨	٩,٨	١٨,٨	٩,٤	٩,٤	١٨,٥	٩,٢	٩,٣
	High	R٢	٢٠,٤	١٠,٠	١٠,٤	١٩,٤	٩,٧	٩,٧	١٩,٠	٩,٤	٩,٦
Mean			٢٠,٠	٩,٩	١٠,١	١٩,١	٩,٥٥	٩,٥٥	١٨,٧٥	٩,٣	٩,٤٥
Average	Low	R١	١٨,٥٥	٩,٢	٩,٣٥	١٨,٠	٨,٩٣	٩,٠٧٥	١٧,٦	٨,٧٥	٨,٨٥
	High	R٢	١٩,١٠	٩,٤	٩,٧٠	١٨,٦	٩,١٨	٩,٤٢٥	١٨,٠	٨,٩٣	٩,٠٧
Overall mean			١٨,٨٣	٩,٣	٩,٥٣	١٨,٠٣	٩,٠٥	٩,٢٥	١٧,٨	٨,٨٤	٨,٩٦

Notes: **١-**Each value is a mean of three replications and the obtained results were calculated on oven dry weight basis at ١٠٥ C˚ for ٢٤ hours

٢- SFC : soil field capacity ; PWP : permanent wilting point and AWC : soil available water capacity

Table(١٠,٢): Field capacity, permanent wilting point and available water capacity of studied soils after maize crop harvesting as affected by natural soil conditioner types, their mixtures and application rates under different soil moisture depletion regimes.

Soil conditioner types and their mixtures	Conditioner application rates (w/w)	Soil moisture depletion levels from its available water capacity(AWSMD-levels)		
		Wet- treatment (٣٠ % AWSMD) Light irrigation Short – intervals (every day)	Medium - treatment (٥٠ % AWSMD) Moderate irrigation Median – intervals (٣ days)	Dry - treatment (٧٠ % AWSMD) Heavy irrigation Long- intervals (٨ days)
		١٥,٣٣ %SMC	١٣,٥ % SMC	١١,٧ % SMC

			Soil moisture constants								
			SFC %	PWP %	AWC %	SFC %	PWP %	AWC %	SFC %	PWP %	AWC %
Control	Without additions		١٨,٠	٩,٠	٩,٠	١٧,٨	٩,٢	٨,٦	١٧,٩	٨,٨	٩,١
Bentonite	Low	R١	١٨,٥	٩,٣	٩,٢	١٨,٣	٩,٥	٨,٨	١٩,٢	٩,٠	١٠,٢
	High	R٢	١٨,٩	٩,٥	٩,٤	١٨,٨	٩,٦	٩,٢	١٩,٨	٩,٢	١٠,٦
Mean			١٨,٧	٩,٤	٩,٣	١٨,٥٥	٩,٥٥	٩,٠	١٩,٥	٩,١	١٠,٤
Compost	Low	R١	١٩,٥	٩,٨	٩,٧	١٩,٦	١٠,٠	٩,٦	٢٠,٣	١٠,١	١٠,٢
	High	R٢	١٩,٧	١٠,٠	٩,٧	٢٠,٣	١٠,٤	٩,٩	٢٠,٥	١٠,٣	١٠,٢
Mean			١٩,٦	٩,٩	٩,٧	١٩,٩٥	١٠,٢	٩,٧٥	٢٠,٤	١٠,٢	١٠,٢
MNRM	Low	R١	١٨,٦	٩,٥	٩,١	١٨,٧	٩,٦	٩,١	١٨,٩	٩,٣	٩,٦
	High	R٢	١٨,٩	٩,٦	٩,٣	١٨,٩	٩,٨	٩,١	١٩,٣	٩,٥	٩,٨
Mean			١٨,٧٥	٩,٥٥	٩,٢	١٨,٨	٩,٧	٩,١	١٩,١	٩,٤	٩,٧
Their mixtures (١:١:١)	Low	R١	١٩,٤	٩.٧	٩,٧	١٩,٥	٩,٩	٩,٦	١٩,٨	٩,٨	١٠,٠
	High	R٢	١٩,٥	٩,٨	٩,٧	١٩,٧	١٠,٠	٩,٧	٢٠,٢	١٠,٢	١٠,٠
Mean			١٩,٤٥	٩,٧٥	٩,٧	١٩,٦	٩,٩٥	٩,٦٥	٢٠,٠	١٠,٠	١٠,٠
Average	Low	R١	١٩,٠	٩,٥٨	٩,٤٣	١٩,٠٢	٩,٧٥	٩,٢٧٥	١٩,٥٥	٩,٥٥	١٠,٠
	High	R٢	١٩,٢٥	٩,٧٣	٩,٥٣	١٩,٤٣	٩,٩٥	٩,٤٧٦	١٩,٩٥	٩,٨	١٠.١٥
Overall mean			١٩,١٢	٩,٦٥	٩,٤٧	١٩,٢٣	٩,٨٥	٩,٣٧٥	١٩,٧٥	٩,٦٧	١٠,٠٧

Notes : ١-Each value is a mean of three replications and the obtained results ere calculated on oven dry weight basis at ١٠٥ C˚ for ٢٤ hours

٢- SFC : soil field capacity ; PWP : permanent wilting point and AWC : soil available water capacity

Table(١١,١): Phyto-availability (concentration) of soil macro-nutrients after wheat and maize crops harvesting as affected by natural soil conditioner types, their mixtures and application rates under different soil moisture depletion regimes.

Soil conditioner types and their mixtures	Conditioner application rates (w/w)		After pot-wheat crop cultivation						After field-maize crop cultivation					
			Wet- treatment (٣٠ % AWSMD) Light irrigation Short – intervals (٣ days)		Medium - treatment (٥٠ % AWSMD) Moderate irrigation Median – intervals (٦ days)		Dry - treatment (٧٠ % AWSMD) Heavy irrigation Long- intervals (٩ days)		Wet- treatment (٣٠ % AWSMD) Light irrigation Short – intervals (every day)		Medium - treatment (٥٠ % AWSMD) Moderate irrigation Median – intervals (٣ days)		Dry - treatment (٧٠ % AWSMD) Heavy irrigation Long- intervals (٨ days)	
			١٤,٤٥ % SMC		١٢,٧٥ % SMC		١١,٠٨ % SMC		١٥,٣٣ %SMC		١٣,٥ % SMC		١١,٧ % SMC	
			Soil nutritional status						**Soil nutritional status**					
			Soil macro-nutrients phytoavailability (*m*g kg$^{-١}$ soil)						**Soil macro-nutrients phytoavailability (*m*g kg$^{-١}$ soil)**					
			N	**P**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**
Control	Without additions		٢٥,٠	٧,٥	٢٦,٧	٨,٥	٢٣,٨	٦,٠	٢٢,٠	٩,٩	٢٣,٠	١٠,٩	٢١,٠	٨,٩
Bentonite	low	R١	٣٠,٥	٨,٥	٣٢,٤	٩,٥	٣١,٠	٧,٥	٢٢,٥	١٠,٨	٢٣,٥	١١,٨	٢١,٥	٩,٨
	high	R٢	٣٥,٦	٩,٥	٣٥,٥	١٠,٥	٣١,٣	٨,٤	٢٥,٥	١١,٥	٢٦,٥	١٢,٥	٢٤,٥	١٠,٥
Mean			٣٣,٠٥	٩,٠	٣٣,٩٥	١٠,٠	٣١,١٥	٧,٩٥	٢٤,٠	١١,١٥	٢٥,٠	١٢,١٥	٢٣,٠	١٠,١٥
Compost	low	R١	٣٨,٥	٨,٧	٣٤,٨	٩,٧	٣٥,٠	٧,٨	٣٥,٥	١٣,١	٣٦,٥	١٤,١	٣٤,٥	١٢,١

	high	R٢	٣٩,٩	٩,٥	٣٩,٨	١٠,٩	٣٦,٥	٨,٥	٤٠,٨	١٣,٥	٤١,٨	١٤,٥	٣٩,٨	١٢,٥
Mean			٣٩,٢	٩,١	٣٧,٣	١٠,٣	٣٥,٧٥	٨,١٥	٣٨,١٥	١٣,٣	٣٩,١٥	١٤,٣	٣٧,١٥	١٢,٣
MNRM	low	R١	٣٧,٨	١٠,٢	٤٦,٥	١١,٢	٣٧,٢	٩,٢	٣٠,٢	١٢.٥	٣١,٢	١١,٥	٢٩,٢	١١,٥
	high	R٢	٤٠,٥	١٠,٥	٤٧,٣	١١,٥	٤٠,٠	٩,٩	٣٥,٣	١٢,٨	٣٦,٣	١٣,٨	٣٤,٣	١١,٨
Mean			٣٩,١٥	١٠,٣٥	٤٦,٩	١١,٣٥	٣٨,٦	٩,٥٥	٣٢,٧٥	١٢,٦٥	٣٣,٧٥	١٢,٦٥	٣١,٧٥	١١,٦٥
Their mixtures (١:١:١)	low	R١	٤٣,٥	١١,٢	٤٩,٣	١٢,٢	٤٣,٠	١٠,٢	٣٦,٣	١٢,٩	٣٧,٣	١٣,٩	٣٥,٣	١١.٩
	high	R٢	٤٦,٥	١٣,٩	٤٩,٥	١٤,٩	٤٤,٥	١٢,٩	٣٩,٥	١٣,٢	٤٠,٥	١٤,٢	٣٨,٥	١٢,٢
Mean			٤٥,٠	١٢,٥٥	٤٩,٤	١٣,٥٥	٤٣,٧٥	١١,٥٥	٣٧,٩	١٣,٠٥	٣٨,٩	١٤,٠٥	٣٦,٩	١٢,٠٥
Average	low	R١	٣٧,٥٨	٩,٦٥	٤٠,٧٥	١٠,٦٥	٣٦,٥٥	٨,٦٧	٣١,١٣	١٢,٣٣	٣٢,١٣	١٢,٨٣	٣٠,١٣	١١,٣٣
	high	R٢	٤٠,٦٣	١٠,٨٥	٤٣,٠٣	١١,٩٥	٣٨,٠٨	٩,٩٣	٣٥,٢٨	١٢,٧٥	٣٦,٢٨	١٣,٧٥	٣٤,٢٨	١١,٧٥
Overall mean			٣٩,١٠	١٠,٢٥	٤١,٨٩	١١,٣٠	٣٧,٣١	٩,٣٠	٣٣,٢١	١٢,٥٤	٣٤,٢١	١٣,٢٩	٣٢,٢١	١١,٥٤

Notes : ١-Each value is a mean of ٣ replications and all obtained values were calculated on oven dry weight basis at ١٠٥ C^{o} for ٢٤ hours

٢-Each experimental plastic pot received (w/w) ١٢٠,٦ kg-N fed$^{-١}$ (١,٢٠٦ g- N pot $^{-١}$) as ammonium nitrate (٣٣,٥ % N); ١٣,٥٤ kg-P fed$^{-١}$(١٣٥,٤ mg-P pot$^{-١}$)as normal super phosphate (١٥,٥ % $P_{٢}O_{٥}$) and ٢٨,٨ kg-K fed$^{-١}$(١٩٩,١٥ mg-K pot$^{-١}$) as potassium sulfate (٤٨ % $K_{٢}O$).

٣- Each experimental plot area received ٢٦٠ kg fed$^{-١}$ urea (٤٦,٥٪ N) equivalent ٠,١٢٧ kg – N plot$^{-١}$; ٢٠٠ kg fed$^{-١}$ ordinary super phosphate (١٥,٥ % $P_{٢}O_{٥}$) equivalent (١٤,١٦ g-P plot$^{-١}$) and ٥٠ kg fed$^{-١}$ potassium sulfate (٤٨ % $K_{٢}O$) equivalent ٢٠,٨٤ g-K plot$^{-١}$.

Table(١٢،١): Biomass grains and straw yields of wheat and maize crops after full maturity as affected by natural soil conditioner types, their mixtures and application rates under wet-treatment (light irrigation) .

Soil conditioner types and their mixtures	Conditioner application rates (w/w)		Biomass wheat crop yield						Biomass maize crop yield					
			Light irrigation (short – intervals ٣ days)						Light irrigation (short – intervals every day)					
			Biomass grains yield		١٠٠٠ grains weight (gm)	Harvest index (%)	Biomass straw (tepn)yield		Biomass grains yield		١٠٠ grains weight (gm)	Harvest index (%)	Biomass straw yield	
			g pot-١	(kg fed-١)			g pot-١	(kg fed-١)	(kg plot-١)	(kg fed-١)			(kg plot-١)	(kg fed-١)
Control	**Without additions**		١٣,٧٧	١٢٧٦,٥	٣٠,٥	٣٠,٧٥	٣١,٠١	٢٨٧٥	١,٩٥٠	١٨٢٠	٤٠,٦	٤٧	٢,١٩٩	٢٠٥٣
Bentonite	low	R١	١٧,٥٥	١٦٢٧,٥	٤٠,٥	٣٤,١٤	٢٩,٨٤	٢٧٦٧	٢,٩٠٤	٢٧١٠	٤٢,٥	٤٩,١٨	٢,٩٩٩	٢٨٠٠
	high	R٢	٢٠,١٩	١٨٧٢.٠	٤٠,٨	٤٠,٣٥	٣٣,٨٧	٣١٤٠	٢,٩٤٢	٢٧٤٦	٤٢,٨	٤٧,٧٢	٣,٢١٩	٣٠٠٥
Mean			١٨,٨٧	١٧٤٩,٨	٤٠,٦٥	٣٧,٢٥	٣١,٨٦	٢٩٥٣	٢,٩٢٣	٢٧٢٨	٤٢,٦٥	٤٨,٤٥	٣,١١٠	٢٩٠٣
Compost	low	R١	١٥,٨١	١٤٦٥,٥	٤٠,٢	٣٣,٢٩	٣٠,٦٣	٢٨٤٠	٣,١٢٩	٢٩٢٠	٤٤,٧	٤٥,١٥	٣,٨٠٠	٣٥٤٧
	high	R٢	١٨,٧٢	١٧٣٥,٥	٤٠,٥	٣٧,٩٣	٣١.٦٨	٢٩٣٧	٣,١٨٥	٢٩٧٣	٤٥,٠	٤٤,٣٩	٣,٩٨٩	٣٧٢٤
Mean			١٧,٢٦	١٦٠٠,٥	٤٠,٣٥	٣٥,٦١	٣١,١٦	٢٨٨٨	٣,١٥٧	٢٩٤٦	٤٤,٨٥	٤٤,٧٧	٣,٨٩٥	٣٦٣٥
MNRM	low	R١	١٩,٦٦	١٨٢٢,٥	٤٢,٦	٣٦,٧٥	٣٣,٣٦	٣٠٩٣	٣,٠٥٤	٢٨٥٠	٤٣,١	٥٠,٤٤	٢,٩٩٩	٢٨٠٠
	high	R٢	٢٣,٩٣	٢٢١٨,٥	٤٣,٥	٤١,٧٦	٣٣,٨٤	٣١٣٧	٣,١٠٧	٢٩٠٠	٤٣,٨	٤٧,٩٤	٣,٢٩٩	٣٠٨٠
Mean			٢١,٧٩	٢٠٢٠,٦	٤٣,٠٥	٣٩,٢٦	٣٣,٦	٣١١٥	٣,٠٨٠	٢٨٧٥	٤٣,٤٥	٤٩,١٩	٣,١٨٢	٢٩٧٠
Their mixtures (١:١:١)	low	R١	٢٣,٦٧	٢١٩٤,٥	٤٦,٢	٣٨,٦٤	٣٦,٣٥	٣٣٧٠	٣,١١١	٢٩٠٣	٤٣,٧	٤٧,٠٥	٣,٥٠٠	٣٢٦٧
	high	R٢	٢٤,١٩	٢٢٤٢,٦	٤٤,٥	٤٠,٣٠	٣٧,٠٧	٣٤٣٧	٣,١٦١	٢٩٥٠	٤٤.٥	٤٤,٨٩	٣,٨٧٩	٣٦٢١
Mean			٢٣,٩٣	٢٢١٨,٦	٤٥,٣٥	٣٩,٤٧	٣٦,٧١	٣٤٠٣	٣,١٣٦	٢٩٢٦	٤٤,١٠	٤٥,٩٤	٣,٦٩٠	٣٤٤٤
Average	low	R١	١٩,١٧	١٧٧٧,٠	٤٢,٣٧	٣٥,٨٩	٣٢,٥٤	٣٠١٧	٣,٠٤٩	٢٨٤٦	٤٣,٥	٤٧,٩٥	٣,٣٢٥	٣١٠٣

	high	R٢	٢١,٧٥	٢٠١٧,٠	٤٢,٣٢	٤٠,١٧	٣٤,١١	٣١٦٢	٣,٠٩٩	٢٨٩٢	٤٤,٠	٤٦,٢٣	٣,٦٩٧	٣٣٥٧
Overall mean			٢٠,٤٦	١٨٩٧,٣	٤٢,٣٥	٣٨,٠٥	٣٣,٣٣	٣٠٩٠	٣,٠٧٤	٢٨٦٩	٤٣,٧٥	٤٧,٠٩	٣,٤٦١	٣٢٣٠

Notes: **١-** Each figure is a mean of ٣ variables and all obtained data were calculated on oven dry weight basis at ٧٠ Cº for ١٨ hours
٢- Ardeb of wheat grains = ١٥٠ kg and heml straw (tepn) = ٢٥٠ kg, while, ardeb of maize grains = ١٤٠ kg
٣-Winter growing season elongated ١٣٥ days for wheat and growing summer season period elongated ٩٣ days.
٤- Wet – treatment (light irrigation): ٣٠ % AWSMD (short – intervals)(٣ days) for wheat and every day for maize crop.

Table(١٢,٢): Biomass grains and straw yields of wheat and maize crops after full maturity as affected by natural soil conditioner types, their mixtures and application rates under medium-treatment (moderate irrigation).

Soil conditioner types and their mixtures	Conditioner application rates (w/w)		Biomass wheat crop yield						Biomass maize crop yield					
			Moderate irrigation (median – intervals ٦ days)						Moderate irrigation (median – intervals ٣ days)					
			Biomass grains yield		١٠٠٠ grains weight (gm)	Harvest index (%)	Biomass straw (tepn)yield		Biomass grains yield		١٠٠ grains weight (gm)	Harvest index (%)	Biomass straw yield	
			g pot-١	(kg fed-١)			g pot-١	(kg fed-١)	(kg plot-١)	(kg fed-١)			(kg plot-١)	(kg fed-١)
Control	**Without additions**		١٤,٠٤	١٣٠٢	٣٠,٦	٣٢,٦٩	٢٨,٩١	٢٦٨٠	٢,١١٨	١٩٧٧	٤١,٢	٤٢,٤٦	٢,٨٧٠	٢٦٧٦
Bentonite	low	R ١	١٧,٢٢	١٥٩٦	٤٠,٣	٣٦,٢٥	٣٠,٢٨	٢٨٠٧	٣,٠٠٣	٢٨٠٣	٤٢,٦	٤٩,٢١	٣,٠٩٩	٢٨٩٣
	high	R ٢	٢٠,١٦	١٨٦٩	٤٠,٦	٣٧,٨٩	٣٣,٠٤	٣٠٦٣	٣,٠٩٦	٢٨٩٠	٤٣,٥	٤٩,١٧	٣,٢٠٠	٢٩٨٧
Mean			١٨,٦٩	١٧٣٢,٥	٤٠,٤	٣٧,٠٧	٣١,٦٦	٢٩٣٥	٣,٠٥٠	٢٨٤٦	٤٣,٠٥	٤٩,١٩	٣,١٥٠	٢٩٤٠
Compost	low	R ١	١٥,٩٧	١٤٨٠,٥	٤٠,٠	٣٤,٨١	٢٩,٩١	٢٧٧٣	٣,٢٠٤	٢٩٩٠	٤٢,٢	٤٤,٤٨	٣,٩٩٩	٣٧٣٣

	high	R ٢	١٨,٠٧	١٦٧٥,٥	٤٠,٢	٣٦,٨٤	٣٠,٩٨	٢٨٧٨	٣,٣٠٤	٣٠٨٤	٤٥.٢	٤٤,٠٣	٤,١٩٩	٣٩٢٠
Mean			١٧,٠٢	١٥٧٨	٤٠,١	٣٥,٨٢	٣٠,٤٥	٢٨٢٣	٣,٢٥٤	٣٠٣٧	٤٣,٧	٤٤,٢٦	٤,١٠٠	٣٨٢٧
MNRM	low	R ١	١٩,٢٥	١٧٨٥	٤٢,٢	٣٨,٠٩	٣١,٢٨	٢٩٠٠	٣,١٠٧	٢٩٠٠	٤٣,٩	٤٩,١١	٣,٢١٩	٣٠٠٥
	high	R ٢	٢٢,٨١	٢١١٥	٤٢,٩	٤١,٠٥	٣٢,٧٦	٣٠٣٧	٣,٢٠٤	٢٩٩٠	٤٤,٥	٤٥,١٦	٣,٨٩٤	٣٦٣١
Mean			٢١,٠٣	١٩٥٠	٤٢,٥	٣٩,٥٧	٣٢,٠٢	٢٩٦٩	٣,١٥٥	٢٩٤٥	٤٤,٢	٤٧,١٤	٣,٥٦٥	٣٣١٨
Their mixtures (١:١:١)	low	R ١	١٩,٨٥	١٨٤٠,٥	٤٣,٦	٣٨,٥٦	٣١,٦٣	٢٩٣٣	٣,٢٤٢	٣٠٢٦	٤٤,٥	٤٤,٨٣	٣,٩٨٩	٣٧٢٤
	high	R ٢	٢٣,٦٧	٢١٩٤,٥	٤٥,٢	٤٠,٨٥	٣٤,٢٧	٣١٧٧	٣,٢٩٦	٣٠٧٦	٤٥,٠	٤٤,٨٩	٤,١٠٠	٣٨٢٧
Mean			٢١.٧٦	٢٠١٧,٥	٤٤,٤	٣٩,٧٧	٣٢,٩٥	٣٠٥٥	٣,٢٦٩	٣٠٥١	٤٤,٧٥	٤٤,٨٦	٤,٠٤٥	٣٧٧٦
Average	low	R ١	١٨,٠٧	١٦٧٥,٥	٤١,٥٣	٣٦,٩٩	٣٠,٧٨	٢٨٥٣	٣,١٣٩	٢٩٣٠	٤٣,٣	٤٦,٩١	٣,٥٧٩	٣٣٣٨
	high	R ٢	٢١,١٧٨	١٩٦٣,٥	٤٢,٢٣	٣٩,٢٦	٣٢,٧٦	٣٠٣٨	٣,٢٢٥	٣٠١٠	٤٤,٦	٤٥,٨١	٣,٨٤٨	٣٥٩١
Overall mean			١٩,٦٣	١٨١٩,٥	٤١,٨٨	٣٨,١٩	٣١,٧٦	٢٩٤٦	٣,١٨٢	٢٩٧٠	٤٣,٩٣	٤٦,٣٦	٣,٧١٣	٣٤٦٥

Notes: ١- Each figure is a mean of ٣ variables and all obtained data were calculated on oven dry weight basis at ٧٠ Cº for ١٨ hours

٢- Medium – treatment (moderate irrigation): ٥٠ % AWSMD (median – intervals)(٦ days) for wheat and ٣ days for maize crop.

٣- Harvest index (%) =[Biomass grains yield(g pot$^{-١}$) /Biological crop yield (g pot$^{-١}$)] x ١٠٠ on oven dry weight basis at ٧٠ Cº for ١٨ hours.

Table(١٢,٣): Biomass grains and straw yields of wheat and maize crops after full maturity as affected by natural soil conditioner types, their mixtures and application rates under dry-treatment (heavy irrigation).

Soil conditioner types and	Conditioner application	Biomass wheat crop yield	Biomass maize crop yield
		Heavy irrigation (long – intervals ٩ days)	Heavy irrigation (long – intervals ٨ days)

their mixtures	rates (w/w)		Biomass grains yield		١٠٠٠ grains weight (gm)	Harvest index (%)	Biomass straw (tepn)yield		Biomass grains yield		١٠٠ grains weight (gm)	Harvest index (%)	Biomass straw yield	
			g pot-١	(kg fed-١)			g pot-١	(kg fed-١)	(kg plot-١)	(kg fed-١)			(kg plot-١)	(kg fec
Control	Without additions		١٠,٧٩	١٠٠٠	٣٠,٣	٣٤,٤٥	٢٠,٥٣	١٩٠٣	٢,٠٣٦	١٩٠٠	٤٠,٠	٤٩,٢٢	٢,٠٩٩	١٩٦٠
Bentonite	low	R ١	١٣,٠٩	١٢١٣	٣٩,٥	٣٦,٢٢	٢٣,٠٥	٢١٣٧	٢,٨١٨	٢٦٣٠	٤١,٠	٤٩,٤٥	٢,٨٨	٢٦٨٨
	high	R ٢	١٨,٣٨	١٧٠٤	٤٠,١	٣٨,٨٧	٢٨,٩١	٢٦٣٠	٢,٨٠٧	٢٦٢٠	٤٢,١	٤٨,٣٥	٢,٩٩	٢٨٠٠
Mean			١٥,٧٤	١٤٥٨	٣٩,٨	٣٧,٧٢	٢٥,٩٨	٢٤٠٨	٢,٨١٢	٢٦٢٥	٤١,٥٥	٤٨,٨٩	٢,٩٣٩	٢٧٤٤
Compost	low	R ١	١٢,٢٦	١١٣٧	٣٨,٩	٣٣,٢٤	٢٤,٦٢	٢٢٨٣	٢,٩٨٢	٢٧٨٣	٤١,٢	٤٦,٤٣	٣,٤٤	٣٢١١
	high	R ٢	١٥,٩٢	١٤٧٦	٤٠,١	٣٧,٤١	٢٦,٦٤	٢٤٧٠	٣,١٠٧	٢٩٠٠	٤٢,٣	٤٤,٤	٣,٨٩	٣٦٣١
Mean			١٤,٠٩	١٣٠٦	٣٩,٥	٣٥,٤٧	٢٥,٦٣	٢٣٧٦	٣,٠٤٤	٢٨٤١	٤١,٧٤	٤٥,٤٢	٣,٦٦٥	٣٤٢١
MNRM	low	R ١	١٥,٠٦	١٣٩٦	٤٢,٩	٣٩,٥٢	٢٣.٠٥	٢١٣٧	٢,٩٨٩	٢٧٩٠	٤٢,٧	٤٩,٩٢	٢,٩٩	٢٨٠٠
	high	R ٢	٢٤,٧٩	٢٢٩٨	٤٤,٥	٤٧,٦٧	٢٧,٢١	٢٥٢٣	٣,٠٠١	٢٨٠١	٤٢,٨	٤٨,٣٩	٣,٢٠	٢٩٨٧
Mean			١٩,٩٣	١٨٤٧	٤٣,٧	٤٤,٢٣	٢٥,١٣	٢٣٣٠	٢,٩٩٥	٢٧٩٥	٤٢,٧٣	٤٩,١٦	٣,٠٩٩	٢٨٩٣
Their mixtures (١:١:١)	low	R ١	١٦,٣١	١٥١٢	٤٢,٥	٣٥,٧٩	٢٩,٢٦	٢٧١٣	٣,٠٥٤	٢٨٥٠	٤٢,٥	٤٧,٨٣	٣,٣٣	٣١٠٨
	high	R ٢	٢٠,٣١	١٨٨٢	٤٤,٢	٤٠,٠٦	٣٠,٣٨	٢٨١٧	٣,٠٩٦	٢٨٩٠	٤٤,٠	٤٦,٥٩	٣,٥٤	٣٣١٣
Mean			١٨,٣٠	١٦٩٧	٤٣,٤	٣٨,٠٢	٢٩,٨٢	٢٧٦٥	٣,٠٧٥	٢٨٧٠	٤٣,٢٥	٤٧,٢١	٣,٤٤	٣٢١١
Average	low	R ١	١٤,١٨	١٣١٤	٤٠,٩٥	٣٦,٢	٢٤,٩٩	٢٣١٧	٢,٩٦١	٢٧٦٣	٤١,٩	٤٨,٤١	٣.١٦	٢٩٥١
	high	R ٢	١٩,٨٦	١٨٤٠	٤٢,٥١	٤١,٢٣	٢٨,٢٩	٢٦١٠	٣,٠٠٣	٢٨٠٣	٤٢,٧	٤٦,٩٣	٣,٤١	٣١٨٢

Overall mean	١٧,٠٢	١٥٧٧	٤١,٦١	٣٨,٩٨	٢٦,٦٤	٢٤٦٣	٢,٩٨٢	٢٧٨٣	٤٢,٣٢	٤٧,٦٧	٣,٢٨٥	٣٠٦٧

Notes :

١- Each experimental plastic pot received (w/w)٣٦٠ kg $fed^{-١}$ $NH_{٤}NO_{٣}$(٣٣,٥ % N) equivalent ١,٢٠٦ g-N $pot^{-١}$;٢٠٠ kg $fed^{-١}$ ordinary superphosphate (١٥,٥ % $P_{٢}O_{٥}$)equivalent (١٣٥,٤ mg –P $pot^{-١}$) and ٥٠ kg $fed^{-١}$ $K_{٢}SO_{٤}$ (٤٨ % $K_{٢}O$) equivalent ١٩٩,١٥ mg-K $pot^{-١}$).

٢- Each experimental plot area received ٢٦٠ kg $fed^{-١}$ urea (٤٦,٥ % N) equivalent ٠.١٢٧ kg-N $plot^{-١}$; ٢٠٠ kg $fed^{-١}$ ordinary superphosphate (١٥,٥ % $P_{٢}O_{٥}$)equivalent (١٤,١٦ g –P $plot^{-١}$) and ٥٠ kg $fed^{-١}$ $K_{٢}SO_{٤}$ (٤٨ % $K_{٢}O$) equivalent ٢٠,٨٤ g-K $plot^{-١}$).

٣- Each figure is a mean of ٣ variables and all obtained data were calculated on oven dry weight basis at ٧٠ C^{o} for ١٨ hours.

٤- Dry – treatment (heavy irrigation): ٧٠ % AWSMD (long – intervals)(٩ days) for wheat and ٨ days for maize crop.

Table(١٢,٤): Yield components of wheat crop after full maturity as affected by soil conditioner types, their mixtures and application rates under different soil moisture depletion regimes over the growing winter season period ٢٠١٠/٢٠١١.

Soil conditioner types and their mixtures	Conditioner application rates (w/w)	Soil moisture depletion levels from its available water capacity (AWSMD-levels)														
		Wet - treatment (٣٠ % AWSMD) Light irrigation Short- intervals (٣ days)					Medium- treatment (٥٠ % AWSMD) Moderate irrigation Median - intervals (٦ days)					Dry -treatment (٧٠ % AWSMD) Heavy irrigation Long-intervals (٩ days)				
		١٤,٤٥ % SMC					١٢,٧٥ SMC					١١,٠٨ %SMC				
		Plant height (cm)	No of tillers /spike	No of spikelets/ spike	Spike length(cm)	Panicle mean weight ton $fed^{-١}$	Plant height (cm)	No of tillers /spike	No of spikelets /spike	Spike length(cm)	Panicle mean weight ton fed-١	Plant height (cm)	No of tillers /spike	No of spikelets/ spike	Spike length(cm)	Panicle mean weight ton $fed^{-١}$

Control	Without additions		٧٩,٥	٢,٢	١٧	١٠,٨	١,٠	٧٧,٥	٣,٣	١٧,٢	١٠,٧	١,٣٢	٧٢,٥	٣,٢	١٦,٨	١٠,٥	١,١٩
Bentonite	low	R١	٨٥,٦	٣,٦	١٧,٥	١١,٥	١,٧٦	٨٢,٥	٣,٤	١٧,٢	١١,٣	١,٧٥	٨٠,٥	٣,١	١٦,٩	١١,٠	١,٥٥
	high	R٢	٨٨,٥	٣,٨	١٧,٩	١١,٨	٢,٠٦	٨٤,٥	٣,٦	١٧,٥	١١,٥	٢,٠٤	٨١,٥	٣,٣	١٧,٥	١١,٣	١,٨٣
Mean			٨٧,٠٥	٣,٧	١٧,٧	١١,٦٥	١,٩١	٨٣,٥	٣,٥	١٧,٣٥	١١,٤	١,٨٩٥	٨١,٠	٣,٢	١٧,٢	١١,١٥	١,٦٩
Compost	low	R١	٨٢.٤	٣,٣	١٧,٢	١١,٢	١,٦٤	٨٠,٥	٣,٢	١٧,٢	١١,٠	١,٦١	٧٨,٥	٢,٩	١٧,٠	١٠,٩	١,٥٣
	high	R٢	٨٤,٥	٣,٦	١٧,٥	١١,٥	١,٨٥	٨٢,٥	٣,٤	١٧,٣	١١,٣	١,٧٧	٧٩,٩	٣,١	١٧,١	١١,٢	١,٧٠
Mean			٨٣,٤٥	٣,٤٥	١٧,٣٥	١١,٣٥	١,٧٤٥	٨١,٥	٣,٣	١٧,٢٥	١١,١٥	١,٦٩	٧٩,٢	٣,٠	١٧,٠٥	١١,٠٥	١,٦١٥
MNRM	low	R١	٨٨.٥	٤,٢	١٨,٥	١١,٨	١,٦٥	٨٧,٥	٣,٩	١٨,٢	١١,٥	١,٧١	٨٣,٥	٣,٢	١٨,٠	١٠,٩	١,٦٧
	high	R٢	٩٠,٥	٤,٥	١٨,٨	١٢,٣	١,٩٠	٨٩,٥	٤,٢	١٨,٥	١٢,١	١,٨٧	٨٥,٥	٣,٨	١٨,٢	١١,٨	١,٨٠
Mean			٨٩,٥	٤,٣٥	١٨,٦٥	١٢,٠٥	١,٧٧٥	٨٨,٥	٤,٠٥	١٨,٣٥	١١,٨	١,٧٩	٨٤,٥	٣,٥	١٨,١	١١,٣٥	١,٧٣٥
Their mixtures (١:١:١)	low	R١	٩١,٥	٤,٦	١٩,٢	١٢,٠	٢,٠٣	٩٠,٥	٤,٣	١٨,٨	١١,٩	٢,٠٠	٨٥,٥	٤,٠	١٨,٤	١١,٥	١,٨٨
	high	R٢	٩٢,٥	٤,٧	١٩,٨	١٢,٨	٢,٣٧	٩١,٥	٤,٦	١٩,٥	١٢,٥	٢,٣٧	٨٧,٤	٤,٣	١٩,٢	١٢,٢	٢,١٢
Mean			٩٢,٠	٤,٦٥	١٩,٥	١٢,٤	٢,٢٠	٩١,٠	٤,٤٥	١٩,١٥	١٢,٢	٢,١٨٥	٨٦,٤٥	٤,١٥	١٨,٨	١١,٨٥	٢,٠٠
Average	low	R١	٩١,٣	٤,٥	١٩,٢	١٢,٣	٢,٠٩	٩٠,٣	٤,٣٥	١٨,٩٥	١٢,١	٢,٠٨	٨٥,٩٦	٣,٩٨	١٨,٦	١١,٧	١,٩٣
	high	R٢	٩١,٨	٤,٦	١٩,٤٤	١٢,٣	٢,١٧	٩٠,٨٤	٤,٤٢	١٩,١٠	١٢,١	٢,١٦	٨٦,٣٢	٤,١٠	١٨,٧	١١,٨١	١,٩٨
Overall mean			٩١,٦	٤,٦	١٩,٣٦	١٢,٣٤	٢,١٠	٩٠,٦	٤,٣٨	١٩,٠٢	١٢,١٣	٢,١٢	٨٦,١٤	٤,٠٤	١٨.٦٩	١١,٧٧	١,٩٥

Notes: Each figure is a mean of ٣ replicates.

Table(٥,٥): Yield components of maize crop after full maturity as affected by soil conditioner types, their mixtures and application rates under different soil moisture depletion regimes over the summer growing season period ٢٠١١.

Soil conditioner types and	Soil moisture depletion levels from its available water capacity (AWSMD-levels)

their mixtures	Conditioners application rates (w/w)		Wet - treatment (٣٠ % AWSMD) light irrigation Short- intervals (every day)			Medium- treatment (٥٠ % AWSMD) Moderate irrigation Median - intervals (٣ days)			Dry -treatment (٧٠ % AWSMD) Heavy irrigation Long-intervals (٨ days)		
			١٥,٣٣ %SMC			١٣,٥ % SMC			١١,٧ % SMC		
			Ear weight (g)	**Plant height (cm)**	**Ear length (cm)**	**Ear weight (g)**	**Plant height (cm)**	**Ear length (cm)**	**Ear weight (g)**	**Plant height (cm)**	**Ear length (cm)**
Control	Without additions		٢٥١,٥	١٨٠,٠	١٤,٥	٢٥٢,٠	١٨٢,٥	١٥,٥	٢٥٠,٠	١٧٧,٠	١٣,٨
Bentonite	low	R١	٢٨٨,٤	١٩٠,٠	١٥,٥	٢٩٠,٠	١٩٥,٣	١٦,٠	٢٨٧,٥	١٨٨,٠	١٥,٠
	high	R٢	٢٩٠,٤	١٩٥,٠	١٦,٠	٢٩٢,٥	١٩٦,٠	١٦,٧	٢٩٠,٠	١٩٤,٠	١٤,٥
Mean			٢٨٩,٤	١٩٢,٥	١٥,٧٥	٢٩١,٢٥	١٩٥,٦٥	١٦,٣٥	٢٨٨,٧٥	١٩١,٠	١٤,٧٥
Compost	low	R١	٣٤٠,٨	٢٠٤,٠	١٩,٠	٣٤٢,٥	٢٠٨,٠	٢٠,٠	٣٤٠,٠	٢٠٣,٠	١٩,٠
	high	R٢	٣٥٥,٩	٢٠٦,٠	٢٠,٠	٣٦٠,٠	٢١٠,٠	٢٢,٠	٣٥٢,٧	٢٠٥,٠	١٩,٥
Mean			٣٤٨,٣٥	٢٠٥,٠	١٩,٥	٣٥١,٢٥	٢٠٩,٠	٢١,٠	٣٤٦,٣٥	٢٠٤,٠	١٩,٢٥
MNRM	low	R١	٣١٠,٣	١٩٥,٥	١٦,٦	٣١٥,٠	١٩٦,٠	١٧,٥	٣٠٩,٧	١٩٤,٩	١٦,٠
	high	R٢	٣٢٢,٢	١٩٧,٥	١٨,٥	٣٢٥,٠	٢٠٠,٠	١٩,٠	٣٢٠,٠	١٩٥,٥	١٨,٠
Mean			٣١٦,٢٥	١٩٦,٥	١٧,٥٥	٣٢٠,٠	١٩٨,٠	١٨,٢٥	٣١٤,٨٥	١٩٥,٢	١٧,٠
Their mixtures (١:١:١)	low	R١	٣٣٣,٦	٢٠٠,٠	١٩,٠	٣٣٥,٠	٢٠٥,٠	٢٠,٠	٣٣٢,٠	١٩٩,٠	١٨,٧
	high	R٢	٣٤٣,٧	٢٠٣,٠	١٩,٥	٣٤٠,٠	٢٠٥,٥	٢٢,٠	٣٤٠,٠	٢٠٤,٠	١٩,٠
Mean			٣٣٨,٦٥	٢٠١,٥	١٩,٢٥	٣٣٧,٥	٢٠٥,٢٥	٢١,٠	٣٣٦,٠	٢٠١,٥	١٨,٨٥

Average	low	R١	٣١٨,٢٧	١٩٧,٣٧	١٧,٥٢	٣٢٠,٦	٢٠١,٠٧	١٨,٣٧	٣١٧,٣	١٩٦.٢٢	١٧,٠٥
	high	R٢	٣٢٨,٠٥	٢٠٠,٣٧	١٨,٥٠	٣٢٩,٤	٢٠٢,٨٧	١٩,٩٢	٣٢٥,٧	١٩٩,٦٣	١٧,٣٨
Overall mean			٣٢٣,١٦	١٩٨,٨٧	١٨,٠١	٣٢٤,٩٨	٢٠١,٩٧	١٩,١٤	٣٢١,٤٨	١٩٧,٩٢	١٧,٢١

Notes: Each figure is a mean of ٣ replicates.

Soil Characters	Obtained values	
	Site (١)* Pot-experiment	Site(٢)** Field-experiment
Chemical analysis		
Soil reaction pH (١:٢.٥ soil-water suspension)	[illegible]	٧,٩٠
Electrical conductivity, EC dS$m^{-١}$ (Soil past extract)at ٢٥ Cº	٢,٦٠	٣,٧٥
Saturation percentage(S.P) %	٣٨,٠	٤٠,٠
Total soluble salts(T.S.S) *m*g $kg^{-١}$ soil	٦٣٢(٠,٠٦٣٪)	٩٦٠(٠,٠٩٦٪)
Calcium carbonate ($CaCO_{٣}$) %	٠,٤٠	٠,٦٠
Total soluble ions(١:٥ Soil-water extractions)		
Soluble cations		
$Ca^{+٢}$ *m*eq $L^{-١}$	١,١٠	١,٠٠
$Mg^{+٢}$ *m*eq $L^{-١}$	١,٤٦	١,٢٠
Na^{+} *m*eq $L^{-١}$	١,٥٠	٣,٧٠
K^{+} *m*eq $L^{-١}$	٠,١٤	٠,١٠
Soluble anions		
$CO_{٣}^{=}$ *m*eq $L^{-١}$	٠,٠٠	٠,٠٠
$HCO_{٣}^{-}$ *m*eq $L^{-١}$	٢,٣٠	١,٥٠
CL^{-} *m*eq $L^{-١}$	١,٤٠	٢,٠٠
$SO_{٤}^{-٢}$ *m*eq $L^{-١}$	٠,٣٠	٢,٥٠
EC , dS$m^{-١}$ (١:٥ soil-water extraction)	٠,٤١٦	٠,٦٠٢
Ionic strength (I.S) *mm*oles $L^{-١}$	٤,٥٠	٤,٤٥
Sodium adsorption ratio(SAR)	١,٣٢٧	٣,٥٣
Soluble sodium percentage(SSP) %	٣٥,٧١	٦١,٧
Physical analysis		
Particle size distribution (g/١٠٠g soil)		
Coarse sand fraction %	٦٥,٠	٥٠,٠
Fine sand fraction %	١٠,٠	٥,٥٠
Silt fraction %	١٥,٠	٣١,٠
Clay fraction %	١٠,٠	١٣,٥
Soil texture class	Loamy sand	Loamy sand
Soil bulk density(Db) Mg $m^{-٣}$	١,٥٧	١,٥٥
Soil particle density (Dp)) Mg $m^{-٣}$	٢,٦٦	٢,٦٦
Total porosity(pt) on volume basis %	٣٤,٢١	٤١,٧٣
Soil saturated hydraulic conductivity (S.H.C) *m* $day^{-١}$	٢,٥٢	٢,٦٥

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