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Integrated Input Soil and Water Managements in Maximizing Peanut Crop under the Eastern Drought–front Desert Outskirt of El Fayoum Governorate, Egypt

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Abstract: The current study aimed at identifying the integrated input soil and water management practices such as applying some natural soil amendments derived from either organic or inorganic sources for improving characteristics of the drought-front desert soils of El Fayoum depression, and in turn maximizing the crop yields and their quality. To achieve this target, a field experiment was carried out on peanut (*Arachis hypogaea*, Giza 5 cv.) grown on a newly reclaimed sandy soil at the eastern desert outskirt of El Fayoum district and Governorate during the summer growing season of 2007. The applied treatments were composted plant residues at the rate of 12.5 ton/fed, enriched bentonite shale at the rate of 10 ton/fed and other one rich in gypsum at the rate of 500 kg/fed, added solely or together under different levels of soil moisture regimes, *i.e.,* 50 and 75 % depletion of the available soil moisture range. The obtained results indicate that the experimental soil is characterized by coarse textural class, which is poorer in the nutrient bearing minerals as well as it is not partially capable to retain neither soil moisture nor nutrients for both growing plants. Also, the studied soil could be classified as "Typic Torripsamments, siliceous, hyperthermic" and its evaluated class was a marginally suitable class ($S3s_1$), with soil texture as an effective current or potential limitation for soil productivity. So that, soil properties responded markedly to the all the tested treatments, particularly the combined one of ½ (organic compost + bentonite shale) under the application of gypsum and irrigation at 50 % depletion of available water range, which surpassed the full rates of the applied solely treatments. This hold was true, since the derived active organic acids and charged silicate clays from organic compost and enriched bentonite shale, respectively, had been found to be a profound effect on not only the adaptation of soil structure parameters, *i.e.,* bulk density and total porosity, but also the positive impact was extent to the values of soil saturated water flow, available water range, cation exchange capacity, available contents of macro and micronutrients. In addition, the beneficial effect of this combined treatment cleared through enhancing the chelating agent by active groups of micronutrients and forming organo-metalic complexes, which are considered as a strategic storehouse and more mobile or available to uptake by plants, and in turn reflected positively on growth development of peanut plants as well as seed yield and its quality. Such favourable conditions for the adapted experimental soil were confirmed by the obtained data in the current workgroup. The significance of either adapted soil properties or moisture regimes in the drought front desert outskirts at El Fayoum district is of the most important factors limiting both horizontal and vertical agricultural utilization as well as maximizing peanut seed yield and its quality. Moreover, such interaction led to control the best use efficiency of available water and nutrients for maximize the return of peanut pod, seed and straw yields as well as seed quality, *i.e.*, weight of 100 seeds, crude protein, oil, macro and micronutrient contents.

Key words: Peanut, compost, soil moisture regime, drought-front desert outskirts, integrated input soil and water management practices

INTRODUCTION

The significance of either available arable land or fresh water resources for agricultural utilization in the drought front desert outskirts at El Fayoum districts is one of the most important factors limiting both horizontal and vertical expansions as well as maximizing crop yield and its quality. Such conditions are the result of a complex combination of soil, plant and atmosphere factors, which all interact to control the best use efficiency of water for crop production as well as to maximize the return of water unit for irrigation[7]. The main mechanical constituent of sandy soils is the sandy fraction, which is not partially capable to retain neither water nor nutrients for growing plants. Accordingly, these soils are poor not only in the

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nutrient-bearing minerals, but also in organic matter, which are a storehouse for the essential plant nutrients. In addition, the occurrence of inadequate water retention under such severe conditions, in turn the productivity of different crops tends to decrease markedly[38]. Thus, locally tremendous efforts should be implemented to face or mitigate the shortage in water resources that have accelerated the direction towards expansion of conventional agriculture, particularly in the drought-front desert outskirts for cereal and oil crops that represent a problem facing Egypt at the present time.

Under the conditions of arid and semi-arid regions, such as El Fayoum Governorate, where the rainfall is scarce, water resources are limited and skeletal nature of soils; the best use of water for crop production must be made. This requires a proper understanding of the crop response to water to maximize the return of water unit used for irrigation. Thus, water management practices in such coarse textured soils are considered of importance to improve their water retention and excessive downward movement of water through the conductive pores[37]. Irrigation requirements have a vital role in crop production and irrigation planning. The irrigation methods often need to be applied under climatic and agronomic conditions very different from those under which they were originally developed. Thus, it is very important to evaluate these methods to be adapted if needed for application under different conditions[3].

The changes in water stress (soil potential) in the soil led to a considerable difference in either water consumptive use values or water utilization efficiency for grown plants, and in turn net input of crop yield. This statement is in harmony with those obtained by Demion *et al.*[16] who found that all yield and yield components of peanut increased as soil moisture depletion decreased, however, the seasonal water consumptive use by peanut amounted 45.07, 41.35 and 36.74 cm for 25, 50 and 75 % depletion from the available soil moisture, respectively. Accordingly, water use efficiency reached its maximum value at 25 % depletion, while the converse was true at 75 % depletion from the available soil moisture.

Also, Aziz-Nagat[6] and Al Ajmi *et al.*[2] studied the effects of both soil and water management through using different levels of some organic amendments (i.e., sludge, cattle manure and poultry manure) and/or irrigation treatments (i.e., 25,50 and 75 % depletion of the available soil water) and found that an ameliorative role as well as sufficient available water was achieved as a result of the applied treatments. This beneficial effect of organic material is more related to a direct effect on the retention function because of its the hydrophilic nature, which is coupled with the processes of infiltration, runoff, erosion chemical movement and crop growth.[22,23,42] found that application of bentonite at the rate of 10 ton/fed followed by organic compost at a rate of 10 ton/fed gave the greatest figure of beneficial effects of some sandy soil characteristics. Moreover, application of organic matter had an indirect effect on the modification of the soil structure that influences the water movement into (infiltration) and out (evaporation and drainage) as well as within (conductivity) a soil, and thus affects the quantity of water retaining in the soil.

Whenever, the application of organic materials as a soil management is of direct relevance in that it has drastic effects on some soil properties which reflect positively on the existed grown crops, in particular, their growth, yield and yield quality[24,12]. At the same time, peanut is considered one of the most summer oil crops in Egypt due to it has been adapted to cultivate in the newly reclaimed desert sandy soil as well as it gains an economical input for the producers. Also, the importance of this crop is mainly attributed to its high nutritive values for human consumption and industrial purposes. It contains about 30 % protein, 45 % oil and rich in vitamins B and C[18]. In such relatively coarse textured soils, however, peanut production is concentrated, fertilization with different plant nutrients as well as gypsum as a soil amendment and a source of Ca and S is necessary for enhancing the vegetative growth. In addition, the released Ca and S from gypsum are often presented a yield limiting factor for pod growth and increasing peg strength.

In this concern,[8] reported that an increase in peanut seed yield was achieved as a result of applying 112 kg gypsum/ha due to improving the shelling percentage by 2.2 %. Also, Sharma *et al.*[47] found that application of gypsum at a rate of 270 kg/ha increased the pod yield significantly by 537 kg/ha over the control treatment, which produced 2432 kg/ha pod yield. David *et al.*[15] and Borhamy[10] pointed out that application of Ca significantly increased pod yield of peanut, and in turn increased the yield of seeds. Accordingly, this study was conducted to clarify the integrated input soil and water management practices, i.e., applying some natural organic and inorganic materials as soil amendments under different levels of soil moisture regimes for improving soil characteristics of the drought-front desert outskirt of El Fayoum depression, and in turn for maximizing the peanut seed yield and its quality.

MATERIALS AND METHODS

To achieve the previous target a field experiment was carried out on peanut (*Arachis hypogaea*, Giza 5 c.v) grown on a newly reclaimed sandy soil at the eastern drought-front desert outskirt of El Fayoum district and Governorate. Disturbed and undisturbed soil samples were collected from the initial state of the experimental soil at a depth of 0-30 cm for determining the main physical (*i.e.*, particle size distribution, particle density, dry bulk density, total porosity, hydraulic conductivity and soil moisture content at available water range) and chemical properties (*i.e.,* pH in 1: 2.5 soil water suspension, ECe & soluble ions in soil paste extract, CEC, ESP, $CaCO_3$ and organic matter contents) according to the standard methods outlined by Black *et al.*[9] and Page *et at*.[40]. In addition, the nutrients status in soil, however, available N, P and K were extracted and determined according to Jackson[32] and Soltanpour and Schwab[48]. Also, available micronutrients (Fe, Mn, Zn, and Cu) were extracted using ammonium bicarbonate DTPA extract according to Lindsay and Norvell[34], and measured by using Atomic Absorption Spectrophotometer. The obtained data of the studied soil properties and nutrients status are presented in Table (1).

The current field experiment was started, after winter wheat, at summer season of 2007. The applied locally soil amendments were represented by organic compost (composted plant residues), enrich bentonite and gypsum shale's. The main physical, chemical and nutrient status of the applied soil amendments are determined according to the previous standard methods, besides semi-quantitative of clay minerals for bentonite shale, which was carried out on the basis of visual estimates of X-ray diffraction intensity from test samples and standard mixtures of clay fractions according to Jackson[31], and then the obtained data are illustrated in Table (2).

The applied treatments were performed as solely or combined treatments with ½ of the applied rates under two levels of soil moisture regimes (irrigation at 50 and 75 % depletion of the available soil moisture) in fixed plots, with an area of 10.5 m^2 for each plot, which arranged in a split-split design, with three replicate, as follows:

1. Water management, *i.e.,* soil moisture regime (main plots):
   * Irrigation at 50 % depletion of the available soil moisture.
   * Irrigation at 75 % depletion of the available soil moisture.
2. Gypsum treatments (sub-plots):
   * 0 (control, untreated soil).
   * 500 kg/fed.
3. Organic and inorganic treatments (sub-sub-plots):
   * 0 (control, untreated soil).
   * Organic compost at a rate of 12.5 ton/fed.
   * Bentonite shale at a rate of 10 ton/fed.
   * ½ the applied rates of both organic compost and bentonite shale.

The tested soil amendments were added to the experimental soil plots during their preparation for planting, where the plots were ploughed twice in two ways and received superphosphate (15 P_2O_5 %) at a rate of 200 kg/fed (30 kg P_2O_5/fed). Peanut seeds (Giza 5) were sown under sprinkler irrigation system at last of May 2007. Nitrogen as ammonium sulphate (20.5 N%) and potassium as potassium sulphate (48 K_2O) were added at the rates of 40 kg N/fed as basal dose and 36 K_2O/fed, respectively, in two equal doses, i.e., after 1 and 2 months from planting. The other agronomic practices, except irrigation and organic fertilization, have been followed according the usual methods being adapted for peanut crop.

Soil samples were collected from a depth of 0-30 cm of each plot at 75 days of sowing (figure of maximum vegetative growth stage of peanut) for identifying impact of the applied treatments on some soil physical properties (*i.e.,* bulk density, hydraulic conductivity and available water range) and the nutrients status (*i.e.,* available contents of N, P, K, Fe, Mn, Zn and Cu) in the treated soil plots. Available nutrients of N, P and K were extracted by 1% potassium sulphate, 0.5 M sodium bicarbonate and 1.0 N ammonium acetate, respectively[32,13,9]. Also, the available micronutrient contents (*i.e.* Fe, Mn and Zn) were extracted with DTPA according to Lindsay and Norvell[34] and measured by using the Atomic Absorption Spectrophotometer.

Crop water relations were determined as follows:
a. Seasonal water consumptive use (ETc), which calculated as a water depth in cm using the following equation[30].

$Cu = (Q_2 - Q_1) \times Bd \times D/100$ where

Cu = Consumptive use (cm).
Q_2 = Soil moisture % 48 hours after irrigation.
Q_1 = Soil moisture % before irrigation.
Bd = Soil bulk density (g cm^{-3}).
D = Soil depth (cm).
b. Water use efficiency (WUE), which calculated using the equation of Vites[57] for grain yield, as follows:
WUE = Seed yield in kg/fed/actual consumptive use in m^3*/fed*

At harvest (last of September 2007), pod and straw yields of peanut were determined from each studied plot. Peanut pods were dried to separate seeds, and then their samples were dried and weighted to determine seed yield as well as seed quality (*i.e.*, weight of 100 seeds, crude protein, oil and nutrient contents). Seed samples were dried, ground and digested according to Thomas *et al.*[54], then subjected to the determination of N, P, K, Fe, Mn, Zn and Cu by using the standard methods described by Chapman and Pratt[26,13]. Crude protein of peanut seed was calculated by multiplying total N-content by 6.25[17]. Oil content of peanut seed was determined by using Solvent Extraction Method in Soxhlets apparatus with N-hexane as solvent[4]. Also, the micronutrients (i.e. Fe, Mn and Zn) were determined spectrophotometrically using the Atomic Absorption Spectrophotometer, (Berkin Elemer, 2380).

The obtained data of soil and plant characteristics were statistically analyzed according to the methods suggested by Gomez and Gomez[29] using the L.S.D. values at a 0.05 level of significance.

RESULTS AND DISCUSSION

General Information about the Experimental Soil: The experimental soil is mainly developed on the wind blown sand deposits as a parent material, and occupying the desert zone adjacent to the eastern rim of El Fayoum Governorate, Egypt. The prevailing climatic conditions of the studied area are long hot rainless summer and short mild winter with scare amounts of rainfall. The obtained data in Table (1) reveal that studied soil is characterized by coarse texture grade of sand and low CEC value as well as poorer in each of organic matter and nutrient bearing minerals, consequently its capacity to retain either plant nutrients or soil moisture is low. Such severe conditions get more attention for soil supplying essential nutrients to plants as well as soil amendments. That is true, since the available macro and micronutrient contents in the experimental sandy soil, Table (1), are lying at the low levels according to the critical levels of available plant nutrients outlined by Lindsay and Norvell[34,40]. Such unfavourable conditions are more attributed to the siliceous in nature of soil, which is dominated by sand fraction that is not only poorer in the nutrient bearing minerals but also it is not partially capable to retain nutrients or moisture for grown plants.

According to USDA[56], the studied soil could be classified as “Typic Torripsamments, siliceous, hyperthermic” at the family level. Data presented in Table (3) indicate that, by applying the parametric system undertaken by Sys and Verheye[50], the suitability class of studied sandy soil could be evaluated as marginally suitable class of (S3) either in current or potential conditions, besides soil texture (S_1) and gypsum (S_4) represent the most effective limitations for soil productivity, with intensity degrees of very severe (rating < 40) and slight (rating > 90), respectively.

Effect of the Applied Treatments on Some Hydrophysical Properties of the Studied Soil: The associated changes in the studied hydrophysical properties of the experimental sandy soil as related to the applied treatments, *i.e.,* gypsum shale, organic compost and bentonite shale under both soil moisture regime levels are presented in Table (4). The studied soil characteristics, in general, responded greatly to all the applied treatments added either solely or combined together at the half rates under peanut cultivation. However, the solely and combined treatments showed positive and significant effects for improving the values of soil bulk density, total porosity, hydraulic conductivity and available water range.

The results obtained in Table (4) indicate that a superiority for the applied combined treatment of ½ the added rates of organic compost + bentonite shale, however, it plays a dual positive role, *i.e.*, reducing soil bulk density vs increasing total soil porosity. Such promotive effects of organic (compost) or inorganic (gypsum and bentonite shale) application may be related to the increase of storage pores in the studied sandy soil, which can be regarded as an index of an improved soil structure. In addition, a thin coat of translocated fine particles of colloidal organic (active organic acids) and inorganic (fine clays) materials partially covered the walls interconnected vughs[11], which are usually the most common pores in this soil.

The pronounced decrease in hydraulic conductivity of the studied sandy soil may be attributed to the creation of meso or micro pores, which refer to the irrigation regimes and natural conditioners as well as represent a restrictive agent for water flow down movement[20]. These results are in agreement with those of El-Fayoumy and Ramadan[23]. In general, the magnitudes of soil available water range showed a positive response towards the soils treated with the applied treatments as compared to those untreated. This is due to the fact that both organic compost and bentonite shale attain a pronounced high content of active organic and inorganic charged colloidal particles, *i.e.,* active organic acids and charged silicate clays, besides the inter created micro-pores, which enhancing the water molecules to be chelated under matric and capillary potentials.

It is noteworthy to mention that the combined treatment of ½ the applied rates of organic compost (12.5 ton/fed) and bentonite shale (10.0 ton/fed) was surpassed the solely ones of them, particularly under gypsum shale and soil moisture regime at 50 % depletion of available water range for improving the aforementioned soil hydophysical properties. This hold was true, since the active organic acids and charged silicate clays have been found to be a profound effect on not only the adaptation of soil structure parameters (bulk density and total porosity), but also on saturated water flow and available water range[19,49]. These findings emphasized by El Maghraby[21] who reported that the applied organic materials produced polysaccharides and polyuorinides that are capable for binding soil particles or aggregates. Moreover, the

Table 1: Some physical, chemical and fertility characteristics of the studied soil.

Soil characteristics	Value	Soil characteristics.	Value						
Particle size distribution %:		Organic matter %	0.13						
Sand	87.9	Analysis of soil paste extract:							
Silt	8.4	EC (dS/m)	4.12						
Clay	3.7	*Soluble ions (m $mol_c L^{l}$):*							
Textural class	Sand	Ca^{++}	15.62						
Some soil physio-chemical properties:		Mg^{++}	8.41						
Particle density (g/cm^3)	2.67	Na^{+}	17.20						
Bulck density (g/cm^3)	1.64	K^{+}	0.15						
Total porosity %	41.03	CO_3^{--}	0.00						
Hydraulic cond. (cm/h)	8.79	HCO_3^{-}	2.35						
Available water range %	7.15	Cl^{-}	24.75						
pH (1:2.5 soil water suspension)	7.81	SO_4^{--}	14.28						
CEC ($Cmol_c\ kg^{-1}$)	4.95	*Available nutrients (mg/kg soil):*							
Exchangeable Na % (ESP)	6.34	N	P	K	Fe	Mn	Zn	Cu	
$CaCO_3$ %	0.97	13.87	3.45	41.20	4.73	0.81	0.65	0.47	

Critical limits of nutrients in mg/kg soil according to Lindsay and Norvell (1978) and Page et al. (1982)

Limits	N	P	K	Fe	Mn	Zn	Cu
Low	< 40.0	< 5.0	< 85.0	< 4.0	< 2.0	< 1.0	< 0.5
Medium	40.0-80.0	5.0-10.0	85.0-170.0	4.0-6.0	2.0-5.0	1.0-2.0	0.5-1.0
High	> 80.0	> 10.0	> 170	> 6.0	> 5.0	> 2.0	> 1.0

Table 2: Some characteristics of the studied locally organic and inorganic soil amendments.

Organic compost		Bentonite shale		Gypsum shale	
pH (1:10 water suspension)	7.15	pH (1:2.5 water suspension)	7.39	pH (1:2.5 water susp.)	5.7
Weight of 1 m^3 (kg)	497	CEC (me/100 g shale)	64.1	Total components of shale %	
EC (dS/m, 1:10 water extract)	2.34	EC (dS/m, paste extract)	7.12	$CaSO_4.2H_2O$ %	84.95
Organic matter %	49.6	$CaCO_3$ %	0.35	Soluble salts %	4.63
Organic carbon %	28.8	Gypsum %	0.14	$CaCO_3$ %	5.46
Total N %	1.63	*Particle size distribution %:*		Organic matter %	0.11
C/N ratio	17.7	Sand	2.74	Sand %	4.85
Total P %	0.42	Silt	9.81		
Total K %	3.07	Clay	87.45		
Available nutrients (mg/kg):		*Semi-quantitative analysis of clays%*			
N	1675	Smectites	71.3		
P	704	Kaolinite	9.56		
K	2014	Illite	6.7		
Fe	41.9	Vermiculite	5.93		

Table 2: Continue

Mn	23.8	Chlorite	3.14
Zn	19.8	Feldspars	2.5
Cu	14.9	Quartz	0.92

Table 3: Soil limitations and rating indices for the evaluation of the studied soil.

			S							
Suitability condition	Topography(t)	Wetness(w)	Soil texture(S1)	Soil depth (S2)	$CaCO_3$ (S3)	Gypsum (S4)	Soil Salinity/ Alkalinity(n)	Rating(Ci)	Suitabilition class	Suitabilition sub class
Current	100	100	30	100	100	90	100	27	S3	$S3S_1S_4$
Potential	100	100	30	100	100	90	100	27	S3	$S3S_1S_4$

Table 4: Some soil hydrophysical properties at the vegetative growth stage as affected by the applied treatments under both soil moisture regime levels.

Soil moisture regime (I)	Gypsum shale (ton/fed)	Organic compost or bentonite shale (T) (ton/fed)	Soil bulk density(g cm^3)	Soil total porosity%	Hydraulic conductivity (cm h^{-1})	Available water range %
Irrigation at 50 % depletion of the available soil moisture range	0.0	0	1.6	40.07	8.39	8.34
		12.5 Compost (OC)	1.56	41.57	7.73	8.5
		10 Bentonite (BS)	1.52	43.07	7.34	9.07
		6.25 OC + 5.00 BS	1.47	44.95	6.85	9.56
	0.5	0	1.58	40.82	8.18	7.92
		12.5 Compost (OC)	1.53	42.7	7.47	8.73
		10 Bentonite (BS)	1.49	44.19	7.15	9.25
		6.25 OC + 5.00 BS	1.43	46.44	6.27	9.98
Irrigation at 75 % depletion of the available soil moisture range	0.0	0	1.62	39.34	8.57	7.69
		12.5 Compost (OC)	1.58	40.82	7.8	7.41
		10 Bentonite (BS)	1.55	41.95	7.42	8.78
		6.25 OC + 5.00 BS	1.49	44.19	7.03	9.15
	0.5	0	1.59	40.45	8.27	7.65
		12.5 Compost (OC)	1.54	42.32	7.63	8.37
		10 Bentonite (BS)	1.51	43.45	7.28	8.89
		6.25 OC + 5.00 BS	1.44	46.07	6.67	9.56
Statistical analysis (ANOVA, L.S.D. at 0.05)						
T			`0.03	1.2	1.01	1.1
G			0.04	1	0.3	0.22
I			0.14	0.52	0.11	0.34
T x G			0.21	0.93	0.88	1.34
T x I			0.12	1.11	1.2	1.2
G x I			0.12	1.11	1.2	1.2
T x G X I			0.2	1.01	0.91	0.73

humus products from microbial decomposition of organic materials can absorb more than six times of its own weight water, thereby increases the soil moisture retention[53]. In addition, such organic and inorganic colloidal particles not only improve the soil structure parameters but also the properties of solid-liquid system interface due to the change in the contact angle of the soil particle with water[43].

In this respect Tayel *et al*[52]. stated that the increase in water retained in sandy soil treated with some organic materials may be due to one or more of the following reasons, a) decrease in soil bulk density and the increase in soil total porosity, b) the modification of soil structure and consequently its pore size distribution, c) the higher capacity of the released active organic acids for water retention in comparison to sand particles, and the rise in soil hydraulic resistively and the drop in soil hydraulic conductivity accompanying soil structure modification.

Effect of the Applied Treatments on Nutrients Availability in the Studied Soil: With exception of the pronounced increases in available P and Fe contents which were more related to the applied bentonite shale, data illustrated in Table (5) revealed that the studied available nutrient contents (N, P, K, Fe, Mn and Zn) in the experimental sandy soil were more affected by the addition of organic compost as individual treatment. In general, the magnitudes of soil available nutrient contents showed a positive response towards the soils treated with organic compost at the rate of 12.5 ton/fed, which was surpassed the combined treatment of ½ (organic compost + bentonite shale) > bentonite shale alone. That was true since the applied organic compost was not only enhancing the availability of essential plant nutrients, but also it is considered as a source or a storehouse with easily mobile for the released nutrients. It is evident that the applied organic compost, either as individual or together with bentonite, achieved many of the beneficial effects that are more attributed to improve soil hydrophysical, and in turn enhancing nutrients availability, particularly under the application of gypsum and irrigation at 50 % depletion of available water range. This can be interpreted on the fact that the released active organic acids leads to improve the air-water balance due to partially capable to retain water, and in turn enhancing the microorganisms activity for organic materials decomposition and releasing the available nutrients for growing plants as well as minimizing the loss of nutrients by leaching[14].

It is noteworthy to mention that in spite the applied gypsum caused an increase for the studied available nutrient contents, yet its positive effect was more pronounced for the availability of phosphorus. This may be due to the beneficial effect of gypsum as a source of Ca and S, which seemed to promote rhizosphere activity and consequently increased the soil capacity for available plant nutrients[10]. In addition, the obtained finding of gypsum effect on P availability stands in well agreement with that of Hilal *et al.*[27] who reported that the released S increased P mobility from bulk soil to the rhizosphere and tended to increase the accumulation of organic materials.

It could be concluded that the beneficial effects of the applied treatments on the studied different soil hydrophysical properties under cultivated peanut could be arranged in the following order: ½ (organic compost + bentonite shale) > bentonite shale > organic compost > control, especially under the application of gypsum and irrigation at 50 % depletion of available water range. While, the corresponding beneficial effects of those treatments on soil available nutrient contents could be arranged in the following order: organic compost > ½ (organic compost + bentonite shale) > bentonite shale > control for N, P, Mn, Zn and Cu as well as bentonite shale > ½ (organic compost + bentonite shale) > organic compost > control for K and Fe, may be due the bentonite shale is enrichment for both nutrients.

Effect of the Applied Treatments on Crop Yield and its Attributes:

A. Foliage, Pod and Seed Yields: Results in Table (6) indicated that there was a significantly positive effect of applied treatments added either solely or together on each of peanut foliage, pod and seed yields, with a superiority for the combined treatment of ½ the applied rates of organic compost + bentonite shale under the application of gypsum and irrigation at 50 % depletion of available water range, followed by bentonite shale ≥ organic compost > control.

In addition, the beneficial effects of the applied treatments took place the same trend when irrigation was carried out at 75 % depletion of available water range, but with useful-less for peanut foliage, pod and seed yields. It is evident that the application of organic compost in combination with bentonite shale enhanced the role of soil hydrophysical properties for increasing foliage, pod and seed yields of peanut plants, probably due to their positive effects on the increment of available nutrients for the growing plants[19]. Also, the beneficial effect of either active organic or inorganic materials is not only due to the biological activity, soil structure and bentonite and rich nutrient shale, but also on the plant itself. These results could be explained according to the findings of MacCarthy *et al.*[35] and Cheng *et al.*,[14] who reported that the beneficial effect of the released active organic acids on plant growth is more related to their role,

Table 5: Available nutrients status in soil at the vegetative growth stage as affected by the applied treatments under both soil moisture regime levels.

Soil moisture regime (I)	Gypsum shale (G) (ton/fed)	Organic compost or bentonite shale (ton/fed)	Macronutrients (mg kg^{-1} soil) N	P	K	Micronutrients (mg kg^{-1} soil) Fe	Mn	Zn	Cu
Irrigation at 50 % depletion of the available soil moisture range	0	0	17.43	4.22	47.92	5.04	0.89	0.7	0.53
		12.5 Compost (OC)	43.76	8.35	59.8	6.78	1.73	1.47	1.19
		10 Bentonite (BS)	23.81	5.21	63.4	8.05	1.45	0.93	0.7
		6.25 OC + 5.00 BS	28.35	6.27	61.65	7.64	1.6	1.39	1.09
	0.5	0	19.74	5.23	49.15	5.48	0.98	0.8	0.58
		12.5 Compost (OC)	57.93	10.04	65.32	7.13	1.95	1.53	1.27
		10 Bentonite (BS)	26.05	6.12	72.65	9.36	1.52	0.96	0.74
		6.25 OC + 5.00 BS	38.62	7.31	68.07	8.47	1.69	1.45	1.15
Irrigation at 75 % depletion of the available soil moisture range	0	0	16.54	3.75	45.91	4.83	0.84	0.67	0.5
		12.5 Compost (OC)	36.85	7.89	57.4	6.25	1.68	1.43	1.12
		10 Bentonite (BS)	21.9	5.08	59.87	7.41	1.4	0.9	0.67
		6.25 OC + 5.00 BS	23.76	5.96	58.93	6.85	1.53	1.35	1
	0.5	0	18.13	4.87	48.55	5.23	0.92	0.74	0.55
		12.5 Compost (OC)	49.54	9.25	62.08	6.74	1.87	1.48	1.2
		10 Bentonite (BS)	24.7	5.86	70.52	8.68	1.48	0.92	0.71
		6.25 OC + 5.00 BS	32.25	6.93	64.91	7.95	1.62	1.41	1.05
Statistical analysis (ANOVA, L.S.D. at 0.05)									
T			12.5	2.7	17.81	1.41	0.92	0.22	0.31
G			2.72	0.71	1.7	1.47	0.34	0.05	0.11
I			2.9	0.92	2	1.01	0.14	0.04	0.15
T x G			1.21	0.99	2.1	1.18	0.2	0.32	0.19
T x I			11.7	1.95	16.89	1.7	0.85	0.2	0.29
G x I			1.31	0.85	1.91	1.01	0.19	0.29	0.11
T x G X I			2.95	1.17	3.2	2.91	0.13	0.77	0.22

Table 6: Straw, pod and seed yields of peanut as affected by the applied treatments under both soil moisture regime levels.

Soil moisture regime	Gypsum shale (ton/fed)	Organic compost or bentonite shale (ton/fed)	Foliage yield (kg/fed)	Pod yield (kg/fed)	Seed yield (kg/fed)
Irrigation at 50 % depletion of the available soil moisture range	0	0	2579	1659	917
		12.5 Compost (OC)	4494	2685	1484
		10 Bentonite (BS)	4615	2836	1567
		6.25 OC + 5.00 BS	5058	3092	1712
	0.5	0	2849	1891	983
		12.5 Compost (OC)	4772	2945	1592
		10 Bentonite (BS)	4978	3100	1676
		6.25 OC + 5.00 BS	5590	3387	1834

Table 6: Continue

Irrigation at 75 % depletion of the available soil moisture range	0	0	2417	1532	870
		12.5 Compost (OC)	3819	2058	1194
		10 Bentonite (BS)	3946	2092	1208
		6.25 OC + 5.00 BS	4270	2369	1375
	0.5	0	2700	1684	945
		12.5 Compost (OC)	4059	2315	1318
		10 Bentonite (BS)	4235	2297	1297
		6.25 OC + 5.00 BS	4743	2586	1473
Statistical analysis (ANOVA, L.S.D. at 0.05)					
T			233	451	175
G			300	217	101
I			305	311	117
T x G			251	210	115
T x I			312	344	217
G x I			420	215	110
T x G X I			970	203	121

since they act like plant growth hormones, decreased the loss of soil moisture, enhanced the water retention, increased the ability rate of leaves for photosynthetic process, increased the seed filling intensity, enhanced the drought resistance of seed and increased its hundred weight. A similar conclusion was also suggested by Yakadri and Satyanarayana[59] who found that the dry matter of pods was maximized due to increasing nutrients uptake and adequate supply of them to plant for proper growth and metabolic process. These results are also confirmed by Mackowiak[36] and Salib[46] who reported that the beneficial effect of final product of organic matter decomposition on dry matter yield may be attributed to improve the bio-availability of micronutrients by complexion, which prevent early micronutrients deficiency.

The obtained data showed that the soil treated with gypsum gave relatively high values for peanut foliage, pod and seed yields than that of untreated one. That was found true under any addition of applied organic and inorganic soil amendments, probably due to its role, since it acts like soil amendment and attains some plant nutrients such as Ca and S that plays an effective role for P and micronutrients availability. Consequently, it is necessary for enhancing the vegetative growth as well as the released Ca and S is often presented a yield limiting factor for pod growth, increasing peg strength, improving the shelling percentage and peanut pod or seed yield[8]. In this concern Sharma *et al.*[47] found that application of gypsum at a rate of 270 kg/ha increased the pod yield significantly by 537 kg/ha over the control treatment, which produced 2432 kg/ha pod yield. These results are confirmed with those obtained by David *et al.*[15,10,44] who pointed out that application of gypsum (as a source of Ca and S) significantly increased pod yield of peanut, and in turn increased the yield of seeds.

B. Nutritional Status of Peanut Seed as Affected by the Applied Treatments: The N, P, K, Fe, Mn, Zn and Cu uptake by peanut seed as affected by different applied organic and inorganic amendments are shown in Table (7). It is noticed a significantly and positive response to applied treatments for the studied nutrient contents in peanut seed, since progressive increases found to be reached their maximum values at the combined treatment at half of the applied solely organic compost and bentonite shale rates, particularly under the applied gypsum and soil moisture regime at 50 % depletion of available water range. That was true, since the relatively increases of nutrient contents in peanut seed for the aforementioned combined treatment averaged 1.5-1.9 times raised over the control treatment. Addition of gypsum exerts a more beneficial effect on the studied nutrient contents in peanut seed, probably due to the ability of gypsum to supply available Ca and S in soil, besides the positive effect of released S on either P or micronutrients availability and mobility from bulk soil to the rhizosphere and tended to increase their accumulation in plant tissues.

Table 7: Nutrient contents in peanut seed as affected by the applied treatments under both soil moisture regime levels.

Soil moisture regime (I)	Gypsum shale (G) (ton/fed)	Organic compost or bentonite shale (ton/fed)	Macronutrients %			Micronutrients (mg kg^{-1} soil)			
			N	P	K	Fe	Mn	Zn	Cu
Irrigation at 50 % depletion of the available soil moisture range	0	0	2.54	0.3	1.23	160.71	39.68	26.35	10.74
		12.5 Compost (OC)	3.78	0.47	1.85	204.37	53.9	36.81	16.97
		10 Bentonite (BS)	3.67	0.45	1.98	217.52	55.43	34.37	15.8
		6.25 OC + 5.00 BS	4.1	0.53	2.05	230.64	59.25	38.22	18.63
	0.5	0	2.69	0.31	1.27	164.8	41.03	27.96	11.25
		12.5 Compost (OC)	4.07	0.5	2.01	219.05	57.96	39.12	18.74
		10 Bentonite (BS)	3.95	0.48	2.13	234.16	59.74	36.87	17.32
		6.25 OC + 5.00 BS	4.35	0.57	2.25	247.95	63.71	41.54	20.08
Irrigation at 75 % depletion of the available soil moisture range	0	0	2.46	0.28	1.14	152.08	37.45	23.93	9.67
		12.5 Compost (OC)	3.29	0.41	1.61	177.3	46.82	32.78	14.15
		10 Bentonite (BS)	3.18	0.39	1.72	188.52	48.13	30.04	13.79
		6.25 OC + 5.00 BS	3.55	0.46	1.78	200.26	51.4	33.79	16.32
	0.5	0	2.61	0.39	1.19	156.34	38.56	25.12	10.09
		12.5 Compost (OC)	3.53	0.43	1.74	189.87	50.25	28.8	15.08
		10 Bentonite (BS)	3.42	0.42	1.85	203.08	51.77	26.46	14.92
		6.25 OC + 5.00 BS	3.79	0.49	1.97	215.16	55.92	36.95	17.64
Statistical analysis (ANOVA, L.S.D. at 0.05)									
T			0.13	0.21	0.3	37.2	1.5	0.95	1.4
G			0.31	0.24	0.13	21.1	2.42	2.5	2.5
I			0.31	0.07	0.16	18.5	3.45	0.37	0.71
T x G			0.52	0.13	0.92	17.71	2.51	0.5	0.83
T x I			1.05	0.2	0.91	19.53	1.1	0.85	0.93
G x I			0.21	0.12	0.65	11.71	2.5	1.51	1.31
T x G X I			0.3	0.05	0.09	17.5	1.21	1.25	1.11

The beneficial effects of the applied treatments are more attributed to the improvement status of air-water balance of the studied sandy soil, consequently increasing nutrients availability and mobility towards plant roots as well as the mechanism of their uptake by plant roots[58]. Moreover, Kachinsk and Mosolova[33] reported that the applied organic materials contain the essential nutrients for plant in their molecules, and found to be available for plant utilization. So, it could be arranged the applied treatments according their positive effects into the descending order of: ½ (organic compost + bentonite shale) > bentonite shale ≥ organic compost > control. The aforementioned results indicated that the applied soil organic and inorganic amendments affect either directly nutrients availability in soil or indirectly nutrients accumulation in seed tissues. That means the applied treatments are considered as a nutrients storehouse with easily mobile or available to uptake by plant roots.

C. Seed Quality Parameters of Peanut as Affected by the Applied Treatments: Data in Table (8) showed a positively response of the studied treatments upon some quality parameters of peanut seed, *i.e.,* weight of 100 seed, seed protein and oil contents.

The greatest increase in 100 seed weight of peanut was strictly associated with the combined treatment of ½ (organic compost + bentonite shale) followed by

Table 8: Some seed quality parameters of peanut as affected by the applied treatments under both soil moisture regime levels.

Soil moisture regime	Gypsum shale (ton/fed)	Organic compost or bentonite shale (ton/fed)	Weight of 100 seed (g)	Seed protein content %	Seed oil content %
Irrigation at 50 % depletion of the available soil moisture range	0	0	55.21	15.88	32.57
		12.5 Compost (OC)	77.65	23.63	37.45
		10 Bentonite (BS)	76.98	22.94	36.98
		6.25 OC + 5.00 BS	83.15	25.63	40.78
	0.5	0	58.07	16.81	35.62
		12.5 Compost (OC)	84.07	25.44	39.19
		10 Bentonite (BS)	82.93	24.69	38.75
		6.25 OC + 5.00 BS	89.54	27.19	42.76
Irrigation at 75 % depletion of the available soil moisture range	0	0	53.62	15.38	31.94
		12.5 Compost (OC)	67.18	20.56	35.01
		10 Bentonite (BS)	66.75	19.88	34.75
		6.25 OC + 5.00 BS	71.84	22.19	37.87
	0.5	0	56.56	16.31	33.47
		12.5 Compost (OC)	72.27	22.06	37.14
		10 Bentonite (BS)	71.95	21.38	36.78
		6.25 OC + 5.00 BS	77.81	23.69	39.87
Statistical analysis (ANOVA, L.S.D. at 0.05)					
T			1.9	1.74	1.84
G			2.45	1.22	1.79
I			2.67	1.07	1.92
T x G			3.5	2.1	1.52
T x I			2.73	1.7	1
G x I			2.57	1.12	1.33
T x G X I			5.32	2.78	1.59

organic compost and bentonite shale ones under the applied gypsum and soil moisture regime at 50 % depletion of available water range, since its corresponding relative increase percentages over the control treatment by 62.18, 50.21 and 52.27 %, respectively. These results were true for studied peanut as a summer crop, and are by Askar *et al.*[5] who reported that the residual effect of the added materials resulted in an improvement in soil structure condition, consequently enhanced crop production through encouraging nutrients uptake by growing plants.

Data of peanut seed protein content as affected by the applied solely treatments and their combinations, as illustrated in Table (8), showed a positive and significantly increased. In general, it obvious that the beneficial effect of combined treatment of ½ (organic compost + bentonite shale) under the applied gypsum and soil moisture regime at 50 % depletion of available water range was surpassed the other tested individual ones of bentonite shale and organic compost. The corresponding relative increase percentages were 71.22, 55.48 and 60.20 %, respectively. It is noticed that the beneficial effect of the N-enriched organic compost was cleared when added solely or in combination with the bentonite shale as compared to the control treatment. In addition, the beneficial effects of such applied treatments under gypsum application at 75 % depletion of available water range act like their direct effects on peanut seed protein contents at 50 % DAW with useful-less.

Regarding peanut seed oil content, data in Table (8) revealed that the magnitude of the increases for the applied treatments acts like their direct effects on peanut seed protein content. The relative increase percentages were 31.28, 18.97 and 20.32 % for the combined, bentonite shale and organic compost treatments over the control one under the applied gypsum and soil moisture regime at 50 % depletion of available water range, respectively. The progressively increased in peanut seed oil content as a percentage may be due to the effect of applied treatments especially organic component on enhancing the biosynthesis for peanut seed oil.

It is noteworthy to mention that the positive effects of the applied treatments on the aforementioned parameters of peanut seed quality are more related to the improvement of soil hydrophysical properties, which increased soil ability to supply plants with their requirements of water, air and nutrients uptake along the growing season. Consequently, such favourable conditions were reflected positively on development of peanut seed yield and its quality[41].

Crop Water Relations:

A. Seasonal Water Consumptive Use (Etc): Data in Table (9) showed that irrigating peanut plants whenever 50 % depletion of available soil moisture range gave the greatest value of seasonal water consumptive use (56.92 cm) for the combined treatment of ½ (organic compost + bentonite shale) under the applied gypsum shale at the rate of 500 kg/fed. The reverse was true when irrigating peanut plants at 75 % available soil moisture depletion, since the seasonal water consumptive use was tended to decrease as its value reached 52.48 cm at the same applied combined treatment. It is noteworthy to mention that the greatest value of seasonal water consumptive use was associated with the best treatment of integrated use of organic compost, bentonite shale and gypsum shale under 50 % soil moisture depletion. Therefore, it is concluded that increasing soil moisture stress led to a significantly decrease in daily ETc rate during the growing season months. Such findings are in harmony to those obtained by Osman and Khalifa[39] and Saied[45] for some summer crops cultivated in the same growing period of peanut plants. It is evident also that differences between water consumptive use values may be attributed to the irrigation number and the noticeable reduction in plant growth. These findings indicate that seasonal consumptive use increased as the available soil moisture content increased, *i.e.,* at 50 % AMD as compared to the other irrigation treatment (75 % AMD). These findings are also in harmony with those obtained by Demian *et al.*[16].

B. Water Use Efficiency: The water use efficiency (Table 9) is expressed as kg seed/m^3 water consumed by the peanut plants. This criterion has been used to evaluate the crop production under different applied treatments per unit of consumed water by the crop plants. The obtained results showed that irrigating peanut plants at 50 % available soil moisture depletion achieved a significantly increase for the water use efficiency value, particularly for the combined treatment ½ (organic compost + bentonite shale) under the applied gypsum shale at the rate of 500 kg/fed, and it tended to reduce when increasing available soil moisture depletion to 75 % by 15.38 %. These results are in agreement with those obtained by Demian *et al.*[16]. Also, these findings are in harmony with the scientific approaches that supposed the plant roots could be extract more soil water from a greater depth under moderate stress as compared to those irrigated at a relatively wet level. That means the stored water in soil at a moderate irrigation can be more available for roots as well as can be used with more efficiency. These results are in agreement with those reported by Tisdale *et al.*[55] and Taha[52] who found that water use efficiency decreased with increasing soil moisture depletion.

From the abovementioned results, it is evidence that peanut plants able to overcome pronounced amounts of available water and nutrients under the applied organic and inorganic amendments at available moisture depletion of 50 %. This is undoubtedly of great importance due to the superiority was not only taken as a criterion for increasing the outputs of vegetative growth and crop yield for peanut plants, but also for minimizing the possible adverse fears of both human health and environmental risks resulted from the intensive used of mineral fertilizers. Moreover, the beneficial effect of the organic compost was more attributed with enhancing the biological activity in the soil which have ability to encourage the released nutrients, particularly the micronutrients that are considered as a storehouse in more mobile or available forms to uptake by plant roots. These results are in harmony with those reported by Abou Zied *et al*[1]

Table 9: Seasonal consumptive use and water use efficiency as affected by the applied treatments under both soil moisture regime levels.

Soil moisture regime	Gypsum shale (ton/fed)	Organic compost or bentonite shale (ton/fed)	Seasonal consumptive use (cm)	Water consumptive use (m^3/ fed)	Peanut seed yield (kg/fed)	Water use efficiency (kg/m^3)
Irrigation at 50 % depletion of the available soil moisture range	0	0	44.25	1858.5	917	0.493
		12.5 Compost (OC)	52.67	2212.14	1484	0.671
		10 Bentonite (BS)	52.15	2190.3	1567	0.715
		6.25 OC + 5.00 BS	54.79	2301.18	1712	0.744
	0.5	0	46.08	1935.36	983	0.508
		12.5 Compost (OC)	55.27	2321.34	1592	0.686
		10 Bentonite (BS)	54.8	2301.6	1676	0.728
		6.25 OC + 5.00 BS	56.92	2390.64	1834	0.767
Irrigation at 75 % depletion of the available soil moisture range	0	0	43.71	1835.82	870	0.474
		12.5 Compost (OC)	50.15	2106.3	1194	0.567
		10 Bentonite (BS)	49.94	2097.48	1208	0.576
		6.25 OC + 5.00 BS	51.93	2181.06	1375	0.63
	0.5	0	45.37	1905.54	945	0.496
		12.5 Compost (OC)	52.17	2191.14	1318	0.601
		10 Bentonite (BS)	51.86	2178.12	1297	0.595
		6.25 OC + 5.00 BS	53.98	2267.16	1473	0.649
Statistical analysis (ANOVA, L.S.D. at 0.05)						
T			1.54	113.5	57.9	0.201
G			2.31	79.3	45.2	0.11
I			2.5	67.8	50.7	0.1
T x G			1.17	30.5	42.2	0.05
T x I			1.4	132.7	36.7	0.171
G x I			1.01	60.5	51.4	0.111
T x G X I			1.21	78.9	70.1	0.105

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