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SORPTION WATER POTENTIAL OF DIFFERENT SOILS AS INFLUENCED BY NITROGEN AND POTASSIUM FERTILIZERS ADDITIONS.

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ABSTRACT

Laboratory experiment was carried out during three month at 2006-2007 in Soils Dept., Faculty of Agric., Mansoura Univ., Egypt, to study the effect of adding two type of nitrogen fertilizers, ammonium sulfate and ammonium nitrate both of rates (0, 100, 150 and 200 kg N fed^{-1}) and potassium fertilizer (i.e. 0, 80, 120 and 160 kg K_2O fed^{-1}) on soil water potential under different soils.

The results of sorption curves illustrated that the most effective treatment on increase maximum hygroscopic water (M.H.W) was the third one of any fertilizer used in this study (200 kg N fed^{-1} or 160 kg K_2O fed^{-1}). Furthermore the most affected fertilizer in clayey soil was potassium sulfate then ammonium Nitrate, but in loamy soil it was potassium sulfate then ammonium sulfate at relative humidity (R.H) 93%. In sandy soil potassium sulfate was the affected one then ammonium sulfate at R.H 100%.

Based on the results, adding chemical fertilizers had obvious effect on the increase of (M.H.W) in all studied soils. Whereas they considered salts and may be have ability to absorb high amounts of water especially potassium sulfate and ammonium sulfate fertilizers. In addition they increase soluble salts in all studied soils. E.C values of adding 160 kg K_2O fed^{-1}in clayey, loamy and sandy soils were 3.4, 3.0 and 1.9 dS m^{-1}, respectively. While E.C values of adding 200 kg N fed^{-1}in clayey, loamy and sandy soils were 3.0, 2.8 and 1.4 dS m^{-1}, respectively at R.H 93%.

Also, clayey soil was higher in its adsorption water content comparing with loamy and sandy soils. This illustrates the effect of both soil texture and the chemical fertilizers in soil water retention and accordingly its availability in soils.

Keywords: Soil water potential, Sorption curve, Ammonium sulfate fertilizer, Ammonium nitrate fertilizer, K fertilizer, Soil suction.

INTRODUCTION

The measurement of soil water potential is one of the most common kinds of soil analysis performed. The potential effects of soil water content on the behavior of soil make it an important measurement in every type of soil study. The relationship between soil water content and matric suction is as the soil water characteristic curve. (Burckhard, *et al.,* 2000).

The component of soil water potential showed by Mengel and Krikby, (1982) which found that the water potential described by the following equation:

$$\Psi = \Psi_p + \Psi_s + \Psi_m$$

Ψ_p the pressure potential is numerically equal to the hydrostatic pressure. Increasing the hydrostatic pressure increases the water potential and for this reason the term Ψ_p has a positive sign.

Ψ_s the potential resulting from the presence of solutes, and is called the osmotic potential or solute potential. The introduction of solutes into water reduces the water concentration. This decreases the water potential.

Ψ_m the matric potential. It represents suction. This is the component of the water potential made up by the effect of solid surface on the water phase. Also, the concept of water potential has been introduced as a basic means of describing water status and water movement. The concept useful in allowing a uniform treatment of soil and plant water relation. Water movement plays an important role in the water supply of plants. But total soil moisture potential is often thought of as the sum of matric and osmotic (solute) potentials.

Also, the important of soil water potential illustrated by Siller and Fredlund, (2001) which stated that the soil water charactèristic curve can be viewed as the continuous sigmoidal function describing the water storage capacity of a soil as it subjected to various soil suctions. And Fernández-Gálvez, (2005) showed that soil water retention curves (WRCs) are required to predict the availability of water to plants and the movement of water through the soil.

On the other hand, the presence of solutes in soil water affects its thermodynamic properties and lowers its potential energy. In particular, solutes lower the vapor pressure of soil water. The osmotic effect is important in the interaction between plant root and soil, as well as, in processes involving vapor diffusion (Hillel, 1980).

Also, Kirkham, (2005) confirmed that there are three cardinal properties of a solvent (e.g., water): freezing point, which is lowered by solutes; boiling point, which is raised by solutes; and vapor pressure, which is lowered by solutes.

Therefore, the objective of the present work was to study the effect of using nitrogen and potassium fertilizers rates on sorption water potential under different soils.

MATERIALS AND METHODS

This experiment was conducted on three types of soils (clayey, loamy and sandy soils) at Soils Dept., Faculty of Agric., Mansoura Univ., Egypt,. There were 12 fertilizer treatment, involved control (T) without NPK, control N ($A.S_0$) without N fertilizer, control K ($P.S_0$) without K fertilizer, ammonium sulfate fertilizers (20.6% N) with rates i.e.100, 150 and 200 kg N fed^{-1} ($A.S_1$, $A.S_2$ and $A.S_3$), ammonium nitrate fertilizers (33% N) with rates i.e.100, 150 and 200 kg N fed^{-1} ($A.N_1$, $A.N_2$ and $A.N_3$), and potassium sulfate fertilizers (48% K_2O) with rates i.e. 80, 120 and 160 kg K_2O fed^{-1} ($P.S_1$, $P.S_2$ and $P.S_3$), all treatments replicated twice.

The studied soils were air dried, grinding and passed through 2 mm sieve. Some physical and chemical properties of the experimental soils are presented in Table 1.

Table 1. Some chemical and physical properties of the studied soils.

	Soil characteristics	Soil type		
		Clayey	Loamy	Sandy
Some chemical properties	pH (in suspension of soil paste)	7.32	7.38	7.82
	E.C $dS\ m^{-1}$ (in suspension 1:2.5)	1.96	0.91	0.19
	$CaCO_3$ %	2.00	1.00	0.30
	O.M%	2.18	1.71	0.00
Soluble Cations ($meq\ L^{-1}$)	Ca^{++}	5.10	4.30	0.70
	Mg^{++}	4.90	2.10	0.40
	K^{+}	0.60	0.30	0.10
	Na^{+}	9.00	2.40	0.70
Soluble Anions ($meq\ L^{-1}$)	CO_3^{--}	0.00	0.00	0.00
	HCO_3^{-}	4.74	2.22	1.00
	Cl^{-}	8.91	1.98	0.80
	SO_4^{--}	5.95	4.90	0.10
Available nutrients (ppm)	$N\text{-}NO_3^{-}$	130.40	42.50	0.00
	$N\text{-}NH_4^{+}$	218.10	127.60	52.00
	Phosphorus (P)	33.67	20.30	9.56
	Potassium (K)	846.00	440.00	82.00
Total nutrients (%)	Nitrogen (N)	0.25	0.14	0.07
	Phosphorus (P)	0.05	0.04	0.002
	Potassium (K)	6.47	5.89	2.44
Mechanical analysis	Coarse Sand%	7.00	13.00	40.00
	Fine Sand%	9.00	20.00	55.00
	Silt%	28.00	29.00	3.00
	Clay%	56.00	38.00	2.00
	Texture Class	Clayey	Loamy	Sandy
Some physical properties	H.W%	8.36	5.52	0.29
	S.P (saturation %)	73.54	54.79	23.86
	F.C.%	39.70	27.40	11.20
	W.P%	20.00	13.70	5.60
	A.W%	19.70	13.70	5.60
	Hydraulic conductivity ($m\ s^{-1}$)	$3.80*10^{-6}$	$3.50*10^{-6}$	$2.92*10^{-4}$
	Bulk Density ($g\ cm^{-3}$)	1.03	1.22	1.66
	Real Density ($g\ cm^{-3}$)	2.10	2.20	2.60
	Total Porosity%	50.90	44.50	36.20
	Air Porosity (Ea %)	9.90	13.90	17.70
	Void Ratio (e)	1.04	0.80	0.60
	θ_V	0.41	0.31	0.19

The experiment was carried at (August 23rd 2006) nitrogen fertilizers rates were divided into two equal doses, the 1st applied before currying experiment and the 2nd after month of experiment but P and K fertilizers applied as before currying experiment.

This experiment depends on sorption curve which was determined by soil water- vapor pressure relationships according to Danielson (1980) and as used by Hammad (1985). The pF of hygroscopic water (M.W.D) was calculated as described by Schofield (1935):

$$pF = 6.5 + \log (2 - \log R.H).$$

Which R.H = relative humidity in percent.

The following saturated salts solutions were used to obtain the different percentages of relative humidity (p/p_0).

Table 2. The saturated salts solution.

Sat. solutionsof salts	p/p_0*	R.H (%) **	pF
LiCl	0.15	15	6.4
CrO_3	0.35	35	6.2
NH_4NO_3	0.65	65	5.8
NaCl	0.75	75	5.6
KCl	0.85	85	5.3
$NH_4H_2PO_4$	0.93	93	5
H_2O (distilled)	1.00	100	--

*p= Vapor pressure of salts, *p_0= Vapor pressure of water.
**R.H= Relative humidity %.

RESULTS AND DISCUSSION

1. Effect of Chemical Fertilizers on Soil Water Potential.

The justification of conducting the vapor pressure method to study the hydroscopic water retention in order to complete the moisture retention curves of the studied soils under different treatments, and to study the reasons of the moisture content variation in some studied soils having the same texture.

Hygroscopic water exists as a very thin water film at the soil particles. The maximum thickness is not more than 5 or 6 microns making up about 15-20 layers of water molecules. At the interface the lowest layer of the water film is held by 10000 bars, (pF= 7). The soil moisture tension gradually decreases until at the outer layer of the water film, it is at 31 bars. Hence the maximum hydroscopic water is sometimes defined as the water which held at tension greater than 31 bars, (pF= 4.45) as described by (Hillel, 1980).

1.1. Sorption Curve.

The vapor pressure results of the studied soils as affected by the chemical fertilizers application are given in Table (3). The data reveal that the chemical fertilizers application in the all studied soils increased the maximum hygroscopic water (M.H.W) at relative humidity (R.H) of 93% (pF= 5) as compared to control, but applied chemical fertilizers have a slight effect on M.H.W at relative humidity less than 84% (pF= 5.4). These changes are obvious in the studied treatments. The increase in (M.H.W) values over the control is a result of increasing chemical fertilizers application. This result is confirmed with the work of Hammad, (1985) who found that additions of both salts and the chemical fertilizers increased the (M.W.D) and the moisture contents of the chernoziem soil.

Table 3. Soil-water vapor relationships as affected by adding nitrogen and potassium application on studied soils.

Treat.	% Moisture Content at values of P/P$_0$						
	0.15	0.35	0.65	0.75	0.84	0.93	1.00
				Clayey Soil			
T	1.60	5.10	5.00	7.80	8.40	10.40	13.40
A.S$_0$	1.70	5.20	5.65	7.85	8.50	10.50	13.50
A.S$_1$	1.70	5.35	5.75	7.85	8.50	11.00	14.50
A.S$_2$	1.75	5.20	5.80	7.90	8.60	11.05	14.55
A.S$_3$	1.77	5.25	5.85	7.90	8.80	11.10	14.75
A.N$_1$	1.55	5.50	5.70	7.85	8.90	11.00	16.00
A.N$_2$	1.80	4.90	5.70	8.00	9.90	11.20	16.30
A.N$_3$	1.85	5.50	5.65	8.00	11.90	11.30	16.60
P.S$_0$	1.45	5.15	5.30	8.0	6.90	10.20	14.70
P.S$_1$	1.50	5.15	5.60	8.05	8.40	10.30	15.20
P.S$_2$	1.50	4.95	5.80	7.90	8.60	11.30	15.50
P.S$_3$	1.70	5.25	5.80	8.20	8.80	11.50	15.30
				Loamy Soil			
T	1.05	3.10	3.20	5.30	5.30	6.30	7.85
A.S$_0$	1.20	3.55	3.20	5.35	5.60	6.40	7.90
A.S$_1$	1.20	3.55	3.50	5.50	5.60	6.60	8.60
A.S$_2$	1.20	3.40	3.45	5.30	5.60	6.70	8.70
A.S$_3$	0.90	3.80	3.50	5.40	5.60	6.80	9.30
A.N$_1$	1.10	3.45	3.35	5.30	5.35	6.60	8.25
A.N$_2$	1.20	3.30	3.50	5.35	5.80	6.70	8.40
A.N$_3$	1.30	3.55	3.40	5.30	5.80	6.75	8.45
P.S$_0$	0.95	3.60	3.55	5.35	5.60	7.10	6.60
P.S$_1$	0.95	3.55	3.55	5.30	5.25	6.60	6.90
P.S$_2$	1.20	3.70	3.50	5.35	5.70	7.10	7.10
P.S$_3$	1.25	4.35	3.75	5.40	5.70	6.90	7.20
				Sandy Soil			
T	0.00	0.00	0.00	0.20	0.20	0.20	0.30
A.S$_0$	0.00	0.00	0.20	0.30	0.10	0.20	0.35
A.S$_1$	0.00	0.00	0.20	0.20	0.20	0.20	0.37
A.S$_2$	0.00	0.10	0.20	0.20	0.20	0.20	0.50
A.S$_3$	0.00	0.20	0.20	0.25	0.20	0.20	0.66
A.N$_1$	0.00	0.20	0.10	0.20	0.20	0.30	0.38
A.N$_2$	0.00	0.10	0.20	0.25	0.10	0.40	0.50
A.N$_3$	0.00	0.30	0.20	0.25	0.10	0.50	0.55
P.S$_0$	0.00	0.10	0.15	0.00	0.10	0.25	0.40
P.S$_1$	0.00	0.10	0.20	0.20	0.10	0.20	0.65
P.S$_2$	0.00	0.20	0.20	0.20	0.20	0.20	0.70
P.S$_3$	0.00	0.20	0.20	0.20	0.20	0.30	0.79

The data indicated that the effect of increasing chemical fertilizers application is differed with different soils and depend on the rate and the source of fertilizers used.

1.1.1 Effect of Ammonium Sulfate Fertilizer.

Figures 1, 2 and 3 illustrate the relation between the different vapor pressure and percentage of water content of the studied soils as affected by ammonium sulfate application.

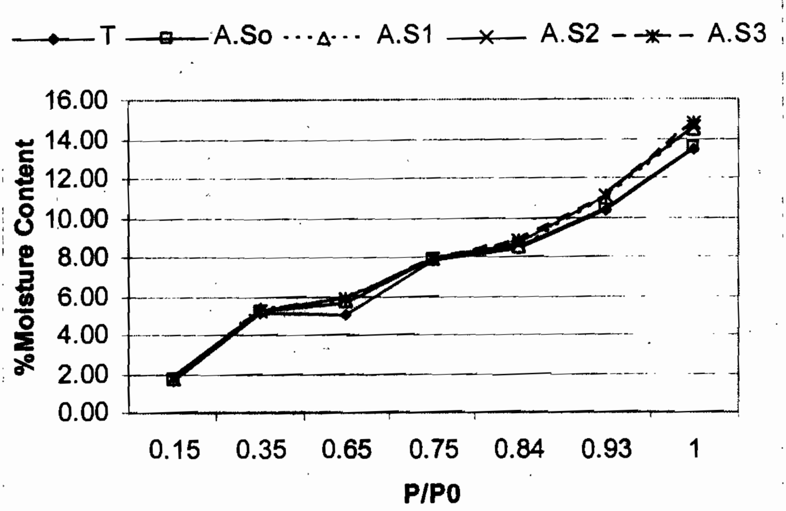

Figure1. Sorption curves of clayey soil as affected by ammonium sulfate application.

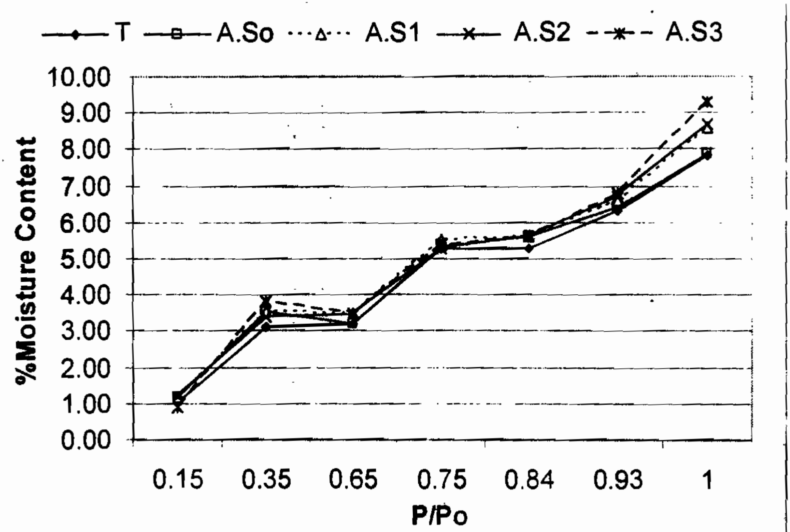

Figure 2. Sorption curves of loamy soil as affected by ammonium sulfate application.

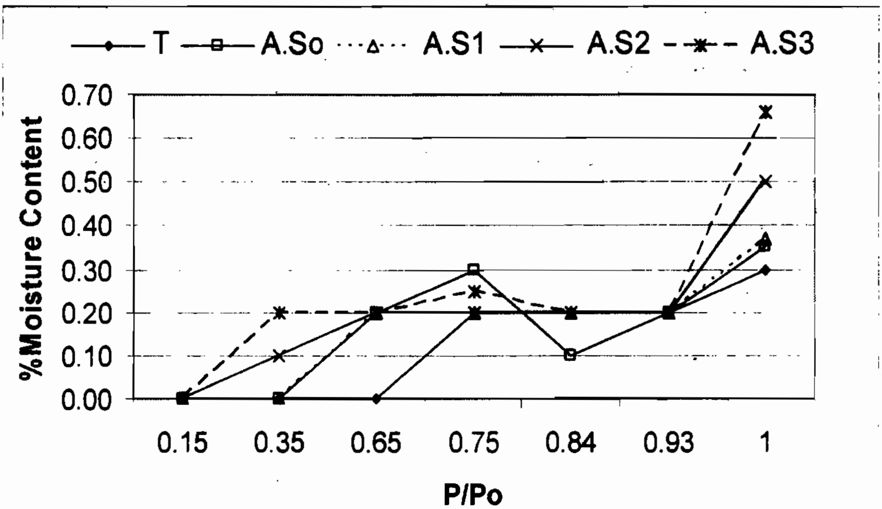

Figure3. Sorption curves of sandy soil as affected by ammonium sulfate application.

The addition of ammonium sulfate had a moderate effect on (M.H.W) in all studied soils with increasing fertilizer application.

In clayey soil, the application of ammonium sulfate fertilizer cause an increase in (M.H.W) at different relative humidity levels, but the high increase at the relative humidity 93% and 100% whereas addition of ammonium sulfate rates increased (M.H.W) by 4.8, 5.2 and 5.7% over the control ($A.S_0$) at relative humidity 93% (pF= 5), and also increases it by 7.4, 7.8 and 9.3% over the control ($A.S_0$) at relative humidity 100%.

The application of ammonium sulfate in the studied loamy soil cause a high increase in (M.H.W) at relative humidity 93% by 3.1,4.7 and 6.3% over the control ($A.S_0$). While at the relative humidity 100% these increases were 8.9, 10.1 and 17.7% over the control ($A.S_0$).

The water content in sandy soil is generally low, for this reason applying ammonium sulfate fertilizer increase (M.H.W) at a high relative humidity 100%. Whereas it had no effect on (M.H.W) at the other relative humidity levels. The increases were 5.7, 42.6 and 88.5% over the control ($A.S_0$) at R.H 100%.

1.1.2 Effect of Ammonium Nitrate fertilizer.

Figures 4, 5 and 6 show the relation between the different vapor pressure and the percentage of water content of the studied soils as affected by ammonium nitrate application.

Using ammonium nitrate fertilizer had a noticeable effect on (M.H.W) in all the studied soils. Also, data show that the water content of clayey soil with ammonium nitrate fertilizer higher than the treated soil with ammonium sulfate fertilizer.

Applying ammonium nitrate in clayey soil cause increases in (M.H.W) at R.H 84,93 and 100% over the control ($A.S_0$) with 4.7, 16.5 and

40% & 4.8, 6.7 and 7.6% & 18.5, 20.7 and 23% at R.H 84, 93 and 100%, respectively.

On the other hand, ammonium nitrate fertilizer in loamy soil increase (M.H.W) at relative humidity 93% by 3.1, 4.7 and 5.5%. Also, they were 4.4, 6.3 and 7% at R.H 100%.

In sandy soil, the (M.H.W) increased by 50, 100 and 150% over the control ($A.S_0$) at R.H 93%, but they were 8.6, 42.9 and 57% over the control ($A.S_0$) at R.H 100%.

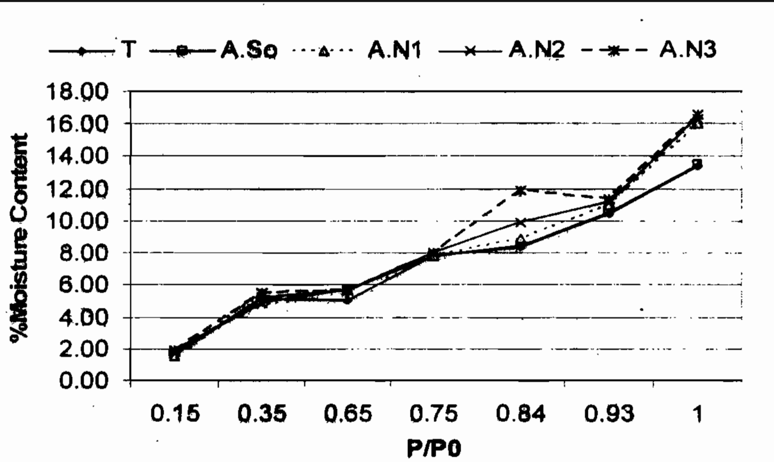

Figure4. Sorption curves of clayey soil as affected by ammonium nitrate application.

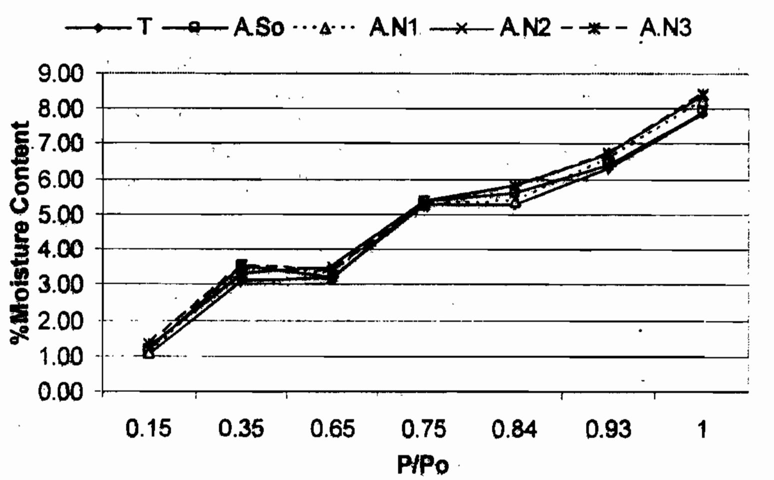

Figure5. Sorption curves of loamy soil as affected by ammonium nitrate application.

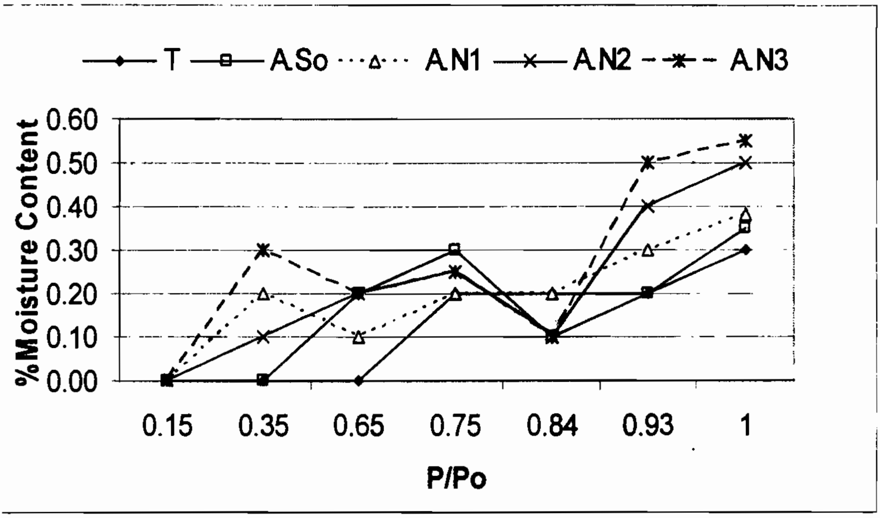

Figure6. Sorption curves of sandy soil as affected by ammonium nitrate application.

1.1.3 Effect of Potassium Sulfate Fertilizer.

These results illustrated in Figures 7, 8 and 9 which show the relation between vapor pressure levels and the percentages of water content of the studied soils as affected by potassium sulfate application.

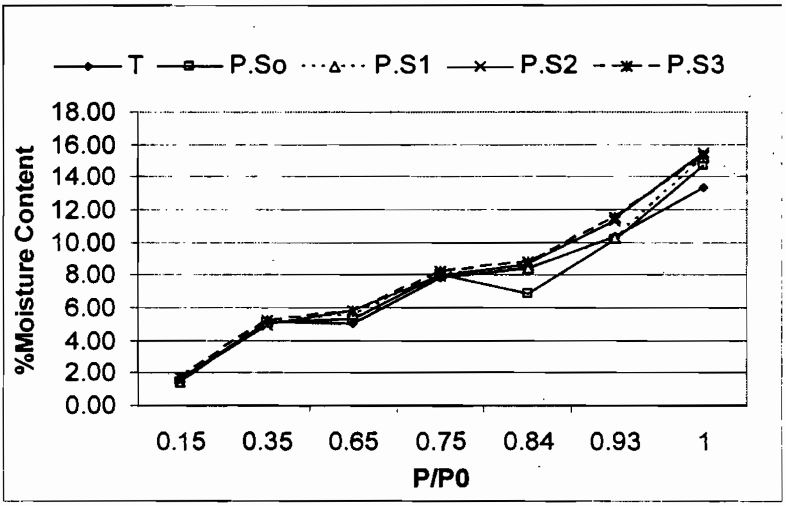

Figure7. Sorption curves of clayey soil as affected by potassium sulfate application.

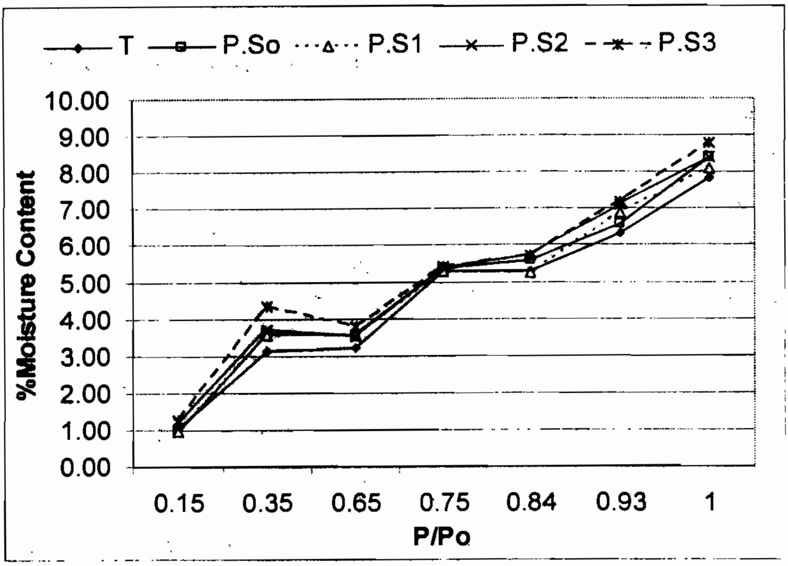

Figure8. Sorption curves of loamy soil as affected by potassium sulfate application.

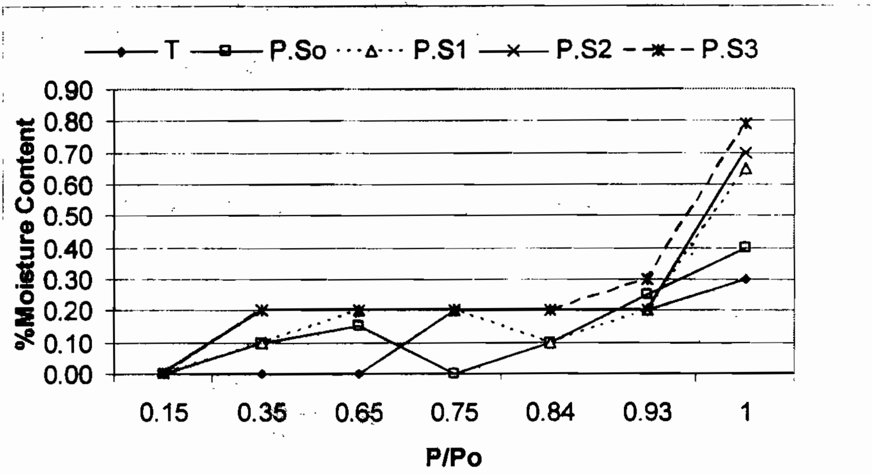

Figure9. Sorption curves of sandy soil as affected by potassium sulfate application.

In clayey soil, the application of potassium sulfate fertilizer rates increased the (M.H.W) at relative humidity 84 and 93%. Whereas at R.H 84% potassium sulfate fertilizer increase (M.H.W) by 21.7, 24.6 and 27.5%. While these increases were 0.9, 10.8 and 12.7% over the control ($P.S_0$) at R.H 93%. But in loamy soil they were 4.5, 7.6 and 9.1% over the control ($P.S_0$) at R.H 93%. The increases of (M.H.W) in sandy soil illustrated at R.H 100% by 62.5, 75 and 97.5% over the control ($P.S_0$).

Finally, the results of sorption curves illustrated that the most effective treatment on increase (M.H.W) was the third one of any fertilizer (200 kg N fed^{-1} or 160 kg K_2O fed^{-1}). Furthermore the most affected fertilizer in clayey soil was potassium sulfate then ammonium nitrate, but in loamy soil it was potassium sulfate then ammonium sulfate at relative humidity 93%. Also, potassium sulfate was the most affective in sandy soil then the ammonium sulfate but at R.H 100% only.

Based on the results, firstly chemical fertilizers had obvious effect on the increase of (M.H.W) in all the studied soils. Whereas it considered salts and might be have ability to absorb high amounts of water especially potassium sulfate and ammonium sulfate fertilizers. In addition it increased soluble salts in all the studied soils resulted in an increase of E.C values. E.C values of adding 160 kg K_2O fed^{-1}in clayey, loamy and sandy soils were 3.4, 3.0 and 1.9 dS m^{-1}, respectively. While E.C values of adding 200 kg N fed^{-1}in clayey, loamy and sandy soils were 3.0, 2.8 and 1.4 dS m^{-1}, respectively at R.H 93%. These results confirmed with those of Firman, (1968) and Hammad, (1985) who reported that soluble salts might arise from several sources, such as fertilizers salts and mineralization of organic matter.

Secondly, Figures showed that clayey soil was higher in its adsorption water content comparing with loamy and sandy soils. This illustrates the effect of both soil texture and the chemical fertilizers in soil water retention and accordingly its availability in soils.

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الجهد الرطوبي للأدمصاص للأراضي المختلفة متأثراً بإضافات أسمدة النيتروجين والبوتاسيوم

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أجريت تجربة معملية خلال ثلاث شهور في عام ٢٠٠٧/٢٠٠٦ بمعمل قسم الأراضي بكلية الزراعة جامعه المنصورة لدراسة تأثير إضافة نوعي من التسميد النيتروجيني وهما سلفات الامونيوم ونترات الامونيوم وكلاهما بمعدل (صفر, ١٠٠, ١٥٠, ٢٠٠ كجمN فدان⁻١) ومعدلات من التسميد البوتاسي متمثلة في (صفر، ٨٠، ١٢٠, ١٦٠ كجم K_2O فدان⁻١) علي الجهد الرطوبي بالأراضي المختلفة.

أوضحت نتائج منحنيات الترطيب أن المعاملة الثالثة في إي سماد مستخدم في الدراسة (٢٠٠ كجمN فدان⁻ أو ١٦٠ كجم K_2O فدان⁻١) هي الأكثر تأثيرا في زيادة السعة الهيجروسكوبية العظمي. بالإضافة لذلك كان سماد سلفات البوتاسيوم هو الأكثر تأثيرا بالأراضي الطينية يليه سماد نترات الامونيوم لكن بالأراضي الطميية كان الأكثر تأثيراً سلفات البوتاسيوم يليه سماد سلفات الامونيوم عند رطوبة نسبية ٩٣%. وبالأراضي الرملية كان الأكثر تأثيراً سلفات البوتاسيوم يليه سماد سلفات الامونيوم عند رطوبة نسبية ١٠٠%.

وبناءاً علي هذه النتائج نجد أن إضافة الأسمدة الكيميائية كان له تأثير واضح علي زيادة السعة الهيجروسكوبية العظمي في كل الأراضي تحت الدراسة. حيث تعتبر أملاح وربما لها قدرة علي امتصاص كميات كبيرة من الماء خاصة سمادي سلفات البوتاسيوم و سلفات الامونيوم. بالإضافة إلي أنها تزيد الأملاح الذائبة في كل أراضي الدراسة. وكانت قيم التوصيل الكهربي للأراضي الطينية, الطميية والرملية 3.0, 2.8, 1.4 ديسمينز م⁻١ علي التوالي عند رطوبة نسبية ٩٣%.

كذلك كانت الأراضي الطينية الأعلى في محتواها من الماء المدمص مقارنة بالأراضي الطميية والرملية, وهذا يوضح تأثير كل من القوام والأسمدة الكيماوية علي الجهد الرطوبي وتيسير الماء بالتربة.