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CHANGES OF SOIL PHYSICAL PROPERTIES AND MACRO NUTRIENT UPTAKE BY WHEAT IN DIFFERENT SOILS AS AFFECTED BY POLYMERS

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ABSTRACT

A pot experiment was carried out to study the effect of three kinds of soil conditioners on the changes of soil physical properties and N, P, and K uptake by wheat in different soils. The tested polymers were: Aequa Kept "P1", Super-Hydro "P2", and Polyvinyllalkohol "P3" these were tested at three levels of 0.05 "L1", 0.10 "L2", and 0.15% "L3" under three types of soils used (sandy, calcareous and alluvial soils).

Results obtained indicated that:

- The application of synthetic soil conditioners significantly decreased the bulk density after cultivation and increased the porosity, saturation percentage and organic matter content of the studied soils.
- The dry weights of wheat plants significantly increased with increasing the levels of polymers application. The highest dry weights are recorded in different types of treated soils with the P2L3 treatment.
- N, P and K uptake significantly increased with soil conditioners and their application rates.
- Results obtained indicated that both wheat dry weight and N,P,K uptake by wheat plants increased due to application of soil conditioners especially with "P2" at L3, following the order: Super-Hydro "P2" > Aequa Kept "P1" > Polyvinyllalkohol "P3"

INTRODUCTION

Soil physical condition is one factor that can limit crop production. Poor soil physical condition can restrict water intake into the soil and subsequent movement, plant root development, and aeration of the soil. Producers and researchers alike are interested in improving the physical condition of the soil and, thus, enhance crop production. These goals can be accomplished in part through the use of good management techniques. In addition, there are amending materials that claim to improve the soil physical condition. Such material are call soil conditioners (El-Ghamry, 1996; El-Hadidi *et al.*, 1998).

Soil conditioners are not new, however, recent emphasis on maximum economic yield had renewed interest in them. Soil conditioners vary greatly in their composition, application rate, and expected or claimed mode of action. Claims for various products include, but are not limited to improve soil physical properties.

Several polymers have been shown to improve various soil physical properties. Polymers received a lot of attention in the 1950s when a particular polymer (Krilium) was marketed. The product was shown to improve physical properties and even crop yields on certain soils.

This paper is one in a series of publications for many researchers focusing on the use of synthetic soil conditioners for improving physical properties in different soils i.e. improving sandy soil (Salem *et al.*, 1991; Sabrah, 1993), calcareous soil (Sadek *et al.* 1993) and alluvial soil (Nadler and Letey, 1989), also improving plant growth (Wallace and Wallace, 1986; El-Hady and Lotfy, 1987; Sabrah *et al.*, 1993), the other publication consider biological inoculants and activators (El-Ghamry *et al.*, 2000). Soil conditioners were defined as materials added to the soil, with primary function of improving the physical condition of the soil.

The new polymers applied at much lower rates have been promoted as soil conditioners. These polymers include natural polysaccharides, anionic and cationic polymers, and polyacrylamides. The compounds are very high molecular weight, long-chain, polymeric, organic compounds, which bind particles together and form stable aggregates (Wallace *et al.*, 1986).

The present study aimed to investigate the effect of three kinds of synthetic soil conditioners on some soil properties and wheat growth and its nitrogen, phosphorus, potassium uptake under different Egyptian soils.

MATERIALS AND METHODS

Soils

The experimental soils used in the present study were sampled from the surface layer (0~15 cm). Sandy soil (sandy in texture) was collected from Alabsho area Dakahlia Governorate near the cost, Calcarous soil (sandy loam in texture) from Nobaria area Alexandria Governorate, and Alluvial soil (clayey loam texture) from El-Mansoura City, Dakahlia Governorate. The soils were air-dried, passed through a 2-mm sieve and stored. A subsample of each soil was taken and analyzed for various physico-chemical characteristics listed in Table 1.

Table 1: Characteristics of the experimental soils

Character / Soil type	Mechanical analysis			Water retention (% weight)		EC*** dS m^{-1}	PH****	$CaCO_3$ %	O.M. %	Total N %
	Clay	Silt	Sand	HW*	S P**					
Sandy	1.50	0.10	98.4	0.82	25.53	0.65	7.7	0.130	0.27	0.010
Calcareous	3.10	26.9	80.0	1.64	38.26	1.74	7.3	33.07	0.75	0.021
Alluvial	28.1	41.4	30.5	9.01	77.41	0.59	7.6	1.740	1.89	0.038

* % hygroscopic water ** saturation percentage *** in soil paste extract **** in soil past

Polymers Used:

(1) P1 Aequa Kept - EDX5 GEL (Polyacrylamide)

Product name: Aequa Kept - EDX 5 GEL, Company Name : Chemil S.R.L. Milano Italy, Appearance: White Graings, Solubility: Virtually insoluble in water and organic solvents. Active Substances:Co-polymer of acrylic acid and sodium acrylate. Bulk density (Dry): 0.8 - 0.85 g/cm3. Absorption

Capacity: Deionized water 500-600 g/g polymers, Time of form Gel: 40-60 second.

(2) P2 Super-Hydro-gel (Polyacrylamide)

BDH laboratory Supplies. Poole, BH 15 1TD, England. Tel: (0202) 669700. Description: off - white granual powder, Viscosity: (0.5% aqueous solution at 25C. About 280 CP, M.W.: over 5.000.000.

(3) P3 Polyvinyllalkohol 72000

Art.821038 Polyvinylalkohol 72000 Zur Synthese (-C2H4O)n MERCK-chuchardt Schuchardt,8011 Hohenbrunn bei Munchen spezifi Kation Mittlere Mol. Mass 72000 Hydrolysierungs grad (bezogen auf polyvinylacetat, ber. Auf Trocken Substanz) > 98% Trocknung Sver lust. (110C, 4 Stunden) ~ 3% .

Soil treatments

In 5 kg capacity plastic pots (25 height x16 cm diameter), wheat grain (Sakha 69) was sown in sandy, calcarous and alluvial soils and three Polymers [Aequa Kept - EDX5 GEL (P1), Super-Hydro-gel (P2) and Polyvinyllalkohol (P3)] were applied at the concentrations of: 0 (control), 0.05% (L1), 0.10% (L2), and 0.15% (L3). All the treatments were replicated thrice.

Wheat plants were fertilized with N, P, and K at recommended dose (as ammonium nitrate, single superphosphate and potassium sulphate). The sowing and harvesting of wheat was done on 1st November and 15th December, respectively.

Soil and statistical analyses

Soil mechanical analysis and CaCO3 % was done according to piper (1947), pH, EC, as by Jackson (1967). Total organic carbon in soil was measured by the dichromate digestion method (Nelson and Sommers, 1982), Total nitrogen in soil will be measured by Kjeldahl digestion (Bremner and Mulvaney, 1982)

The statistical analysis was done according to the methods described by (CoStat software, 1991) using L.S.D. to compare the treatments and Duncan's Multiple Range test to compare each treatments. A Randomized Complete Block Design (RCBD) was used.

RESULTS AND DISCUSSION

Effect of polymers on some physical properties

Data in Table 2 illustrate that there is considerable change in bulk density, porosity, saturation percentage and organic matter with application of synthetic soil conditioners (polymers used) under different soils used (sandy, calcareous and alluvial soils).

Table 2: Some soil physical properties as affected by kinds and rates of synthetic soil conditioners application in different soil types

Treatment		Sandy Soil				Calcareous Soil				Alluvial Soil			
		Bulk D g/cm³	Poro % sity	S.P.	OM %	Bulk D g/cm³	Poro% sity	S.P. %	OM %	Bulk D g/cm³	Poro% sity	S.P. %	OM %
Control	Co	1.47	44.53	25.53	0.27	1.43	46.04	38.26	0.75	1.22	53.96	77.41	1.98
P1	L1	1.4	47.17	28.45	0.47	1.4	47.17	40.56	0.82	1.18	55.47	83.78	2.12
	L2	1.35	49.06	32.67	0.54	1.35	49.06	44.65	0.89	1.17	55.85	85.64	2.27
	L3	1.28	51.70	35.07	0.74	1.32	50.19	47.4	0.89	1.13	57.36	88.31	2.49
P2	L1	1.36	48.68	27.12	0.4	1.38	47.92	39.89	0.82	1.16	56.23	82.14	2.27
	L2	1.3	50.94	29.74	0.54	1.34	49.43	43.56	0.89	1.14	56.98	83.46	2.42
	L3	1.22	53.96	33.56	0.54	1.3	50.94	46.39	0.96	1.1	58.49	85.04	2.49
P3	L1	1.47	44.53	26.1	0.47	1.42	46.42	39.21	0.96	1.19	55.09	80.17	2.49
	L2	1.45	45.28	28.43	0.61	1.38	47.92	42.55	1.09	1.18	55.47	81.12	2.71
	L3	1.43	46.04	30.05	0.67	1.34	49.43	44.35	1.16	1.15	56.60	82.86	3.00
LSD	0.05	0.087	3.279	2.999	0.047	0.049	1.833	3.320	0.054	0.040	1.498	4.066	0.053
	0.01	0.119	4.473	4.090	0.065	0.066	2.500	4.529	0.073	0.054	2.044	5.547	0.071

P1=Aequa Kept, P2=Super-Hydro,and P3=Polyvinyllalkohol (at three levels L1=0.05%, L2=0.10% and L3=0.15%)

The obtained results could be discussed as follows:

The application of synthetic soil conditioners (Aequa Kept "P1", Super-Hydro "P2", and PVA "P3") significantly decrease the bulk density after cultivation, under sandy, calcareous and alluvial soils. The highest decrease in bulk density was recorded at P2L3 under different types of soil used.

Other favorable effects of the synthetic soil conditioners include the porosity which increases with increasing the addition of polymers, the highest increase observed with P2L3 treatment in different soils used.

Data of saturation percentage (SP) of the tested soils with different of application rates of synthetic soil conditioners (Table 2) have positive relationships, it indicate that with increasing the rate of soil conditioners SP increases in different soil types.

Addition of synthetic soil conditioners P1, P2, and P3 to different soils used increase organic matter content with increasing the level of polymers addition.

The improving bulk density, porosity, and saturation percentage in different studied soils may attributed to improving soil structure, where neutral polymers are believed to attach to clay by hydrogen bonding or adsorption (De Boodt, 1972; Greenland, 1965; Harris *et al.*, 1966). While cationic polymers are believed to attach to clay by binding to negative charges on clay (Harris *et al.*, 1966; Schamp and Huylebroecd, 1972). On the other hand Dzhanpeisov (1984) found that soil conditioners improved carbon content when converted to humus.

The results above also, in harmony with many investigators, (El-Ghamry, 1996; El-Hadidi *et al.*, 1998; sadek *et al.*, 1993; and Wright and Rajper, 2000)

Effect of polymers on dry weight (g/pot) of wheat plants

The results obtained in Figures (1-3) show that dry weight of whole wheat plants increase significantly with increasing the polymers addition under different soils (sandy Fig. 1; calcareous Fig. 2; and alluvial in Fig. 3). The dry weights of plants are increased with increasing the levels of application of polymers at all treatments compared to the control. the highest dry weights are recorded in different types of treated soils with the P2L3 treatment, the mean values are 7.61, 6.21 and 9.72 g/pot under different soil types of sandy, calcareous and alluvial soils respectively.

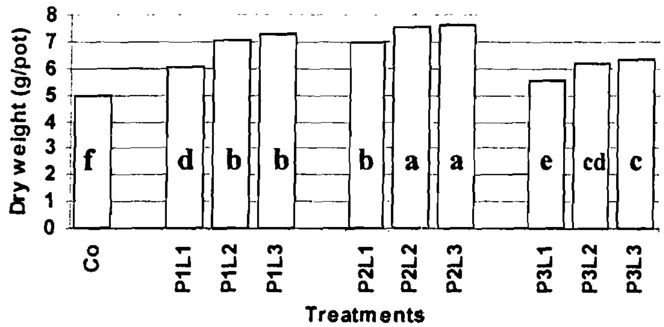

Fig. (1) Dry weight (g/pot) of wheat plants as affected by synthetic soil conditioners in sandy soil.
Letters means Duncan's Multiple Range test at 5% with LSD= 0.257 and F-test **
P1=Aequa Kept, P2=Super-Hydro,and P3=Polyvinyllalkohol (at three levels L1=0.05%, L2=0.10% and L3=0.15%)

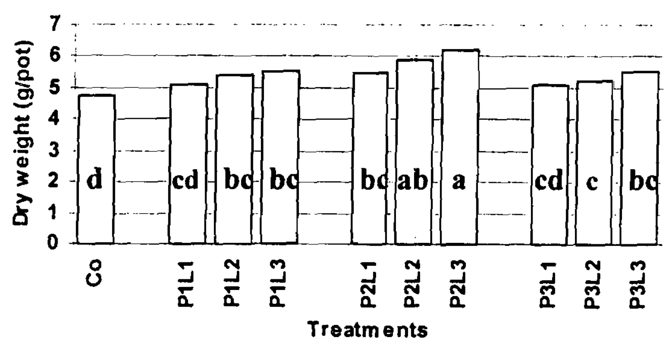

Fig. (2) Dry weight (g/pot) of wheat plant as affected by synthetic soil conditioners in calcareous soil.
Letters means Duncan's Multiple Range test at 5% with LSD= 0.491 and F-test **
P1=Aequa Kept, P2=Super-Hydro,and P3=Polyvinyllalkohol (at three levels L1=0.05%, L2=0.10% and L3=0.15%)

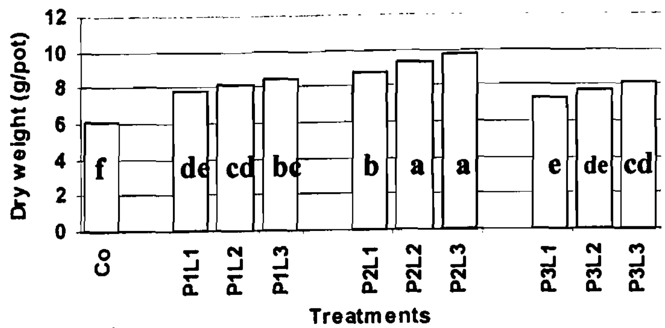

Fig. (3) Dry weight (g/pot) of wheat plant as affected by synthetic soil conditioners in alluvial soil.
Letters means Duncan's Multiple Range test at 5% with LSD= 0.529 and F-test **
P1=Aequa Kept, P2=Super-Hydro,and P3=Polyvinylalkohol (at three levels L1=0.05%, L2=0.10% and L3=0.15%)

The dry weight at all treatments have a significant effect compared to the control, while in all polymers used it was observed that there is no significant effect between dry weight with L2 and L3 in all types of soils used. The obtained results could be discussed as follows:

In sandy soil using synthetic soil conditioners increase the dry matter of wheat this may be due to decrease the loss of applied nutrients especially N, by leaching with mixing PAM (El-Hady *et al*, 1986; Monem *et al*, 1995) also using synthetic soil conditioners improving the hydrophysical properties and nutritional status of sandy soils (El-Hady *et al*, 1983; Sabrah, 1993; Rajpur and Wright, 1999).

In calcareous soil the increase of dry matter with application of polymers may attributed to their characteristics of preventing the formation of surface crust which is considered the main obstacle in cultivation such soils (El-Hady and Lotfy, 1987), also soil conditioners can convert soil evaporation into plant transpiration. This causes an increase in dry matter.

In alluvial soil the beneficial effect of soil conditioners on dry matter could be related to their ability to bind clay particles together, this binding action may subsequently increasse porespace and water infiltration and reduce crusting of soils finally lead to increase dry matter. It was known that there is a very high degree of correlation between physical state of soil and crop production (Martine 1953)

Effect of polymers on N, P, and K uptake

The uptake of macro nutrients by wheat plant are shown in Table 3. It shows that N, P and K uptake are generally increase with soil conditioners and their application rates. The highest rate of N uptake reached to 57.08, 68.93, and 121.50 mg/pot, rate of P uptake reached to 9.13, 9.32, and 23.33 mg/pot, and K uptake reached to 85.99, 78.25, and 204.12 mg/pot caused by using P2L3 with sandy calcareous and alluvial soils respectively compared to the control.

Table 3: N, P, K Uptake by wheat plants (mg/pot) in different soils as affected by Synthetic soil Conditioners

Treatment		Sandy soil			Calcareous soil			Alluvial siol		
		N	P	K	N	P	K	N	P	K
Control	Co	35.22 g	5.46 e	53.57 g	49.56 e	6.61 f	57.11 g	76.630 f	12.87 e	119.54 i
P1	L1	44.09 ef	6.64 c	66.44 e	56.54 cd	7.20 e	64.25 ef	100.75 de	17.18 cd	164.01 f
	L2	52.39 c	7.79 b	79.30 c	60.27 bc	8.15 cd	68.96 cd	102.31 de	18.68 bcd	171.33 de
	L3	53.80 bc	8.72 a	81.42 bc	61.27 b	8.28 c	70.66 bc	106.60 cd	19.46 bc	178.51 c
P2	L1	51.95 c	7.72 b	77.22 c	60.39 bc	8.24 c	67.53 cde	112.13 bc	19.27 bc	176.08 cd
	L2	56.55 ab	9.05 a	84.45 ab	65.27 a	8.82 b	74.09 b	118.36 ab	21.44 ab	195.72 b
	L3	57.08 a	9.13 a	85.99 a	68.93 a	9.32 a	78.25 a	121.50 a	23.33 a	204.12 a
P3	L1	41.22 f	6.13 d	61.27 f	55.30 d	7.17 e	63.49 f	94.300 e	16.08 d	145.47 h
	L2	46.89 de	7.40 b	69.10 de	57.86 bcd	7.89 cd	65.75 def	100.75 de	17.83 cd	156.55 g
	L3	48.41 c	7.64 b	71.34 d	60.72 b	7.73 d	69.00 cd	106.24 cd	18.65 bcd	166.26 ef
F- Test		**	**	**	**	**	**	**	**	**
LSD (0.05)		3.095	0.424	3.859	3.770	0.469	3.463	6.748	2.626	5.623

Letters means Duncan's Multiple Range test, within column, differ significantly according to LSD (0.05)
P1=Aequa Kept, P2=Super-Hydro,and P3=Polyvinylalkohol (at three levels L1=0.05%, L2=0.10% and L3=0.15%)

Table (3) illustrates that NPK uptake at all treatments have a significant effects compared to the control, while in all polymers used it was observed that there is no significant effects between NPK uptake with L2 and L3 treatments in all types of soils used.

The positive effects of the polymers used on the N, P, and K uptake by wheat plant could be attributed to the creation of an artificial soil structure and their effect on enhancing aggregation, reducing crust formation, improving hydraulic properties of the soil and conserving water, either PAM or PVA may be added to the soil. This may affect the nutrients uptake by plants grown in treated soils with such conditioners (Kachinskiy *et al.*, 1967 and Varnavskaya *et al.*, 1967, El-Ghamry, 1996, El-Hadidi *et al.*, 1998)

Soil conditioners are known to improve the nutrient uptake by plant and their yields. Khader *et al.* (1988) showed that super absorbent hydrogel has promotive effect on alfalfa yield especially in first year and increase the total amount of N and P in plant when its application rate exceeded 0.2% to a sandy soil.

Also El-Hady and Lotfy 1987 illustrated that dry weight of plants and N, P and K uptake were positively affected by gel treatments. Produced yield by the unit of either irrigation water or added fertilizers refer to the beneficial effect of examined hydrogel for reducing water consumption and increasing both water and fertilizers use efficiencies by plants.

From the above results, it can be concluded that high application rates used of P2 improve soil physical properties and subsequently increase dry weight and also nutrient uptake by wheat plants in different soils used. Results obtained indicate that both dry weight and N,P,K uptake in wheat plant increased by application of soil conditioners especially with P2 at L3, following the order: Super-Hydro "P2" > Aequa Kept "P1" > Polyvinyllalkohol "P3"

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التغيرات في خواص التربة الطبيعية وامتصاص العناصر الغذائية الكبرى بواسطة محصول القمح في مختلف أنواع الأراضي تحت تأثير البوليمرات

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أجريت تجربة أصص لدراسة تأثير ثلاث أنواع من محسنات التربة على التغيرات الطبيعية وإمتصاص كل من النيتروجين والفوسفور والبوتاسيوم لنبات القمح لأنواع مختلفة من الأراضي. البوليمرات تحت الدراسة هي: الأكواكيبت P1، السوبر هيدرو P2 وكحول البوليفينيل P3 بثلاث مستويات إضافة هي ٠,٠٥% L1، ٠,١٠% L2، ٠,٥% L3 تحت ثلاث أنواع من التربة المستخدمة (الرملية ، الجيرية ، الطينية)

النتائج تشير إلى:

١-بإضافة محسنات التربة الصناعية إنخفضت الكثافة الظاهرية معنويا بعد زراعة القمح كما زادت التهوية وزادت نسبة التشبع وكذلك محتوى التربة من المادة العضوية.

٢-زادت نسبة المادة الجافة زيادة معنوية مع زيادة مستويات إضافة البوليمرات. وأعلى نتيجة لوحظت مع إضافة P2L3 في مختلف أنواع التربة المستخدمة.

٣- زاد إمتصاص كل من النيتروجين والفوسفور والبوتاسيوم زيادة معنوية مع إضافة محسنات التربة المختلفة لأنواع الأراضي تحت الدراسة.

٤-النتائج تشير إلى كل من الوزن الجاف وإمتصاص العناصر الكبرى تزيد عند إضافة المحسنات وكان ترتيب التأثير كالآتي:

السوبر هيدرو P2 > الأكواكيبت P1 > كحول البوليفينيل P3