International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume: 08, Issue: 05 "September-October 2022"

EFFECT OF ORGANIC AND SYNTHETIC SOIL CONDITIONERS WITH DIFFERENT NITROGEN LEVELS ON THE PERFORMANCE OF WHEAT IN SANDY SOIL

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DOI: https://doi.org/10.51193/IJAER.2022.8506

Received: 13 Oct. 2022 / Accepted: 22 Oct. 2022 / Published: 04 Nov. 2022

ABSTRACT

The main problems of sandy soil are its inability to hold on to nutrients, its fast drainage, its lack of soil structure and its small buffering capacity. It cannot hold on to nutrients because it has little or no clay and organic matter. Therefore, the objective of this study was to determine the effect of the combined application of some synthetic soil conditioners with two forms of humic acids (HA) as organic soil conditioners in reducing nitrogen fertilizer requirements to maximize wheat yield productivity. So, two experiments were designed in a split-split plot design with three replicates at the Experimental Station Farm in El-Ismailia governorate during the two successive winter seasons using wheat plant (*Triticum Sativa*cv Giza 168). The treatments included two forms of organic acids and synthetic soil conditioners in the presence of three levels of nitrogen fertilizer. The common agricultural practices for growing wheat according to the recommendations of the Ministry of Agriculture were followed.

Obtained results revealed that the application of humic acids type either HK or HCa in combination with PVA or bitumen emulsion under different application rates of nitrogen fertilizers enhanced wheat plant productivity (yield, straw, and grains kg/fed) along with uptake macronutrient as compared to control treatment. The superior one was HCa in combination with PVA and B in presence of 75% N application in the first and second season, respectively.

Moreover, soil fertility was improved by adding soil conditioners in different forms with/without nitrogen fertilizers as compared to the control treatment i.e. EC values, OM, and available NPK were significantly increased in all treatments applied; the maximum increase was observed with HCa combination with B at 75% from nitrogen dose. Also, the same trend was observed with dry stable aggregates and total porosity of sandy soil for an average of two seasons. An opposite trend was observed with bulk density whose values generally decreased with all treatments.

In conclusion, can be clarified that the application of humic materials either HK or HCa was increasing soil fertility which is reflected in wheat plant productivity but it was more efficient when in combination with synthetic polymers especially B, and can save about 25% from nitrogen fertilizer applied.

Keywords: Synthetic polymers, humic acids, nitrogen fertilizers, sandy soil, and wheat plant

INTRODUCTION

Sandy soils represent about 90 % of the Egyptian soils. These soils are characterized by their poor physical and chemical properties and fertility as well as their low capacity to retain water and low supply of nutrients which are lost by leaching and volatilization. It is there for necessary to apply different sources of organic fertilizers for this soil beside the usual fertilizers (Abdel – Fattah *et al.*, 2015). Any process that increases the ability of sandy soil to enhance crop yields, or improves the performance of soil for any function, can be described as soil conditioning, and any product used in soil conditioning is a soil conditioner either organic materials, gypsum, natural deposits or various water-soluble polymers. Soil needs conditioning for several reasons, one of the vital needs is to control soil degradation, and another is to improve soil air water relations, soil drainage and soil aggregation. The combined application of soil conditioners alongside mineral fertilizers is increasingly gaining recognition as one of the appropriate practices for addressing low soil fertility, especially in arid regions (Vanlauwe *et al.*, 2010).

Wheat is the main winter cereal crop in all the world, where the properties of its kernel make it the leading cereal for human food (El-Ghamry *et al.*, 2016 and Salim and Raza, 2020). In Egypt, there is an urgent need for maximization of wheat crop production due to the local production isn't sufficient to equal the annual requirements (Kasim *et al.*, 2020). Moreover, total wheat consumption drastically increases due to overall population growth of about 2.5 % per year according to Economic Affairs Annual Report, (2017).

In general, 85 to 90% negative charge in HS originated from the dissociation of ion H from functional groups especially carboxyl and phenol, having similar negative charges, and are not able to bond ion nitrate; therefore, become easier subject to leaching. To bond the nitrate from urea with HS, the process needs cation, i.e. calcium to bridge the functional humic group and ion nitrate. The cation Ca is selected because it has two positively charged and the bonding energy weaker but has a strong bond not to be leach by irrigation. One of Ca positively charged aims to bond NO_3^-, while the other positively charged will be bonded to the oxygen of humic (Oviasogie and Okolo 2008). Humic substances enhance membrane permeability, enzyme activities, and hormonal activity in plant and water holding capacity, therefore increasing plant yield, nutrient availability and uptake (Kamh and Hedia, 2018).

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Potassium humate (K-humate) is a natural material that can improve soil's physical and chemical properties and nutrient dynamics (Kumar *et al.,* 2013; Abd-All *et al.*, 2017). Synthetic polymers such as polyacrylamide (PAM), polyvinyl alcohol (PVA), and bitumen proved to be effective when used as soil conditioners for sandy soils (Sojka and Lentz, 1994). However, the positive effects of these synthetic polymers are always temporary and frequent applications are required, because of the fast degradation by microorganisms, which involves extra costs and labor (Grula *et al.*, 1994).

Polyvinyl alcohol (PVA) is used as a soil ameliorant with a very low concentration, 0.1% PVA significantly increases the aggregate stability (Kukal *et al.,* 2007). PVA has many hydroxyl groups in its chains and this group will easily form hydrogen bonding (Jiang *et al.,* 2016). The soil particles are bonded by natural and synthetic polymers so that the moisture and nutrient retention increase (Xu *et al.*,2015 and Zhou *et al.,* 2019).

Asphalt/bitumen, mainly composed of hydrocarbon, is a by-product of petroleum or coal tar refineries. Petroleum asphalt is more suitable for sand stabilization. Previous studies indicated that surface mulching with bitumen emulsions particularly those locally prepared from Egyptian row materials as hydrophobic materials is considered one of the applied techniques that can provide adequate conditions for sandy soil plantation. It protects the soil against wind and water erosion, reduces evaporation, increases the preserved moisture below the mulch layer, modifies soil temperature, increases plant growth and nutrients and stimulates the biological activity of the soil (Al-Omran *et al.,* 2002 and El-Hady *et al.*, 2008). Bitumen application increased the total organic carbon, and decreased the pH values in soil, suggesting asphalt can alter the nutrient composition (Yu *et al.*, 2012). More recently, Silvrano *et al.* (2020) added that high asphalt emulsion contents to the sandy soil provided the soil with a cohesion intercept. This cohesion in the materials was due to the binding action caused by the presence of the residual asphalt binder coating the soil particles.

Inorganic fertilizers have rapid and better effects on crop growth and yield components of wheat crops. Nitrogen is an essential nutrient for plant growth and is essential component of chlorophyll, amino acid, ATP (Adenosine triphosphate) and nucleic acids such as DNA. Also, it is a critical factor in root uptake and N supply improved root length density (Cihlar *et al.,* 2014).

Nitrogen uptake and utilization by plants and wheat are determined by genotypic differences and are linked to a variety of morphological and physiological factors, including the length and activity of the root system, the intensity of nitrate uptake, the activity of nitrate reductase, sink of grains, carbohydrate production and N losses due to soil characteristics and leaching (Fathi *et al.*, 1997 and Shibu *et al.,* 2010). Despite mineral nitrogen fertilizer having a good effect on plant productivity; nevertheless, it also has a pollutant effect on the environment, whereas it is more

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rapidly leaching into groundwater, which affects human and animal health. Antoun *et al.* (2010) and Atia and Ragab (2013) stated that raising mineral nitrogen fertilizer level lead to significant increases in spike length, grain and straw yields/fed and protein content of grains. Also, NPK uptake of grain and straw was significantly increased.

Soil aggregate stability and diameter are closely related to soil carbon and nitrogen contents (Conceição *et al.*, 2013). Moreover, the physical fractionation of soil organic matter into particulate carbon and mineral-associated carbon may greatly contribute to the understanding of C and N dynamics and soil aggregation (Diekow *et al.*, 2005). Carbon in a particulate fraction represents the lowest carbon stock in Oxisols, although it is the most active fraction and is highly susceptible to soil management and cropping systems (Conceição *et al.*, 2013), whereas mineral-associated carbon fraction is the greatest and most stable carbon stock in the soil (Lal, 2005).

The objective of this study is to find a cost-effective, environmentally friendly technique to minimize the utilization of nitrogen fertilizers applied to sandy soil with the interference effect of organic and synthetic soil conditioners application on wheat crop productivity and macronutrients content and its availability in soil.

MATERIALS AND METHODS

The field experiments were carried out at the Experimental Station Farm in El-Ismailia governorate (Latitude, 30o 35' 41.9" N and longitude, 32o 16' 45.8" E), during the two successive winter seasons, cultivated with wheat *(Triticum Sativa* cv Giza 168). The characteristics of investigated soil before its cultivation were shown in Table (1).

Table 1: Some physical and chemical properties of the soil sample represent the studied location.

Particle size distribution					Soil physical properties		
Coarse sand(%)	Fine sand (%)	Silt (%)	Clay (%)	Soil texture	Bulk density (gm cm^{-3})	Total porosity (%)	SP
70.0	23.65	3.54	2.81	Sandy	1.74	34.7	23

Soil chemical properties:

O.M (%)	pH Soil-water suspension ratio (1:2.5)	EC dSm^{-1}	Soluble cations (meq L^{-1})				Soluble anions (meq L^{-1})				Available macronutrients (mg kg^{-1})		
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO^{-}	HCO_3^{-}	Cl^{-}	SO_4^{--}	N	P	K
0.34	7.73	0.44	1.02	0.99	1.30	1.00	-	1.92	1.2	1.19	39	8.1	50

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Experimental design and treatments

Two experiments were designed in a split-split plot design; each treatment was replicated three times. The main plots were three treatments of organic soil conditioners (Control, potassium humate and calcium humate at 30 L fed^{-1}). The sub-main plots three treatments of synthetic soil conditioners (without, polyvinyl alcohol (PVA) at 0.2 % and bitumen (B) at 0.4 %). The sub-sub plots represented three levels of nitrogen fertilizer (50, 75 and 100% from recommended dose of application).

Fertilization:

During soil preparation, calcium super phosphate (15 % P_2O_5) was applied at the rate of 200 kg fed-1, while potassium sulphate (48 % K_2O) was added at the rate of 50 kg fed-1as a basal dose before heading. Ammonium nitrate fertilizer (33.5 % N) was applied at the levels in four equal doses after 15, 30, 45 and 60 days from sowing.

Examined parameters:

1. Soil samples:

Surface soil samples (0-30 cm) were collected from all experimental plots at plant harvesting, air dried and sieved to pass through a 2 mm sieve to determine:

A- Soil chemical analysis: Soil pH values were determined at 1:2.5 (soil: water suspension) using the Beckman pH meter, Electrical conductivity was determined at 1:5 (soil water extraction) and available soil NPK was determined as described by Cottenie *et al.*, 1982.

B- Soil Physical analysis:

1. Dry sieving stability (D.S.S):- Stability of dry aggregates was determined according to Richards (1954).

2. Soil bulk density was calculated by the formula of Black and Hartae (1986).

$$\boldsymbol{Bulk\ Density\ (BD) = \frac{Oven\ dry\ weight\ soil}{Sample\ volume}\ \ g/cm3}$$

3. Total porosity of the soil was calculated from bulk density assuming a particle density of 2.65 g/m^3 with the following formula:

$$\textbf{Total Porosity}(\boldsymbol{TP}) = \mathbf{1} - \frac{\boldsymbol{Bulk\ density}}{\boldsymbol{Particle\ density}}\ \ \%$$

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2. Plant analysis:

The collected plant materials i.e. straw and grain after harvested and determined the yield for them Kg/fed., after that the sample of plants were oven dried at 70° C for 48h, grounded and sieved, then digested using H_2SO_4 and H_2O_2 mixture for nutritional status determinations (N, P and K) according to Page *et al.* (1982). Nitrogen uptake efficiency was calculated according to Gallais and Coque (2005) and Valle *et al.* (2011) as follows

$$\textbf{Nitrogen uptake efficiency (NPE)} = \frac{\boldsymbol{Kg\ N\ in\ above\ ground\ part(straw + grain)x100}}{\boldsymbol{kg\ N\ in\ soil\ \ including\ fertilizers}}$$

3. Statistical analysis:

According to Gomez and Gomez (1984) all obtained results in each growing season were exposed to statistical analysis to compare the means through L. S. D. test at a level of significance (0.05).

RESULTS AND DISCUSSION

Biological yield and yield components:-

Data in Table (2) revealed the effect of organic and synthetic soil conditioners in combination with different nitrogen rates application on wheat yield components (biological yield, grain and straw). Yield components of wheat were significantly increased with humic acids forms in combination with PVA and B in the presence of nitrogen rate as compared to control. Yield components of wheat in the first and second seasons increased by applied HCa combined with PVA and B at 75% N fertilizer, respectively. The corresponding yield components of wheat plants at the first season, as compared to control, recorded 173, 195 and 148 % for biological yield, straw and grains, respectively; the corresponding increases in components in the second season recorded 181, 159, and 214, respectively. Such increases in wheat yield may be due to the indirect effects of HS on increased soil enzyme activity and promoted the growth of rhizosphere microorganisms (Sellamuthu and Govindaswamy, 2003) along with the calcium ions can improve the absorption of other nutrients by roots and their translocation within the plant, activates many plant growth-regulating enzyme systems, helps convert nitrogen-nitrate into forms needed for protein formation, is needed for cell wall formation and normal cell division and improves disease resistance. Also, the results are in harmony with Wali *et al.* (2018) who found that the addition of 65 kg N fed^{-1} combined with 2 kg humic acids improved the quality, chemical composition, and yield of barley.

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Table 2: Responses of wheat yield (Kg fed^{-1}) at two seasons to apply different of soil conditioners and different rates of nitrogen fertilizer.

Treatments			First season			Second season		
Soil conditioners		Nitrogen rates (%)	Biological yield	Straw	Grains	Biological yield	Straw	Grains
Organic	Synthetic							
Control			3266	1739	1527	3371	2030	1341
Humate potassium	Without	50	3758	1834	1924	5544	3340	2204
		75	5136	3333	1803	6104	3074	3030
		100	7932	4214	3718	6216	3926	2290
	Mean		5609	3127	2482	5955	3447	2508
	PVA	50	5267	3489	1778	5360	2578	2782
		75	6666	4402	2264	5420	3170	2250
		100	6396	3809	2587	5236	2548	2688
	Mean		6109	3900	2209	5339	2765	2573
	Bitumen	50	4949	3097	1852	5096	2201	2895
		75	6054	4782	1272	8190	4010	4180
		100	6566	3430	3136	6636	4516	2120
	Mean		5856	3769	2086	6640	3575	3065
Humate calcium	Without	50	5458	3402	2056	5208	2383	2825
		75	5543	3406	2138	5964	2977	2987
		100	5484	2849	2635	6720	3305	3415
	Mean		5495	3218	2276	5964	2888	3075
	PVA	50	4712	3026	1687	8064	4354	3710
		75	8916	5134	3782	8820	4997	3823
		100	4513	2941	1572	8185	5069	3116
	Mean		6047	3699	2347	8356	4807	3549
	Bitumen	50	6096	2552	3545	8107	4705	3402
		75	8434	5069	3365	9478	5267	4211
		100	6715	4413	2302	7833	5103	2730
	Mean		7081	4011	3071	8473	5025	3448
Mean of organic soil conditioner		control	3266	1739	1527	3371	2030	1341
		HK	5858	3598	2259	5978	3262	2716
		HCa	6207	3643	2565	7598	4240	3358
Mean of synthetic soil conditioner		Without	4789	2695	2095	5097	2788	2308
		PVA	5140	3113	2028	5689	3201	2488
		Bitumen	5401	3173	2228	6162	3544	2618
Mean of nitrogen rates		50 %	4449	2513	1936	5277	2850	2427
		75 %	5616	3483	2134	6009	3287	2723
		100 %	5267	2986	2281	5660	3395	2265
L.S.D at 0.05 %								
organic soil conditioner			448	516	128	626	744	204
synthetic soil conditioner			219	230	258	410	421	148
A*B			379	398	448	711	729	256
nitrogen rates			201	241	186	250	256	146
A*C			348	418	322	433	443	252
B*C			348	418	322	433	443	252
ABC			602	724	558	750	767	437

ISSN: 2455-6939

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Concerning the effect of soil conditioners forms either organic or synthetic, data indicated that the application of humate calcium (HCa) and bitumen (B), generally, gave more significantly favorable wheat yield components. This increase may be due to the role of humate calcium as affected root morphology, nutrients uptake, cell membrane stability and permeability. Also, this result agrees with Zein El-abdeen *et al.* (2018) reported that applying Ca-H individually or in combination with mineral nitrogen fertilizer significantly increased the growth of faba bean (yield, biological yield, 100 seeds, plant height, number of branches and number of pods) as compared to control treatment, the superior treatment is 75 % N + Ca-H. On the other hand, Youssef *et al.* (2019) showed that yield components of maize and wheat were increased by applying different rates of conditioners at all rates of N fertilizer compared to control. Values of both maize and wheat yield components were more stimulated with the application of bitumen. Also, irrespective of the effect of both soil conditioner forms, values of wheat yield components at two seasons increased general significantly by applying 75% of nitrogen fertilizer.

In general, the mechanism of increasing the yield was explained by Hua *et al*. (2020), who found that the use of chemical fertilizer combined with organic fertilizer on yield has been widely studied. It is well-known that organic fertilizer can improve the soil's physical and chemical properties, increase soil nutrient availability and promote crop growth. Organic materials from organic fertilizer transformed into soil organic matters through a series of complex biochemical reactions after the manure were applied to the soils. The soil organic matter contained many organic functional groups, such as carboxylic and phenolic groups. The dissociation of these acidic functional groups increased the soil negative charge and thus soil CEC, and also increased the resistance to acidification. On the one hand, the application of organic fertilizer stabilized the soil structure, slowed down the N migration, and effectively reduced the fertilizer N loss; on the other hand, the improvement of soil microbial biomass and activity was conducive to the immobilization of N in the pre-growing stage and the gradual demineralization afterward. Therefore, the application of organic fertilizer was beneficial to improving the NUE, which also increased the crop yield.

Total contents of macronutrients

Regarding the application effect of organic and synthetic soil conditioners alone or combined with different nitrogen rates at two seasons, data in Tables (3 and 4) clearly that all values of macronutrients uptake (NPK) in straw and grain of wheat plant at two seasons were increased significantly with all treatments applied as compared to control. The maximum value was observed with HCa combined with PVA and B in presence of 75% N rate at the first and second season, respectively. Also, the behavior of the total macronutrient content followed the same trend as those recorded by yield components.

ISSN: 2455-6939

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Table 3: Macronutrients total contents (Kg fed^{-1}) of both straw and grains of studied wheat plant at first season as affected by different of soil conditioner under different rates of nitrogen fertilizer.

Treatments			Straw			Grains		
Soil conditioners: Organic	Soil conditioners: Synthetic	Nitrogen rates (%)	N	P	K	N	P	K
Control			15.0	8.55	14.7	20.4	11.8	5.89
Humate potassium	Without	50	19.7	11.5	15.9	22.5	16.3	9.86
		75	25.7	18.6	29.7	29.5	19.3	11.9
		100	30.5	26.6	35.4	32.6	34.8	14.6
	Means		25.3	18.9	27.0	28.2	23.5	12.1
	PVA	50	35.1	13.8	29.6	31.3	29.2	10.6
		75	47.6	19.2	38.5	40.5	35.9	17.2
		100	32.9	16.4	23.1	48.6	28.5	13
	Means		38.5	16.5	30.4	40.1	31.2	13.6
	Bitumen	50	32.2	12.4	28.7	45.9	28.1	15.3
		75	44.8	22.3	22.5	31.8	19.6	12.5
		100	35.5	16.9	34.8	59.9	28.8	13.7
	Means		37.5	17.2	28.7	45.9	25.5	13.8
Humate calcium	Without	50	23.4	9.96	26.9	25.5	25.3	9.9
		75	27.8	14.9	27	30.8	34.1	10.2
		100	31.5	14.6	29.8	33.4	32.6	15.3
	Means		27.6	13.2	27.9	29.9	30.7	11.8
	PVA	50	30.8	13.9	24.1	32.8	23.7	10.8
		75	57.8	27.1	54.2	72.4	48.8	27.7
		100	40.4	12.7	19.8	31.5	22.7	12.4
	Means		43.0	17.9	32.7	45.6	31.7	17.0
	Bitumen	50	27.8	8.9	20.4	60.6	25.1	9.68
		75	47	19.5	45.2	63	47.8	22.9
		100	38.4	18.2	34.8	53.7	33.1	14.6
	Means		37.7	15.5	33.5	59.1	35.3	15.7
Means of organic soil conditioner		control	15.0	8.55	14.7	20.4	11.8	5.89
		HK	33.8	17.5	28.7	38.1	26.7	13.2
		HCa	36.1	15.5	31.4	44.9	32.6	14.8
Means of synthetic soil conditioner		Without	22.6	13.5	23.2	26.2	22.0	9.9
		PVA	32.2	14.3	25.9	35.4	24.9	12.2
		Bitumen	30.1	13.8	25.6	41.8	24.2	11.8
Means of nitrogen rates		50%	23.8	10.7	21.1	31.1	20.3	9.3
		75%	32.9	16.4	29.0	36.6	26.8	13.3
		100%	28.2	14.6	24.6	35.7	24.0	11.3
L.S.D at 0.05 %								
organic soil conditioner			7.14	2.78	2.86	3.11	5.58	1.31
synthetic soil conditioner			2.35	0.83	4.04	6.17	3.5	0.63
A*B			4.08	1.44	6.99	10.7	6.06	1.09
nitrogen rates			3.4	1.11	3.15	5.28	3.26	0.62
A*C			5.89	1.91	5.46	9.15	5.64	1.07
B*C			5.89	1.91	5.46	9.15	5.64	1.07
ABC			10.2	3.32	9.46	15.8	9.77	1.85

ISSN: 2455-6939

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Table 4: Macronutrients total contents (Kg fed^{-1}) of both straw and grains of the studied wheat plant in the second season as affected by different soil conditioners under different rates of nitrogen fertilizer.

Treatments			Straw			Grains		
Soil conditioners		Nitrogen rates (%)	N	P	K	N	P	K
Organic	Synthetic							
Control			15.7	7.74	10.6	20	10.7	5.6
Humate potassium	Without	50	20.4	9.83	14.6	25.2	14.4	7.18
		75	25.2	10	16.7	32.9	19.2	9.21
		100	36.4	13.7	25	33.6	22.5	9.22
	Means		27.3	11.2	18.8	30.6	18.7	8.5
	PVA	50	31.4	9.77	12.9	38.6	16.8	6.44
		75	55.4	13.5	25.6	46.3	18.1	8.4
		100	40.1	10.3	15.9	47	22	8.44
	Means		42.3	11.2	18.1	44.0	19.0	7.8
	Bitumen	50	31.9	13.1	14.9	52.3	23.2	9.55
		75	58.8	23.2	29.7	87.4	31.5	13.9
		100	64.1	25.8	34.4	52.9	23.5	10.1
	Means		51.6	20.7	26.3	64.2	26.1	11.2
Humate calcium	Without	50	33.3	15.8	18.1	40.8	14.7	6.54
		75	45.9	22.7	25.7	60.8	23.8	10.9
		100	51.2	18.3	25.7	81.3	29.7	12.6
	Means		43.5	18.9	23.2	61.0	22.7	10.0
	PVA	50	60.9	20.5	34.9	58.3	22.3	10.4
		75	69.9	25.6	39.9	78.5	30.3	13.2
		100	70.8	20.9	40.9	60.1	23.9	11.4
	Means		67.2	22.3	38.6	65.6	25.5	11.7
	Bitumen	50	66.1	19.8	36.1	51.9	17.8	7.87
		75	83.6	26.5	46	90.8	33.8	14.1
		100	75.4	17.2	40.7	56.9	21.9	9.24
	Means		75.0	21.2	40.9	66.5	24.5	10.4
Means of organic soil conditioner		control	15.7	7.74	10.6	20	10.7	5.6
		HK	40.4	14.4	21.1	46.2	21.2	9.2
		HCa	61.9	20.8	34.2	64.4	24.2	10.7
Means of synthetic soil conditioner		Without	28.8	12.6	17.5	37.2	17.4	8.1
		PVA	41.7	13.8	22.4	43.2	18.4	8.3
		Bitumen	47.4	16.5	26.0	50.2	20.4	9.1
Means of nitrogen rates		50%	32.3	12.4	18.1	36.3	15.7	7.2
		75%	42.9	16.1	23.9	50.7	21.0	9.6
		100%	42.8	14.4	23.8	43.5	19.5	8.6
L.S.D at 0.05 %								
organic soil conditioner			7.29	1.86	2.11	6.42	2.29	1.57
synthetic soil conditioner			5.12	1.63	1.75	5.63	2.22	0.57
A*B			8.87	2.82	3.03	9.74	3.85	0.98
nitrogen rates			3.72	1.99	1.9	4.32	1.34	0.73
A*C			6.43	3.45	3.29	7.48	2.33	1.27
B*C			6.43	3.45	3.29	7.48	2.33	1.27
ABC			11.1	5.98	5.69	12.9	4.03	2.19

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Such increases may be due to the humic acids-based fertilizers improving the nutrient use efficiency of the crop directly by influencing its utilization and accumulation of the nutrients for better plant growth reflecting in enhanced dry matter yield and improvement in various physiological and compositional changes in plants (Du *et al.*, 2007). Selimand Mosa (2012) showed that the concentrations of N, P, and K in broccoli heads were increased by increasing the mineral fertilization application rates under the effect of humic acids application.

These effects can predominantly be ascribed to increases in nutrient availability of the soil. In addition, the stimulation of N uptake by HA might be attributed to the promoting effect of HA on nitrate carrier proteins (Vaughan and Malcom, 1985) and/or due to modification of some kinetic parameters after HS application (Cacco *et al.*, 2000). Humic substances appear to have a stimulating effect on the physiological properties of plants, which might also increase potassium uptake by plants (Samson and Visser, 1989). The application of HS may have decreased K+ leaching due to the influence of functional groups commonly present in HA, including carboxyl, phenol, and hydroxyl, which contributed to K+ binding by HA (Wang and Huang, 2001).

With respect to the effect of organic soil conditioner, data indicated that the treatment of HCa gave significant positive influences on the total content of macronutrients as compared to Hk treatment. This result may be attributed to the calcium source which improves the absorption of nutrients by roots and their translocation within the plant not only is a nutrient itself but interestingly in its function as a second messenger, it is involved in signaling nutrient availability and changes thereof (Kudla *et al.*, 2018).

Also, the NPK content in straw and grain of wheat, generally, was increased by the addition of PVA and B as synthetic soil conditioners compared to without additional treatment. However, The PVA treatments were significantly higher than the B in the first season; an opposite trend was encountered in the second season whose values were highest when applying B treatments. This result may be attributed to because either PVA or B is a polymer which in turn keeps a large amount of water containing element and act as slow-release fertilizers as well as its ability to binding soil particles to improve their characteristic.

Nitrogen uptake efficiency (NPE)

Nitrogen is one of the most yield-limiting nutrients in crop production around the world. Crop response to applied nitrogen and harvest index as well as use efficiency are important criteria for evaluating crop nitrogen requirements for maximum economic yield.

The fact that nitrogen uptake efficiency (NPE) is part of the decision–making process to quantify nitrogen application to crops is an indication that losses are an unavoidable element of the fate of

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nitrogen in agricultural systems, although some of this efficiency also accounts for nitrogen incorporated into soil organic matter.

Data presented in Fig (1) showed that the nitrogen uptake efficiency was the highest (147.4 and 198.7) for the first and second seasons receiving HCa combined with bitumen and PVA, respectively, in the presence 50 % rate of nitrogen fertilizer. These results agree with those reported by Khadem *et al.* (2010) who observed that polymer (PAM) slightly increased the amount of N in the soil.

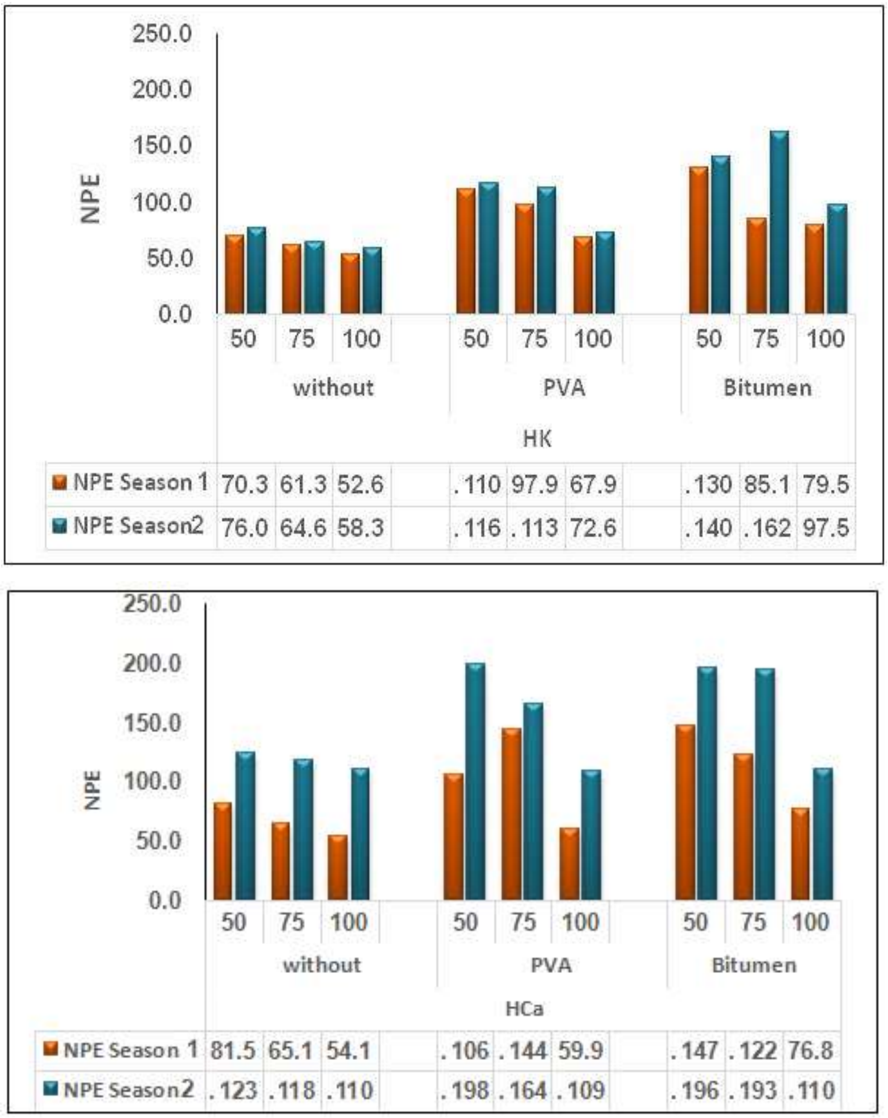

Fig. 1: Effect of applied different organic and synthetic soil conditioners in the presence of nitrogen rates on nitrogen uptake efficiency (NPE) at two seasons.

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The values of NPE increase when adding synthetic soil conditioners compared to the control in the presence of two forms of HA under the influence of nitrogen levels 50 and75 % and decrease with 100 % nitrogen during the two seasons. This indicated that the use of synthetic soil conditioners in the presence of humic acids reduces nitrogen fertilizer rates, and this lead to reducing nitrogen fertilizer consumption, which saves the price of fertilizers used. Based on the previous results we found that the application of synthetic soil conditioners in presence of HA forms has an effective effect on NPE.

Soil chemical properties:

Data in Table (5) showed the changes in some soil chemical properties (pH, EC, and OM) as affected by the studied treatments.

Soil reaction (pH)

The pH in soil was decreased slightly as affected by applied organic and synthetic soil conditioner treatments in presence of nitrogen rates as compared to control; this trend was true for two seasons.

Regarding the application of organic and synthetic soil conditioners, the results showed that HCa and PVA gave a decrease in soil pH as compared to other soil conditioners. These results agree with Adnan *et al.* (2014) who concluded that PVA as a polymer conditioner decreased pH values over control treatment.

With respect to the individual effect of the nitrogen fertilizer rates, the values of soil second season whose values were slightly increased.

Electric conductivity (EC) and organic matter (OM).

Soil electric conductivity and organic matter content, generally, increased due to the application of studied treatments of soil conditioners in the presence of nitrogen rates as compared to control. The HCa and PVA in presences of 75 % N rate a high significant EC and OM of 0.259 dSm-1 and 0.61 % in the first season against 0.207 dSm^{-1} and 0.67 % in the second season compared to control of 0.137 dSm-1 and 0.31 % at the first season against 0.172 dSm^{-1} and 0.37 % at the second season. These results agree with Youssef *et al.* (2019) who found that the electric conductivity increased gradually with an increase in rates for both nitrogen fertilizer and soil conditioners. The values of EC and OM were highest due to applied HCa and PVA as organic and synthetic soil conditioners than HK and B.

With respect to nitrogen fertilizers rates, EC and OM values have a positive trend with application nitrogen rates increased, especially in the first season. The applied 75 % N fertilizer

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Table 5: Response of some chemical properties of the tested soil after wheat crops were harvested at two seasons to applied different soil conditioners and different rates of nitrogen fertilizer.

Treatments			First season			Second season		
Soil conditioners		Nitrogen rates (%)	pH (1:2.5)	EC (dSm^{-1})	OM (%)	pH (1:2.5)	EC (dSm^{-1})	OM (%)
Organic	Synthetic							
Control			7.23	0.137	0.31	7.23	0.172	0.37
Humate potassium	Without	50	7.04	0.171	0.41	7.22	0.175	0.51
		75	7.24	0.167	0.45	7.21	0.177	0.52
		100	7.13	0.185	0.47	7.18	0.182	0.55
	Mean		7.14	0.174	0.44	7.20	0.178	0.53
	PVA	50	7.17	0.137	0.46	7.15	0.188	0.49
		75	7.09	0.187	0.47	7.29	0.189	0.54
		100	7.20	0.223	0.57	7.32	0.172	0.56
	Mean		7.15	0.194	0.50	7.26	0.183	0.53
	Bitumen	50	7.24	0.134	0.40	7.31	0.187	0.47
		75	7.21	0.178	0.49	7.21	0.187	0.53
		100	7.14	0.172	0.52	7.21	0.191	0.61
	Mean		7.19	0.191	0.47	7.24	0.188	0.53
Humate calcium	Without	50	7.31	0.150	0.45	6.83	0.204	0.55
		75	7.14	0.170	0.50	7.25	0.189	0.55
		100	7.08	0.180	0.54	7.21	0.184	0.56
	Mean		7.18	0.167	0.49	7.09	0.192	0.55
	PVA	50	7.24	0.156	0.52	7.18	0.186	0.41
		75	7.26	0.259	0.61	7.13	0.207	0.67
		100	7.26	0.167	0.56	7.19	0.185	0.43
	Mean		7.25	0.194	0.56	7.17	0.193	0.50
	Bitumen	50	7.34	0.149	0.50	7.22	0.179	0.47
		75	7.22	0.166	0.51	7.21	0.186	0.62
		100	7.15	0.240	0.53	7.19	0.178	0.63
	Mean		7.24	0.185	0.51	7.21	0.181	0.57
Meanof organic soil conditioner		control	7.23	0.137	0.31	7.23	0.172	0.37
		HK	7.16	0.172	0.47	7.23	0.183	0.53
		HCa	7.22	0.182	0.53	7.16	0.189	0.54
Mean of synthetic soil conditioner		Without	7.18	0.171	0.42	7.18	0.181	0.48
		PVA	7.21	0.188	0.46	7.22	0.183	0.49
		Bitumen	7.22	0.173	0.43	7.23	0.180	0.47
Mean of nitrogen rates		50 %	7.23	0.145	0.41	7.18	0.182	0.45
		75 %	7.21	0.171	0.44	7.22	0.183	0.50
		100 %	7.18	0.175	0.46	7.22	0.179	0.49
L.S.D at 0.05 %								
organic soil conditioner			0.03	0.008	0.13	0.26	0.024	0.101
synthetic soil conditioner			0.06	0.019	0.02	0.06	0.006	0.046
A*B			0.10	0.033	0.04	0.11	0.010	0.079
nitrogen rates			0.02	0.006	0.04	0.07	0.006	0.039
A*C			0.04	0.009	0.05	0.12	0.009	0.068
B*C			0.04	0.009	0.05	0.12	0.009	0.068
ABC			0.07	0.017	0.09	0.22	0.017	0.471

in the second season was superior. Also, Zein El –Abdeen *et al.* (2018) reported that organic matter was enhanced by added Ca-H alone or when applied in combination with 75 % N as compared to control; the such increase was marked with 75 % N + Ca-H. This trend was observed in both seasons.

Available macronutrients (NPK).

Results representing the availability of macronutrients (N, P and K) in the soil after wheat was harvested were shown in Table (6).

All applied soil conditioners increase the N, P and K availability compared to the control treatment. However, the highest values of soil nutrients available at two seasons were due to applied PVA as synthetic soil conditioner combined with humate calcium as organic soil conditioner treatment compared to the other tested treatments. These results agree with Zhou *et al*. (2019) who concluded that PVA has many hydroxyl groups in their chains and this group will easily form hydrogen bonding with soil particles so that the moisture and nutrient retention increases. Also, mean values of HCa and PVA were superior for N, P and K availability in the soil as compared to other treatments. A previous study showed that the application of organic matter to soil increased the availability of nitrogen, phosphor, and potassium (Shokalu *et al.*, 2010).

Regarding the application of nitrogen fertilizer rates, results indicated that 75 % of nitrogen fertilizer was generally superior for P availability, but 100 % was superior for K availability.

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Table 6: Responses of macronutrient availability (mg Kg^{-1}) for the tested soil after wheat harvesting at two seasons to apply different soil conditioners and different rates of nitrogen fertilizer.

Treatments			First season			Second season		
Soil conditioners		Nitrogen rates (%)	N	P	K	N	P	K
Organic	Synthetic							
Control			82.0	12.3	31.0	85.0	13.0	44.0
Humate potassium	Without	50	120	15.7	39.7	127	14.0	55.3
		75	135	23.3	42.0	137	21.7	56.6
		100	157	17.3	48.7	141	24.7	64.3
	Mean		137	18.8	43.4	135	20.1	58.3
	PVA	50	139	26.3	44.3	111	22.7	46.3
		75	126	25.0	46.3	143	30.3	55.3
		100	122	24.7	51.0	148	21.3	57.3
	Mean		129	25.3	47.2	134	24.8	53.0
	Bitumen	50	137	17.0	40.3	140	15.7	52.7
		75	130	20.7	43.0	145	28.0	55.3
		100	111	14.0	61.0	161	28.0	62.3
	Mean		126	17.2	48.1	148	23.9	56.8
Humate calcium	Without	50	118	18.7	35.7	145	17.3	45.3
		75	136	19.3	47.0	182	20.0	47.7
		100	147	29.7	51.0	185	23.0	53.7
	Mean		133	22.6	44.6	170	20.1	48.9
	PVA	50	124	24.0	42.0	116	21.0	56.0
		75	162	29.0	50.3	133	39.7	69.3
		100	137	24.0	88.3	192	19.3	71.3
	Mean		141	25.7	60.2	147	23.3	65.6
	Bitumen	50	126	20.0	33.3	133	21.7	54.3
		75	137	21.7	56.3	174	30.0	59.3
		100	136	17.3	63.7	192	21.7	65.0
	Mean		132	19.7	51.1	166	24.6	59.6
Meanof organic soil conditioner		control	82.0	12.3	31.0	85.0	13.0	44.0
		HK	130	20.4	46.3	139	22.9	56.0
		HCa	136	22.6	51.9	161	22.6	58.0
Mean of synthetic soil conditioner		Without	118	17.9	39.7	130	17.7	50.4
		PVA	117	21.1	46.1	122	20.4	54.2
		Bitumen	114	16.4	43.4	133	20.5	53.4
Mean of nitrogen rates		50 %	112	17.6	36.5	114	16.9	49.1
		75 %	119	19.6	42.0	129	22.1	52.7
		100 %	117	18.2	50.7	142	19.7	56.2
L.S.D at 0.05 %								
organic soil conditioner			29.1	2.99	7.49	25.7	4.76	9.04
synthetic soil conditioner			5.29	1.87	6.29	17.7	1.93	10.3
A*B			9.16	3.23	10.9	30.6	3.33	17.8
nitrogen rates			4.77	2.19	3.78	10.9	1.92	3.22
A*C			8.26	3.80	6.54	18.9	3.32	5.58
B*C			8.27	3.80	6.54	18.9	3.32	5.58
ABC			14.3	6.59	11.3	32.7	5.75	9.66

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Soil physical properties:

Bulk density (BD) and total porosity (TP)

Bulk density in the soil at the end of the experiment for both two seasons was shown in Table (7). In general, BD decreased as a result of applying all the treatments compared to the control treatment. The BD values decreased from 1.63 to 1.33 g/cm^{-3} for soil. Also, the maximum decrease was found with applied HCa compared with B in the presence of 75 % of nitrogen fertilizer rate.

Total soil porosity is an index of the relative volume of pores in the soil. This is a special formula that explains the relationship between both the soil real and bulk densities. Data presented in Table (7) showed that the greatest value of total soil porosity was found in the soil treated with a combination of HCa and B, the relative increases of mean values of total porosity were 29.4 % compared with control. The increased porosity is especially important to crop development because it may have a direct effect on soil aeration and can enhance root growth.

Dry–sieved aggregates:

The dry stable aggregates showed marked variations associated with different treatments. The aggregate categories studied in this experiment are 7 categories, of the following diameters (mm): 10-2, 2-1, 1-0.5, 0.5-0.25, 0.25-0.125, 0.125- 0.063, and <0.063, they are designated as follows: very large, large, medium, sub – medium, small, very small and extremely small.

Data in Table (7) illustrates the percentages of dry stable aggregates (D.S.A %), as affected by different soil amendments (humic acids forms and synthetic conditioner), in seven fraction sizes.

The dry aggregates showed the most abundant fraction with 1 to 0.5 mm either with organic soil conditioner applied alone or in combination with synthetic soil conditioner, such increase in weight diameter ranged from 22.23 to 58.21 mm. On the other hand, the percentages of other sizes of dry aggregates decrease as their diameters decrease, especially the aggregates that have diameters less than 0.063 mm which were the lowest values. Moreover, B as a synthetic soil conditioner and HCa as an organic soil conditioner had the largest granular size with a diameter (1 to 0.5) more than other treatments. Increasing aggregate size refers to decreasing soil bulk density and increasing macro pores as described by Ali (2011). Also, previously Kukal *et al*. (2007) reported that the use of PVA as a soil conditioner with a very low concentration, 0.1% PVA significantly increases the aggregate stability.

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Table 7: Responses of Bulk density (BD), total porosity (TP), and dry-sieved aggregates for the tested soil after wheat harvesting (average of two successive seasons) to applied different soil conditioners and different rates of nitrogen fertilizer.

Organic soil conditioner	Synthetic Soil conditioner	N rates %	BD gcm^{-1}	TP (%)	Dry stable aggregate diameter (mm)						
					10-2	2-1	1-0.5	0.5-0.25	0.25-0.125	0.125-0.063	<0.063
control			1.63	38.5	4.52	3.00	22.2	65.2	4.37	0.58	0.10
HK	without	50	1.57	40.8	1.15	2.00	45.3	37.7	10.9	2.69	0.11
		75	1.52	42.6	0.20	0.93	47.1	33.4	14.2	4.00	0.03
		100	1.53	42.3	0.52	2.26	40.7	37.5	14.5	4.32	0.06
	Mean		1.54	41.9	0.62	1.73	44.4	36.3	13.3	3.70	0.10
	PVA	50	1.53	42.3	2.51	2.16	45.1	31.6	17.2	1.28	0.15
		75	1.52	42.6	0.51	1.10	49.4	31.2	14.3	3.19	0.21
		100	1.55	41.5	0.40	1.00	55.5	22.4	16.0	4.25	0.40
	Mean		1.53	42.1	1.14	1.42	50.0	28.4	15.8	2.90	0.30
	B	50	1.57	40.8	2.63	1.76	47.2	30.4	13.1	4.45	0.33
		75	1.55	41.5	0.77	1.73	39.5	37.0	17.8	3.06	0.12
		100	1.45	45.3	0.41	1.22	52.2	36.8	7.28	1.57	0.39
	Mean		1.52	42.5	1.27	1.57	46.4	34.8	12.7	3.00	0.30
HCa	without	50	1.55	41.5	0.40	1.13	46.1	26.9	20.5	4.85	0.10
		75	1.46	44.9	1.65	3.00	39.0	38.0	14.9	2.50	0.94
		100	1.44	45.7	0.20	1.33	43.1	36.9	15.4	2.84	0.20
	Mean		1.48	44.0	0.75	1.82	42.7	33.9	16.9	3.40	0.40
	PVA	50	1.46	44.9	0.88	3.37	39.8	41.6	11.1	3.16	0.02
		75	1.57	40.8	0.79	2.27	50.9	30.3	4.13	1.43	0.10
		100	1.55	41.5	0.75	1.23	45.5	32.2	16.1	4.02	0.08
	Mean		1.52	42.4	0.81	2.29	45.4	34.7	10.5	2.90	0.10
	B	50	1.47	44.5	1.53	0.99	58.2	21.0	14.1	4.11	0.03
		75	1.33	49.8	0.45	1.53	57.1	26.1	11.1	3.44	0.20
		100	1.61	39.2	1.71	2.95	43.2	40.5	9.63	1.84	0.15
	Mean		1.48	44.5	1.23	1.82	52.8	29.2	11.6	3.10	0.10
Mean of organic		HK	1.54	41.8	1.36	1.72	44.4	36.3	12.9	2.94	0.19
		HCa	1.49	43.7	0.93	1.98	47.0	32.6	13.0	3.13	0.20
Mean of synthetic		Without	1.51	42.9	0.69	1.78	43.5	35.0	15.1	3.53	0.24
		PVA	1.53	42.2	0.97	1.86	47.7	31.5	13.1	2.89	0.16
		B	1.50	43.5	1.25	1.70	49.6	31.9	12.1	3.08	0.20
Mean of N rates		50	1.78	49.5	1.94	2.26	54.5	36.8	17.3	3.64	0.15
		75	1.75	50.8	0.81	1.94	55.4	37.9	15.1	3.47	0.30
		100	1.78	49.5	0.73	1.83	55.9	38.1	15.8	3.85	0.28

* BD = Bulk density *TP = Total porosity

CONCLUSION

In general, the utilization of humic acids forms (potassium humate (HK) and calcium humate (HCa)) as organic soil conditioners alone or in combination with polyvinyl alcohol (PVA) or bitumen emulsion enhanced the biological yield of wheat plants and their total macronutrients content, as well as, improved chemical-physical properties of sandy soil by increasing available NPK, EC, total porosity and OM% which lead to increasing dry stable aggregates whereas pH values were slightly decreased. Moreover, calcium humate in combination with B was become more effective than other treatments on NPK uptake and can save about 25% from the consumption of nitrogen fertilizers. Also, calcium humate was more effective with bitumen emulsion on soil BD, TP and dry stable aggregate.

ACKNOWLEDGMENT

The authors wish to express their sincere gratitude and appreciation to the Development of Soil Conditioners Project, Dept. of Physics and Chemistry of Soil, Soils, Water and Environ. Res. Inst., Agric. Res. Center (ARC), Giza, Egypt, for introducing all facilities needed to accomplish this study.

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