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Evaluation of Some Synthetic Soil Conditioners and Nitrogen Rates on Nitrogen Use Efficiency by Maize - Wheat Crops System in Calcareous Soil

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ABSTRACT

The use of synthetic soil conditioners such as polyvinyl alcohol (PVA), bitumen (Bit.) and polyacrylamide (PAC) can be considered as a specific management to improve the efficiency of the use of nitrogen fertilizers and some chemical properties of calcareous soils that are reflected in crop productivity. Two rates of synthetic soil conditioners (PAV, Bit. and PAC) and three rates of nitrogen fertilizer (50, 75 and 100% N of recommended dose) were included in this study to evaluate their effects on some chemical properties, nutritional status and yield components of both maize and wheat crops along with nitrogen use efficiency. Field experiments were conducted in calcareous soil at Nubaria Agriculture Research Station farm during two successive seasons, summer season cultivated with maize (*Zea mays* L., cv Giza 10) and winter season cultivated with wheat (*Triticum aestivum* L., cv Giza 168). Results showed that the highest significant yield components of maize and wheat crops along with their total content of the indicated macronutrients were observed when applied high rate of polyvinyl alcohol (0.2 %) accompanied with high rate of nitrogen fertilizer (100% N of recommended dose) as compared to other tested treatments. On the contrary, application of high rate polyacrylamide combined with low rate of nitrogen fertilizer generally was inferior for yield components of both maize and wheat plants. Also, data revealed that the nitrogen use efficiency was the highest (65.0 and 42.4) for maize and wheat plant, respectively, receiving 50 % nitrogen fertilizer rate in presence of 0.2 % polyvinyl alcohol. However, applied high rate of polyvinyl alcohol accompanied with low rate of nitrogen fertilizer was superior decreased pH values of soil as compared to either control or other tested treatments. An opposite trend for EC values which were superior increased in presences of all nitrogen fertilizer rates. Also, $CaCO_3$ values were lower when applied high rate of polyacrylamide in two seasons. The highest values of available nitrate and ammonium in soil were due to applied 0.2 % of polyvinyl alcohol combined with 75 % of nitrogen fertilizer rate compared to the other tested treatments.

Keywords: Polyvinyl alcohol, bitumen, polyacrylamide, nitrogen fertilizer,, maize, wheat and calcareous soil.

INTRODUCTION

The growth of plant depends on the soil condition, quantity of water and quality of fertilizer. Fertilizers are main factors that limit the development of agricultural production and very important to improve the utilization of mineral nutrients for plants. Nitrogen (N) is the one of nutrient most limiting to crop production and nutrient generally applied in the largest amount (Pinpeangchan and Wanapu, 2015).

Several strategies have been proposed to reduce N losses, such as the use of urease and nitrification inhibitors or coated fertilizers (Bremner, 1995; Han *et al*., 2008; Khalil *et al*., 2009). However, all these fertilizer technologies have disadvantages. For example, coated fertilizer is too expensive for wide agricultural use. Several nitrification inhibitors are also not easily available and likely to be toxic to animals and other microorganisms (Iizumi *et al*., 1998). Therefore, we need some treatments to reduce the loss of N without exposure to the previously risks.

The need to food demands in Egypt requires more desert areas as sandy and sandy calcareous soils, to be used for cultivation. Such this soils are poor in their physico-bio-chemical properties, soil water plant relationships, also their nutritional status. High $CaCO_3$ content in the soil cause more difficulties, these are: surface crusting and cracking, high pH and loss of fertilizers N, low availability of nutrients particularly P and micro-nutrients (Zn, Fe, Mn and Cu) and nutritional imbalance between some elements (K and Mg) and calcium. Under such severe conditions, desired yield levels are difficult to attain. In the last few years, considerable attention has been paid to the use of synthetic soil conditioners, such as water soluble polymers and hydrogels. Conditioners are substances added to soil in order to improve its structure. Many studies have been conducted in improving the productivity of sandy soils using.

Superabsorbent polymers are employed in agriculture to improve the physical and chemical properties of soil, particular to increase its water capacity. Moreover, germination process, plant growth, nutrients uptake by the plants and both water and fertilizers use efficiency were beneficially increased by mixing the plant pits in sandy soil with hydrogels (El-Hady and Wanas, 2006). According to many authors, superabsorbent polymers also have a beneficial effect on plant nutrient uptake, and increase the saturation of the sorption complex with bases, which prevents leaching losses of nutrients, thereby increasing the effectiveness of fertilization, and conduces to environmental protection (Guiwei and De Varennes, 2009, Kim *et al*., 2010 and Mikiciuk *et al*., 2015).

Bres and Weston (1993) studied that the effect of incorporated hydrogel amendments (Hydro source and Agri-gel, at rates of 1, 2, or 3 g L^{-1}) to a soil less growth medium on ammonium, nitrate, and water retention and tomato *(Lycopersicon esculentum* Mill.) seedling growth. Water retention by the growth medium increased linearly with gel application; hydro source generally was more effective than Agri-gel. Between 90% and 96% of the applied nitrate-N was recovered in the resulting

leachate of the gel-amended media, while 33% to 55% of the ammonium-N was recovered. Nitrate-N and ammonium-N retention was higher when 3 g liter^{-1} of either gel was added to the growth medium than when lower amounts or no gel was added. Total foliar N concentration in tomato leaves was significantly higher in the Hydro Source treatments than in the control or Agri-gel treatments.

Also, El-Saied el al. (2016) reported that the application of two rates; 2 and 4 g Kg^{-1} soil rice straw-based hydrogels as soil conditioners for sandy calcareous soil, after the third growing season, led to positively affects biochemical properties of the soil. These effects are assembled in the following: (a) slightly decreasing soil pH, (b) increasing cation exchange capacity (CEC) of the soil indicating improvement in activating chemical reactions in the soil, (c) increasing organic matter (OM), organic carbon, total nitrogen percent in the soil. Because the increase in organic nitrogen surpassed that in organic carbon, a narrower C/N ratio of treated soils was obtained. This indicated the mineralization of nitrogen compounds and hence the possibility to save and provide available forms of N to growing plants, (d) increasing available N, P and K in treated soil, and (e) improving biological activity of the soil expressed as total count of bacteria and counts of *Azotobacter* sp., phosphate dissolving bacteria (PDB).

Asphalt (or bitumen) is a highly viscous liquid or semi-solid material, which is mainly produced from crude oil refinery process and is also present in some natural deposits. Bitumen application increased the total organic carbon, decreased the total phosphorus and pH values in soil while total nitrogen was not altered, suggesting asphalt can alter the nutrient composition (Yu *et al*., 2012). Previous studies indicated that surface mulching with bitumen emulsions- particularly those locally prepared from Egyptian row materials as hydrophobic materials- is considered as 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 uptake and stimulates the biological activity of the soil (Al-Omran *et al*., 2002 and EL-Hady *et al*., 2008).

Al-Hadi (2014) concluded that, coating of bitumen emulsion to the soil particles and its penetration into aggregates of the soils caused an improvement in the soil structure units and porosity. The application of bitumen caused increasing in the macro pore spaces (drainage pores) and reduction in the micro pore spaces (capillary pores) of the soils, which, consequently, resulted in a decline in rising movement velocity of saline water by capillarity in all soils.

The current work was planned to investigate the individual effects of different synthetic soil conditioner sources in presences of different rates of N fertilizer to maximizing the utilization efficiency of this fertilizers and affected on some chemical properties of the studied calcareous soil along with reflection of these treatments on nutrients uptake by plant and yield components.

MATERIALS AND METHODS

Two successive growing seasons cultivated with maize (*Zea mays* L., cv Giza 10) at summer season and wheat (*Triticum aestivum* L., cv Giza 168) at winter season. The experiments were carried out at Nubaria Agriculture Research Station Farm in El Bheraa, Government, Egypt. The institute farm is located at 30^{o} 54' 48.220" N latitude and 29^{o} 51' 50.634" E longitude. Some physical and chemical characteristics of the studied soil are presented in Table (1).

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

(a) Mechanical analysis

Sand	Silt	Clay	Soil Texture
66.7	16.2	17.1	Sandy loam

(b) Chemical analysis

pH* 1:2.5	EC** dSm-1	CaCO3 %	OM %	Soluble cations (Ceq Kg^{-1})				Soluble anions (Ceq Kg^{-1})			
				Na^+	K^+	Ca^{++}	Mg^{++}	CO_3^-	HCO_3^-	Cl^-	SO_4^-
8.41	2.08	24.5	0.65	11.90	0.65	6.55	2.85	-	6.90	8.30	6.75

(c) Availability nutrients

Available macronutrients (mg Kg^{-1})		
N	P	K
139	19.0	185

***Soil: water suspension ** Soil paste extract**

Experimental design and treatments:

The experiments were conducted on a sandy loam calcareous soil in a randomized split – split plot design with plot dimensions of 4.0 X 2.8 m (plot area 11.2 m^2); each treatment was replicated three times. The main plots were three rates of nitrogen fertilizer with (50, 75 and 100 % of recommended nitrogen dose). The sub main plots three treatments of synthetic soil conditioner forms (polyvinyl alcohol, bitumen and polyacrylamide). The sub–sub plots represented concentrations of synthetic soil conditioners (0.1 and 0.2 %).

Soil conditioners:

a- Polyvinyl alcohol

Synthetic soil conditioners used are polyvinyl alcohol (PVA). The formulation of the polymer is $(C_2H_3O)n$, molecular weight (8.5X104 – 12.4X104), the pH is in the range of 5.0-6.5.

b- Bitumen

High molecular weight phenols and heterocyclic compounds. Additionally, most natural bitumen contains organosulfur compounds.

c- Polyacrylamide

The formula of the polyacrylamide, PAM (C_3H_5NO) in with pH of 4-9

Fertilization:

Superphosphate (15 % P_2O_5) at the rate of 200 Kg fed.$^{-1}$ and potassium sulphate (48 % K_2O) at the rate of 100 Kg fed.$^{-1}$ was added as a basal dose before transplanting. Nitrogen treatments (50, 75 and 100 % of recommended nitrogen dose) were applied as ammonium nitrate (33.5 % N) in three split equal doses after 15, 30 and 60 days from sowing.

Examined parameters:

After harvesting stage, straw and grains samples from maize and wheat crops were collected from each plot, weighed and oven dried at 70°C for 48 h up to a constant dry weight, ground and digested as described by Page *et al*. (1982). The digests were than subjected to the evaluation of nutrients (N, P and K) according to the method described by Cottenie *et al*. (1982) and calculated total content of nutrients in both straw and grains of plants.

Surface soil samples, at the end of the growing season, were subjected to the analysis of some soil chemical properties as soil pH determined in 1:2.5 soil water suspension, EC in extract of 1:5, % $CaCO_3$, available ammonium and nitrate were determined according to Cottenie *et al*. (1982).

Nitrogen use efficiency (NUE) by plants calculated as Kg/fed. of the marketable yield produced by each unit of fertilizer nitrogen (N) used (Kg/Fed.).

$$\text{NUE} = \frac{\text{(DMY of S+G in N fertilizer plot – DMY of S+G in N control)}}{\text{Rate applied of N}}$$

Where: **DMY= dry matter of yield, S = straw, G= grain**

Statistical analysis:

Obtained data were subjected to statistical analysis according to Snedecor and Cochran (1980) and the treatments were compared by using L.S.D. at 0.05 level of probability.

RESULTS AND DISCUSSION

1- Yield components of both maize and wheat crops

Data presented in Table (2) show the effect of conditioning the sandy loam calcareous soil with different synthetic conditioners in presence nitrogen rates on the productivity of both maize and wheat crops. Yield components of maize and wheat were increased by applied 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 application of both bitumen and polyacrylamide at low rate as compared to their applied at high rate in presences of all nitrogen rates; opposite trend was obtained by applied polyvinyl alcohol. This could be explained by viscous effect of polyacrylamide and bitumen forms which might clog larger soil pores or form a distinct layer on the soil surface. Also, with an increased rate applied polyacrylamide leads to the higher moisture retention in the treated soil over the needs of the growing plants and its adverse effects on the aeration of the root-zone as a results of increasing the soil micro- porosity on the expense of its macro – ones may explain why the yield decrease by an increased amount of applied polyacrylamide. (El – Hady and El – Dewiny, 2006).

The highest significant yield components of maize and wheat crops were observed for the application of high rate (0.2 %) of polyvinyl alcohol accompanied with high rate of nitrogen fertilizer as compared to other tested treatments. These results are in good agreement with those obtained by Dar and Ram (2017) who reported that nutrient and hydrogel levels behaved significantly with 100% NPK + hydrogel which recorded the highest biological yield of wheat plant than another treatments (100% NPK, 75% NPK and 75% NPK+50% hydrogel). This might be due to fact that hydrogel retain water in the soil conditions and thus reduction nutrient losses by leaching. In spite of that application of high rate polyacrylamide combined with low rate of nitrogen fertilizer generally was inferior for yield components of maize or wheat plants.

Regarding the applied of nitrogen fertilizer rates, as expected, results indicated that the added 100 % of N fertilizer was significantly superior for the yield components of both studied crops. These results are in conformity of work performed by Dar and Ram (2017) who found that the application of 100% NPK level results in significantly higher biological yield than 75% NPK level, irrespective of hydrogel.

Also, irrespective of effect of both rate of N fertilizer and forms of soil conditioner, values of both yields maize and wheat increased unsignificantly by applied soil conditioners at low rate (0.1 %) as compare to high rate (0.2 %).

With respect to the effect of soil conditioner forms, data indicate that the application of polyvinyl alcohol conditioner gave more significantly favorable yield components for both maize and wheat plants. Generally, soil conditioner forms treatment can be arranged as follows: polyvinyl alcohol >bitumen > polyacrylamide for both yield components (straw and grains).Obtained results may be due to these polymers improve the physical of soil by way of increasing their water-holding capacity, water and fertilizer use efficiency, soil permeability and infiltration rates, soil aggregate stability thus improve soil structure and reducing irrigation frequency. Based on the above previously, that polymers improved physical properties which improved the productivity of cultivated crops (Sojka et al., 2007 and Wu *et al*., 2010).

Table 2. Responses of maize and wheat yields (Kg fed.$^{-1}$) to applied different rates of nitrogen and soil conditioners

Nitrogen rates (%)	Soil conditioners		Maize yield		Wheat yield	
	Forms	Concentrations	Straw	Grains	Straw	Grains
	Control		2435	1527	2619	1758
	Polyvinyl alcohol		5113	2331	3727	2536
	Bitumen	0.1 %	4748	1933	3301	2499
50	Polyacrylamide		4261	1707	3030	2484
	Polyvinyl alcohol		5478	2406	3908	2589
	Bitumen	0.2 %	4383	1788	3547	2176
	Polyacrylamide		3774	1702	3539	2145
	Control		3409	1794	2433	2133
	Polyvinyl alcohol		6695	2827	3968	2871
	Bitumen	0.1 %	6087	2268	3671	2526
75	Polyacrylamide		4991	1998	3458	2525
	Polyvinyl alcohol		7913	3022	4434	3283
	Bitumen	0.2 %	4991	2027	3573	2523
	Polyacrylamide		4747	1950	3636	2353
	Control		4504	1841	3331	2380
	Polyvinyl alcohol		7621	3474	4419	3146
	Bitumen	0.1 %	6077	2649	3862	2803
100	Polyacrylamide		5820	2192	3839	2709
	Polyvinyl alcohol		8400	3490	4575	3568
	Bitumen	0.2 %	5779	2267	3630	2723
	Polyacrylamide		5645	2054	3837	2658
Mean values of nitrogen rates (A)						
	50 % N		4078	1865	3286	2243
	75 % N		5280	2210	3451	2543
	100 % N		6044	2476	3853	2796
Mean values of soil conditioner rates (B)						
	0.1 %		5146	2212	3471	2531
	0.2 %		5122	2156	3589	2524
Mean values of soil conditioner forms (C)						
	Polyvinyl alcohol		6870	2925	4172	2999
	Bitumen		5344	2155	3597	2542
	Polyacrylamide		4873	1934	3557	2479
LSD. At 0.05% for						
	A		401	239	315	527
	B		396	193	166	344
	C		444	135	304	256
	AB		685	137	287	596
	AC		769	234	526	445
	BC		628	191	429	363
	ABC		1088	331	744	629

2- content macronutrients

The statistical interaction analyses showed that all applied treatments increased the total content of macronutrients over the control treatment; this trend was true for both straw and grains of maize and wheat crops (Tables 3 and 4). Also, the behavior of macronutrients total content followed the same trend of those recorded by yield components of both maize and wheat.

Application of high rate of polyvinyl alcohol combined with recommended dose of nitrogen was superior to macronutrients either in straw and grains of two crops. The corresponding increases as compared to control for the N, P and K were 102, 125 and 109 % for straw of maize crop as well as 149, 166 and 138 % for grains against 42.0, 77.5 and 78.6 % for straw of wheat plants as well as 51.6, 74.5 and 102.0 % for grains as compared to control, respectively. In spite of that application of high rate polyacrylamide combined with low rate of nitrogen fertilizer generally was inferior for nutrients total content either in yield components of maize or wheat plants. These results agree with Naing and Lay (2017) who reported that the super absorbent polymers can absorb the nutrients needed by the plants and releases them gradually for the plants and thus prevent leaching of these elements. Also, Mikiciuk *et al*. (2015) added that the application of hydrogel with two rates 1.8 and 3.6 g dm^{-3} of soil were increased significantly the amount of both nitrogen and potassium. Moreover, hydrogels also affect nutrients respectively uptake indirectly by increasing the moisture in the soil and subsequently ion mobility. Therefore, the availability of some nutrients either present in the soil or added in the form of relatively insoluble fertilizers will be increased (El-Hady *et al*., 2008).

Table 3. Macronutrients total contents (Kg fed.$^{-1}$) of both straw and grains of studied maize plant as affected by different concentrations of soil conditioner under different nitrogen rates

Nitrogen rates (%)	Soil conditioners		Straw			Grains		
	Forms	Concentrations	N	P	K	N	P	K
	Control		21.2	3.83	20.2	13.3	3.76	4.73
	Polyvinyl alcohol		48.7	9.80	52.5	25.8	7.96	8.48
	Bitumen	0.1 %	40.0	9.10	42.7	17.8	5.75	6.13
50	Polyacrylamide		39.9	7.28	35.6	15.2	4.09	5.37
	Polyvinyl alcohol		53.6	11.1	57.1	27.5	9.50	9.36
	Bitumen	0.2 %	44.1	9.14	38.2	17.4	5.42	5.31
	Polyacrylamide		33.0	6.78	31.6	14.4	4.02	5.34
	Control		37.8	7.43	30.6	18.9	5.66	5.44
	Polyvinyl alcohol		66.6	15.9	78.5	31.6	14.0	10.8
	Bitumen	0.1 %	62.7	11.4	62.9	23.8	9.48	7.78
75	Polyacrylamide		55.2	10.0	47.0	20.7	6.46	6.22
	Polyvinyl alcohol		67.1	19.0	91.9	36.1	16.4	13.2
	Bitumen	0.2 %	55.9	11.0	50.1	21.9	7.69	7.17
	Polyacrylamide		52.8	9.72	44.6	19.8	5.98	6.06
	Control		43.2	10.2	49.1	17.4	7.22	6.51
	Polyvinyl alcohol		76.6	19.6	86.9	40.4	17.4	14.6
	Bitumen	0.1 %	62.9	13.6	63.9	27.8	11.8	9.66
100	Polyacrylamide		61.9	12.6	66.5	20.3	8.93	7.12
	Polyvinyl alcohol		87.3	22.9	103	43.4	19.2	15.5
	Bitumen	0.2 %	61.3	12.5	62.3	23.8	10.8	8.27
	Polyacrylamide		58.7	12.0	61.7	20.4	7.30	7.01
Mean values of nitrogen rates (A)								
	50 % N		37.7	7.61	37.3	18.1	5.53	6.18
	75 % N		54.5	11.5	54.5	23.9	8.92	7.76
	100 % N		61.9	14.2	67.8	26.4	11.2	9.39
Mean values of soil conditioner forms (B)								
	Polyvinyl alcohol		66.6	16.4	78.4	34.1	14.1	12.0
	Bitumen		54.5	11.1	53.4	22.1	8.49	7.39
	Polyacrylamide		50.3	9.73	47.8	18.5	6.13	6.19
Mean values of soil conditioner rates (C)								
	0.1 %		51.4	10.9	53.0	22.8	8.54	7.74
	0.2 %		51.4	11.3	53.4	22.9	8.58	7.83
LSD. At 0.05% for								
	A		7.85	0.825	6.66	2.50	2.25	1.06
	B		2.29	0.657	3.13	1.25	0.41	0.78
	C		3.99	0.980	4.58	1.81	0.98	0.93
	AB		3.97	1.14	5.43	2.18	0.72	1.35
	AC		6.92	1.69	7.93	3.13	1.69	1.62
	BC		5.65	1.39	6.48	2.56	1.38	1.32
	ABC		9.78	2.40	11.2	4.43	2.39	2.29

Regarding the application of N fertilizer rates, obtained results showed that increasing nitrogen rates was favorable for NPK total content for straw and grains of maize and wheat plants. This increase of nutrients total content with nitrogen rate may be attributed to nitrogen sources induced acidity on the availability of native element especially in root zone which increases most of the studied elements for plant as described by Schwamberger and Sims (1991).

Irrespective of effect of soil conditioner forms, values of NPK total content were insignificantly more stimulated with application of high rate of soil conditioners. An opposite trend was encountered for grains of wheat whose values were highest when application low rate of soil conditioner.

With respect to total content of macronutrients for straw and grains of maize and wheat plants, generally, results revealed that the application of polyvinyl alcohol gave more favorable for total content of macronutrients. Generally, soil conditioner forms treatments can arranged as follows: polyvinyl alcohol > bitumen > polyacrylamide for both straw and grains of maize and wheat yield.

Table 4. Macronutrients total contents (Kg fed.$^{-1}$) of straw and grains of studied wheat plant as affected by different concentrations of soil conditioner under different nitrogen rates

Nitrogen rates (%)	Soil conditioners		Straw			Grains		
	Forms	Concentrations	N	P	K	N	P	K
	Control		18.4	6.56	20.0	24.8	7.96	1.89
	Polyvinyl alcohol		26.4	9.53	39.4	41.5	14.2	3.62
	Bitumen	0.1 %	25.8	9.33	33.8	41.1	13.5	3.45
50	Polyacrylamide		25.2	8.92	23.4	40.7	12.8	3.49
	Polyvinyl alcohol		29.6	13.6	47.9	41.7	12.9	3.95
	Bitumen	0.2 %	25.6	12.4	37.4	36.1	12.6	2.79
	Polyacrylamide		25.4	12.1	19.8	31.3	9.37	2.46
	Control		21.3	8.32	18.8	34.1	9.13	2.44
	Polyvinyl alcohol		28.7	13.3	38.0	58.3	14.9	4.99
	Bitumen	0.1 %	25.1	12.2	32.0	44.2	12.9	4.56
75	Polyacrylamide		24.4	10.4	24.8	43.3	10.6	4.38
	Polyvinyl alcohol		32.1	15.3	44.1	58.7	18.2	5.56
	Bitumen	0.2 %	27.3	12.9	26.9	44.0	13.7	3.39
	Polyacrylamide		26.1	12.8	19.6	40.2	13.2	3.15
	Control		23.8	10.2	29.0	40.7	10.6	2.90
	Polyvinyl alcohol		33.4	13.9	43.2	56.2	15.4	5.75
	Bitumen	0.1 %	29.1	13.9	37.9	46.7	13.8	4.48
100	Polyacrylamide		26.7	11.6	29.3	45.7	12.3	4.18
	Polyvinyl alcohol		33.8	18.1	51.8	61.7	18.5	5.86
	Bitumen	0.2 %	25.3	14.8	40.8	44.1	12.6	3.93
	Polyacrylamide		27.7	13.6	30.3	43.4	11.3	4.04
Mean values of nitrogen rates (A)								
	50 % N		24.3	9.87	30.2	35.3	11.4	2.94
	75 % N		25.8	11.7	27.9	44.6	12.7	3.87
	100 % N		27.8	13.3	36.4	47.4	13.0	4.26
Mean values of soil conditioner forms (B)								
		Polyvinyl alcohol	30.7	15.7	44.1	53.0	15.5	4.96
		Bitumen	26.4	12.6	34.8	42.7	13.2	3.77
		Polyacrylamide	25.9	11.6	21.3	33.2	11.6	3.62
Mean values of soil conditioner rates (C)								
		0.1 %	25.7	10.7	30.8	43.1	12.3	3.85
		0.2 %	26.3	12.6	32.2	41.7	12.4	3.53
LSD. at 0.05% for								
	A		4.18	3.13	5.57	10.9	2.07	1.33
	B		1.65	1.40	2.35	3.48	2.81	0.64
	C		2.15	2.19	3.28	3.56	2.57	0.71
	AB		2.89	2.47	4.09	6.04	4.87	1.13
	AC		3.72	3.81	5.67	6.17	4.45	1.23
	BC		3.03	3.11	4.63	5.04	3.63	1.01
	ABC		5.26	5.39	8.02	8.72	6.29	1.74

3-Nitrogen use efficiency (NUE)

Nitrogen is the most limiting nutrient for crop production in many of the world's agricultural areas and its efficient use is important for cropping systems. Crop response to applied nitrogen and use efficiency are important criteria for evaluating crop nitrogen requirements for maximum economic yield.

Data presented in Fig. (1) revealed that the nitrogen use efficiency was the highest (65.4 and 42.4) for maize and wheat plant, respectively, receiving 50 % rate of nitrogen fertilizer in presence of 0.2 % polyvinyl alcohol. On the other hand, the lowest value was (11.3) for maize when applied high rate of nitrogen fertilizer and PAM; similar trend for wheat plant was (6.4) with bitumen.

Also, data showed that NUE of maize and wheat plants increased with increasing rate of PVA at all rates of nitrogen fertilizer application. Conversely, NUE for two crops decreased with increasing high rates of both bitumen and PAM. These results agreewith El-Hady *et al*. (2001) who found that the fertilizers use efficiency by growing plants may decrease by increased amount of applied some hydrogel. Also, results show that the NUE in maize plants was high response to applied treatments compared to wheat plant. Sahrawat (1980 a,b) explained that quick transformation of NH_4^+ to NO_3^- in the soil reduces the efficiency of applied N fertilizer. Almost 90% of the applied N fertilizers are in the form of NH_4^+ which is nitrified within four weeks. Thus nitrification is responsible from

conversion of highly immobile NH_4^+ to highly mobile NO_3^- which is susceptible to leaching beyond the root zone. Also, Yue *et al*. (2011) reported the nitrogen apparent utilization rate of the group treated with the polymer was 0.2-1.9 times larger than that of the group treated with fertilizers of the same nutrient level. Based on the previously results we found that the applied of synthetic soil conditioners lead to slow release nitrogen fertilizers and reduce nitrification process and consequently increased NUE.

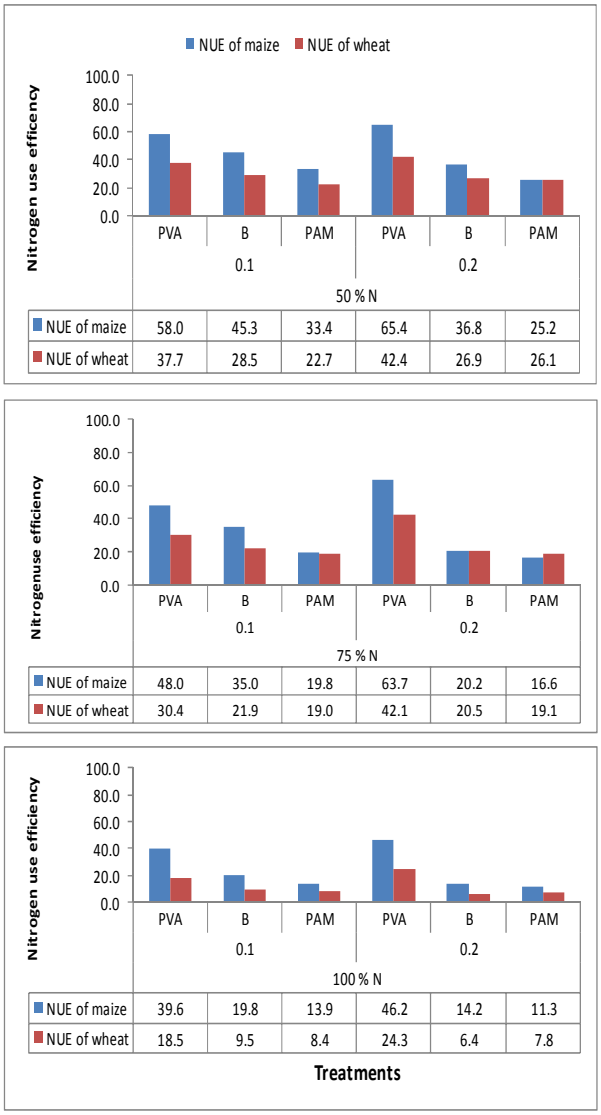

Fig. 1. Effect of applied different rates of nitrogen fertilizer and synthetic soil conditioners on nitrogen use efficiency (NUE) for maize and wheat crops.

Changes in soil properties

Data in Table (5) show the changes of some soil chemical properties (pH, EC and $CaCO_3$) as affected by the studied treatments.

Soil reaction (pH)

Results of pH in soil have slightly gradually decreased as affected by applied treatments as compared to control; this trend was true for the tested crops. Application high rate of polyvinyl alcohol with low rate of nitrogen fertilizer was superior decreased values of pH in soil as compared to either control or other tested treatments. These results agree with Adnan *et al*. (2014) who concluded that PVA as polymer conditioner deceased pH values over control treatment. Also, El-Hady *et al*. (2006) added that using 2 g or 4g hydrogel as soil conditioner lowered soil pH by 0.45 and 0.48 units, respectively.

With respect to the individual effect of the nitrogen fertilizer rates, the values of soil reaction showed slightly increased, an opposite trend being encountered for rates of soil conditioners whose values were slightly decreased. These results were in conformity of work performed by Khan *et al*. (2013) who found that additions of N fertilizers in alkaline soils are more prone to NH_3 volatilization. Also, Freney *et al*. (1995) reported that the relative concentration of NH_3 increases from 0.1 to 1%, 10% and 50% as the pH changes from 6 to 7, 8 and 9, respectively. On the other hand, application of synthetic soil conditioners led to decrease soil pH, these may be due to the used synthetic soil conditioner, which is with low pH as mentioned earlier (the pH of polyvinyl alcohol (PVA) in the range of 5.0-6.5).

Regarding application of soil conditioner forms, the results showed that polyvinyl alcohol gave decrease in soil pH as compared to other soil conditioners. Generally, soil conditioners treatments can be arranged as follows: polyvinyl alcohol > polyacrylamide > bitumen for both tested crops. Such decreases may be due to the acidity of synthetic soil conditioners; along with Herrman *et al*. (2005) added that some compounds (synthetic or natural material) can be delay the bacteriological oxidation of ammonium (NH_4^+) to nitrate (NO_3^-) for the shorter period of time .

Electric conductivity (EC)

Generally, electric conductivity increased in presence of soil conditioners as compared to control of nitrogen fertilizer alone. Application of high rate of polyvinyl alcohol was superior increased values of soil EC in presences of all nitrogen fertilizer. Rajpar and Sial (2002) and Ashworth (2007) reported that the increase in EC by application of PVA might be due to increase in concentration of other ions that make salts with combination of opposite ions like NaCl salt, also the resulted that by application of soil conditioner, polyacrylamide (PAM), there was slight effect of PAM on soil pH, while after harvesting of seedling EC was markedly increased.

Table 5. Response of some chemical properties of the tested soil after maize and wheat crops harvested to applied different nitrogen rates and concentrations of soil conditioners

Nitrogen rates (%)	Soil conditioners		Maize soil			Wheat soil		
	Forms	Concentrations	pH	EC dSm^{-1}	$CaCO_3$ %	pH	EC dSm^{-1}	$CaCO_3$ %
	Control		7.85	0.28	35.2	7.85	0.35	30.2
	Polyvinyl alcohol		7.70	0.38	33.5	7.71	0.45	28.4
	Bitumen	0.1 %	7.82	0.30	32.0	7.83	0.36	26.6
50	Polyacrylamide		7.75	0.36	30.1	7.73	0.42	22.3
	Polyvinyl alcohol		7.69	0.45	31.1	7.69	0.51	26.2
	Bitumen	0.2 %	7.74	0.35	28.6	7.81	0.38	20.9
	Polyacrylamide		7.71	0.40	29.7	7.71	0.49	19.4
	Control		7.87	0.28	30.6	8.01	0.38	25.8
	Polyvinyl alcohol		7.74	0.35	29.4	7.79	0.42	25.6
	Bitumen	0.1 %	7.81	0.31	28.9	7.92	0.39	24.7
75	Polyacrylamide		7.78	0.33	29.0	7.83	0.45	23.4
	Polyvinyl alcohol		7.71	0.40	26.4	7.74	0.49	22.0
	Bitumen	0.2 %	7.79	0.31	25.5	7.91	0.40	22.7
	Polyacrylamide		7.75	0.36	25.5	7.84	0.51	21.9
	Control		7.87	0.30	31.9	8.05	0.45	22.7
	Polyvinyl alcohol		7.72	0.44	29.2	7.74	0.49	21.3
	Bitumen	0.1 %	7.81	0.36	29.3	7.85	0.45	21.3
100	Polyacrylamide		7.79	0.33	28.6	7.75	0.52	21.7
	Polyvinyl alcohol		7.73	0.46	28.9	7.70	0.54	20.9
	Bitumen	0.2 %	7.79	0.40	27.9	7.86	0.46	19.9
	Polyacrylamide		7.75	0.35	27.9	7.75	0.52	20.6
Mean values of nitrogen rates (A)								
	50 % N		7.76	0.35	31.9	7.77	0.41	26.1
	75 % N		7.79	0.33	28.2	7.88	0.42	24.6
	100 % N		7.79	0.37	29.5	7.84	0.47	22.5
Mean values of soil conditioner forms (B)								
	Polyvinyl alcohol		7.72	0.41	29.7	7.73	0.483	24.1
	Bitumen		7.79	0.33	28.7	7.86	0.407	22.7
	Polyacrylamide		7.76	0.36	28.5	7.77	0485	21.6
Mean values of soil conditioner rates (C)								
	0.1 %		7.77	0.34	30.0	7.83	0.439	23.9
	0.2 %		7.74	0.36	27.9	7.78	0.478	21.6
LSD. at 0.05% for								
	A		0.288	0.098	7.30	0.32	0.172	2.43
	B		6.05	2.57	3.96	0.08	0.131	1.06
	C		0.079	0.077	2.54	0.08	0.105	1.87
	AB		0.105	0.141	6.87	0.14	0.227	1.85
	AC		0.139	0.134	4.40	0.14	0.181	3.24
	BC		0.113	0.109	3.59	0.12	0.148	2.64
	ABC		0.196	0.189	6.23	0.20	0.257	4.58

The electric conductivity increased gradually with increase of rates for both nitrogen fertilizer and soil conditioners, in spite of the values decreased with increase rate of N fertilizer in maize soil. Treatments of soil conditioner forms may be arranged as follows: polyvinyl alcohol > polyacrylamide > pitumen. Obtained data agreement with Shahid *et al*. (2012) who explained that the application of polymer hydrogel in combination with organic fertilizer source lead to decrease in soil pH and EC. Such decreases might have enhanced the discharge of soil inorganic salts thereby increasing EC of the soil. Similar effect on the pH and EC of soils due to the chemical structure of the superabsorbent polymer and soil characteristics has previously been appraised by Liu *et al*. (2007).

Calcium carbonate ($CaCO_3$ %)

The calcium carbonate content in soil at the end of the experiment for both crops was shown in Table (5). In general, $CaCO_3$ content decreased as a result of applied all the treatments compared to control treatment. The $CaCO_3$ values were lower at treatment of high rate of polyacrylamide in two seasons. Also, $CaCO_3$ decreased with increases of nitrogen fertilizer and soil conditioner rates at two seasons. The high positive effects of soil conditioner forms followed the order: polyacrylamide > bitumen > polyvinyl alcohol.

To explain these obtained results, it is possible the reduction of calcium carbonate in the soil treated with either synthetic soil conditioners or increasing nitrogen fertilizer rates due to decrease the pH and

hence the appearance of H^+ ions with the CO_2 gases which works on the formation of H_2CO_3 then solubility of calcium carbonate and its decrease in soil.

3- Nitrate and ammonium availability in the studied soil

Results representing availability of nitrate and ammonium in soil after maize and wheat harvested were shown in Table (6). Statistical interaction analyses showed that all applied soil conditioners increase non-significant the soil nitrate and ammonium availability compared to the control treatment. However, the highest values of soil available nitrate and ammonium of 54.0 and 24.8 mg L^{-1} in maize soil against 46.7 and 27.2 mg L^{-1} in wheat soil were due to applied 0.2 % of polyvinyl alcohol combined with 75 % rate of nitrogen fertilizer treatment compared to the other tested treatments.

Regarding the applied of nitrogen fertilizer rates, results indicated that the 75 % of nitrogen fertilizer was generally superior for the nitrate and ammonium availability. On the other hand, the applied rates of nitrogen fertilizer treatments had not significantly increased ammonium availability in winter season.

To differentiate between the influence of low and high rate of soil conditioners, results showed that the high rate was significantly higher than the low rate for improving the availability of the corresponding ammonium in soil but not significantly higher with nitrate in soil at two seasons.

Table 6. Responses of nitrate and ammonium availability (mg Kg^{-1}) for the tested soil after maize and wheat harvesting to applied different concentrations soil conditioners and different nitrogen rates

Nitrogen rates (%)	Soil conditioners		Mazie soil		Wheat soil	
	Forms	Concentrations	NO_3	NH_4	NO_3	NH_4
	Control		31.6	19.6	28.5	16.5
	Polyvinyl alcohol		37.1	23.8	33.8	25.3
	Bitumen	0.1 %	39.2	21.8	35.0	20.2
50	Polyacrylamide		40.0	21.6	36.8	22.2
	Polyvinyl alcohol		38.0	23.5	34.9	23.4
	Bitumen	0.2 %	52.3	22.2	39.4	25.7
	Polyacrylamide		40.1	22.4	36.4	22.5
	Control		33.7	19.8	31.4	18.7
	Polyvinyl alcohol		52.5	21.7	36.9	21.3
	Bitumen	0.1 %	44.1	23.2	38.5	21.6
75	Polyacrylamide		40.1	21.2	36.6	20.2
	Polyvinyl alcohol		54.0	24.8	46.7	27.2
	Bitumen	0.2 %	40.3	21.5	39.1	24.3
	Polyacrylamide		40.1	21.4	40.8	24.5
	Control		36.3	20.5	31.4	20.4
	Polyvinyl alcohol		45.0	23.4	36.2	22.5
	Bitumen	0.1 %	45.0	24.1	36.9	25.1
100	Polyacrylamide		37.8	22.4	39.3	20.7
	Polyvinyl alcohol		40.9	22.3	39.7	26.0
	Bitumen	0.2 %	39.2	22.9	37.3	23.9
	Polyacrylamide		36.8	21.8	33.3	24.5
Mean values of nitrogen rates (A)						
	50 % N		33.9	21.8	34.2	22.1
	75 % N		42.3	25.3	37.7	21.7
	100 % N		39.7	22.2	35.7	22.9
Mean values of soil conditioner forms (C)						
		Polyvinyl alcohol	44.6	23.1	38.6	24.3
		Bitumen	43.4	22.6	37.7	23.5
		Polyacrylamide	39.2	21.8	37.2	22.4
Mean values of soil conditioner rates (B)						
		0.1 %	40.2	21.9	35.1	21.2
		0.2 %	40.3	24.3	36.6	23.1
LSD. at 0.05% for						
	A		5.16	1.02	2.62	2.46
	B		4.37	1.27	3.28	0.84
	C		5.20	1.36	3.06	2.19
	AB		7.57	2.19	5.68	1.45
	AC		9.01	2.37	5.30	3.79
	BC		7.36	1.93	4.33	3.09
	ABC		12.8	3.35	7.49	5.35

With regard to synthetic soil conditioner forms, results indicated that the highest non-significant nitrate and ammonium availability in soil of maize and wheat were reported in case of applying synthetic soil conditioner of polyvinyl alcohol as compared to other soil conditioners. The treatments of soil conditioner forms may be arranged as polyvinyl alcohol > bitumen > polyacrylamide. These results agree with those reported by Khadem *et al*. (2010) who observed that polymer (PAM) was slightly increased the amount of nitrogen in the soil.

Osuji *et al*. (2012) reported that the low concentration of NO_3-N in the soil may be an indication that the process of nitrification might have

been impaired as a result of asphalt production activities. This may be attributed in part to the lack of optimum conditions for nitrifying bacteria and the incorporation into the soil system of organic compounds (probably hydrocarbons) which have high carbon to nitrogen ratio (C/N). This is because the organisms tend to compete for the limited supply of available N since the residue does not provide adequate N to form proteins in the nitrifying organisms. During this process, available soil N is decreased and the C in the residues is liberated as CO_2.

CONCLUSION

In the end, it is possible to reach that the application of high rate of polyvinyl alcohol accompanied with recommended dose of nitrogen fertilizer may be helpful to improve yield productivity of both maize and wheat crops along with their total content of macronutrients. Also, the treatments of synthetic soil conditioners in presence of different nitrogen fertilizer rates lead to decreasing in vales of both pH and $CaCO_3$. An opposite trend being obtained for EC in soil at the end of the experiment for both crops. However, applied high rate of polyvinyl alcohol in presence 75 % from recommended dose of nitrogen fertilizer was superior for the availability of both NO_3 and NH_4 which reflected on values of nitrogen use efficiency for plants.

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تقييم بعض المحسنات الصناعية ومعدلات النيتروجين على كفاءة استخدام النتروجين بواسطة محصولى الذرة والقمح فى الاراضى الجيرية

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تم استخدام المحسنات الصناعية مثل البولى فينيل الكحول و البيتومين و البولي اكريلاميد لتحسين خواص الأراضى الجيرية و التى تنعكس على انتاجية المحاصيل. و لتحقيق ذلك تم استخدام معدلين (٠.١ و ٠.٢%) من المحسنات الصناعية (البولى فينيل الكحول و البيتومين و البولي اكريلاميد) و ثلاث معدلات من التسميد النيتروجينى (٥٠ و٧٥و ١٠٠%) وذلك لدراسة تأثير هذه المعدلات على الخواص الكيميائية للتربة و حالة العناصر و مكونات محصولى الذرة و القمح بالاضافة الى كفاءة استخدام النيتروجين. و قد اقيمت التجارب الحقلية فى الاراضى الجيرية بمحطة البحوث الزراعية بالنوبارية أثناء موسميين متتابعين وتم زراعة الموسم الصيفى بالذرة و الموسم الشتوى بالقمح. أوضحت النتائج ان هناك زيادة معنوية لمكونات محصولى الذرة و القمح و كذلك المحتوى الكلى للعناصر الكبرى بها عند اضافة المعدل المرتفع (٠.٢%) من البولى فينيل الكحول مصاحب للمعدل المرتفع من التسميد النيتروجينى مقارنة بالمعاملات الاخرى. على العكس، وجد ان اضافة المعدل المرتفع من البولى اكريلاميد مصاحب للمعدل المنخفض من التسميد النيتروجينى اعطى معدلات منخفضة لمكونات محصولى الذرة و القمح. أيضا، اشارت النتائج إلي أن كفاءة الاستفادة من النيتروجين كان مرتفعا (٦٥.٠ و ٤٢.٤) فى نباتات الذرة و القمح على التوالى، عند المعاملة بمعدل ٧٥ % من التسميد النيتروجينى فى وجود معدل ٠.٢ % من البولى فينيل الكحول. علاوة على ذلك وجد ان أضافة المعدل المرتفع من البولى فينيل الكحول مع اضافة المعدل المنخفض من معاملة التسميد النيتروجينى اعطت نتائج منخفضة لقيم pH التربة مقارنة بالكنترول و المعاملات الأخرى. على العكس فان قيم EC للتربة تكون مرتفعة فى وجود كل معدلات التسميد النيتروجينى. وجد ان قيم كربونات الكالسيوم تنخفض عند المعاملة بالمعدل المرتفع من البولى اكريلاميد فى الموسميين. وجد أن اضافة ٠.٢ % من البولى فينيل الكحول مع ٧٥ % من المعدل الموصى به من التسميد النيتروجينى قد أعطى قيم مرتفعة من النترات و الأمونيوم الميسر فى التربة بالمقارنة بالمعاملات الأخرى او الكنترول.