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EFFECT OF NITROGEN SUPPLY BY AMMONIUM HUMATE ON MAIZE PRODUCTION UNDER SANDY SOIL AND NITROGEN-DEFICIENT CONDITIONS

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ABSTRACT: A field experiment was conducted during the two successive summer seasons of 2022 and 2023 under sandy soil conditions at Ismailia Agricultural Research Station of Ismailia Governorate, Egypt. This study aims to investigate the effect of mineral N fertilizer application at three rates i.e. 50, 75 and 100 % from recommended dose and application of ammonium humat at four rates of N without humat, 10, 15 and 20 g N L^{-1} (H_0, H_{10}, H_{15} and H_{20}) along with two application methods (soil and foliar application) on the yield, yield components, chemical composition of maize plants (Zea maize *L.*) grown and available NPK in sandy soil. The obtained results indicated that grain and straw yields as well as content of available nutrients were affected significantly by increased levels of mineral N, rates of ammonium humat and application methods. In most cases, the highest mean values in both grain and straw yields were recorded at the treatment of 75 % mineral N * H_{20} with the foliar application, which gave results equal to or better than those received 100 % mineral N solo. A similar trend was detected with respect to NPK uptake by both grain and straw yields. Also, the highest of available NPK content in the soil due to the soil application of humat. In view of the above-mentioned results, it has been concluded that the efficiency of mineral N fertilizer increased with the application of ammonium humat as which with 20 g N L^{-1} (foliar or soil addition) and reflected on the yield and chemical composition of maize plants and also, can be used as a partial substitute to 25 % of mineral – N fertilizer under sandy soil conditions.

Key words: Humic substances, Nitrogen level, Maize, Sandy soil

INTRODUCTION

Maize (Zea mays *L.*) belongs to the family Poaceae and is commonly grown all over the world (Abdo *et al.*, 2022). Maize is called the “king of cereals” because of its productivity potential compared to any other cereal crop, it is an important cereal crop (Kandil *et al.*, 2020) having numerous applications, including food, industrial materials, and bioenergy, it is ranked third after wheat and rice (Wulandari *et al.*, 2019).

Under greenhouse conditions foliar and soil application of3 % ammonium humate due to the highest tomato fruits, the highest shoot, increased root length in sandy soil , increased phenolic compounds, increased carotenoids, increased total amino acids, reducing sugar content, increased chlorophyll, and increased total protein (Sahar *et al.*, 2020) .

Ammonium humate due to reacts between humic acid with ammonium hydroxide. ammonium humate foliar at 3% foliar and spraying on the soil added for wheat, faba beans and lupine increased yield and yield components, increased macronutrient uptak, increased macronutrient availability, increased protein content, and increased soil organic matter were applied ammonium humate to the soil compared with foliar application (Shehata *et al.*, 2023).

Ammonium humate due to the combines of humic acid and nitrogen (According to Pehlivan and Arslan 2006), ammonium humate including many functional groups as carboxyl groups, , aldehyde, phenolic hydroxyl, amino acid groups and sulfur. Replacing N in ammonium humate give positive effect on soil fertility (Gupta *et al.*, 2010).

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Mineral nutrition is one of the most important factors of plant growth and yield. Mineral fertilizers, particularly mineral–nitrogen, are important means of plant nutrition; however they are also a potential source of environmental pollution. Nowadays there is renewed interest in organic substances for nutrient supply and improving soil fertility (Magdi *et al.* 2011).

Humic substances are commercial products that contain elements that improve soil fertility, increase the availability of nutrient elements and consequently have positive effects of plant growth and yield (Rady, 2011). In addition, the mechanism of humic acid activity in promoting plant growth has been proposed to be increased cell membrane permeability, respiration and nutrient uptake (Obsuwan *et al.* 2011 and Kandil *et al.,* 2020).

In maize seedlings, humic acid compounds improved root growth, carbohydrates, nitrogenous responses and photosynthesis. Using humic (soil or spraying application) can by stimulate shoot and root growth and improve resistance to environmental stress in plants. (Yang *et al.,* 2000).

Mineral N fertilizer is a necessary component for plant growth to be successful. The use of mineral fertilizers alone may be cause problems for human health and the environment so the need to integrate the organic and inorganic fertilizers is necessary to achieve better crop yields. Also, N fertilizer is essential for synthesis for chlorophyll, enzymes and protein (Souza *et al.* 2008 and Lan *et al.* 2010).

Therefore, this study aimed to evaluate the possibility of reducing mineral N fertilizer by using of humic substances and select the best combined rate of minerals and organic fertilizers. This study serves the efforts of achieving the dual goals of sustainable agriculture by maintaining optimal yields accompanied by minimize the environmental pollution.

MATERIALS AND METHODS

Two field experiments were carried out at Ismailia Agricultural Research Station, ARC, Egypt (Lat. 30^o 35$^-$ – 41^o 9$^-$ N, Long. 32^o 10$^-$ - 45^o 83$^-$ E), during two successive growing summer seasons of 2022 and 2023 to study the effect of ammonium humat with nitrogen supply on maize plant production in sandy soil under nitrogen fertilizer deficient. Main properties of the experimental soil were carried out according to Jackson (1973) and Klute (1986). The obtained data are recorded in Table 1.

The experimental treatments were arranged in a split–split plot design including 24 treatments with three replicates. The experiment included 3 factors as follows:

(1) Three rates of mineral nitrogen fertilizer (ammonium sulphate 200 g N kg^{-1}) were assigned to main plots i.e. 50 % (N_{50}), 75 % (N_{75}) and 100% (N_{100}) from recommended dose of N fertilizer (279.5 k gm N ha^{-1}).

(2) Two application methods (soil and foliar) for ammonium humat addition were represented by subplot.

(3) Four levels of ammonium humat with nitrogen supply were arranged in sub – subplot i.e. control (H_0) without ammonium humat application, 10 g N L^{-1} (H_{10}), 15 g N L^{-1} (H_{15}) and 20 g N L^{-1} (H_{20}). The main characteristics of the used ammonium humat are shown in Table 2.

Table 1. Main characteristic of the studied soil.

Coarse sand	**Fine sand**	**Silt**	**Clay**	**Texture class**	**Calcium carbonate (g kg^{-1})**	**Organic matter (g kg^{-1})**	**pH**	**EC (dSm^{-1})**	**Available macronutrients (mg kg^{-1} soil)**		
									N	P	K
41.02	46.35	9.69	2.94	Sandy	6.54	1.90	8.01	1.12	9.81	3.90	49.6

*pH soil: water suspension at 1: 2.5, EC in soil saturation extract.

Table 2. Main characteristics of the used humic substances.

Organic matter (g L^{-1})	pH	EC (dSm^{-1})	CEC ($cmol_c$ kg^{-1})	Total Ca (g L^{-1})	Total Mg (g L^{-1})	macronutrient (g L^{-1})		
						N	P	K
549.70	7.91	7.80	405.00	5.90	9.80	30.00	4.00	43.00

pH (1: 5 humic : water suspension), EC (solution 1:5) and nutrients (total in solution)

Ammonium humat was extracted from compost prepared at the Ismailia Agricultural Research Station (IAR), Agricultural Research Center (ARC) farm. Ammonium humat was extracted from compost according to the standard method described by Sanchez-Monedero *et al.*, (2002). The compost was treated with NH_4OH solution 2 N, a mixture of 80 g of animal compost and 800 ml of NH_4OH solution 2 N was soaked overnight and shaken for 12 hours at 120 rpm, then centrifuged at 6000 rpm for 15 minutes and the supernatant was removed then pH was adjusted to 7.0 with H_2SO_4 solution 4 N. Humic substances extracted (at pH 7) and purified solution by passage through charcoal and transferee via membrane filter (Essawy *et al.*, 2017). ammonium humat extracted (at pH 7) contained 49.4% total organic carbon, 2.5% N, 0.43% K and 0.40% P. final solutions for 2.5 % N (25 g L^{-1} N) and dilution with water for (10, 15, 20 g N L^{-1}) by ammonium humat solutions prepared at 1 : 1.5 , 1 : 0.66 , 1 : 0.25 (solution : water) vlv. Soluble N, P, K, and other nutrients were determined according to the methods of Page *et al.*, (1982). The ammonium humat included aqueous solutions by mixing with water (from the Ismailia canal) in a v/v at a ratio of 0.3% (3.2 L ha^{-1} ammonium humat in 948.8 L ha^{-1} water, solutions EC: 481 – 495 mg kg^{-1}) then left for two hours to equilibrium. Seven times for foliar spraying and soil application of ammonium humat at 20, 30, 40,50, 60, 70, and 80 days from sowing.

Maize (Zea mays L. hybrids third cross 321) grains recommended for sandy soil were obtained from Field Crops Institute Research, ARC - Egypt. Grains were sown on the first day of May 2022 and 2023 at a seeding rate of 83.3 k gm ha^{-1} under a sprinkler irrigation system. One grain/hill was manually sowed 25 cm apart between hills. Phosphorus was applied in the form of superphosphate (0.068 kg P kg^{-1}) at a rate of 16.09 P ha^{-1} during the final stage of land preparation for planting and potassium was added in the form of potassium sulfate (0.398 kg K kg^{-1}) at a rate of 95 kg K ha^{-1} in two equal doses after sowing and flowering, nitrogen fertilizer (ammonium sulphate 200 g N kg^{-1}) at rates of 297.5, 209.63 and 148.75 Kg N ha^{-1} were 100, 75 and 50% from recommended dose of N fertilizer 279.5 k gm N ha^{-1} at six times (20, 32, 45, 55, 65 and 75 days from sowing).

The experimental unit area was 10.5 m^2 with dimensions 3 x 3.5 m. After harvesting soil samples were collected from the surface layer (0-30 cm) to determine soil properties (field capacity, EC, bulk density, CEC and organic matter content) according to Page *et al.* 1982 and Klute 1986. Available N was extracted in KCl (1: 10 w/v), available P was extracted in 0.5 N $NaHCO_3$ as well as soluble, while available K was extracted by 1 N NH_4 OAc at (pH 7.0). Concentration of the total and available N was estimated by distillation using Kjeldahl apparatus, total and available P was determined by Olsen *et al*. (1954), P calorimetrically by UV-Vis. Spectrophotometer using stannous chloride ($SnCl_2$) indicator according to Page *et al.* (1982) and K by the flame photometer, (Black, 1982).

Harvesting was carried out after 140 days of planting. The plants were air-dried. Grain and straw samples of the harvested plants were oven dried at 72^0C for 48 h and a portion (0.25 g) of each sample was digested by using sulfuric (H_2SO_4) and perchloric acid ($HClO_4$) - mixed (3:1) (Chapman and Pratt 1961.)

Effect of N fertilizer, ammonium humat solution treatments (HS) and mothed application of ammonium humat were statistically analyzed by analysis of variance (ANOVA) test, using the Co-State software to calculate the LSD at a significance level $P \leq 0.05$ (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Yield of maize plant

Data presented in Table 3 showed the effect of mineral N levels and different levels of ammonium humat in soil or foliar applications on grain and straw yields of maize plants. These results clear that, grain and straw yield increased significantly with the increase of mineral N fertilizer from 50 up to 100 % of the recommended dose. The higher increase effective dose of mineral N was recorded at a treatment of 100 % while, the lowest values in grain, straw yields were observed with treatment of N_{50}, where the percentages of these increases were 62.33, and 70.80 % for grain, and straw yields, respectively. These results may be due to the application of mineral N increasing physiological activities which enhance growth and lead to better yield. These results are in similar with hose observed by Hafez (2003), El-Edfawy (2017), Zakaria (2018), Sahar *et al.*, (2020) and Shehata *et al.*, (2023).

In terms of the effect of ammonium humat levels contain N (10, 15 and 20 g N L^{-1}) on maize yield, the results in the same table reveal that, using any level of ammonium humat recorded a positive increase in grain, and straw yield when compared with untreated plots (H_0). The increases resulted from the treatment of H_{20} were 9.66, and 9.11 % for grain, and straw yield, respectively as compared with H_0.

In addition, it looks to be true in all treatments, the use of foliar application of ammonium humat at any level recorded values higher than using soil application. These results due to that humic substances had been claimed to promote plant growth and yield by increasing the permeability of cell membrane, oxygen uptake, photosynthesis, nutrient uptake, and root cell elongation. These findings are in similar with this obtained before that by Magdy *et al.* (2011), Sahar *et al.*, (2020) and Ibrahim *et al.* (2013).

With respect to the interaction effect between the different levels of mineral N application and the levels of ammonium humat at the two application methods, results in Table 3 indicate that increasing application rates of mineral N from 50 up to 100 % of the recommended dose as combined with ammonium humat at treatment H_{10} by using foliar or soil application recorded a significant increase in grain, and straw yield of maize plants.

The highest mean values of maize yield were recorded at the application of mineral N at a rate of 279.5 kg ha^{-1} (N_{100}) flowed by 209.63 kg N ha^{-1} (N_{75}) combined with treatments of H_{15} and of H_{20} at the two application methods (foliar and soil). Moreover, the obtained results clearly that, the treatment of N_{75} as combined with the treatments of H_{15} and H_{20} at the foliar application of ammonium humat in all cases produced mean values similar to the individual application of N_{100} treatment with non-significant differences between them. This stimulatory effect may be related to increased nutrient uptake by plants and consequently improve the growth and yield of maize plants. These results are with those obtained by Yldirim (2007), El-Gohary *et al.* (2010), El-Hassanin *et al.* (2016), Zakaria (2018), Khan *et al.* (2019) and Shehata *et al.*, *(*2023).

Nutrient uptake

The main effect of mineral N application on total NPK uptake (kg N ha^{-1}) in both grain and straw by maize plants is given in Tables 4 and 5. Generally, the obtained results show a significant increase in NPK uptake by maize plants at any level of N mineral application. The highest NPK uptake was recorded by using the high level of N mineral (N_{100}) which gave values over using treatment of N_{50} by 27.0, 25.0 and 22.6 for N, P and K uptake by grain respectively and 15.6, 38.4 and 22.3 for straw, respectively similar results were observed by El-Edfawy (2017), Zakaria (2018), Sahar *et al.*, (2020) and Shehata *et al.*, (2023).

Table 3. Effect of mineral N fertilizer, ammonium humat and application methods on yield of maize plants (mean values of the two growing seasons).

N levels	App. method	N Humate level									
		H_0	H_{10}	H_{15}	H_{20}	Mean	H_0	H_{10}	H_{15}	H_{20}	Mean
		Grain yield (Mg ha^{-1})					Straw yield (Mg ha^{-1})				
N_{50}	Soil	2.59	2.66	2.86	3.33	2.86	3.52	3.81	4.19	5.19	4.18
	Foliar	3.40	3.82	3.88	3.97	3.77	5.16	5.39	5.73	5.81	5.52
Mean		3.00	3.24	3.37	3.65	3.31	4.34	4.60	4.96	5.50	4.85
N_{75}	Soil	4.19	4.40	4.62	4.84	4.51	4.35	4.56	4.65	4.70	4.57
	Foliar	5.14	5.22	5.31	5.33	5.25	6.07	6.18	6.21	6.29	6.19
Mean		4.67	4.81	4.97	5.09	4.88	5.21	5.37	5.43	5.50	5.38
N_{100}	Soil	5.18	5.24	5.28	5.39	5.27	6.15	6.22	6.28	6.33	6.25
	Foliar	5.36	5.35	5.35	5.37	5.36	6.23	6.59	6.91	6.90	6.66
Mean		5.27	5.30	5.31	5.38	5.31	6.19	6.41	6.59	6.61	6.45
Grand mean		4.31	4.45	4.55	4.71	4.50	5.25	5.46	5.66	5.87	5.56
Means of application method											
Soil		3.99	4.10	4.25	4.52	4.22	4.67	4.86	5.04	5.40	5.00
Foliar		4.63	4.80	4.85	4.89	4.79	5.82	6.05	6.29	6.33	6.12
$LSD_{0.05}$		N=0.072 A=0.063 H=0.028 NxA=0.034 NxH=0.052 AxH=0.045 NxAxH=0.77					N=0.049 A=0.041 H=0.030 NxA=0.034 NxH=0.051 AxH=0.042 NxAxH=0.072				

N_{50}, N_{75} and N_{100}: 50, 75 and 100 % from recommended dose of N fertilizer. H_0, H_{10}, H_{15} and H_{20}: humic substances loaded with nitrogen at 0, 10, 15 and 20 % from recommended dose of N.

Also, data in Tables 4 and 5 indicate that the application of the ammonium humat shows a significant increase effect in NPK uptake by both grain and straw of maize plants. The stimulation of NPK uptake may be due to the effect of humic substances on the membrane permeability and the better-developed root system (Fahmy *et al.*, 2016 and Kandil *et al.*, 2020 and Sahar *et al.*, 2020).

In addition, it can be seen in Tables 4 and 5 that, using foliar spraying of ammonium humat gave higher mean values in NPK uptake in all cases as compared with the soil application method.

As regards to the interaction effect of both mineral N and ammonium humat data in Tables 4 and 5 illustrated that the combined application of mineral N and ammonium humat at the different studied levels had significant increases in total NPK uptake by grain and straw of maize plants at the two application methods (foliar and soil application). The highest increases in all determined nutrients were observed by plants fertilized with the treatment of N_{100} and foliar application of treatment H_{20}. The beneficial effects of using humic substances along with mineral N on increasing NPK uptake could be due to their effect on providing plants with their requirements from different nutrients. (Yldirim, 2007; EL Bassiony *et al.* 2010; EL- Gohary *et al.* 2010 and Fahmy *et al.* 2016 and Shehata *et al.*, 2023).

It is worth noting that in most cases, the second rate of mineral N_{75} along with foliar spraying by treatment of H_{20} received values in NPK uptake by grain and straw of maize plants similar to or better than the treatment of N_{100} when added individually and there were non-significant differences between them. It is clear that foliar application of the treatment of $N_{75}*H_{20}$ can be the best treatment among all treatments.

Soil content of available NPK

Results in Table 6 illustrate the effect of mineral N levels, application methods and the rates of ammonium humat on soil content of available N, P and K after harvesting of maize plants. The results indicate that soil content of available NPK were affected significantly by the levels of mineral N and application of the ammonium humat methods . The high level of N-application fertilizer dose (N_{100}) recorded the highest values of available NPK in the soil while the lowest level of N-application fertilizer dose (N_{50}) treatment resulted in the lowest values for soil content of available NPK.

Also, data in Table 6 indicate that the different levels of ammonium humat application significantly increase the soil content of available NPK compared with control. Generally, soil application of ammonium humat gave values higher than foliar application. The increments between the two application methods were 4.0, 7.8 and 7.7 for N, P and K respectively. These results are in agreement with EL Gohary *et al.*, (2010); EL Masry *et al.*, (2014); Shehata *et al.*, (2023) and Abdo *et al.*, (2022) who reported that ammonium humat caused an increase in the availability of nutrients in the soil. ammonium humat influence of increase the permeability of plant membranes, activity enzyme systems positive effect on cell division, root development, decrease plant stress, growth stronger, reduce sandy soil erosion, increase the soil cohesive, development the sandy soil structure, improve soil physical characteristics , increase the CEC and soil buffering, promoting the soil elements chelation, development the nutrients available to plants, soil water contents improve nutrients uptake and the plant growth (Grapevines *et al.*, 2013, Calvo *et al.*, 2014, Rady and Mohamed, 2015, Sahar *et al.*, 2020and Shehata *et al.*, (2023).

The increase of the soil content of available NPK due to soil application of ammonium humat may be humat containing many elements which improve the soil fertility and increase the availability of NPK nutrients but increased the plant growth, yield and plant nutrients uptake due to the ammonium humat foliar application methods. These results are in harmony with those obtained by (Padem *et al.* 1997, Doran *et al.* 2003, Hafez 2003, Sahar *et al.*, 2020 and Shehata *et al.*, 2023.

Concerning the result in Table 6 show that the combined of mineral N and ammonium humat treatments under two application methods positively effect on the available NPK in soil. Soil application of ammonium humat method gave the higher value than foliar application for all combined treatments particularly at rate $N_{100}*H_{20}*$ soil application to nitrogen and humate application. But it is worth noting that,

Table 4. Effect of mineral N fertilizer, ammonium humat and application methods on NPK uptake (kg ha^{-1}) by grains of maize plants (mean values of the two growing seasons).

N levels	App. method	N Humate level														
		H_0	H_{10}	H_{15}	H_{20}	Mean	H_0	H_{10}	H_{15}	H_{20}	Mean	H_0	H_{10}	H_{15}	H_{20}	Mean
		N					P					K				
N_{50}	Soil	60.19	60.25	62.33	62.97	61.44	22.17	22.39	23.20	23.27	22.76	43.25	43.29	45.16	45.26	44.24
	Foliar	63.79	64.06	64.47	64.93	64.31	23.55	23.61	23.93	24.11	23.80	46.39	46.47	46.89	47.05	46.70
Mean		61.99	62.16	63.40	63.95	62.88	22.86	23.00	23.56	23.69	23.28	44.82	44.88	46.03	46.15	45.47
N_{75}	Soil	73.13	73.26	73.86	73.67	73.48	25.96	26.14	26.18	26.24	26.13	52.17	52.30	52.33	52.98	52.44
	Foliar	78.86	78.95	78.71	78.99	78.88	27.95	28.93	28.91	28.97	28.69	55.22	55.87	55.30	55.91	55.58
Mean		75.99	76.11	76.29	76.33	76.18	26.95	27.54	27.55	27.61	27.41	53.70	54.09	53.82	54.44	54.01
N_{100}	Soil	79.05	79.16	79.21	79.34	79.19	29.00	29.08	28.93	29.01	29.01	55.86	55.89	55.26	55.34	55.59
	Foliar	79.80	80.15	80.82	80.96	80.44	29.14	29.16	29.17	29.22	29.17	55.59	55.70	56.05	56.29	55.91
Mean		79.42	79.66	80.02	80.15	79.81	29.07	29.12	29.05	29.11	29.09	55.72	55.79	55.66	55.81	55.75
Grand mean		72.47	72.64	73.24	73.48	72.96	26.29	26.55	26.72	26.80	26.59	51.41	51.59	51.83	52.14	51.74
Means of application method																
Soil		70.79	70.89	71.80	72.00	71.37	25.71	25.87	26.10	26.17	25.96	50.43	50.49	50.92	51.19	50.76
Foliar		74.15	74.39	74.67	74.96	74.54	26.88	27.23	27.34	27.43	27.22	52.40	52.68	52.75	53.08	52.73
$LSD_{0.05}$		N=0.117 A=0.056 H=0.094 NxA=0.115 NxH=0.163 AxH=0.133 NxAxH=0.231					N=0.044 A=0.028 H=0.033 NxA=0.041 NxH=0.058 AxH=0.047 NxAxH=0.081					N=0.055 A=0.044 H=0.031 NxA=0.038 NxH=0.054 AxH=0.044 NxAxH=0.077				

N_{50}, N_{75} and N_{100}: 50, 75 and 100 % from recommended dose of N fertilizer. H_0, H_{10}, H_{15} and H_{20}: humic substances loaded with nitrogen at 0, 10, 15 and 20 % from recommended dose of N.

Table 5. Effect of mineral N fertilizer, ammonium humat and application methods on NPK uptake (kg ha^{-1}) by straw of maize plants (mean values of the two growing seasons).

N levels	App. method	N Humate level														
		H_0	H_{10}	H_{15}	H_{20}	Mean	H_0	H_{10}	H_{15}	H_{20}	Mean	H_0	H_{10}	H_{15}	H_{20}	Mean
		N					P					K				
N_{50}	Soil	33.26	33.78	34.49	34.67	34.05	8.38	8.51	8.43	8.95	8.57	19.61	19.66	19.92	20.21	19.85
	Foliar	36.14	36.27	36.62	36.87	36.48	9.10	9.26	10.04	10.46	9.71	21.61	21.71	22.09	22.17	21.90
Mean		34.70	35.03	35.56	35.77	35.26	8.74	8.89	9.23	9.71	9.14	20.61	20.69	21.00	21.19	20.87
N_{75}	Soil	38.03	38.20	38.43	38.61	38.32	10.96	11.10	11.28	11.35	11.17	23.18	23.50	23.58	25.91	24.04
	Foliar	38.96	39.23	39.72	39.97	39.47	11.55	11.84	11.84	12.07	11.83	26.11	26.30	26.08	26.46	26.24
Mean		38.50	38.71	39.07	39.29	38.89	11.26	11.47	11.56	11.71	11.50	24.65	24.90	24.83	26.18	25.14
N_{100}	Soil	40.17	40.23	40.43	40.55	40.35	11.81	12.05	12.25	12.43	12.14	25.97	26.03	26.23	26.39	26.16
	Foliar	40.89	41.09	41.31	41.48	41.19	12.01	12.50	13.68	13.88	13.02	26.20	26.84	27.90	28.00	27.23
Mean		40.53	40.66	40.87	41.02	40.77	11.91	12.28	12.97	13.16	12.58	26.08	26.44	27.06	27.20	26.69
Grand mean		37.91	38.13	38.50	38.69	38.31	10.63	10.88	11.25	11.53	11.07	23.78	24.01	24.30	24.86	24.24
Means of application method																
Soil		37.16	37.40	37.78	37.94	37.57	10.38	10.55	10.65	10.91	10.63	22.92	23.06	23.24	24.17	23.35
Foliar		38.66	38.86	39.22	39.44	39.05	10.89	11.20	11.85	12.14	11.52	24.64	24.95	25.36	25.54	25.12
$LSD_{0.05}$		N=0.0834 A=0.0374 H=0.0394 NxA=0.048 NxH=0.068 AxH=0.056 NxAxH=0.097					N=0.055 A=0.049 H=0.037 NxA=0.047 NxH=0.069 AxH=0.055 NxAxH=0.057					N=0.06 A=0.040 H=0.033 NxA=0.040 NxH=0.056 AxH=0.046 NxAxH=0.080				

N_{50}, N_{75} and N_{100}: 50, 75 and 100 % from recommended dose of N fertilizer. H_0, H_{10}, H_{15} and H_{20}: humic substances loaded with nitrogen at 0, 10, 15 and 20 % from recommended dose of N.

Table 6. Effect of mineral N fertilizer, ammonium humat and application methods on soil content of available NPK (gm Kg^{-1} soil) (mean values of the two growing seasons).

N levels	App. method	N Humate level														
		H_0	H_{10}	H_{15}	H_{20}	Mean	H_0	H_{10}	H_{15}	H_{20}	Mean	H_0	H_{10}	H_{15}	H_{20}	Mean
		N					P					K				
N_{50}	Soil	21.03	21.37	22.12	22.47	21.75	5.16	5.42	5.38	5.61	5.40	31.66	31.87	33.80	33.96	32.82
	Foliar	20.26	20.45	20.93	21.23	20.72	4.27	4.96	5.10	5.29	5.06	30.89	31.03	31.26	31.52	31.17
Mean		20.65	20.91	21.52	21.85	21.23	5.13	5.19	5.24	5.45	5.23	31.27	31.45	32.53	32.74	32.00
N_{75}	Soil	26.95	27.24	27.61	27.90	27.43	7.45	7.55	7.77	7.96	7.68	37.86	38.00	39.97	38.16	38.00
	Foliar	20.65	24.35	24.59	24.85	24.47	5.88	6.15	6.34	6.51	6.23	34.94	35.02	36.35	36.70	35.75
Mean		25.53	25.80	26.10	26.38	25.95	6.65	6.87	7.06	7.23	6.96	36.41	36.51	37.16	37.34	36.88
N_{100}	Soil	28.74	28.70	28.93	29.10	28.87	8.05	8.75	8.98	9.13	8.72	38.12	38.74	38.59	39.04	38.62
	Foliar	27.54	28.04	27.85	28.20	27.91	7.97	8.12	8.15	8.25	8.12	38.05	38.21	38.21	38.33	38.20
Mean		28.14	28.37	28.39	28.65	28.39	8.01	8.43	8.57	8.69	8.43	38.09	38.47	38.40	38.69	38.41
Grand mean		24.77	25.03	25.34	25.62	25.19	6.57	6.83	6.95	7.12	6.87	35.25	35.48	36.03	36.29	35.76
Means of application method																
Soil		25.58	25.77	26.22	26.49	26.01	6.90	7.24	7.38	7.57	7.27	35.88	36.20	36.78	37.06	36.48
Foliar		23.97	24.28	24.46	24.76	24.37	6.24	6.42	6.53	6.68	6.47	34.63	34.75	35.27	35.52	35.04
$LSD_{0.05}$		N=0.052 A=0.039 H=0.037 NxA=0.046 NxH=0.065 AxH=0.053 NxAxH=0.91					N=0.021 A=0.028 H=0.032 NxA=0.039 NxH=0.055 AxH=0.045 NxAxH=0.078					N=0.063 A=0.080 H=0.056 NxA=0.040 NxH=0.055 AxH=0.050 NxAxH=0.088				

N_{50}, N_{75} and N_{100}: 50, 75 and 100 % from recommended dose of N fertilizer. H_0, H_{10}, H_{15} and H_{20}: humic substances loaded with nitrogen at 0, 10, 15 and 20 % from recommended dose of N.

the plants that received the treatment of N_{75}*H_{20}* soil application in some cases produced values for soil available NPK equal to or higher than those that received 100 % of mineral N from a recommended dose as a solo. These results are in accordance with those obtained by Magdi *et al.* (2011); Fahmy *et al.* (2016), El-Edfawy (2017), Sahar *et al.*, (2020) and Shehata *et al.*, (2023).

Conclusion

Based on the obtained results, it could be concluded that using ammonium humat contain 20 g N L^{-1} N by foliar application along with 75% of mineral N fertilizer from recommended dose could substitute 25 % of mineral N fertilizer and its consider the best application method which contributes to saving production costs and reducing the potential risk of environmental pollution and also minimize the harmful effect of nitrogen on human life. The highest plant character show that with should be determined in foliar compared with humic addition to soil. And as a results nitrogen in ammonium humat its positive effect on maize yield, yield components, plant nutrients uptake and soil available NPK.

Recomondation

Ammonium humate can be used for source of nitrogen it can significantly increase of plant growth character in sandy soils. Furthermore, increase the yield, yield components, plant nutrients uptake and soil available NPK. We found that the addition ammonium humat supplement 10, 15 and 20 g N L^{-1} doses are benefit from humic and positive effect under sandy soil. benefit level addition and the highest production should be determined at ammonium humate contain 20 g N L^{-1} in foliar with both nitrogen chemical fertilizer added to soil 100 or 75%.

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تأثير المحتوى النيتروجينى فى هيومات الامونيوم على زيادة إنتاج محصول الذرة تحت ظروف الأراضى الرملية و انخفاض التسميد النتروجينى

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الملخص العربي

أجريت تجربتين حقليتين أثناء موسمي صيف ٢٠٢٢ / ٢٠٢٣ في محطة البحوث الزراعية بالإسماعيلية – مصر. وذلك لدراسة تأثير إضافة النتروجين المعدني بمعدل ٥٠ ، ٧٥ و ١٠٠% من المعدل الموصى به مع إضافة المواد الهيومية فى صورة هيومات الامونيوم المتأثرة بالنتروجين بمعدل ١٠ ، ١٥ و ٢٠ جرام نيتروجين لكل لتر بطريقتين للإضافة وهما إضافة أرضية وإضافة بالرش الورقي على إنتاج الذرة الشامية والتركيب الكيماوي للنبات وتيسرالعناصر بالتربة تحت ظروف الارض الرملية بتصميم قطع منشقة مرتين وأوضحت النتائج ما يلي:- تأثر محصول الحبوب والقش تاثيرًا معنويًا بإضافة المعدلات المختلفة للنيتروجين المعدني منفردًا أو مختلطًا مع إضافة المواد الهيومية سواء كانت إضافة أرضية أو رش ورقي. كانت أعلى قيم سجلت فى محصول الحبوب والقش في المعاملة ٧٥ % نتروجين معدني + هيومات الامونيوم ٢٠ جرام نيتروجين لكل لتر والمضاف رشًا على الأوراق وهذه المعاملة أعطت نتائج مساوية أو أعلى من المعاملة ١٠٠ % من النتروجين المعدني منفردًا. أوضحت النتائج أيضًا نفس الإتجاه بالنسبة للممتص من النتروجين والفوسفور والبوتاسيوم بواسطة كل من الحبوب والقش لنبات الذرة و بالنسبة للنتروجين والفوسفور والبوتاسيوم الميسر في التربة فقد اوضحت النتائج زيادة تيسر هذة العناصر بزيادة تركيز النيتروجين المضاف و ان اعلى القيم كانت مع الاضافة الارضى لهيومات الامونيوم. ويمكن تلخيص النتائج المتحصل عليها بزيادة كفاءة النتروجين المعدني بإضافة هيومات الامونيوم المتاثرة بالنتروجين بمعدل ٢٠ جرام نيتروجين لكل لتر سواء رشًا على الأوراق أو إضافة أرضية والذي انعكس على زيادة الإنتاجية للاراضى الرملية و انتاج الذرة و جودة المحصول وبذلك يمكن عمل إحلال جزئي للنتروجين المعدني بنسبة ٢٥ % تحت ظروف الأرض الرملية.