Current Chemistry Letters 11 (2022) 207–218

Contents lists available atGrowingScience

Current Chemistry Letters

homepage: www.GrowingScience.com

Chemical composition and productivity for corn as affected by inorganic, organic nitrogen fertilizers and activators (Humic and Fulvic acid)

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C H R O N I C L E

Article history:
Received July 20, 2021
Received in revised form October 20, 2021
Accepted January 12, 2022
Available online January 12, 2022

Keywords:
Nitrogen fertilizer
Organic and Bio-fertilizer
Humic acid
Nutrients content
Corn

A B S T R A C T

The present investigation was carried out to study the effects of inorganic, organic nitrogen fertilizers and activators (Humic and Fulvic acid) on chemical composition and productivity of corn. This study was conducted at Shandweel Agricultural Research Stations, Sohag Governorate, Egypt, and is situated at 26.6^0 N latitude and 37.7^0 E longitude. Its altitude is about 70 m above mean sea level. Also, this study was performed during two successive summer seasons 2014 and 2015. The experiments were laid down in split-split plot design with four replications. The treatments were included mineral nitrogen application in three levels (i.e. 60, 90 and 120 kg N $fed.^{-1}$), organic and bio fertilizer application (without organic and bio fertilizer, 10 m^3 FYM $fed.^{-1}$ and Microbeine inoculume) as well as foliar spray of humic acid (water spraying, humic and fulvic acid spraying). The obtained results revealed that the interaction effects of all factors under study were significant for all studied traits.

1. Introduction

There are different applications for chemical compounds found recently, and this thing is important and can encourage scientists for more useful work.[1-18] Corn (*Zea mays* L.) is one of the main cultivated cereals around the world. It is the third most important crop worldwide following wheat and rice. It is one of the important crops principally during the summer season in Egypt. Egypt produces about 5.8 million tons of white corn and 1.3 million tons of yellow corn annually.[19] Intensive farming practices, which warrant high yield and quality, requiring extensive use of chemical fertilizers that are costly and create environmental problems. In fact, the danger of fixation and/or leaching of the synthetic fertilizers are harmful for soil and environment.[20] Organic farming aims to produce healthy food and to respect the environment, emerging as an alternative to the negative consequences of conventional farming. In the context of sustainable organic agriculture, the successful use of biological nitrogen fixation without a decrease in productivity will reduce chemical fertilization. So, it is important to have previous knowledge of mineral nutrient requirements to optimize symbiotic nitrogen fixation and cereal crops production. The organic manure improves soil fertility by influencing its physical, chemical and biological properties. According to previous studies,[21] the organic manure also improves the soil by the formation of clay humic complexes which increase the soil adsorbent capacity of basic nutrients (calcium, magnesium and potassium) and enhance the activity of microorganisms involved in the mineralization process. Bio-fertilizers may affect plant growth by one or more mechanisms such as nitrogen fixation, enhancing nutrient uptake, production of organic acids, protection against plant pathogens and excretion growth regulators like IAA and GA3, which stimulated growth and resulted in high yield. Bio-fertilizers are inputs containing microorganisms which are capable of mobilizing nutritive elements from non-usable form to usable form through biological processes, they include mainly the nitrogen fixing, phosphate solubilizing and plant growth promoting microorganisms.[22] Increasing and extending the role of bio-fertilizers can reduce the need for chemical fertilizers and decrease adverse environmental effects. Bio-fertilizers can also play a significant role in fixing atmospheric N and

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doi: 10.5267/j.ccl.2022.1.001

production of plant growth promoting substances. Therefore, in the development and implementation of sustainable agricultural techniques, bio-fertilization has a great importance in alleviating environmental pollution and deterioration of nature.[23-25] Biological fertilizers have special significance in increasing crop production and preserving soil sustainable fertility. Inoculation with *Bacillus megaterium* increased significantly nutrients content and uptake (N, P and K) in maize compared with control.[26-28] Humic acid and Fulvic acid are of the major components of humus substances.[29] The role of humic acid is well known in improving soil health and nutrient uptake by plants and mineral availability.[30-32] The effect of humic acid foliar application was significant on all measured traits experiment of corn. Humic acid and fulvic acid increase the length and weight of root, number of lateral roots and flow of sap through the vessels. Moreover, they improve the quality and quantity of crops such as wheat, maize, etc., via increasing cell division and growth of crops, seeds germination.[33] It is well known that maize crops need large amounts of fertilizers especially nitrogen. So, the major problems facing farmers are the high costs of excessive manufactured fertilizers needed for plants. Besides, these chemical fertilizers are considered as air, soil and water polluting agents during their production and utilization. Therefore, the present research aimed to study the effects of inorganic, organic nitrogen fertilizers and activators (Humic and Fulvic acid) on chemical composition and productivity of maize to reduce the mineral nitrogen fertilizer applications and also to reduce production costs.

2. Results and Discussion

2.1 Grain yield (kg fed.$^{-1}$) and 100-grain weight (gm) of maize as affected by inorganic, organic nitrogen fertilizers and activators (H.A and F.A).

A significant and gradual increase in grain yield (Table 1) was found by increasing nitrogen fertilizer levels from 60 to 120 kg N fed.$^{-1}$. The highest value of grain yield was obtained in applied 90 kg N fed.$^{-1}$ (3872.8 kg fed.$^{-1}$). Nitrogen is the key element in increasing grain yield and quality of maize. Nitrogen contributes 1-4 % of dry matter production of the plants. These results are in agreement with the reported data.[34-35] Also, the results indicated that application of nitrogen fertilizer levels significantly increase the 100-grain weight (gm) of maize, over those obtained by control. The highest value of 100-grain weight (gm) was found by adding 90 kg N fed.$^{-1}$ (32.729 gm). The results are in good agreement with those obtained before.[35]

Data given in **Table 1** indicated that a significant improvement in grain yield was found due to the application of FYM or bio-fertilizer (Microbeine) compared with the control. The highest grain yield was obtained in the application of 10m^3 FYM fed.$^{-1}$ (3706.3 kg fed.$^{-1}$). The increase of growth and yield components may be due to the effect of applied nutrients and addition of FYM. This is in conformity with the findings reported before which demonstrate that an increase in maize grain yield after application of FYM may be due to slow release of nutrients to soil slowly for longer duration after decomposition resulting in better plant growth and yield attributing characters.[36-37] Application of FYM or Microbeine significantly increase 100- grain weight more than the control. It was found that the highest value of 100- grain weight was obtained by adding Microbeine (32.480 gm), without significant difference could be noticed between. These findings is in the same side of those obtained before.[38-41]

Spraying of Humic acid or Fulvic acid (**Table 1**) gave significantly an increase in grain yield. The highest grain yield was obtained by spraying humic acid (3675.5 kg fed.$^{-1}$). This may be attributed to humic acid functions on plant physiology, including enhancement of biomass yields, induction of lateral roots emergence, increase of cell respiration and membrane uptake of nutrients and exertion of hormone- like activities.[42] Also, explained that humus had beneficial effects on nutrient uptake, transport and availability to maize plant that enhances the maize plant growth and increases maize yield.[43] The ability of HA to release the nutrient slowly due to the decomposition of residue for a longer time could explain the improved in grain yield.[44-45] Also, it was observed that H.A or F.A spraying had positive and significant effects on 100-grain weight on maize. The highest value of 100-grain weight (32.493 gm) was found by spraying humic acid. Similar results were obtained previously.[31,46,47]

By examining the data obtained in **Table 1**, it is clear that the interaction between nitrogen fertilizer levels and FYM or Microbeine led to a significant increase in grain yield. It was found that application of 90 kg N fed.$^{-1}$ combined with 10m^3 FYM fed.$^{-1}$ gave the highest value of grain yield (3999.2 kg fed.$^{-1}$). Increasing grain yield due to application of nitrogen fertilizer levels combined with FYM over the control may be due to the effect of FYM in improving the physical and chemical properties of the soil. As well as organic manures plays a direct role in plant growth as a source of all necessary macro and micronutrients in available forms during mineralization. The results are consistent with the reported work before.[48-49] The results obtained also showed that the interaction effects between nitrogen fertilizer levels and FYM or Microbeine gave significant increases in the 100-grain weight more than those obtained by control. The highest value of 100-grain weight (33.310 gm) was found by adding 90 kg N fed.$^{-1}$ combined with 10 m^3 FYM fed.$^{-1}$. These results are in agreement with those obtained before,[41] which indicate that application of organic manure had distinctly influenced yield components of maize. This might be due to higher yield components that are directly responsible for grain yield that appeared to be determined by physiological characteristics, both during vegetative and reproductive phase of the crop growth. Moreover, it showed that the interaction between nitrogen fertilizers levels with the studied activators (H.A and

F.A) gave significant and positive increases more than those without (H.A and F.A) in grain yield. The highest grain yield value (3954.0 Kg fed.$^{-1}$) was found in adding 90 kg N fed.$^{-1}$ with spraying of (H.A). Similar results were also reported,[44] that indicate 20-23 % of maize grain yield over control were obtained with application of humic acid in combination with recommended dose of NPK. These results are also in agreement with the reported work.[50-51] Examining the data listed in **Table 1**, it is clear that the interaction between nitrogen fertilizer levels and the studied activators (H.A or F.A) had significant effects in increasing 100-grain weight, The highest value (32.949 gm) of 100-grain weight, was recorded in adding 90 kg N fed.$^{-1}$ with spraying (F.A). This finding is consistent with studies conducted before.[43,52] Fulvic acid stimulates and balances cells, creating optimum growth and replication conditions.[53]

Also, the results indicated that the interaction effect between adding FYM or Microbeine with spraying of H.A or F.A give significant effect on grain yield. The highest value was obtained by adding 10m^3 FYM fed.$^{-1}$ with spraying of H.A (3758.8 Kg fed.$^{-1}$). These results are in agreement with the findings reported before.[54] The results in **Table 1** shows that application of FYM or Microbeine combined with studied activators (H.A or F.A) had a significant effect on increasing 100-grain weight (gm). The highest value (32.984 gm) of 100-grain weight was obtained by applying Microbeine alone. These results to some extent corroborate the findings reported before.[39,55,56]

Consequently, **Table 1** shows that interaction between the different factors under study led to significant increases in grain yield of maize. It was found that the highest grain yield (4046.9 kg fed.$^{-1}$) was recorded in applied 90 kg N fed.$^{-1}$ combined with 10m^3 FYM fed.$^{-1}$ with spraying (F.A). These results were in harmony with the findings reported before.[49,54] Moreover, show that interactions between all factors under study led to significant increases in 100-grain weight more than those obtained by control (60 kg N fed.$^{-1}$). The highest of 100-grain weight (34.701 gm), was resulted in adding 90 kg N fed.$^{-1}$ combined with 10m^3 FYM fed.$^{-1}$ and spraying (H.A). These results are in agreement with the data obtained before.[57,58]

Table 1. Grain yield (kg fed.$^{-1}$) and 100-grain weight (gm) of maize plants as affected by inorganic, organic nitrogen fertilizers and activators (H.A and F.A)

Treatments		**Grain yield (kg fed.$^{-1}$)**				**100-grain weight (gm)**			
Mineral nitrogen fertilizer (A)	**Organic & bio fertilizer (B)**	**Foliar application of Humic & Fulvic acic (C)**							
		Water spray	Humic spray	Fulvic spray	**Average**	Water spray	Humic spray	Fulvic spray	**Average**
60 kg N Fed.$^{-1}$ (Control)	(without)	2931.3	3064.3	3071.1	**3022.2**	29.672	31.836	29.727	**30.412**
	Org.	3084.7	3306.3	3229.8	**3206.9**	30.636	31.975	32.794	**31.802**
	Bio.	3137.2	3222.5	3215.1	**3191.6**	32.126	31.985	32.080	**32.064**
Average		**3051.1**	**3197.7**	**3172.0**	**3140.2**	**30.812**	**31.932**	**31.534**	**31.426**
90 kg N Fed.$^{-1}$	(without)	3599.9	3894.5	3755.2	**3749.8**	31.636	31.604	32.655	**31.965**
	Org.	3946.4	4004.4	4046.9	**3999.2**	32.076	34.701	33.151	**33.310**
	Bio.	3822.5	3963.1	3822.9	**3869.5**	33.919	31.780	33.040	**32.913**
Average		**3789.6**	**3954.0**	**3875.0**	**3872.8**	**32.544**	**32.695**	**32.949**	**32.729**
120 kg N Fed.$^{-1}$	(without)	3784.7	3797.4	3809.3	**3797.2**	31.440	33.177	31.766	**32.128**
	Org.	3869.7	3965.9	3902.4	**3912.7**	32.439	32.213	31.586	**32.079**
	Bio.	3812.9	3861.7	3825.8	**3833.5**	32.908	33.163	31.324	**32.465**
Average		**3822.4**	**3875.0**	**3845.9**	**3847.8**	**32.262**	**32.851**	**31.559**	**32.224**
Average for Org. & Bio.	(without)	3438.6	3585.4	3545.2	**3523.1**	30.916	32.206	31.383	**31.501**
	Org.	3633.6	3758.8	3726.4	**3706.3**	31.717	32.963	32.510	**32.397**
	Bio.	3590.9	3682.4	3621.3	**3631.5**	32.984	32.309	32.148	**32.480**
Average		**3554.4**	**3675.5**	**3630.9**		**31.872**	**32.493**	**32.014**	
L.S.D at			*0.05*				*0.05*		
A			*18.2*				*0.087*		
B			*20.8*				*0.195*		
C			*36.0*				*0.339*		
A × B			*19.3*				*0.203*		
A × C			*33.4*				*0.351*		
B× C			*33.4*				*0.351*		
A × B × C			*57.8*				*0.609*		

2.2 Chemical composition of maize i.e. N, P and K content in leaves and grains (g kg^{-1}) as affected by inorganic, organic nitrogen fertilizers and activators (H.A and F.A).

2.2.1 Nitrogen content in leaves and grains (g kg^{-1}) of maize.

The data presented in **Table 2** show that N content (%) in leaves of maize increased by increasing nitrogen levels from 60 up to 120 kg N fed.$^{-1}$. The addition of 90 and 120 kg N fed.$^{-1}$, gave a significant increase in N content in leaves and these increases were increased by 4.34 and 7.09 %, respectively, more than those obtained by 60 Kg N fed.$^{-1}$ (control). They indicated that increasing nitrogen levels led to an increase in nitrogen content in leaves.[59] Results, showed that there is a significant and gradual increase in N content in grains by increasing nitrogen levels from 60 up to 120 kg N fed.$^{-1}$. Addition of 90 and 120 kg N fed.$^{-1}$, gave a significant increase in N content in grains. Their increased percentages were 7.79 and 18.34 %, respectively, from those obtained by 60 kg N fed.$^{-1}$ (control). They reported that varying levels of nitrogen influenced the concentration of nutrients N, P and K in maize grain significantly.[60-61] Application of FYM or Microbeine significantly increased N content in leaves more than those obtained by control (without organic and bio-fertilizers). Application of 10 m^3 FYM fed.$^{-1}$ and Microbeine gave a significant increase in N content in leaves and these increases amounted by 4.14 and 4.14 %, respectively, more than those obtained by control. Consequently, It can be observed that the effect of added FYM or Microbeine on N content in grains in both seasons under study was significant. Application of 10m^3 FYM fed.$^{-1}$ and Microbeine resulted in a significant N content in grains and these increases amounted to 4.74 and 3.40 % more than those obtained by control, respectively. The maximum value of N content in grains (17.23 g kg^{-1}) was recorded by adding10m^3 FYM fed.$^{-1}$. These results are in agreement with the reported work,[62,63,64,41] which indicated that N content in grain and stover of maize was significantly influenced by application of FYM. In case of adding Microbeine, it was reported that N content in grain and stover of maize was significantly influenced by seed inoculation with biofertilizers.[65,66]

Spraying H.A and F.A activators resulted in significant increases in N content in leaves and grains. The highest of N content in leaves was found by spraying H.A (32.19 g kg^{-1}). While, the highest value of N content in grains (17.14 g kg^{-1}) was obtained with spraying of F.A. These results are in agreement with the work obtained before which indicated that the minerals (N, P and K) content of maize fodder significantly varied between HA levels.[67,68] Higher mineral and total nitrogen in stem, leaves and grains at maturity in which 2.5 kg ha^{-1} of humic acid was applied. Also, it was reported that humic substances provoked a better efficiency of plant water uptake and improved the mineral nutrition and grain protein content.[69-70] **Table 2** shows that interactions between nitrogen fertilizer levels and FYM or Microbeine led to significant and positive increases in N content in leaves and grains more than those obtained by control. Adding 120 kg N fed.$^{-1}$ alone obtained the highest value of N content in leaves (32.90 g kg^{-1}). Whereas, The highest of N content in grains (19.25 g kg^{-1}) was resulted by adding 120 kg N fed.$^{-1}$ combined with 10m^3 FYM fed.$^{-1}$. Similar results were found before,[59,60,61] which indicated that increasing nitrogen levels led to an increase in nitrogen content in leaves. Also, it was reported that N content in grain and stover of maize was significantly influenced by application of FYM.[62,63,64,41]

Table 2. Nitrogen content in leaves and grains (g kg^{-1}) of maize plants as affected by inorganic, organic nitrogen fertilizers and activators (H.A and F.A)

Treatments		**N content in leaves (g kg^{-1})**				**N content in grains (g kg^{-1})**			
Mineral nitrogen fertilizer (A)	**Organic & bio fertilizer (B)**	**Foliar application of Humic & Fulvic acic (C)**							
		Water spray	Humic spray	Fulvic spray	**Average**	Water spray	Humic spray	Fulvic spray	**Average**
60 kg N Fed.$^{-1}$ (Control)	(without)	27.74	30.46	29.08	**29.10**	14.48	15.23	15.38	**15.03**
	Org.	30.83	31.35	31.62	**31.27**	15.23	15.79	16.12	**15.71**
	Bio.	31.27	31.27	31.94	**31.49**	15.00	16.31	16.31	**15.87**
Average		**29.95**	**31.03**	**30.88**	**30.62**	**14.90**	**15.78**	**15.94**	**15.54**
90 kg N Fed.$^{-1}$	(without)	29.95	31.89	30.58	**30.80**	16.60	16.77	16.59	**16.65**
	Org.	32.23	33.47	31.85	**32.52**	16.60	16.73	16.83	**16.72**
	Bio.	32.27	32.80	32.49	**32.52**	16.63	16.91	17.13	**16.89**
Average		**31.49**	**32.72**	**31.64**	**31.95**	**16.61**	**16.80**	**16.85**	**16.75**
120 kg N Fed.$^{-1}$	(without)	35.35	32.89	30.45	**32.90**	17.58	17.53	17.85	**17.66**
	Org.	33.42	33.32	31.83	**32.86**	18.08	20.25	19.41	**19.25**
	Bio.	31.72	32.27	33.88	**32.63**	17.81	18.41	18.62	**18.28**
Average		**33.50**	**32.83**	**32.05**	**32.79**	**17.83**	**18.73**	**18.63**	**18.39**
Average for Org. & Bio.	(without)	31.01	31.75	30.03	**30.93**	16.22	16.51	16.61	**16.45**
	Org.	32.16	32.71	31.77	**32.21**	16.64	17.59	17.45	**17.23**
	Bio.	31.76	32.12	32.77	**32.21**	16.48	17.21	17.35	**17.01**
Average		**31.64**	**32.19**	**31.52**		**16.45**	**17.10**	**17.14**	
L.S.D at		*0.05*				*0.05*			
A		*0.27*				*0.16*			
B		*0.30*				*0.12*			
C		*0.53*				*0.20*			
A × B		*0.28*				*0.12*			
A × C		*0.49*				*0.21*			
B× C		*0.49*				*0.21*			
A × B × C		*0.84*				*0.37*			

By examining the data in **Table 2**, it is clear that the interaction between nitrogen fertilizer levels and spraying of H.A or F.A gave significant increase in N content in leaves and grains more than those obtained by spraying water only. The highest values of N content in leaves and grains were obtained by applying 120 kg N fed.$^{-1}$ with spraying of H.A (32.83 and 18.73 g kg^{-1}), respectively. Similar results were reported before[59,60,61] which indicated that the nutrient concentration in grains enhanced significantly with the application of higher levels of N as compared with lower doses of N. Also, the humic acid can obviously promote the absorption of nitrogen, phosphorus and potassium by maize plants with an obvious increase of the contents of nitrogen and potassium oxide in the stem and leaves of maize plants, 10% humic acid added in urea is better than other treatments in comprehensive effects.[71]

The data in **Table 2** indicated that the interaction effects between FYM or Microbeine combined with spraying of H.A or F.A had positive and significant effects on increasing N content in leaves and grains. The highest value of N content was obtained by adding Microbeine combined with spraying F.A (32.77 g kg^{-1}). However, The highest value of N content in grains (17.59 g kg^{-1}) was obtained by adding 10m^3 FYM fed.$^{-1}$ with spraying H.A. Similar results were reported before.[41,64,67,72]

The interaction between all studied factors had a positive and significant N content in leaves and grains. The highest value of N content in leaves (35.35 g kg^{-1}) was obtained by adding 120kg N fed.$^{-1}$ alone. But, the highest of N content in grains (20.25 g kg^{-1}) was produced by the treatment received 120 kg N fed.$^{-1}$ beside 10m^3 FYM fed.$^{-1}$ with spraying H.A.

2.2.2 Phosphorus content in leaves and grains (g kg^{-1}) of maize.

Data presented in **Table 3** show that P content in leaves and grains (g kg^{-1}) of maize increased by increasing nitrogen level up to 120 kg N fed.$^{-1}$. The addition of 90 and 120 kg N fed.$^{-1}$, gave a significant increase in P content in leaves which in percentage were 4.09 and 8.49 %, respectively, more than those obtained by 60 kg N fed.$^{-1}$ (control), respectively. The maximum value of phosphorus content (3.45 g kg^{-1}) was recorded by adding 120 kg N fed.$^{-1}$. Addition of 90 and 120 kg N fed.$^{-1}$, gave significant increases in P content in grains; these increases were 4.11 and 7.97 %, from that obtained by 60 kg N fed.$^{-1}$ (control), respectively.

Table 3. Phosphorus content in leaves and grains (g kg^{-1}) of maize plants as affected by inorganic, organic nitrogen fertilizers and activators (H.A and F.A)

Treatments		**P content in leaves (g kg^{-1})**				**P content in grains (g kg^{-1})**			
Mineral nitrogen fertilizer (A)	**Organic & bio fertilizer (B)**	**Foliar application of Humic & Fulvic acid (C)**							
		Water spray	Humic spray	Fulvic spray	**Average**	Water spray	Humic spray	Fulvic spray	**Average**
60 kg N Fed.$^{-1}$ (Control)	(without)	2.81	3.61	3.05	**3.16**	3.94	4.01	4.20	**4.05**
	Org.	3.07	3.17	3.08	**3.10**	4.09	4.34	4.25	**4.23**
	Bio.	3.25	3.18	3.43	**3.29**	3.97	4.22	4.21	**4.13**
Average		**3.04**	**3.32**	**3.19**	**3.18**	**4.00**	**4.19**	**4.22**	**4.14**
90 kg N Fed.$^{-1}$	(without)	3.07	3.14	3.33	**3.18**	4.03	4.35	4.33	**4.23**
	Org.	3.54	3.51	3.34	**3.46**	4.32	4.31	4.30	**4.31**
	Bio.	3.10	3.40	3.37	**3.29**	4.27	4.49	4.38	**4.38**
Average		**3.24**	**3.35**	**3.34**	**3.31**	**4.20**	**4.38**	**4.34**	**4.31**
120 kg N Fed.$^{-1}$	(without)	3.47	3.31	3.14	**3.31**	4.37	4.47	4.42	**4.42**
	Org.	3.43	3.64	3.56	**3.54**	4.57	4.47	4.35	**4.46**
	Bio.	3.43	3.57	3.49	**3.50**	4.57	4.57	4.48	**4.54**
Average		**3.44**	**3.51**	**3.39**	**3.45**	**4.51**	**4.50**	**4.41**	**4.47**
Average for Org. & Bio.	(without)	3.12	3.35	3.17	**3.21**	4.11	4.27	4.32	**4.23**
	Org.	3.35	3.44	3.32	**3.37**	4.33	4.37	4.30	**4.33**
	Bio.	3.26	3.38	3.43	**3.36**	4.27	4.43	4.35	**4.35**
Average		**3.24**	**3.39**	**3.31**		**4.24**	**4.36**	**4.32**	
L.S.D at			*0.05*				*0.05*		
A			*0.03*				*0.01*		
B			*0.02*				*0.01*		
C			*0.04*				*0.02*		
A × B			*0.02*				*0.02*		
A × C			*0.04*				*0.03*		
B× C			*0.04*				*0.03*		
A × B × C			*0.06*				*0.05*		

Data given in **Table 3** clearly showed that application of FYM or Microbeine significantly increased P content in leaves and grains over those obtained with control (without organic and bio fertilizers). Application of $10m^3$ FYM $fed.^{-1}$ and Microbeine gave a significant increase in P content in leaves, which amounted by 4.98 and 4.67 % more than the control, respectively. It can be observed that the application of $10m^3$ FYM $fed.^{-1}$ and Microbeine gave significant increases which amounted by 2.36 and 2.84 % in P content in grains from that gained by control, respectively.

The results in **Table 3**, show that spraying H.A and F.A activators resulted in a significant increase in P content in leaves and grains. The highest value of phosphorus content in leaves was found by spraying of H.A (3.39 g kg^{-1}), The highest of P content in grains (4.36 g kg^{-1}) was obtained by spraying of H.A.

Table 3 showed that interactions between nitrogen fertilizer levels and FYM or Microbeine led to significant and positive increases in P content in leaves and grains more than those obtained by control. Adding 120 kg N $fed.^{-1}$ combined with 10 m^3 FYM $fed.^{-1}$ obtained the highest value of P content (3.54 g kg^{-1}). While, the highest value of P content in grains (4.54 g kg^{-1}) was resulted by adding 120 kg N $fed.^{-1}$ combined with Microbeine.

By examining the data in Table 3, it is clear that the interaction between nitrogen fertilizer levels and spraying of H.A or F.A gave significant increase in P content in leaves and grains. The highest phosphorus content in leaves was obtained by applying 120 kg N $fed.^{-1}$ with spraying of H.A (3.51 g kg^{-1}). Whereas, the highest value of phosphorus content in grains was obtained by applying 120 kg N $fed.^{-1}$ alone (4.51 g kg^{-1}).

The data in **Table 3**, indicated that the interaction effects between adding FYM or Microbeine with spraying H.A or F.A were significant on increasing P content in leaves and grains. The highest value of P content was obtained by adding $10m^3$ FYM $fed.^{-1}$ with spraying H.A (3.44 g kg^{-1}). The highest value of P content in grains (4.43 g kg^{-1}) was obtained by adding Microbeine with spraying H.A.

All interaction between the studied factors were significant in their effect on P content in leaves and grains of maize, Table 3. The highest value of P content in leaves (3.64 g kg^{-1}) was obtained from the treatment received 120 kg N $fed.^{-1}$ combined with $10m^3$ FYM $fed.^{-1}$ with spraying H.A.

2.2.3 Potassium content in leaves and grains (g kg^{-1}) of maize.

Results in **Table 4** clearly showed that there is a significant and gradual increase in K content in leaves and grains by increasing nitrogen levels from 60 up to 120 kg N $fed.^{-1}$. Values of K content in leaves were 30.90, 31.90 and 32.48 g kg^{-1} when 60, 90 and 120 kg N $fed.^{-1}$ were applied, respectively. Values of K content in grains by applying 60, 90 and 120 kg N $fed.^{-1}$ were 5.03, 5.22 and 5.30 g kg^{-1}, respectively. Concerning the effect of FYM or Microbeine on K content in leaves of maize, data in Table 4, revealed that adding FYM or Microbeine had a significant effect on K content in leaves more than those obtained by control (without organic and bio fertilizers). The highest value of K content in leaves (32.10 g kg^{-1}) was obtained by adding Microbeine. On the other hand, the effect of FYM or Microbeine on K content in grains, data in Table 4, revealed that the effect resulted in a significant decrease in K content in grains.

The data listed in **Table 4** indicated that spraying the studied activators (H.A and F.A) gave significant increases in K content in leaves, The highest value of K content in leaves was found by spraying of F.A (31.93 g kg^{-1}). The data listed in Table 4 indicated that the differences in K content in grains by spraying each H.A and F.A were so narrow, without any significant differences. Whereas the effect of spraying each H.A and F.A resulted in a significant decline in K content in grains.

The interaction between nitrogen fertilizer levels and FYM or Microbeine gave a significant increase in K content in leaves and grains. The highest value was obtained by applying 120 kg N $fed.^{-1}$ combined with 10 m^3 FYM $fed.^{-1}$ (32.54 g kg^{-1}) without difference between applying of $10m^3$ FYM $fed.^{-1}$ and/or Microbeine. However, The highest value of K content in grains was obtained by applying 120 kg N $fed.^{-1}$ alone (5.36 g kg^{-1}). These results are in agreement with those obtained before since it was reported that the nutrient concentration in both grain and stover enhanced significantly with the application of higher levels of N as compared with lower doses of N. For the effect of microorganisms and microbial communities like *Azotobacter* sp. and *Azospirillum* sp. in the rhizosphere promotes the growth of the plant through the cycling and availability of nutrients, increasing the health of roots during the growth stage by competing with root pathogens and increasing the absorption of nutrients and water and also, it was noted that microbial enzymatic processes, organic substance could be mineralized and turn into inorganic substances to provide N, P, K and other nutrient that can be absorbed by maize.[73,74,75] From the data in **Table 4**, the interaction between nitrogen fertilizer levels and spraying of H.A or F.A resulted in a significant increase in K content in leaves and grains. The highest value was obtained by applying 120 kg N $fed.^{-1}$ with spraying of H.A (32.87 g kg^{-1}). While the highest value of K content in grains was obtained by applying 120 kg N $fed.^{-1}$ alone (5.40 g kg^{-1}).

Table 4. Potassium content in leaves and grains (g kg^{-1}) of maize plants as affected by inorganic, organic nitrogen fertilizers and activators (H.A and F.A)

Treatments		K content in leaves (g kg^{-1})				K content in grains (g kg^{-1})			
Mineral nitrogen fertilizer (A)	Organic & Bio fertilizer (B)	Foliar application of Humic & Fulvic acid (C)							
		Water spray	Humic spray	Fulvic spray	**Average**	Water spray	Humic spray	Fulvic spray	**Average**
60 kg N $Fed.^{-1}$ (Control)	(without)	28.74	31.05	30.64	**30.14**	5.12	5.06	4.99	**5.06**
	Org.	31.56	31.52	31.09	**31.39**	5.02	4.85	5.17	**5.01**
	Bio.	31.52	31.37	31.37	**31.42**	4.93	5.08	5.05	**5.02**
Average		**30.61**	**31.31**	**31.03**	**30.98**	**5.02**	**4.99**	**5.07**	**5.03**
90 kg N $Fed.^{-1}$	(without)	31.27	31.23	31.39	**31.30**	5.32	5.18	5.45	**5.31**
	Org.	32.17	31.33	32.60	**32.03**	5.34	5.09	5.19	**5.20**
	Bio.	33.01	31.75	32.36	**32.37**	5.10	5.23	5.10	**5.14**
Average		**32.15**	**31.43**	**32.12**	**31.90**	**5.25**	**5.16**	**5.25**	**5.22**
120 kg N $Fed.^{-1}$	(without)	31.88	32.68	32.59	**32.38**	5.50	5.39	5.21	**5.36**
	Org.	32.44	32.59	32.60	**32.54**	5.28	5.22	5.20	**5.23**
	Bio.	31.46	33.36	32.74	**32.52**	5.42	5.28	5.18	**5.29**
Average		**31.92**	**32.87**	**32.64**	**32.48**	**5.40**	**5.29**	**5.19**	**5.30**
Average for Org. & Bio.	(without)	30.63	31.65	31.54	**31.27**	5.31	5.21	5.21	**5.24**
	Org.	32.05	31.81	32.10	**31.99**	5.21	5.05	5.19	**5.15**
	Bio.	32.00	32.16	32.16	**32.10**	5.15	5.19	5.11	**5.15**
Average		**31.56**	**31.87**	**31.93**		**5.22**	**5.15**	**5.17**	
L.S.D at			*0.05*				*0.05*		
A			*0.45*				*0.03*		
B			*0.20*				*0.03*		
C			*0.34*				*0.05*		
A × B			*0.21*				*0.03*		
A × C			*0.37*				*0.05*		
B× C			*0.37*				*0.05*		
A × B × C			*0.64*				*0.09*		

Results in **Table 4** have indicated that the interaction effects between adding FYM or Microbeine with spraying of H.A or F.A was significant on increasing K content in leaves. The highest value of K content in leaves (32.16 g kg^{-1}) was obtained by adding Microbeine with spraying of H.A, However, the same value of K content in leaves (32.16 g kg^{-1}) was obtained by adding Microbeine with spraying F.A. On the other hand, it can be observed that the interaction effects between adding FYM or Microbeine with spraying of (H.A or F.A) was significant decrease on K content in grains. The interactions between all studied factors significantly affected potassium content in leaves and grains positively. The highest value of K content in leaves were 33.36 g kg^{-1} as a result from the treatment received 120 kg N $fed.^{-1}$ combined with adding Microbeine under spraying H.A. However, the maximum value of K content in grains (5.50 g kg^{-1}) was obtained by applying 120 kg N $fed.^{-1}$ alone.

3. Conclusion

The obtained results revealed that a significant and gradual increase in grain yield (kg fed^{-1}, 100-grain weight (gm) N, P and K content in leaves and grains, were found by adding nitrogen fertilizer levels from 60 to 120 kg N fed^{-1}. The results also revealed a significant improvement in grain yield (kg fed^{-1}, 100-grain weight (gm) N, P and K content in leaves and grains due to the application of FYM or Microbein as compared with the control (without organic or bio- fertilizers). Applications of humic acid had a significant effect on all studied traits. The interaction effects of all factors under study were highly significant for all studied traits. Highest values in grain yield (4046.9 kg fed^{-1}) were obtained by adding 90 kg N fed^{-1}. combined with 10m^3 FYM fed^{-1}. under spraying (F.A). The applications of 10m^3 FYM fed^{-1}. or Microbein with spraying of H.A or F.A combined with 75% of the recommended dose of N fertilizer could be enough for improving soil fertility and produce grain yield equal or more than those obtained by the recommended dose.

4. Experimental

4.1 Materials and methods

Field experiments were conducted at Shandweel Agricultural Research Stations, Sohag Governorate, during two successive summer seasons (2014 and 2015) to study the effects of inorganic, organic nitrogen fertilizers and activators (Humic and Fulvic acid) on chemical composition and productivity of maize. The experimental design was a split-split plot with four replicates. Nitrogen levels were assigned to the main plots, application of farm yard manure (FYM) and biofertilizer to the sub-plots while spraying treatments were arranged as sub-sub-plots (Humic acid (H.A), Fulvic acid (F.A) and water spraying).

4.1.1 The treatments were as follows:

A- Main plots: Nitrogen fertilizer levels.
a1- 60 Kg N fed.$^{-1}$ (Control), a2- 90 Kg N fed.$^{-1}$ and a3- 120 Kg N fed.$^{-1}$.
B-Sub-plots: organic and bio-fertilizers.
b1- Without organic or bio-fertilizers, b2- 10m^3 FYM fed.$^{-1}$ and b3- bio-fertilizer (Microbeine).
C-Sub-sub-plots: Foliar spraying of Humic or Fulvic acid.
c1- Water spraying, c2- Humic acid spraying and c3- Fulvic acid spraying.

Nitrogen fertilizer was applied in the form of urea (46.5% N) . This fertilizer was applied in two equal portions, the first portion was added before the first irrigation and the other one was before the second irrigation. Potassium fertilizer in the form of potassium sulphate (48% K_2O) was added to all plots of the experiment at a rate of 24 kg K_2O fed.$^{-1}$ at planting. Super-phosphate (15% P_2O_5) was added at the rate of 15 kg P_2O_5 fed.$^{-1}$ during land preparation. Farm yard manure (FYM) was added at the rate of 10m^3 FYM fed.$^{-1}$ during land preparation. Bio-fertilizer (Microbeine), a mixture of phosphorus dissolving and N_2-fixing bacteria, was produced and distributed commercially by General organization for Agriculture Equalization Fund (GOAEF), Ministry of Agriculture Egypt, Biofertilizer (Microbeine) was added as a soil application before the first irrigation. Foliar application of Humic and Fulvic acids (H.A and F.A) at a rate (4 liter/200 liter water per fed.). Two spraying times at 30 and 45 days after planting were done for H.A, F.A and water. Humic and Fulvic acid is a commercial product supplied from Bio Tec for Bio-cids and Fertilizers Company, Al Sadat City, Egypt.

Table 5. Some physical and chemical properties of the experimental soils

Physical properties				**Chemical properties**			
Particle size distribution (%)			Texture class	O.M g kg^{-1}	pH (1:2.5) soil water susp.	EC dSm^{-1} (1:2.5) soil water ext.	CaCo$_3$ g kg^{-1}
Sand	Silt	Clay					
23.20	38.85	37.95	Clay loam	12.70	7.66	1.11	17.75

Soluble cations and anions								**Available macronutrients**		
Cations meq L^{-1}				Anions meq L^{-1}				N	P	K
Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
55.30	27.75	26.5	2.35	0.00	37.30	22.60	51.55	17.95	9.75	174.00

Table 6. Physiochemical properties of the investigated farm yard manure (FYM)

properties	pH	E.C dSm^{-1}	N g kg^{-1}	P g kg^{-1}	K g kg^{-1}	O.M g kg^{-1}	O.C g kg^{-1}	C/N ratio	Bulk density (kg/m^3)	Moisture content (%)
Value	7.35	6.19	7.80	3.90	29.50	258.7	134.4	17.23	644	10.60

pH and EC of the FYM were measured in 1:5 suspension and extract respectively.

4.2 Measurement of soil properties

Soil samples were taken before planting from the experimental sites in both seasons. Soil samples were taken from 0-30 cm depths, air-dried, crushed and sieved to pass through a 2 mm sieve, to determinate physical and chemical properties. Soil characterization for the experimental sites are listed in Table 5 and were determined a according to the following methods: Particle-size distribution was determined using the pipette method.[76] Organic carbon was determined by the modified Walkely and Black method.[77] Total calcium carbonate ($CaCO_3$) was determined using Collin's Calcimeter.[76] Soil pH was measured in 1:2.5 soil: water suspension.[77] EC (dSm^{-1}) was determined in 1:2.5 soil: water extract.[77] Soluble cations and anions were determined in soil saturation extract using the standard methods.[77] Available nitrogen was determined in the soil samples using micro-Kjeldahl method.[78] Available phosphorus was extracted by 0.5 M $NaHCO_3$[79] and determined by the stannous chloride phosphomolybdic acid method.[77] Available potassium was determined Flame Photometerically in 1 N ammonium acetate extract according to.[77]

4.3 Measurement of farm yard manure (FYM) properties.

Physiochemical properties of the investigated farm yard manure (FYM) are listed in Table 6 and were determined according to the following methods: pH was determined in 1:5 FYM: water suspension. EC (dSm^{-1}) was determined in 1:5 FYM: water extract.[77] Organic matter (O.M) was determined by weight loss on ignition at 430 ˚C for 24h and total organic carbon (TOC) was calculated from (OM) according to the equation of Navarro.[80] Bulk density was determined using the core method according to the method of Black.[81] Total nitrogen was determined by using Kjeldahl digestion method.[77] Total phosphorus was determined in FYM spectrophotometrically in the acid solution of the digested samples using ammonium molybdate and stannous chloride reagents.[78] Total potassium was determined in the acid solution of the digested samples using flame photometric method according to Page.[78]

4.4 Measurement growth parameters

Plant growth, two plant samples were taken from each experimental plot. The first sample was taken after 70 days from planting (during tasseling-silking stage), as the entire leaf of the ear node from 5 plants/plot. Leaf plants were washed with diluted HCl 0.01 M followed by rapid washing with distilled water, oven dried at 70ºC., ground and kept for chemical analysis. The second sample was taken at the harvest time from the grains of each plot to determine 100 grains weight (gm) and chemical analysis. For chemical analysis, the grain samples were ground and kept. For grain yield each plot was harvested to determine grain yield (kg fed.$^{-1}$). Plant analysis, plant samples were oven dried at 70ºC for 24 hours, ground in porcelain mortar and stored for analysis. A sample of 0.5 g of the dried plant material was digested with a mixture of concentrated H_2SO_4 and H_2O_2 30%.[77] The digest was diluted with distilled water to a volume of 50 ml. Aliquots from this digest was analyzed for N, P and K according to the following methods: Total nitrogen was determined using Kjeldahl digestion method.[81] Total phosphorus was determined colorimetrically in the acid digest according to Page.[78] Total potassium was determined using the Flame Photometer according to Page.[78]

4.5 Statistical Analysis

Appropriate analysis of variance was performed using COSTATE Computer Software. The significant differences among the mean of various treatments were established by the Least Significant Differences method (LSD) according to Gomez.[82] The displayed parameters values are the mean of the two seasons. The previous studies confirmed that there is a great need for scientific research in all fields every time.[83-94]

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