I.1. NITROGEN FERTILIZER AND HUMIC ACID EFFECTS ON MAIZE PRODUCTIVITY

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Abstract

A two-year field trial was conducted at Ismailia (sandy soil) and Gemmeiza (clay soil) Research Stations, in a split plot design with three replicates during 2012 and 2013 growing *seasons using maize hybrid single cross 166. The objective of this research was to find out the impact of four humic acid (HA) treatments (control, soaking, spraying, and soaking/spraying) applied under four N fertilizer levels (0, 60, 90 and 120 Kg fed.$^{-1}$) on maize yield and its components. Data recorded from Gemmeiza site had higher values than those from Ismailia. Results from locations and seasons indicated that grain yield increased with increasing N rates. Moreover, these results suggest that the optimum N rate was 120 kg N fed^{-1} at both locations. However, the 4th treatment (Soaking/Spraying) recorded the highest values for yield and most of its traits (ear length, kernels weight, kernels per ear and grain yield) at the two locations across seasons. Generally, grain yield was increased with increasing N up to 120 kg fed.$^{-1}$ with soaked/sprayed seed at the two locations. Application of high nitrogen rates decreased nitrogen use efficiency (NUE) at Gemmeiza under all humic treatment. Results confirmed that grain yield response index was higher at Gemmeiza than that at Ismailia.*

Keywords: *Zea mays* L., Humic acid, yield components.

INTRODUCTION

Humic acid contains carbon-rich highly functionalized organic molecule comprising of carboxylic, phenolic, carbohydrates and enolic groups, colloidal organic matter, water soluble at pH above 2 and insoluble at pH below 2, brownish black color. It increases yields of crops, vegetables and fruits, produces superior turf and deep roots, enhances uptake of fertilizers, replenishes depleted soils and promotes ecological balance.

Nitrogen is the key element in increasing yield. Cultivated soils over Egypt are deficient in available nitrogen and organic matter, and their removal is usually greater than their input. Especially in maize (*Zea mays* L.) intensive farming practices that aims to produce higher yield, require extensive use of agro-chemicals, which are costly and create environmental pollutions (Kozdrò *et. al.,* 2004). Nitrogen is required in large quantities for plants to grow and is mainly provided in the form of synthetic chemical fertilizers. The development and adoption of nitrogen-use efficient maize cultivars could reduce the use of input nitrogen to levels below the recommended rate of 120 to 150 kg N ha^{-1} (Enwezor *et. al.,* 1989). To manage agriculture production in unfavorable soil conditions by enriching their organic matter, various options are found in literature, for example, crop rotation, green manures, residue or animal manures incorporation, etc. and humic acid application (Delfine *et. al.,* 2005; Selim *et. al.,* 2009; Johnson *et. al.,* 2012; and Ludibeth *et. al.,* 2012). All these options basically aim at improving soil conditions for growth and quality of the crop. Many studies have demonstrated the practical importance of humic acid in agriculture, for example, Buyukkeskin and Akinci (2011), Çelik *et. al.* (2011), Tahir *et. al.* (2011) and Humintech (2012) have reported beneficial effects of humic substances (HS) on plant growth, mineral nutrition, seed germination, seedling growth, root initiation, root growth, shoot development and the uptake of macro-and microelements. HS are known to possess bioactivating properties in relation to plants (Pizzeghello *et. al.,* 2001). Farmers use humates to accelerate seed germination and improve rhizome growth. These materials are able to stimulate oxygen transport, accelerate respiration and promote efficient utilization of nutrient by plants (Islam *et. al.,* 2005). Nevertheless, humic acid in proper concentrations can enhance plant and root growth (Bacilio *et. al.,* 2003). Presence of HS is important during all stages of plants development but particularly vital in the early stages. That is why the pre-planting treatment of seeds is very important. Even before germination begins, vital forces are awakened, and the immune system is stimulated (Levinsky, 2009). Numerous researches have demonstrated conclusively that HS have significant impacts on the soil structure and plant growth (Fong *et. al.,* 2007).

Crop production depends on several factors, including level of applied nutrients such as nitrogen (N). The research findings are based on the key parameters necessary for evaluation of maize yield. Biofertilizers are able to fix atmospheric nitrogen in the available form for plants (Chen, 2006). Many attempts have been tried to replace a part of those harmful fertilizers by biofertilizers in maize to get yield of a good quality without loss in its quantity (El-Kholy *et. al.,* 2005).

Humic acid is a commercial product containing many elements which improve soil fertility and increase the availability of nutrients and consequently increase plant growth and grain yield. It is particularly used to ameliorate or reduce the negative effect of salt stress. Abd El-Aal *et. al.* (2005), on onion plant and Hafez (2003) on squash reported that humic acid applications led to a significant increase in soil organic matter, which in turn improves plant growth and crop production. Ibrahim *et. al.* (2014), who studied the effect of mineral fertilizers and humic substances on growth and yield of maize reported that combination of chemical fertilizer with application of humic substances improved growth and grain yield.

In general, it could be concluded that usage of humic acid in maize fields gave good results by reducing the usage of chemical fertilizers because of its variant physiological effects; it is also used as a substance with natural sources that stabilize and increase agricultural production (Ghorbani *et. al.,* 2010). It is important to analyze the productivity of N-efficient maize grain.

The objectives of the present study were to investigate the influence of humic acid application and nitrogen fertilization on yield and yield components of maize and to estimate N-use efficiency of maize plants under humic acid treatments.

MATERIALS AND METHODS

A field trial was conducted at two locations; i.e., Gemmeiza and Ismailia Agric. Res. Stns., Field Crops Res. Inst., Agric. Res. Center, during 2012 and 2013 growing seasons to study the effect of humic acid and nitrogen fertilizer on grain yield and yield components of maize. Four humic acid (HA) treatments [(1) control, (2) soaking seeds in humic acid (1000 ppm) for 24 hrs before planting, (3) spraying humic acid 1000 ppm at 21 days after planting, and (4) soaking seeds in humic acid 1000 ppm for 24 hrs before planting + spraying humic acid 1000 ppm at 21 days after planting)] were applied under four nitrogen fertilizer rates (0, 60, 90 and 120 Kg N fed.$^{-1}$). Single cross hybrid (SC 166) was used in this study. The preceeding crop was wheat for both trials. Soil type was (alluvial) at Gemmeiza, whereas, it was (sandy) at Ismailia.

The experiment procedure

Experimental design was split plot with three replications. Four humic treatments were assigned to main plots (Control untreated, Soaking seeds in humic acid 1000 ppm 24 h before planting, Spraying in humic acid 1000 ppm at 21 days after planting and Soaking seeds 24 h before planting + spraying humic acid 1000 ppm at 21 days after planting.) Nitrogen rates were arranged in the sub plots (0, 60, 90 and 120 kg N fed^{-1}). Plot size was 4 rows, 6-m long, 80-cm apart, and 21-cm between hills. All plants in the 2nd and 3rd rows were harvested and grain yield was adjusted to 15.5% moisture. Phosphorus at a rate of 30 Kg P_2O_5 fed.$^{-1}$ in the form of superphosphate (15% P_2O_5) and potassium at a rate of 24 Kg K_2O per fed. in the form of potassium sulphate 48% K_2O were added before planting. Soil samples at (0-30 cm depth) were taken from the experimental site before planting for physical and chemical analysis. This study was performed at Ismailia (sandy soil) and Gemmeiza (alluvial soil). Soil properties are illustrated in Table 1 according to Page *et. al.* (1982)

to study the effect of humic acid and nitrogen levels on grain yield and yield components of maize. All other cultural practices were applied as recommended.

Table 1. Mechanical and chemical analysis over both experimental sites (Ismailia and Gemmeiza).

Soil characters	Mechanical analysis		Soil characters	Chemical analysis	
	Ismailia	Gemmeiza		Ismailia	Gemmeiza
Coarse sand%	13.2	25.1	pH (1-2.5 suspension)	7.9	8.3
Fine sand	51.2	10.0	Ec (mmohs cm^{-1})	0.132	2. 3
Silt%	20.0	21.5	OM%	0.512	1.8
Clay%	14.3	45.8	Available N ppm	17.3	33.8
Soil texture	sandy	clay	Available P ppm	2.3	15.5
			Available K ppm	80.2	119

Data recorded at harvest

Data recorded for maize crop for both tested seasons were ear length (cm), number of rows ear^{-1}, number of kernels row^{-1}, kernel weight ear^{-1} (g), number of kernels ear^{-1} and grain yield (ard. $fed.^{-1}$).

Nitrogen use efficiency (NUE)

Agronomic efficiency (Nitrogen use efficiency NUE), Kg grain/Kg N applied, was calculated according to (Craswell and Godwin, 1984) as follows:

NUE = Grain yield (f) - Grain yield (c), Kg $fed.^{-1}$ / Fertilizer N applied, Kg $fed.^{-1}$

Where f = fertilized plots and c = non fertilized plots (control)

Grain yield response index (GYRI)

Grain yield index was calculated according to Fageria and Filho (1981) as follows:

$$GYRI = \frac{\text{GY under high N level} - \text{GY under control N level}}{\text{High N level}}$$

Where, GYRI: Grain yield response index, GY: Grain Yield.

High added N level = 120 kg N fed^{-1} and under control N level = 0 kg N fed^{-1}.

Statistical analysis

A combined analysis of variance was computed over two seasons according to Snedecor and Cochran (1980). On the other hand, Levene test (1960) was used to satisfy the assumption of homogeneity of variances before running the combined analysis. In this research several statistical analysis were used in order to show the presence or absence of correlations among different dependent variables of maize. Variance analysis was applied, and then the correlation analysis was used according to

Draper and Smith (1966). Analysis of variance of data and mean comparison were done using MSTAT-C and SPSS programs. Mean comparisons for the traits were done according to Duncan's Multiple Range Test at $P \leq 0.05$ (Duncan, 1955).

RESULTS AND DISCUSSION

Nitrogen levels and humic treatments had significant effects on grain yield and agronomic traits of maize (variance analysis table not shown). On the other hand, the effect of N fertilization at both locations is shown in Figures 5 and 6.

Effect of evaluated treatments on grain yield and yield components

Significance of F-values for evaluated traits at Ismailia and Gemmeiza 2012 and 2013 seasons are shown in Table 2. The results of Levene test (1960) confirmed the homogeneity of variances for all studied traits, which allowed applying the combined analysis.

Table 2. Significance of F-values from ANOVA for ear length (EL), number of rows per ear (RPE), number of kernels per row (KPR), kernels weight (KWT), kernels per ear (KPE), and grain yield (GY) at two locations (Ismailia and Gemmeiza) over two seasons (2012 and 2013).

Location	Ismailia						Gemmeiza					
Year	2012			2013			2012			2013		
Trait	H	N	H*N	H	N	H*N	H	N	H*N	H	N	H*N
El	**	**		**	**						**	
RPE •	**	**		**	**	*		**		*	**	
KPR	**	**			**	**		**	**		**	
KWT		**	**	**	**	*	**	**	*	*	**	*
KPE		**		*	**		*	**		*	**	
GY	**	**	**	**	**	**	**	**	**	**	**	**

H: Humic treatments, N: Nitrogen levels and H*N: Interaction.

Effect of humic acid treatments

Data in Table 3 show the effect of humic acid treatments on the studied traits of maize at Ismailia and Gemmeiza over two seasons. Humic treatments were significantly higher than the control at both locations, indicating that evaluated treatments significantly increased grain yield and its components. Maximum values of ear length, number of kernels per row, kernels weight, kernels per ear and grain yield were observed for the H_4 treatment (soaking seeds in humic acid + spraying humic acid) treatment of humic acid at Ismailia location. Similarly, at Gemmeiza, (soaking seeds in humic acid + spraying humic acid) treatment recorded the highest values for ear length, number of rows ear^{-1}, kernels weight, kernels ear^{-1} and grain yield (Table

3). The 4th treatment (soaked/sprayed seed) recorded the highest values for ear length, kernels weight, kernels per ear, and grain yield at Ismailia and Gemmeiza over both seasons. The response of maize plants to humic acid may be attributed to humic acid effect on improving physiological activities through induction of lateral roots emergence, increase of cell respiration and membrane uptake of nutrients and exertion of hormones. However, Gemmeiza results had values higher than those at Ismailia.

Table 3. Mean comparison of the effects of humic acid treatments on grain yield traits at Ismailia and Gemmeiza over years.

Location	level	El	RPE	KPR	KWT	KPE	GY
Ismailia	H1	16.8c	13.5c	35.4b	255c	498a	17.16b
	H2	17.5b	14.1a	34.6b	277b	535a	18.71b
	H3	17.5b	14.1a	35.4b	278b	535a	18.99b
	H4	18.8a	13.8b	37.5a	299a	533a	22.22a
Gemmeiza	H1	20.6a	13.7b	45.0a	343c	613b	24.55c
	H2	21.3a	14.0ab	44.5a	356b	628b	28.44b
	H3	20.9a	14.0ab	44.3a	362ab	655a	30.56a
	H4	21.4a	14.2a	44.5a	369a	666a	31.31a

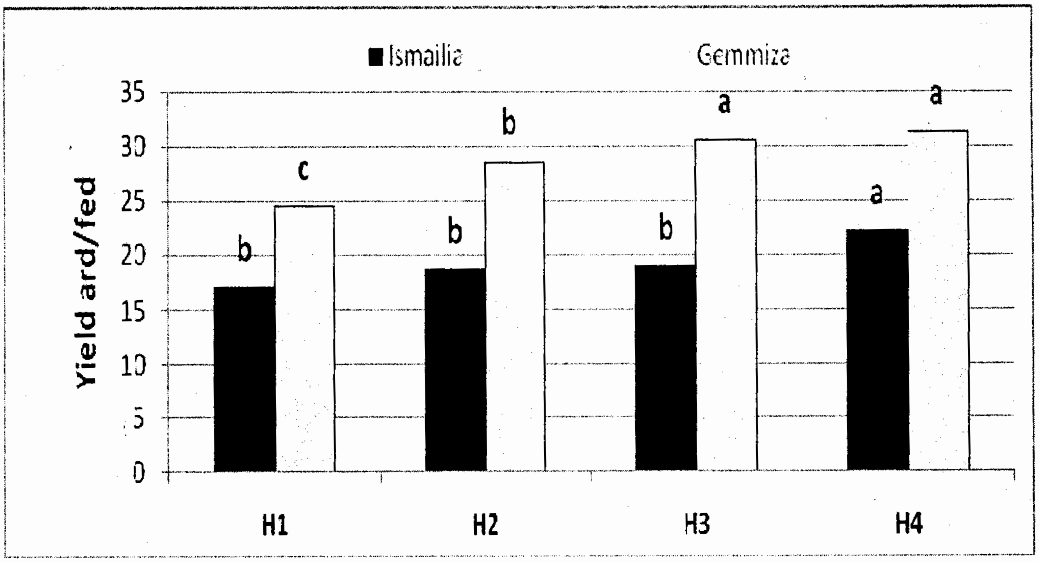
* Means in the same column with the same letter(s) within location are not significantly different at 0.05 level of probability..

Ear length (El), number of row per ear (RPE), number of kernels per row(KPR), kernels weight of ear (KWT), number of kernels per ear (KPE) and, grain yield (GY) .

H_1: control, H_2: Soaking, H_3: Spraying and H_4: Soaking + Spraying.

Figure (1) revealed that the 4th treatment (Soaking + Spaying) recorded the highest values for yield at Ismailia and Gemmeiza over both seasons. On the other hand, Gemmeiza results had values higher than those at Ismailia. The increase in the growth parameters of maize in the HA-amended treatments was most probably due to the improvement of soil condition of the root zone. Our results are supported by Selim *et. al.* (2009), Buyukkeskin & Akinci (2011), Çelik *et. al.* (2011), Tahir *et. al.* (2011), Yoon-Ha Kim *et. al.* (2012), Daur and Bakhashwaln (2013) and Ibrahim *et. al.* (2014) who have reported that HA increases crop growth and productivity.

Figure 1. Effect of humic treatments on grain yield at Ismailia and Gemmeiza, pooled data for 2012 and 2013 seasons.



H_1: control, H_2: Soaking, H_3: Spraying and H_4: Soaking + Spraying.

Effect of Nitrogen rates

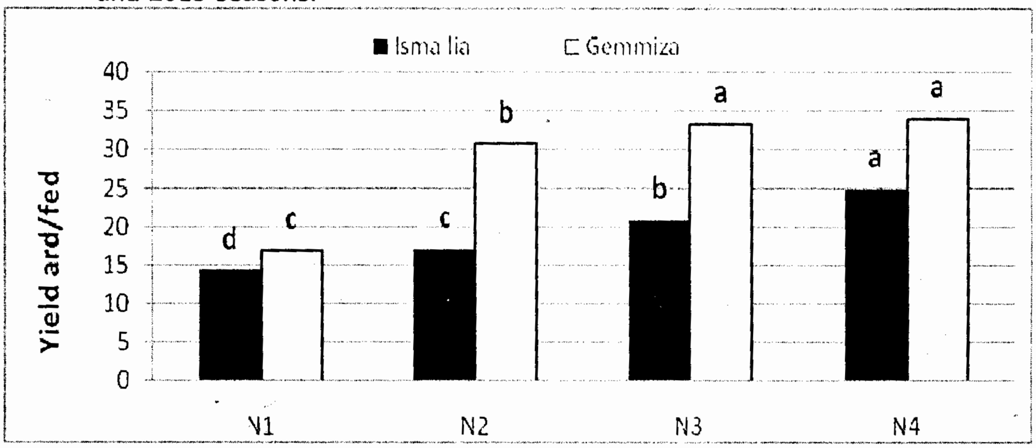
Mean performance of plants were significantly increased by increasing N levels (Table 4). The highest values for all studied traits were obtained under the 4th N level (120 Kg N fed.$^{-1}$), at Ismailia and Gemmeiza. There were significant responses to N with asserting the vital need for N application to maize production at Gemmeiza soil more than Ismailia (Figure 2). The results showed that elevating nitrogen level to the highest level (120 Kg N fed.$^{-1}$) enhanced grain yield of maize. These results clearly indicated the vital role of nitrogen in enhancing the meristematic activity and improved the vegetative growth of maize plants. This agrees with Hokmalipour and Darbandi (2011), Ghazal et. al. (2013) and Ibrahim *et. al.* (2014).

Table 4. Mean comparison of the effect of nitrogen fertilizer on maize yield traits at Ismailia and Gemmeiza over years.

Location	level	El	RPE	KPR	KWT	KPE	GY
Ismailia	N1	16.0d	13.2d	30.9d	236 d	444d	14.29d
	N2	16.9c	13.8c	33.8c	270c	502c	17.08c
	N3	18.2b	14.3a	36.9b	289b	541b	20.80b
	N4	19.5a	14.1b	41.3a	314a	615a	24.91a
Gemmiza	N1	20.6b	11.6c	40.1c	255c	529d	16.94c
	N2	21.0ab	14.3b	45.2a	380b	634c	30.68b
	N3	21.2ab	15.0a	46.5a	396a	684b	33.28a
	N4	21.4a	14.9a	46.5ab	398a	715a	34.08a

* Means in the same column with the same letter(s) within location are not significantly different at 0.05 level of probability.
Ear length (El), number of row per ear (RPE), number of kernels per row(KPR), kernels weight of ear (KWT), number of kernels per ear (KPE), grain yield (GY).
N_1: 0 , N_2: 60, N_3: 90 and N_4: 120Kg fed^{-1}.

Figure 2. Effect of N rates on maize grain yield at two locations, pooled data for 2012 and 2013 seasons.



N_1: 0, N_2: 60, N_3: 90 and N_4: 120Kg fed^{-1}.

Effect of humic acid X nitrogen interaction

Effect of humic treatments X N interaction on grain yield at both locations in 2012 and 2013 seasons is shown in Table 5. Results indicated that the interaction of humic × N was significant for grain yield in both seasons. Evaluated N rates affected grain yield (Figure 3) and the best values were obtained with the highest evaluated rates. In general, it could be noticed that the application of humic acid and nitrogen fertilizer can positively affect the maize yield, especially for the Soaking + Spaying treatment, that received 120 kg N per fed + humic acid soaking/humic acid spray (Figure 3). This agrees with results of Gazal *et. al.* (2013) and Ibrahim *et. al.* (2014).

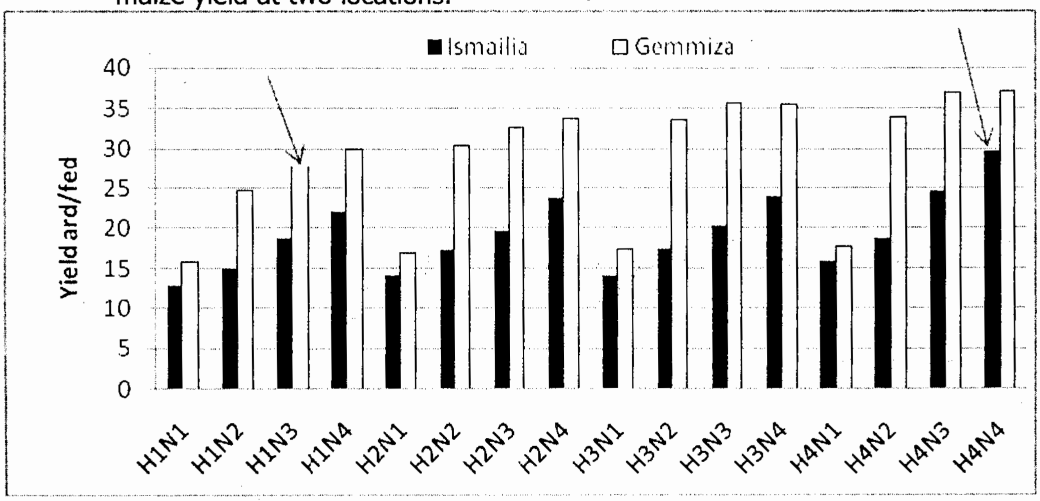
However, maize productivity was improved in sandy soil (Ismailia) by using the 4th treatment (Soaking/Spraying).

Table 5. Interaction between the tested humic acid treatments and nitrogen levels on grain yield at Ismailia and Gemmeiza in 2012 and 2013.

Location	Ismailia			Gemmeiza		
Treatment	2012	2013	Comb.	2012	2013	Comb.
	Grain yield (ard. fed.$^{-1}$)					
H1N1	11.69	14.13	12.91	16.14	15.47	15.81
H1N2	13.57	16.23	14.90	25.91	23.50	24.71
H1N3	19.52	18.00	18.76	28.39	27.10	27.75
H1N4	22.73	21.40	22.07	29.83	30.03	29.93
H2N1	12.657	15.67	14.17	16.98	16.69	16.84
H2N2	15.46	19.00	17.23	29.72	31.13	30.43
H2N3	20.91	18.30	19.61	30.82	34.57	32.69
H2N4	24.56	23.13	23.85	32.19	35.43	33.81
H3N1	13.60	14.73	16.17	17.51	17.23	17.37
H3N2	16.00	18.93	19.47	31.30	35.83	33.57
H3N3	21.28	19.30	22.29	33.78	37.5	35.64
H3N4	25.36	22.70	26.03	33.56	37.47	35.51
H4N1	14.91	16.95	19.93	17.97	17.55	17.76
H4N2	17.89	19.53	22.71	32.13	35.9	34.01
H4N3	25.62	23.43	28.53	34.55	39.53	37.04
H4N4	30.74	28.63	33.69	33.99	40.17	37.08

H_1: control, H_2: Soaking, H_3: Spraying and H_4: Soaking + Spraying.
N_1: 0, N_2: 60, N_3: 90 and N_4: 120Kg fed^{-1}.

Figure 3. Interaction between the tested humic acid treatments and nitrogen levels on maize yield at two locations.



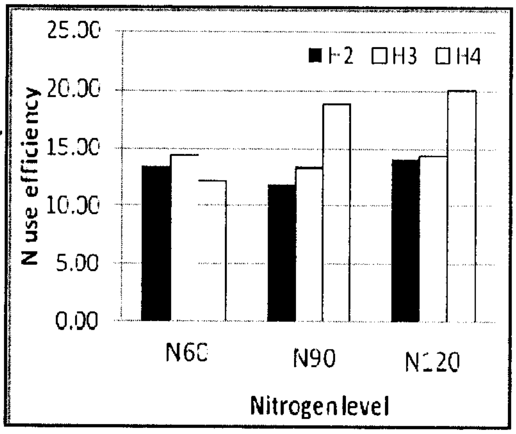
Performance of N-use efficient maize under humic and high N

Nitrogen levels had significant effects on grain yield, agronomic characteristics, and nitrogen use efficiency of maize. The response of grain yield to nitrogen rates was significant. Grain yield ranged between 12.91 and 29.69 ard fed.$^{-1}$ at Ismailia, and between 15.80 and 37.08 ard fed.$^{-1}$ at Gemmeiza. Maximum grain yield was recorded at the highest nitrogen level (120 kg N fed.$^{-1}$) with (soaking seeds and spraying of humic acids (treatment 4). Except for, grain yield under N (120 kg N fed.$^{-1}$) and the 4th treatment (soaking/spray) at Ismailia had higher grain yield under N (120 kg fed.$^{-1}$) without humic treatment at Gemmeiza.

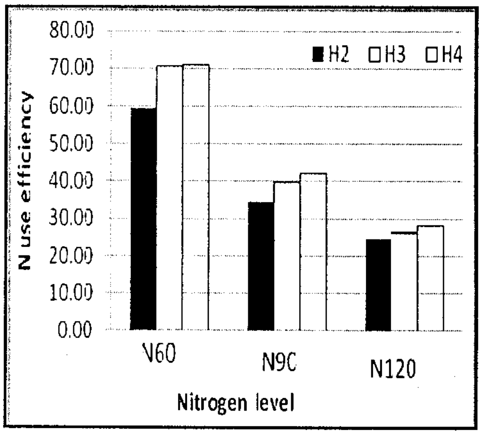
Nitrogen use efficiency (NUE)

Results showed that (NUE) was affected by humic treatments, nitrogen fertilizer rates, and the interaction between humic acids, and N. Mean comparison in treatment combination of humic × nitrogen indicated that NUE values at Gemmeiza was higher than Ismailia. Nitrogen use efficiency value was fluctuating at Ismailia, whereas, at Gemmeiza, maximum nitrogen use efficiency (59.46 kg /kg) was recorded at the application of 60 kg N fed^{-1} under (H_2) soaking seeds in humic acid 1000 ppm for 24 hrs before planting. Similarity under H_3 (spraying humic acid 1000 ppm at 21 days after planting) and H_4 (soaking seeds in humic acid 1000 ppm for 24 hrs before planting + spraying humic acid 1000 ppm at 21 days after planting) recorded NUE (70.88 and 71.09 kg/kg) at 60 kg N fed.$^{-1}$ and became (26.45 and 28.18 kg/kg) at 120 kg N fed^{-1} (Figure 4). These results agree with the findings of Raun and Johnson (1999); Pierce and Rice (1988), who reported that increasing N rates decreased NUE in cereals. Lopez-Bellido and Lopez-Bellido (2001) indicated that a decrease in NUE with increasing fertilizer rates is because yield rises less than the N supply in soil and fertilizer. Sowers *et. al.* (1994); Zhao *et. al.* (2006) reported similar results and indicated that NUE decreased with increasing N rates. Meanwhile, humic treatments increased NUE. Then, grain yield response index (GYRI) at Figure 5 revealed increasing values at Gemmiza more than Ismailia.

Figure 4. Mean comparison of treatment compound of humic ×nitrogen application on nitrogen use efficiency in two locations.



Ismailia

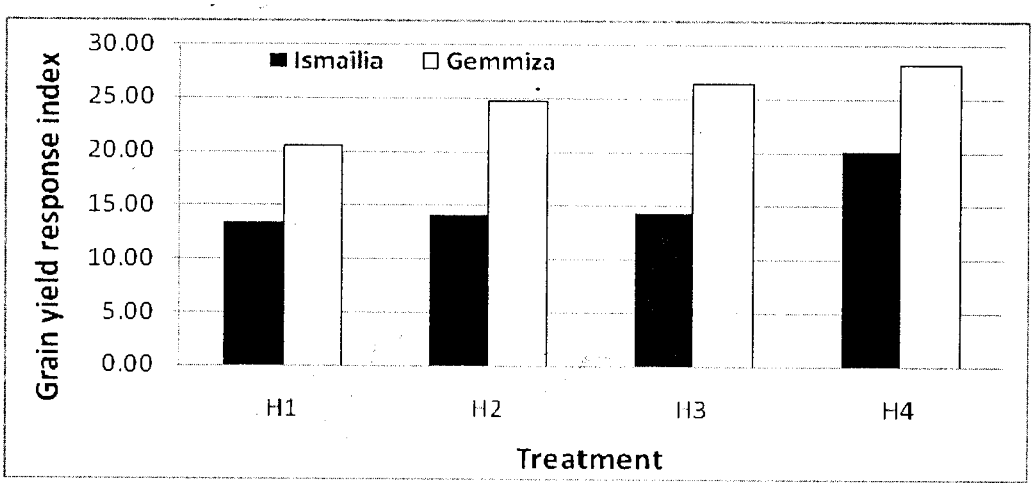


Gemmiza

Response of grain yield

Grain yield response index (GYRI) in Figure 5 revealed increasing values at Gemmeiza more than Ismailia. The response of grain yield to nitrogen rates was significant. Grain yield ranged between 13.4 and 20.07 ard fed.$^{-1}$ at Ismailia, and between 20.6 and 28.2 ard fed.$^{-1}$ at Gemmeiza. Maximum grain yield was recorded at the highest nitrogen levels (120 kg N fed.$^{-1}$) with (soaking seeds and spraying of humic acids (treatment 4). Grain yield under N (120 kg N. fed.$^{-1}$) and 4th treatment (soaking/spray) at Ismailia recorded high value (33.7 ard fed.$^{-1}$) more than grain yield under N (120 kg fed.$^{-1}$) without humic treatment at Gemmeiza.

Figure 5. Means comparison of grain yield response index (GYRI) under treatment combination of humic× nitrogen at two locations.



CONCLUSION

Nitrogen rates used in this experiment showed a significant increase in grain yield compared to the control without N. The relationship between locations and seasons indicated that grain yield was increased with increasing N rates. Moreover, these results suggest that the adequate N rate was 120 kg N fed^{-1} at both Ismailia and Gemmeiza. For humic treatments in maize crop, the highest productivity was obtained from the 4^{th} treatment (soaked/sprayed seed) that also improved most yield traits (ear length, kernels weight, kernels per ear and grain yield) at Ismailia and Gemmeiza over seasons. At Gemmeiza, high nitrogen rates decreased NUE indicating that grain yield response was less than the N supply to the soil under all humic treatments. Meanwhile, maize yield in sandy soil (Ismailia) was generally improved with the application of HA. Results confirmed that grain yield response was greater at Gemmeiza than it was at Ismailia.

REFERENCES

1. Abd El-Aal F.S., M.R. Shafeek, A.A. Ahmed, A.M. Shaheen. 2005. Response of growth and yield of onion plants to potassium fertilizer and humic acid. J. Agric. Sci. Mansoura Univ., 30(1):441-452.
2. Bacilio, M., P. Vazquez and Y. Bashan. 2003. Alleviation of noxious effects of cattle ranch composts on wheat seed germination by inoculation with Azospirillum spp. Biol Fertil Soils, 38:261-266.
3. Buyukkeskin, T. and S. Akinci. 2011. The effects of humic acid on above-ground parts of broad bean (*Vicia faba* L.) seedlings under Al (3+) toxicity. *Fresenius Env. Bull.*, 20(3):539-548.
4. Çelik, H., K.A. Vahap, A.B. Bulent and M.A. Turan. 2011. Effect of foliar-applied humic acid to dry weight and mineral nutrient uptake of maize under calcareous soil conditions. Comm. Soil Sci. Plant Anal., 42(1):29-38.
5. Chen, J. 2006. The combined use of chemical and organic fertilizers for crop growth and soil fertility. Int. Workshop on Sustained Management of the Soil-Rhizosphere System for Efficient Crop Production and Fertilizer Use. 16-20 October, 2006. Thailand.
6. Craswell, E.T. and D.C. Godwin. 1984. The efficiency of nitrogen fertilizers applied to cereal in different climates. In Tinker. P. B. and A. Luchli (ed) Advanced in plant Nitration Vol. 1.
7. Daur, I. and A.A. Bakhashwaln. 2013. Effect of humic acids on growth and quality of maize fodder production. Pak. J. Bot., 45(S1):21-25.

8. Delfine, S., R. Tognetti, E. Desiderio and A. Alvino. 2005. Effect of foliar application of N and humic acids on growth and yield of durum wheat. Agron. Sustain. Dev., 25(2):183-191.
9. Draper, N.R., Smith, H. 1966. Applied Regression Analysis. Wiley, New York 7407.
10. Duncan, D. B. 1955. Multiple ranges and multiple F test. Biometrics. 11:1-42.
11. El-Kholy, M.A., S. El-Ashry and A.M. Gomaa. 2005. Biofertilization of maize crop and its impact on yield and grains nutrient content under low rates of mineral fertilizers. J. Appl. Sci. Res., 1:117-128.
12. Enwezor, W.O., E.J. Udo, N.J. Usoro, J.A. Ayotade, V.O. Chude, and C.C. Udegbe. 1989. Fertilizer use and management Practices for Crops in Nigeria. Series 2. Federal Ministry of Agriculture, Water Resources and Rural Development, 52-56.
13. Fageria, N.K. and M.C. Filho. 1981. Screening rice cultivars for higher efficiency of phosphorus absorption. Pesq. Agropec. Bras. Brasilia, 26:777-782.
14. Fong, S.S., L. Seng and H.B. Mat. 2007. Reuse of Nitric Acid in the Oxidative Pretreatment Step for Preparation of Humic Acids from Low Rank Coal of Mukah, Sarawak. J. Braz. Chem. Soc., 18(1):41-46.
15. Ghazal, F.M., M.B.A. El-Koomy, Kh. A. Abdel-Kawi and M.M. Soliman. 2013. Impact of Cyanobacteria, Humic Acid and Nitrogen Levels on Maize (*Zea Mays* L.) Yield and Biological Activity of the Rhizosphere in Sandy Soils. Journal of American Science 2013; 9(2)
16. Ghorbani, S. Khazaei, H. Kafi, M. BanayanAwal, M. 2010. Effect of Humic acid irrigation water on yield and yield components in maize. Agricultural Ecology J. 2(1):123-131
17. Hafez, M.M. 2003. Effect of some sources of nitrogen fertilizer and concentration of humic acid on the productivity of plant. Egypt J. Appl. Sci. 19(10):293-309.
18. Hokmalipour, S. and H. Maryam Darbandi. 2011. Investigation of nitrogen fertilizer levels on dry matter remobilization of some varieties of corn (*Zea mays* L.). World Appl. Sci. J., 12: 862-870. Journal of American Science 2013; 9(2)
19. Humintech. 2012. Is it possible to replace Humus with organic manure? http://www.humintech.com/001/industry/information/ faq.html#top (accessed 02 Feb, 2012).
20. Ibrahim, H.E.A., Z.E. Ghareeb and H. KH.A. El- Mekser. 2014. Stepwise analysis of maize under different under different humic acid treatments and nitrogen rates Bull. Fac . Agric., Cairo Univ. 65:1-9
21. Islam, K.M.S., A. Schuhmacher and J.M. Gropp. 2005. Humic acid substances in animal agriculture. Pakistan Journal of Nutrition, 4(3):126-134.
22. Johnson, H.J., J.B. Colquhoun, and A.J. Bussan. 2012. The feasibility of organic nutrient management in large-scale sweet corn production for processing. *Horttech.*, 22(1):25-36.

23. Kozdro, J., J.T. Trevors, and J.D. Van-Elsaa. 2004. Influence of introduced potential biocontrol agents on maize seedling growth and bacterial community structure in the rhizosphere. Soil Boil. Biochem, 36:1775-1784.
24. Levene, H. 1960. Robust tests for equality of variances. In Ingram Olkin, Harold Hotelling, Etalia, Stanford Universitypress. pp. 278-292.
25. Levinsky, B. 12009. All about humates. Focus on form: Retrieved May 27, 2009, from http://www.teravita.com/Humates/HumateIntro.htm.
26. Ludibeth, S.M., I.E. Marina and E.M. Vicenta. 2012. Vermi composting of sewage sludge: earthworm population and agronomic advantages. *Compost Sci. Util.*, 20(1):11-17.
27. Lopez-Bellido R.J, L. Lopez-Bellido. 2001. Efficiency of nitrogen in wheat under Mediterranean condition: Effect of tillage, crop rotation and N fertilization. Field Crops Research. 71(1):31-64.
28. Page A.L., R.H. Miller and D.R. Keeney. 1982. "Methods of Soil Analysis" Part I: "Soil Physical Analysis" & Part II: "Chemical and Microbiological Properties". Soil Sci. Amer. Madison, Wisconsin, U.S.A.
29. Pierce F.J, C.W. Rice. 1988. Crop rotation and its impact on efficiency of water and nitrogen use. In: Hargrove (Ed.), Cropping Strategies forEfficient Use of Water and Nitrogen . ASA, Special Publication No.15,Wisconsin, pp.101-113.
30. Pizzeghello, D., G. Nicolini and S. Nardi. 2001. Hormone-like activity of humic substances in Fagus sylvaticae forests. New Phytologist, 151:647-657.
31. Raun, W.R, G.V. Johnson. 1999. Improving nitrogen use efficiency for cereal production. Agronomy Journal, 91:357-363.
32. Selim, E.M., A.A. Mosa and A.M. El-Ghamry. 2009. Evaluation of humic substances fertigation through surface and subsurface drip irrigation systems on potato grown under Egyptian sandy soil conditions. *Agr. Water Manage.*, 96:1218-1222.
33. Snedecor, G.W. and W.G. Cochran. 1980. Statistical Methods. 7th ed. Iowa State Univ. Press, Ames., Iowa, USA.
34. Sowers, K.E, W.L. Pan, B.C. Smith. 1994. Nitrogen use efficiency of split nitrogen applications in soft white winter wheat. Agronomy Journal, 86 - 942-948.
35. Tahir, M.M., M. Khurshid, M.Z. Khan, M.K. Abbasi and M.H. Kazmi. 2011. Lignite-derived humic acid effect on growth of wheat plants in different soils, Pedosphere, 21(1):124-131.
36. Yoon-Ha. Kim, Y.H., A.L. Khan, Z.K. Shinwari, D.H. Kim, M. Waqas, M. Kamran and In-J. Lee. 2012. Silicon treatment to rice (Oryza sativa L. cv 'Gopumbyeo') plants durin different growth periods and its effects on growth and grain yield. Pak. J. Bot., 44(3):891-897.
37. Zhao R.F, X.P. Chen, F.S. Zhang, H. Zhang, J. Schroder, V. Romheld. 2006. Fertilization and N balance.

23. Kozdro, J., J.T. Trevors, and J.D. Van-Elsaa. 2004. Influence of introduced potential biocontrol agents on maize seedling growth and bacterial community structure in the rhizosphere. Soil Boil. Biochem, 36:1775-1784.
24. Levene, H. 1960. Robust tests for equality of variances. In Ingram Olkin, Harold Hotelling, Etalia, Stanford Universitypress. pp. 278-292.
25. Levinsky, B. 12009. All about humates. Focus on form: Retrieved May 27, 2009, from http://www.teravita.com/Humates/HumateIntro.htm.
26. Ludibeth, S.M., I.E. Marina and E.M. Vicenta. 2012. Vermi composting of sewage sludge: earthworm population and agronomic advantages. *Compost Sci. Util.*, 20(1):11-17.
27. Lopez-Bellido R.J, L. Lopez-Bellido. 2001. Efficiency of nitrogen in wheat under Mediterranean condition: Effect of tillage, crop rotation and N fertilization. Field Crops Research. 71(1):31-64.
28. Page A.L., R.H. Miller and D.R. Keeney. 1982. "Methods of Soil Analysis" Part I: "Soil Physical Analysis" & Part II: "Chemical and Microbiological Properties". Soil Sci. Amer. Madison, Wisconsin, U.S.A.
29. Pierce F.J, C.W. Rice. 1988. Crop rotation and its impact on efficiency of water and nitrogen use. In: Hargrove (Ed.), Cropping Strategies forEfficient Use of Water and Nitrogen . ASA, Special Publication No.15,Wisconsin, pp.101-113.
30. Pizzeghello, D., G. Nicolini and S. Nardi. 2001. Hormone-like activity of humic substances in Fagus sylvaticae forests. New Phytologist, 151:647-657.
31. Raun, W.R, G.V. Johnson. 1999. Improving nitrogen use efficiency for cereal production. Agronomy Journal, 91:357-363.
32. Selim, E.M., A.A. Mosa and A.M. El-Ghamry. 2009. Evaluation of humic substances fertigation through surface and subsurface drip irrigation systems on potato grown under Egyptian sandy soil conditions. *Agr. Water Manage.*, 96:1218-1222.
33. Snedecor, G.W. and W.G. Cochran. 1980. Statistical Methods. 7th ed. Iowa State Univ. Press, Ames., Iowa, USA.
34. Sowers, K.E, W.L. Pan, B.C. Smith. 1994. Nitrogen use efficiency of split nitrogen applications in soft white winter wheat. Agronomy Journal, 86 - 942-948.
35. Tahir, M.M., M. Khurshid, M.Z. Khan, M.K. Abbasi and M.H. Kazmi. 2011. Lignite-derived humic acid effect on growth of wheat plants in different soils, Pedosphere, 21(1):124-131.
36. Yoon-Ha. Kim, Y.H., A.L. Khan, Z.K. Shinwari, D.H. Kim, M. Waqas, M. Kamran and In-J. Lee. 2012. Silicon treatment to rice (Oryza sativa L. cv 'Gopumbyeo') plants durin different growth periods and its effects on growth and grain yield. Pak. J. Bot., 44(3):891-897.
37. Zhao R.F, X.P. Chen, F.S. Zhang, H. Zhang, J. Schroder, V. Romheld. 2006. Fertilization and N balance.

١-١ تأثير التسميد الأزوتي وحمض الهيوميك على إنتاجية محصول الذرة الشامية

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١. *قسم بحوث الذرة الشامية – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية – الجيزة – مصر*

٢. *المعمل المركزي لبحوث التصميم والتحليل الإحصائي – مركز البحوث الزراعية – الجيزة – مصر*

أجريت تجربة حقلية في محطتى البحوث الزراعية بكل من الاسماعيلية ممثلة للأراضي الجديدة (الرملية) والجميزة ممثلة للأراضي القديمة (الطينية) خلال موسمي الزراعة ٢٠١٢ و ٢٠١٣ لدراسة تأثير أربع معاملات من حامض الهيوميك (كنترول – نقع البذرة قبل الزراعة – رش ورقي بعد الزراعة – نقع/رش) على محصول الذرة (هجين فردى ١٦٦) تحت أربعة مستويات من التسميد النيتروجينى (٠ – ٦٠ – ٩٠ – ١٢٠ كجم/فدان) باستخدام تصميم القطع المنشقة فى ثلاثة مكررات. أوضحت النتائج أن معاملتي التسميد النيتروجيني والهيوميك سجلتا زيادة معنوية للمحصول ومكوناته فى كلا الموقعين، ولكن نتائج الجميزة كانت أعلى من الاسماعيلية. أوضح تحليل المواقع والسنوات أن المحصول يزداد بزيادة المعدل النيتروجيني، فى حين أن المعدل المناسب كان ١٢٠ كجم نيتروجين/ف بكلا الموقعين. وسجلت المعاملة الرابعة (نقع/رش) أعلى القيم بالنسبة للمحصول ومكوناته (طول الكوز، وزن الحبوب، عدد الحبوب بالكوز، محصول الحبوب) بالموقعين خلال السنتين. عموما تم زيادة محصول حبوب الذرة بزيادة معدل التسميد النيتروجيني إلى ١٢٠ كجم/ف مع استخدام المعاملة بالهيوميك (نقع/رش) بكلا الموقعين. كما أظهرت النتائج أنه يمكن تحسين إنتاجية محصول الذرة فى الأراضي الرملية (الاسماعيلية) باستخدام المعاملة الرابعة (نقع/رش) مع معدل التسميد النيتروجيني ١٢٠ كجم/ف ليصل لإنتاجية الأراضي الطميية (الجميزة) ولكن بدون استخدام الهيوميك. كما أظهرت النتائج أيضا أن معاملة النيتروجين العالية تقلل من كفاءة استخدام محصول الذرة للنيتروجين فى الجميزة مما يدل على أن هذا النقص فى كفاءة استخدام النيتروجين هو نتيجة أن المحصول يزداد بمعدل أقل من الإمداد النيتروجيني للتربة، وذلك عند كل معاملة هيوميك. كذلك أوضحت النتائج أن الاستجابة المحصولية للذرة فى الجميزة كانت أعلى من تلك المتحصل عليها في الاسماعيلية.