

PARTIAL SUBSTITUTION OF MINERAL NITROGEN FERTILIZER BY ORGANIC AND BIO-FERTILIZER ON MAIZE

Dalia A. Sayed; Lamyaa, A. Abd El-Rahman and Magda, A. Ewais
Soils, Water and Environ. Res., Institute, Agric. Res. Center, Giza, Egypt



ABSTRACT

Two field experiments were conducted to study the effect of bio and organic fertilizer as a partial alternative to mineral-nitrogen fertilizer, on growth, yield and quality of maize plants (c.v. tri- hybrid 324). The study was carried out during the two successive seasons of 2013 and 2014 at El- Gemmeiza Research Station (30° 47' 22.5" N- 31° 07' 34" E, elev. 10 m), Agricultural Research Center, El-Gharbia Governorate, Egypt. Significant positive influences of 50% of the recommended N rate (120kg N/fed.) +25% of the recommended N rate as organic N +Bio treatment were observed on growth traits after 75 days from planting, leaf contents of nitrogen, phosphorus, potassium and yield quality when compared to the other combined treatments. The same treatment, gave the highest grain yield (4450 Kg/fed) which was 9.88 % higher than the (100% mineral N) control (4050 Kg/fed) and 51.4% more than the lowest yield of 50% M.N.F. (2940 Kg/fed). Also, results indicated that the treatments comprising 50 or 75% mineral N + 4.2 or 2.1 ton/fed. organic N +Bio and/or humic acid significantly increased plant height, weight of 100 grain, grains, straw and biological yields than control. All quality parameters i.e. protein, oil %, total carbohydrate and starch contents under 50% mineral N + 4.2 ton/fed. organic N +Bio and/or humic acid treatments recorded the highest and significant values comparing to the control. Hence, it can be concluded that organic and biofertilizers could be used to minimizing the amount of mineral N fertilizer for different crops avoiding soil or water pollution.

Keywords: Biofertilizer, humic acid, minerals content, oil, organic manure, protein, Zea mays,

INTRODUCTION

Maize is called "King of cereals" because of its productivity potential compared to any other cereal crop. Being an exhaustive crop, it has very high nutrient requirement and its productivity is closely depends on nutrient management system. Under the present trend of exhaustive agriculture in Egypt, inherent soil fertility can no longer be maintained on the sustainable basis. It is said that nutrient supplying capacity of soil declines steadily under continuous and intensive cropping system. The optimum levels of N, P, K failed to maintain yield levels probably due to increasing secondary and micronutrient deficiencies and also unfavorable alterations in the physical and chemical properties of soil. Apart from the soil fertility and productivity issues, use of chemical fertilizers is also becoming more and more difficult for the farmers due to their high costs and scarcity during peak season. On thus, increasing awareness is being created on the use of organics including biofertilizers which are the sources of macro, micro and secondary nutrients to sustain the soil fertility and productivity.

Mineral nutrition is one of the most important factors for 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 (Hartman, 1988). An attention has been therefore focused on alternative fertilizers, including bio-fertilizers in Middle East. Nowadays, there is renewed interest in bio fertilizers for nutrient supply and improve soil fertility and productivity in this region. The integrated use of bio-fertilizers and mineral fertilizers is considered the best option not only to reduce the intensive consumption of chemical fertilizers, but also to sustain the soil with minimum undesirable impacts and to maximize fertilizer use efficiency in soil. Bio-fertilizers are considered as an eco-friendly way to sustainable agriculture. They positively affect plant growth and yield, reduce the negative effects of chemical fertilizers and minimize some chemicals such as NO_3^- and NO_2^- ions in the soil and consequently in plants. Therefore, the way to a healthy agriculture with a minimum pollution requires a conjunctive use of bio-nitrogen and mineral-nitrogen fertilizers.

Bio-fertilizers, microbial inoculants that can promote plant growth and productivity, are internationally accepted as an alternative source of N-fertilizer. In the bio-fertilizer technology, new systems are being developed to increase the biological N_2 -fixation with cereals and other non-legumes by establishing N_2 -fixing bacteria within the roots (El-Haddad *et al.*, 1993).

Organic matter also improves water holding capacity of sandy soil and drainage in clayey soil. Organic manure provides nutrients for the soil micro-organisms, thus increases the activities of microbes in soil, which in turn help to convert unavailable plant nutrients into available form for plant growth promotion.

Humic acid (HA) is a vital constituent and an intimate part of soil organic structure. It has been used by many scientists, agronomists and farmers for improving soil conditions and plant growth. In plants, humic acids have positive effects on enzyme activity, plant nutrients, and growth stimulant and are considered as a "plant food". Humates are most responsive in high carbohydrate crops like potato, carrot, maize, rice, wheat, etc. (Sharif *et al.*, 2003). Humic acid contains 51% to 57% C, 4% to 6% N and 0.2% to 1% P and other micronutrients in minute amounts. Application of $1.0 \text{ kg} \cdot \text{ha}^{-1}$ to the soil can bring appreciable increase (up to 20%) in yields of wheat, maize, cotton, sugar beet and groundnut and improvement in soil physico-chemical conditions. Application of such minute amounts of HA suggests its enzymatic characteristics. Treating seeds with HA may further increase its beneficial effects to enhance crop yield, (Kaya and Khawar 2005).

Therefore, the objective of this study was to investigate the possibility of using bio and organic fertilization partially instead of recommended N mineral fertilizers on growth, yield and quality of maize.

MATERIALS AND METHODS

Field Experiments

Two field experiments were conducted at El-Gimmeiza Research Station, Agricultural Research Center, El-Gharbia Governorate, Egypt, during the two successive seasons of 2013 and 2014, to study the possibility of using bio and organic fertilization as a partial alternative to mineral-nitrogen fertilizer on growth, yield and quality of maize plants (c.v. tri-hybrid 324).

The experiments included 11 treatments as follows:

- T₁. 100%M.N.F. (control represents a recommended rate) =120kgN/fed (Urea source).
- T₂. 75%M.N.F. (Mineral N fertilizer)
- T₃. 50%M.N.F.
- T₄. 50%M.N.F. + 0.1% HA (potassium humate as foliar 0.1%)
- T₅. 50%M.N.F. + Bio. (containing 10^7 cfu ml⁻¹ from each bacterium)
- T₆. 50%M.N.F. + 0.1% HA+ Bio
- T₇. 50%M.N.F. + 50 % O.N.F. (4.2 ton/fed organic N fertilizer)
- T₈. 50%M.N.F. + 25 % O.N.F. (2.1 ton/fed organic N fertilizer) + Bio.
- T₉. 75%M.N.F + 0.1% HA
- T₁₀. 75%M.N.F+ 0.1% HA + Bio
- T₁₁. 75%M.N.F. + 25 % O.N.F

The treatments were arranged in a completely randomized block design with three replicates. Randomized samples were taken from the experimental soils before sowing and compost to determine the physical and chemical properties according to Jackson, (1973) as shown in Tables (1 & 2). The organic manure (compost) was thoroughly mixed with 0-20 cm soil surface layer two weeks before sowing.

Super phosphate (15 %P₂O₅) was added as a single dose at the rate of 30 kg P₂O₅ /fed and mixed in the same time with such surface layer. The nitrogen fertilizer (as urea 46%N) was added according to the treatment in three equal portions, i.e. 21, 35 and 50 days after sowing. Also, potassium fertilizer (as potassium sulphate, 48% K₂O) was added at a rate of 24kg K₂O/fed., which was divided into three equal portions applied with N fertilizer. Foliar spray of potassium humate 0.1% was done on 30th, 45th and 60th days after sowing.

The compound of potassium humate granule contained of: 85% potassium humates, 12% potassium oxide, 1% iron, 0.9 organic nitrogen, 1.1% other compounds and with a pH= 7.0. As for bio fertilization, seeds of maize were inoculated with bio-nitrogen fertilizer (*Azotobacter chroococcum* + *Azospirillum brasilense*) (containing 10^7 cfu ml⁻¹ from each bacterium) were kindly obtained from Microbio. Dept., Soils, Water and Environ. Res. Instit. Agric. Res. Center, Giza, Egypt. Prior to sowing, maize

Table 1. Physical and chemical properties of the experimental soil

Property	Value
Particle size distribution (%)	
Sand	21.5
Silt	31.2
Clay	47.3
Texture grade	clay
pH(1:2.5 soil water suspension)	7.80
ECe (dS/m) (soil paste extract)	1.74
SP	40
Soluble cations (meq/L)	
Ca ⁺⁺	4.50
Mg ⁺⁺	3.50
Na ⁺	8.95
K ⁺	0.42
Soluble anions (meq/L)	
CO ₃	-
HCO ₃	0.5
Cl ⁻	9.5
SO ₄	7.37
Organic matter (%)	1.62
Available nutrient (mg/kg)	
N	45.00
P	7.35
K	375.00
DTPA-extractable ((mg/kg)	
Fe	3.74
Mn	1.94
Zn	0.78

Table 2. Physical and chemical properties of the compost

Properties	Values
EC value (1:10) (dS/m)	7.90
pH value (1:10)	6.70
Moisture content (%)	28.00
Organic matter (%)	44.48
Organic carbon (%)	25.80
Total nitrogen (%)	1.42
C/N ratio	18.20
Soluble ammonia-N (ppm)	615.00
Soluble nitrate-N (ppm)	362.00
P (%)	0.57
K (%)	0.82

Grains were inoculated by soaking in liquid culture of *Azospirillum* and *Azotobacter*. Arabic gum was added to liquid culture as adhesive agent. Inoculated grains were air dried by spreading over a plastic sheet for short time before planting. After 75 days from sowing, fresh and dry weights/plant were measured. N, P and K percentages in ear leaf were estimated in the digested plant material. At harvesting, the following characteristics were estimated:

1-Yield and its components:

Plant height (cm), ear characters (i.e., ear length (cm), ear diameter (cm), row number/ear and grain number /row), weight of 100 grain (g), grains, straw, biological yield (kg /fed.) and harvest index were measured.

II- Chemical analysis

- Grains and straw samples were digested with $H_2SO_4 + HClO_4$ mixture for chemical analysis to determine N, P and K contents, according to Chapman and Pratt, (1978).
- Nitrogen content in grains and straw was determined by Keldahl method as described by A.O.A.C (1990). Protein content in the grains was calculated by multiplying N% by 5.75 factor. Phosphorus was determined calorimetrically according to Chapman and Pratt, (1978). Potassium was determined by flam photometer according to Jackson (1973).
- Oil content (%) was determined by soxhelt apparatus using hexane as a solvent as described by A.O.A.C. (1990). Oil and protein yield (kg/fed.) was estimated by multiplying grain yield (kg/fed.) by grain oil and protein percentages respectively.
- Total soluble sugars and total carbohydrates content in the grains were also determined according to Smith *et al.* (1956). Starch content was obtained by calculating the difference between total carbohydrate and total soluble sugar content.

The obtained results were statistically analyzed according to Gomez and Gomez (1984) to define the statistical significance of L.S.D. at 0.05.

RESULTS AND DISCUSSION

Fresh and dry weights /plant and ear leaf NPK contents after 75 days from planting

The effect of mineral N, organic and bio-fertilizers on plant fresh and dry weights and ear leaf mineral content of maize plants after 75 days from planting is variable (Table 3). Data revealed that plants received T_8 (50% mineral N +25% compost N +Bio) recorded the highest values of these parameters followed by T_{10} (75%M.N.F+ 0.1% HA + Bio), T_{11} (75% mineral N +25% compost N) and T_1 (100% mineral N). The promotion of vegetative growth of maize plants after 75 days could be attributed to the effect of organic and non symbiotic N_2 -Fixing bacteria *Azotobacter* and *Azospirillum* in exerting a positive effect on plant growth through the synthesis of phytohormones, N_2 fixation, reduction of membrane potential of the root, synthesis of some enzymes (such as ACC deaminase) that modulate the level of plant hormones as well as the solubilization of inorganic phosphate

and mineralization of organic phosphate, which make phosphorus available to the plants (Hellal *et al.*, 2011). The increases in fresh and dry weights of maize plants by N application may be attributed to the beneficial effects of N on stimulating the meristematic activity for producing more tissues and organs, since N plays a major roles in the synthesis of structural proteins and other several macro molecules, in addition to its vital contribution in several biochemical processes in the plant related to growth. In this concern, fertilizing plants with (50% mineral N +25% organic N +Bio) gave the highest leaf N percentage compared with the other treatments followed by (75%M.N.F+ 0.1% HA + Bio), (75% mineral N +25% organic N) and 100% mineral N fertilizer (treatments 8, 10, 11 and 1 respectively). Phosphorus and potassium concentrations were also higher in plants fertilized with (M.N.F + 0.1% HA + Bio) or fertilized with M.N.F +organic fertilized compared to those received (M.N.F) alone. These results emphasized that the (M.N.F + 0.1% HA + Bio) or fertilized with M.N.F + Bio +organic fertilized treatments were great enough to reach the highest levels of N, P and K. This could be attributed to the release of organic acids that can either reduce pH of the surrounding soil or directly dissolve the mineral phosphate or due to the chelating property of the organic acids produced by bio such as acetate, lactate, oxalate and citrate. etc. The same trend was observed by Atiyeh *et al.*, (2002) who reported that the reason behind the effectiveness of humic acid on plant growth and development is the existence of plant growth regulators such as IAA, GAs and CKs. Moreover, some investigators attributed the positive effects of humic acid to its influence on plants root.

Table 3. Effect of mineral N and some organic accompanied with bio fertilizers on fresh and dry weights of maize plants (g/plant) and ear leaf mineral percentages of maize after 75 days from planting during 2013 and 2014 seasons

Treatments	Fresh weight (g/plant)	dry weight (g/plant)	N%	P%	K%
T ₁ 100%M.N.F. (control)	484	90	2.75	0.35	1.45
T ₂ 75%M.N.F.	377	77	2.46	0.33	1.35
T ₃ 50%M.N.F.	276	58	1.72	0.30	1.25
T ₄ 50%M.N.F. + 0.1% HA	294	60	1.88	0.42	1.32
T ₅ 50%M.N.F. + Bio.	369	67	2.46	0.38	1.36
T ₆ 50%M.N.F. + 0.1% HA+ Bio	394	76	2.65	0.45	1.54
T ₇ 50%M.N.F. + 50 % O.N.F	433	84	2.59	0.46	1.51
T ₈ 50%M.N.F. + 25 % O.N.F. + Bio	627	108	2.97	0.48	1.55
T ₉ 75%M.N.F + 0.1% HA	392	88	2.59	0.35	1.36
T ₁₀ 75%M.N.F+ 0.1% HA + Bio	531	101	2.95	0.46	1.52
T ₁₁ 75%M.N.F. + 25 % O.N.F	497	91	2.88	0.45	1.57
L.S.D at 5%	11.43	5.93	0.26	0.08	0.10

Yield and its components

Data in Table (4) show the effect of treatments on yield and yield components of maize (plant height, ear length, ear diameter, No. of row/ear, No. of grain /row, 100-grain weight, grain yield, biological yield and harvest index). The plant height varied significantly among the treatments and maximum plant height (267.33 cm, 265.67 cm, 264.5 cm and 264.33 cm

respectively), were recorded by T₈ (50% mineral +25% compost N +Bio), followed by T₁₀ (75%M.N.F+ 0.1% HA + Bio), T₁₁ (75% mineral +25% compost) and T₁ (100% mineral N) with no significant differences. The lowest value of plant height (226.67 cm) was observed with T₃ (50% mineral N). This indicates clearly that combined use of organic N, bio and humic acid increased the efficiency of fertilizer, solubilization and transport of nutrients and increased the plant height. The increase in plant height can be attributed to the fact that nitrogen promotes plant growth, increases the number and length of the internodes which results in progressive increase in plant height. Similar results were reported by Abdel Gader, (2007). The superiority of T₈ (50% mineral +25% organic N +Bio), T₁₀ (75%M.N.F+ 0.1% HA + Bio) or T₁₁ (75% mineral +25% organic) may be referred to the increase in microorganisms activity and increasing adsorbing capacity of essential nutrients against leaching. Moreover, adding mineral + organic fertilizer together improve the mineralization of organic-N. Furthermore, *Azotobacter* and *Azospirillum* could produce IAA and cytokinins which increase the surface area per unit root length and were responsible for root hair branching with an eventual increase in acquisition of nutrients from the soil. Maximum ear length (26.00 cm) was observed with T₈ (50% mineral +25% organic N +Bio), followed by T₁₁ (75% mineral +25% organic) and T₁₀ (75%M.N.F+ 0.1% HA + Bio respectively). The reason of more ear length may be due to more photosynthetic activities of the plant on the account of adequate supply of nitrogen in these treatments. A typical view of maize cob is that it serves as a temporary storage organ and as a conveyor of nutrients to the developing kernels. Therefore, the better development of cob length will be the index of the better economic yield of maize (Khan *et al.*, 2008). The result in this experiment was in agreement with Rajeshwari *et al.*, (2007). Maximum number of rows per ear (16 rows) and number of grains per row (52 grains) were significantly higher with T₈ (50% mineral N+25% organic N +Bio). These findings may be attributed to the slow and steady supply of N by bio-N and organic, which met the N requirements of plants at different stages of development. N acts as a nutrient reservoir through N₂-fixation and N ions are released slowly over the entire growth period leading to higher yields and yield quality. The data regarding the 100-grain weight in Table (4) showed that all treatments differed significantly from each others. Maximum 100-grain weight 44g, was shown by T₈ (50% mineral +25% organic N +Bio) followed by T₁₀ (75%M.N.F+ 0.1% HA + Bio) T₁₁ (75% mineral+25% organic) and T₁(100% mineral N). Similar results were reported by Shah *et al.*, (2009). The obtained results showed that the beneficial effects of the applied treatments (T₈, T₁₀ and T₁₁) were positively reflected in the nutritional status of maize plants and consequently reflected in the increased growth, yields and their quality. These results may be explained by the role of *Azotobacter* and *Azospirillum* in atmospheric nitrogen fixation, better root proliferation and uptake of nutrients and water. The obtained results are also in harmony with those undertaken by Yu *et al.*, (1999).

Table 4. Effect of mineral N and organic accompanied with bio fertilizers on yield and yield component kg/fed of maize during 2013 and 2014 season

Treatments	Ear characters						Total yield kg/fed		
	Plant height (cm)	Ear length (cm)	Ear diameter (cm)	No. of row /ear	No. grain /row	100-grain weight (g)	Grain Yield (.kg/fed)	Biological Yield (kg/fed)	Harvest index
T ₁ 100%M.N.F. (control)	264.33	24.67	5.09	15	51.00	39.0	4050	8804	0.46
T ₂ 75%M.N.F.	248.00	23.67	4.77	14	44.00	35.0	3651	8298	0.44
T ₃ 50%M.N.F.	226.67	21.00	4.45	12	36.33	32.0	2940	7350	0.40
T ₄ 50%M.N.F. + 0.1% HA	230.33	23.00	4.45	13	39.33	35.0	3268	7781	0.42
T ₅ 50%M.N.F. + Bio.	239.00	23.50	4.56	14	44.00	36.0	3406	7741	0.44
T ₆ 50%M.N.F. + 0.1% HA+ Bio	257.33	24.00	4.77	14	48.50	38.0	3893	8463	0.46
T ₇ 50%M.N.F. + 50 % O.N.F	262.33	24.50	4.88	14	49.00	38.5	3976	8643	0.46
T ₈ 50%M.N.F. + 25 % O.N.F. + Bio	267.33	26.00	5.09	16	52.00	44.0	4450	9468	0.47
T ₉ 75%M.N.F + 0.1% HA	260.00	23.33	4.77	14	47.00	35.5	3717	8448	0.44
T ₁₀ 75%M.N.F+ 0.1% HA + Bio	265.67	25.67	4.94	15	50.00	42.0	4250	9239	0.46
T ₁₁ 75%M.N.F. + 25 % O.N.F	264.50	25.00	5.10	15	48.50	41.0	4081	8872	0.46
L.S.D at 5%	14.27	2.34	n.s	2.14	5.88	3.72	190.06	344.72	0.02

Grain Yield (kg fed⁻¹):

The present study showed that, there was a significant and positive effect of different treatments on grain yield of maize (Table 4). The grain yield of maize responded significantly to combined treatments. The highest grain yield (4450 kg/fed) was recorded by treatment T₈ (50% mineral +25% organic N +Bio) which was 51.36% more than the lowest yield of T₃ and 9.88% more than control (4050 kg/fed.) . This might be due to the positive effect of organic and bio fertilizers on better root development which resulted in more nutrient uptake. These microorganisms also produce vitamins and plant growth promoting substances for the betterment of plant growth. Organic manures not only release nutrients slowly but also prevent the losses of leaching (Arshad *et al.*, 2004). This might lead to more availability of nutrients from compost and beneficial effects accrued due to *Azotobacter* and *Azospirillum* inoculation which provide nitrogen to plant growth. It may also be due to production of promoting substances like indole acetic acid, gibberellic acid and cytokinins as well as some synthesized vitamins secreted by these introduced beneficial microorganisms which resulted in enhanced nutrient uptake, translocation and synthesis of photosynthetic assimilates which resulted increased plant growth characters and in obtaining economically profitable yield (Suke *et al.*, 2011 and Noel *et al.* 1996). These products increase the surface area/unit root length and improved the root hair branching with an ultimate increase on the uptake of nutrients and adsorption of water from the soil that eventually yield larger and in many cases, more productive plants (Dobbelaere *et al.* 2001). The analyzed data revealed that significant differences in harvest index were observed among fertilizer treatments. The comparison of mean showed variation in harvest index ranged from 0.40 to 0.47. The maximum value for harvest index was observed in T₈ (50% mineral +25% organic N +Bio). The treatments T₁₀ (75%M.N.F+ 0.1% HA + Bio), T₁₁ (75% mineral +25% organic), T₁ (100% mineral N) and T₇ (50%M.N.F. + 50 % O.N.F.) was statistically similar for harvest index values 0.46.

Nutrient contents

Nutrient concentrations and contents in both grains and straw of maize plant (Tables 5 and 6) differ significantly amongst all the treatments.

Table 5. Effect of mineral N and some accompanied organic with bio fertilizers on N, P and K contents of maize grains of during 2013 and 2014 seasons.

Treatments	Grains					
	Nitrogen		Phosphorus		Potassium	
	%	Content (Kg/fed.)	%	Content (Kg/fed.)	%	Content (Kg/fed.)
T ₁ 100%M.N.F. (control)	1.93	78	0.47	19	0.77	31
T ₂ 75%M.N.F.	1.70	62	0.38	14	0.64	23
T ₃ 50%M.N.F.	1.50	44	0.35	10	0.58	17
T ₄ 50%M.N.F. + 0.1% HA	1.60	52	0.37	12	0.60	20
T ₅ 50%M.N.F. + Bio.	1.75	60	0.42	14	0.64	22
T ₆ 50%M.N.F. + 0.1% HA+ Bio	1.85	72	0.44	17	0.64	25
T ₇ 50%M.N.F. + 50 % O.N.F	1.88	75	0.51	20	0.81	32
T ₈ 50%M.N.F. + 25 % O.N.F. + Bio	2.08	93	0.48	21	0.79	35
T ₉ 75%M.N.F + 0.1% HA	1.83	68	0.39	14	0.69	26
T ₁₀ 75%M.N.F+ 0.1% HA + Bio	1.98	84	0.44	19	0.71	30
T ₁₁ 75%M.N.F. + 25 % O.N.F	1.95	80	0.49	20	0.78	32
L.S.D at 5%	0.17	7.68	n.s.	3.99	n.s.	6.42

Table 6. Effect of mineral N and some organic accompanied with bio fertilizers on N, P and K content in straw of maize during 2013 and 2014 seasons

Treatments	Straw					
	Nitrogen		Phosphorus		Potassium	
	%	Content (Kg/fed.)	%	Content (Kg/fed.)	%	Content (Kg/fed.)
T ₁ 100%M.N.F. (control)	0.82	39	0.20	10	2.2	105
T ₂ 75%M.N.F.	0.70	33	0.18	8	1.7	79
T ₃ 50%M.N.F.	0.52	23	0.15	7	1.3	57
T ₄ 50%M.N.F. + 0.1% HA	0.60	27	0.17	8	1.5	68
T ₅ 50%M.N.F. + Bio.	0.65	28	0.19	8	1.5	65
T ₆ 50%M.N.F. + 0.1% HA+ Bio	0.75	34	0.20	9	1.8	82
T ₇ 50%M.N.F. + 50 % O.N.F.	0.74	35	0.24	11	2.4	112
T ₈ 50%M.N.F. + 25 % O.N.F. + Bio	0.85	43	0.23	12	2.8	141
T ₉ 75%M.N.F + 0.1% HA	0.72	34	0.18	9	1.9	90
T ₁₀ 75%M.N.F+ 0.1% HA + Bio	0.84	42	0.22	11	2.3	115
T ₁₁ 75%M.N.F. + 25 % O.N.F	0.80	38	0.22	11	2.4	115
L.S.D at 5%	0.09	4.67	0.03	1.80	0.52	24.45

Grain inoculation with bio-fertilizer in combination with 50% mineral N+ 25% organic N or Bio +50%M.N.F. + 0.1% HA increased nutrient content (NPK) compared to control. T₈ (50% mineral N+25% organic N +Bio) recorded the highest nutrient contents for N, P, and K, followed by T₁₀ (75%M.N.F+ 0.1% HA + Bio), T₁₁ (75% mineral +25% organic) and T₁ (100% mineral N). Combined application of inorganic N with biofertilizers as a partial substitute for chemical fertilizers was very effective in stimulating nutrients concentration and contents of maize plant. These findings are in harmony with those obtained by (Wani *et al.*, 2007 and Abou-El-Seoud and Abdel-Megeed, 2012). These results might be due to that *Azotobacter* and *Azospirillum* species increased the solubility of soil nutrients as mentioned before. This might be attributed to the increased activity and efficiency of bacteria in reduction of soil pH by secreting organic acid, i.e. acetic, propionic, fumaric and succinic and consequently more solubility and availability of nutrients for plants. It may also be due to production of amino acids, vitamins and growth promoting substances like indole acetic acid and gibberellic acid secreted by these introduced beneficial microorganisms which resulted in enhanced nutrient uptake, translocation and synthesis of photosynthetic assimilates which resulted in increasing plant growth characters and in obtaining economically profitable yield (Singh *et al.*, 2006 and Suke *et al.*, 2011). The beneficial effects of using organic fertilizers along with mineral -N fertilizer on increasing nutrients concentration and contents of maize plant could be due to their effect on providing plants with their requirements from different nutrients at a longer time as well as their effect on increasing the availability of nutrients in the soil for uptake by plants and enhancing the nutritional status of the plants in favors of yield and quality.

Quality parameters

Protein Content and Yield

The protein content and yield of maize grain were significantly affected by different treatments (Table 7). The combination treatments gave the highest values especially T₈ (50% mineral +25% organic N +Bio) which ranked the first in this respect. The treatment T₃ (50% mineral N only) gave the lowest crude protein (8.6 %) as compared with the other treatments while the highest crude protein content (12.0%) was recorded only with T₈ (50% mineral +25% organic N +Bio). The maximum protein yield (534 kg/fed) was recorded by treatment T₈ (50% mineral +25% organic N +Bio) which was 17.62 % more than the control. Increasing of protein content may be due to the fact that nitrogen often plays a great role in the synthesis of protein. The increase in protein yield of maize could be attributed to the enhanced nutrient use efficiency in the presence of organic fertilizer. Many research studies have shown that the composted organic materials release nutrients slowly and may reduce the leaching losses, particularly N (Nevens and Reheul, 2003 and Naveed *et al.*, 2008). On the other hand, foliar sprays with humic acid (potassium humate) resulted in the highest mean value for protein yield. This result may be due to the role of humic acid as a source of nutrients which consequently increased production of assimilates and results in increased crude protein and protein yield. Free living N-fixing bacteria such as *Azotobacter* and *Azospirillum* have the ability not only to fix nitrogen but

also to release certain phytohormones, i.e. GA3, IAA and cytokinins which could stimulate plant growth and increase the availability of nutrients for plant roots by the increase in their dissolutions (Osman, 2007).

Oil Content and Yield

The applied different treatment combinations caused increases in grain oil content and oil yield (Table 7). T₈ (50% mineral +25% organic N +Bio) recorded the highest oil content (9.78%) and oil yield (435 kg fed⁻¹). Increases in grain oil percentage and oil yield (kg fed⁻¹) by *Azospirillum* and *Azotobacter* might be due to their positive effect on nutrients absorption, higher photosynthetic rate, higher dry matter accumulation and higher vegetative growth (Singh and Sinsinwar, 2006). The application of humic acid (potassium humate) in combination with other fertilizers has significant beneficial effect on the growth and yield of maize. Humic acid influences plant growth both in direct and indirect ways. Indirectly, it improves physical, chemical and biological conditions of soil. While directly, it increases chlorophyll content, accelerates plant respiration and hormonal growth responses, increases penetration in plant membranes, etc. Similarly, Chris *et al.* (2005) reported that both the foliar and soil application of humic acid significantly improved seed yield and oil content of mustard. The total carbohydrates content was maximum with T₈ (50% mineral +25% organic N +Bio) (75.54%) followed by T₁₀ (75%M.N.F+ 0.1% HA + Bio), T₁₁ (75% mineral +25% organic) and T₇ (50%M.N.F. + 50 % O.N.F). The carbohydrate content was 4.90 % increased with application of 50% mineral +25% organic N + bio as compared to the control 100% mineral N. Increase in total carbohydrates content with the use of bio and humic acid might be due to the fact that these substances enhance the nutrients availability to plant nutrients which are associated in sugar synthesis and transport. The promoting effect of humic acid (potassium humate) on the maize quality may be referring to potassium element which is the prevalent action in plant and involved in maintenance of ionic balance in cells and it bounds initially to the enzyme pyruvate kinase which is essential in respiration (Aisha *et al.*, 2007). Cangi *et al.* (2006) indicated that foliar spraying of humic acid on asparagus plants increased uptake of macro and micro elements in shoot and rhizome has increased carbohydrates production, chlorophyll and carotenoids in edible stems. Concerning Total soluble sugars (%) and Starch (%) contents, it is noticed that treatments (T₈, T₁₀ and T₁₁) increased these parameters than the control. These results are agreed with this obtained by Osman, (2007).

Table 7. Effect of mineral N and some organic accompanied with bio fertilizers on quality parameters of maize during 2013 and 2014 season

Treatments	Protein (%)	Protein yield (kg/fed)	Oil %	Oil yield (kg/fed)	Total soluble Sugars (%)	Starch (%)	Carbohydrate %
T ₁ 100%M.N.F. (control)	11.2	454	8.53	345	4.87	67.14	72.01
T ₂ 75%M.N.F.	9.8	358	7.68	280	4.38	67.2	71.58
T ₃ 50%M.N.F.	8.6	253	5.77	170	3.99	63.80	67.79
T ₄ 50%M.N.F. + 0.1% HA	9.2	301	6.42	210	4.15	65.65	69.80
T ₅ 50%M.N.F. + Bio.	10.1	344	6.98	238	4.60	64.30	68.90
T ₆ 50%M.N.F. + 0.1% HA+ Bio	10.6	413	7.50	292	4.65	67.19	71.84
T ₇ 50%M.N.F. + 50 % O.N.F	10.8	429	7.95	316	4.97	67.92	72.89
T ₈ 50%M.N.F. + 25 % O.N.F. + Bio	12.0	534	9.78	435	5.62	69.92	75.54
T ₉ 75%M.N.F + 0.1% HA	10.5	390	7.44	277	4.78	67.4	72.18
T ₁₀ 75%M.N.F+ 0.1% HA + Bio	11.4	485	8.75	372	4.95	69.01	73.96
T ₁₁ 75%M.N.F. + 25 % O.N.F	11.2	457	8.93	364	4.90	68.67	73.57
L.S.D at 5%	1.25	45.29	0.67	26.40	n.s.	0.60	1.53

Table 8: Economic Study

Treatment	Yield/fed.		Income (LE)/fed.			Cost (LE)/fed.						Net Return (LE)/fed.
	Grain (ard./fed.)	Straw (ton/fed.)	Grain (LE)	Straw (LE)	Total (LE)	Compost	N	HA	Bio	others	total	
T ₁ 100%M.N.F. (control)	28.9	4.754	8678.6	713.1	9391.7	-	408	-	-	1000	1408	7983.7
T ₂ 75%M.N.F.	26.1	4.647	7823.6	697.05	8520.6	-	306	-	-	1000	1306	7214.6
T ₃ 50%M.N.F.	21.0	4.41	6300	661.5	6961.5	-	204	-	-	1000	1204	5757.5
T ₄ 50%M.N.F. + 0.1% HA	23.3	4.513	7002.9	676.95	7679.8	-	204	18	-	1000	1222	6457.8
T ₅ 50%M.N.F. + Bio.	24.3	4.335	7298.6	650.25	7948.8	-	204	-	10	1000	1214	6734.8
T ₆ 50%M.N.F. + 0.1% HA+ Bio	27.8	4.57	8342.1	685.5	9027.6	-	204	18	10	1000	1232	7795.6
T ₇ 50%M.N.F. + 50 % O.N.F	28.4	4.667	8520	700.05	9220.1	720	204	-	-	1000	1924	7296.1
T ₈ 50%M.N.F. + 25 % O.N.F. + Bio	31.8	5.018	9535.7	752.7	10288.4	360	204	-	10	1000	1574	8714.4
T ₉ 75%M.N.F + 0.1% HA	26.6	4.731	7965	709.65	8674.7	-	306	18	-	1000	1324	7350.7
T ₁₀ 75%M.N.F+ 0.1% HA + Bio	30.4	4.989	9107.1	748.35	9855.5	-	306	18	10	1000	1334	8521.5
T ₁₁ 75%M.N.F. + 25 % O.N.F	29.2	4.791	8745	718.65	9463.7	360	306	-	-	1000	1666	7797.7

Ardab of maize = 140 kg

Price of straw (ton) =LE 150

Price of N (50kg) =LE170

Price of grain (Ard.) =LE 300

price of compost (ton) =LE180

Price of HA (L) =LE 15

price of bio = LE 10

Another cost =LE 1000

Economic Evaluation:

The Net return of the different treatments was presented in Table (8), which reflects that the most economically beneficial treatment was the application of T₈ (50% mineral +25% organic N +Bio) followed by T₁₀ (75%M.N.F+ 0.1% HA + Bio) where the return reached 8714.4 and 8521.5 LE, respectively. This corresponds to an increase in the return reached about 730.7 and 537.8LE, respectively compared to the control.

CONCLUSION

From the abovementioned results, it could be concluded that fertilizing maize plants with organic manure, bio-fertilizers and/or humic acid with 50% or 75% mineral N treatments had a positive effect on maize growth and yields, since applying bio ,OM with 50% or 75% mineral N increased yield than those fertilized with the recommended N rate. Also, adding bio-fertilizer + humic with 50% mineral N highly increased yield than without adding them. This means that maize plants responded mainly to HA application and bio-fertilizer. On the other hand, treatments (T₈, T₁₀ and T₁₁) increased total carbohydrates, TSS and Starch content than the control. However, it seems that fertilizing maize plants with T₈ (50% mineral +25% organic N +Bio) or T₁₀ (75%M.N.F+ 0.1% HA + Bio), are promising treatments under this study conditions.

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الاستبدال الجزئي للنيتروجين المعدني بالتسميد العضوي والحيوي على الذرة داليا حوروز سيد ، لمياء عبد الحليم عبد الرحمن و ماجدة على عويس معهد بحوث الأراضي والمياه والبيئة - مركز البحوث الزراعية - الجيزة - مصر

أجريت تجربتان حقليتان لدراسة تأثير استخدام الاسمدة البيولوجية والعضوية كبديل جزئي عن الأزوت المعدني على نمو محصول الذرة وجودته (صنف هجين ثلاثي ٣٢٤). وقد أجريت الدراسة خلال موسمي ٢٠١٣ و ٢٠١٤ في محطة بحوث الـجـمـيـزة محافظة الغربية مركز البحوث الزراعية-الجيزة. تم تصميم التجربة في قطاعات كاملة العشوائية بثلاث مكرارات. أظهرت نتائج التجربة:

إن المعاملة رقم (٨) (٥٠% نـتـرـوجـين معدني + ٢٥% نـتـرـوجـين عضوي + حيوي) أثرت إيجابيا على صفات النمو ومحتوى الورقة من العناصر الغذائية (النـتـرـوجـين والفوسفور والبوتاسيوم) مقارنة مع المعاملات الأخرى وذلك بعد ٧٥ يوم من الزراعة.

أدى استخدام الاسمدة البيولوجية والعضوية وحامض الهيوميك مع ٥٠ أو ٧٥% من التسميد الأزوتي المعدني إلى إعطاء أفضل المواصفات للنمو مثل ارتفاع النبات -وزن ١٠٠ حبة-محصول الحبوب والمحصول البيولوجي (كجم للفدان) مقارنة بالنباتات التي استخدم فيها المعدل الموصى به من التسميد النيتروجيني. وتم الحصول على النتيجة نفسها لجميع قياسات الجودة مثل محتوى البروتين والزيت (%) ومحصول البروتين والزيت (كجم للفدان) وكذلك الكربوهيدرات الكلية والنشا عند استخدام نفس المعاملات التي تحتوي على الاسمدة البيولوجية والعضوية مع ٥٠ أو ٧٥% من التسميد الأزوتي المعدني مقارنة بالمعدل الموصى به من الأزوت المعدني.

أعطت المعاملة رقم (٨) والتي تحتوي على ٥٠% نـتـرـوجـين معدني + ٢٥% نـتـرـوجـين عضوي + حيوي أعلى محصول حبوب (٤٤٥٠ كجم للفدان) والذي زادت إنتاجيتها بمقدار ٨٨.٩ % مقارنة بالكنترول (٤٠٥٠ كجم للفدان) وبزيادة مقدارها ١٤.٤% عن أقل محصول في معاملة (٣) ٢٩٤٠ كجم للفدان. وجد أن أفضل عائد اقتصادي عند معاملة ٨ والتي تحتوي على ٥٠% نـتـرـوجـين معدني + ٢٥% نـتـرـوجـين عضوي + حيوي ويليهام معاملة ١٠ والتي تحتوي على ٧٥% نـيـتـرـوجـين معدني + الرش بحمض الهيوميك + حيوي مقارنة بمعاملة الكنترول

ومن هنا يمكن استنتاج أن استخدام الاسمدة البيولوجية والعضوية كبديل جزئي للاسمدة النـتـرـوجـينية المعدنية ربما يكون الطريقة المناسبة للحصول على أعلى محصول حبوب ذات جودة عالية وأفضل عائد اقتصادي والحد من تلوث التربة والمياه الناتجة عن الاستخدام الزائد من هذه الاسمدة ..