Response of Two Yellow Maize Hybrids to Amino Acids, Mineral Npk and Nano-Fertilizers under Toshka District Conditions

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ABSTRACT

This study was carried out during 2018 and 2019 seasons at the Experimental Farm of the Water Studies and Research Complex (WSRC) Station, National Water Research Center, Toshka Region, Egypt (22°32′16″N, 31°30′40″E), to study the effect of two amino cat fertilizer concentrations (AA_1: 100 cm^3 fed^{-1} and AA_2: 200 cm^3 fed^{-1}), six different combinations of mineral NPK and nano-fertilizers (F1= 0.0 fertilizers-control treatment, F2= 100% mineral NPK (120:30:24 kg fed^{-1}), F3= 100% Nano NPK (10 kg fed^{-1}), F4=75% mineral NPK +25% Nano NPK, F5=75% Nano NPK +25% mineral and F6= 50% mineral NPK +50% Nano NPK) on grain production and its attributes as well as net economic return on two yellow maize hybrids (M_1: T.W.C. 353 and M_2: T.W.C. 360). The experiment was laid out in a strip split-plot design with three replications, where amino cat fertilizer allocated in vertical-plots, fertilization treatments were arranged in horizontal-plots and maize hybrids were occupied the sub-plots. Studied traits were number of days to 50% tasseling, number of green leaves $plant^{-1}$, ear leaf area, plant height, ear length, number of ears $plant^{-1}$ and grain yield fed^{-1}. Obtained results showed that maize hybrids, amino cat fertilizer, fertilization treatments, and their interactions significantly influenced most studied traits in both seasons. TWC 353 hybrid gave the maximum mean values of all studied traits in both seasons. Foliar spraying with 200 cm^3 amino cat fertilizer was significantly associated with corresponding increases in all studied traits especially grain yield (3.02 and 3.06 ton fed^{-1}) in the 1st and 2nd seasons, respectively. Maximum average values of studied traits were obtained using 50% mineral fertilization + 50% nano- NPK fertilization in both growing seasons. Foliar appliction of TWC 353 hybrid with 200 cm^3 amino-fertilizer, beside fertilization by 50% mineral NPK+50% NPK nano-fertilizers ($M_1AA_2F_6$), recorded the highest values for net farm incom (12926 L.E fed^{-1}), net farm return (6360 L.E fed^{-1}), BCR (1.97) and economic efficiency (net return/total costs=0.97). This result is due to the highest grain yield prodictivity under this treatment (3.77 ton fed^{-1}) as an average of the two seasons compared with other treatments. Generally, it could be concluded that foliar spraying of maize hybrid TWC 353 with 200 cm^3 fed^{-1} amino cat fertilizer plus 50% mineral fertilization + 50% nano-NPK fertilization resulted in highest growth, production and net farm return under the environmental conditions of Toshka region.

Keywords: Maize Hybrids, mineral NPK, Nano-NPK, Amino Acids, Production, Net farm return.

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INTRODUCTION

In worldwide and Egypt, maize (*Zea mays* L.) is considered as one of the most important cereal crops after wheat and rice. Its demand is incessant food item in human diet, fodder for livestock, and feed for poultry, fuel, and many other industrial purposes (Tajul *et al*., 2013). Maize can be consumed directly as a green ear, roasted ear, or in other various ways, such as corn meal and fried grain.

Total production of maize in Egypt is about 7.45 million tons in 2019 produced from an area of 2.368 million feds, with an average yield of 3.15 ton fed^{-1} (FAOSTAT, 2019). The total production supplies 80 % of the required consumption with a reduction gap of 20 % especially during the last two decades which was to be filled via importation. Concerted efforts are needed to increase maize production through using new maize hybrids which are characterized by high production under conditions of newly reclaimed sandy soils characterized with low fertility, high pH value, different climatic conditions, and low organic matter content as Toshka region for maximizing yield per unit area and reduce the gap between consumption and local production. Egyptian maize cultivars may be differed in their assimilation capacity and distribution of photosynthates among the various plant organs which could be attributed to "source and sink relation" compared with any other cereal crops. Maize is popularly called "King of cereals" because of its carbon pathway (C4), wider adaptability and superior transpiration efficiency (Kannan *et al*., 2013 and EL-Hosary *et al*., 2019).

Many investigators documented significant maize hybrids variations regarding growth, yield and its attributed, as Hassaan (2018) who showed that the TWC 352 hybrid had higher number of rows ear^{-1} and higher grain yield in both seasons compared with the other tested hybrids. El-Hassanin *et al.* (2015), Awadalla and Morsy (2016), Eyasu *et al*. (2018), Ali and Abdelaal (2020), Casimir *et al*. (2020) and Yasser *et al.* (2020) found similar results.

Recently, some studies have proved that Amino acids (AA) a well-known bio-stimulant that play multiplier roles in the plant, where building blocks for proteins, which is constituted of amino acids, that involved in a plethora of cellular reactions and therefore, they had effect on several physiological processes such as plant growth and development, generation of metabolic energy or redox power and resistance to both abiotic and biotic stress, (Pratelli and Pilot, 2014). The addition of amino acids to plants causes increased quality, efficiency, and have direct or indirect effects on the physiological functions. Ahmed *et al*., (2019) showed that sorghum treated with amino acids significantly improved growth characters, yield, and its components.

The same results were recorded on maize (Zaki *et al*., 2014), sweet-corn (Ragheb, 2016), wheat (Kandil and Marie, 2017), soybean (Abd El-Aal and Eid, 2018) and wheat (Al-juthery *et al*., 2019).

Farmers mainly use mineral fertilizers NPK to increase and sustain crop yields. The nutrients in these fertilizers are poorly utilized because of environmental and soil-related factors that led to phosphorous fixation, leaching, and volatilization of nitrogen. Excess application of fertilizers decrease soil micro-flora and lessens nitrogen-fixation. Thus, it is essential to test the other methods to provide the necessary nutrients for productivity of the crop while keeping soil structure in great shape and environmentally clean (Miransari, 2011). Soil application of 100% mineral NPK gave the highest production on all studied traits (El-Hassanin *et al*., 2015). Nano-fertilizers offer an opportunity for efficiently improving plant mineral nutrition, increase food production whilst simultaneously reducing adverse environmental impacts. It is necessary to develop new fertilizers that release nutrients at a rate that more closely matches plant demand (Kopittke *et al*., 2019). The emergence of engineered Nano-materials and their actions within the frame of sustainable agriculture have revolutionized world agriculture canvass dramatically by novelty, fast growth, and enormity meet the projection of global food demand (Shang *et al*., 2019). Using nanotechnology in agriculture, has beneficial values to improve crop growth, yield, and quality traits with increase nutrient use efficiency, reduce wastage of fertilizers, and cost of cultivation which arise from their small size that ranging among from 1 to 100 nm, shape and surface area (Singh *et al*., 2017). Foliar spraying with NPK Nano-fertilizers increased the yield and its components of wheat as well as nano-fertilizers have an enormous impact on the soil and can reduce fertilizer application frequencies (Gomaa *et al*., 2018). Using nanoparticles (NPs) with N nutrients increased growth, yield, and quality of maize compared with conventional urea. (Manikandan and Subramanian, 2016). The objectives of this investigation were to study the effect of amino cat fertilizer application and different combination between mineral NPK and nano-fertilizers on grain production and its attributes as well as economic return of two yellow maize hybrids under Toshka conditions.

MATERIALS AND METHODS

Study site, objective, and Soil analysis:

A field study was carried out at the Experimental Farm of the Water Studies and Research Complex (WSRC) Station, National Water Research Center, in Abu Simbel, Toshka region, Egypt (22°32′16″N, 31°30′40″E) during 2018 and 2019 seasons in sandy loam soil. This work aimed to study the impact of different rates of mineral NPK and nano-fertilizers, Amino acids, and their interaction on grain production and its attributes as well as economic return of two yellow maize hybrids i.e. T.W.C 353 and T.W.C 360 under drip irrigation system. Maize hybrids were obtained from Maize Research Section, Agriculture Research Center, Giza, Egypt. Soil samples were collected from the experimental site to determine some soil physical and chemical properties according to Page *et al*. (1982) Table 1.

Table 1. Soil physical and chemical analysis of the experimental farm at Toshka (Average of the two seasons)

Soil depth	**Particle size distribution (%)**			
	Sand	**Silt**	**Clay**	**Soil texture**
0 - 30	**82.19**	**13.16**	**4.65**	**Sandy Loam**

Chemical properties											
Soil depth	Soluble cations (meL^{-1})				Soluble anions (meL^{-1})			pH	EC	OM (%)	N ppm
	Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	CO_3^{--} + HCO3-	SO_4^{--}				
0 - 30	3.70	0.1	6.10	0.43	2.8	0.2	7.33	8.75	0.06	0.61	35.1

Experimental design and treatments:

The experiment was laid out in strip-split plot design with three replications using Randomized Complete Block Design (RCBD). Treatments included two Amino acids rates in the form of amino cat fertilizer (A_1: 100 cm^3 fed^{-1} and A_2: 200 cm^3 fed^{-1}) were allocated in vertical-plots, six fertilization treatments (F1: 0.0 control treatment, F2: 100% mineral NPK (120:30:24 kg fed^{-1},(F3: 100% NPK Nano-fertilizer (10 kg fed^{-1}), F4:75% mineral NPK +25% Nano NPK, F5:75% Nano NPK +25 % mineral and F6: 50% mineral NPK +50% Nano NPK) occupied the horizontal-plots. While, the sub-plots were devoted to two yellow maize hybrids (M_1: T.W.C 353 and M_2: T.W.C 360). Nitrogen at the level of 120 kg N fed^{-1} as ammonium nitrate (33.5% N) was added with irrigation in eight equal doses, the first one after seven days from sowing and the final dose before flowering stage, phosphorus at 30 kg P_2O_5 fed^{-1} as calcium super-phosphate (15.5% P_2O_5) was added during soil preparation and potassium at 24 kg K_2O fed^{-1} as potassium-sulphate (48% K_2O) was added at planting. Nano-compound namely: Hyper feed motawazen 19:19:19 NPK was obtained from (Bio Nano Tech for fertilizer development, Egypt) at rate of 10 kg fed^{-1}. Amino cat fertilizer and Nano-fertilizer were added as a foliar application at two times i.e., after 30 and 45 days from sowing using hand operated air compressed sprayer. The analysis of the two fertilizer compounds is shown in Table 2. The area of experimental unit was 10.50 m^2 (5 rows x 0.60 m width x 3.5m length).

Agriculture practices:

Seeds of the two maize hybrids were hand planted in hills around the drip point (at spacing of 30 cm on the irrigation lines) on 1st August in both seasons and harvested on 15th and 17th December in 2018 and 2019 seasons, respectively. Thinning was done to one plant $hill^{-1}$ after 20 days from sowing when the crop attained 3-4 leaves stage. The preceding winter crop was faba bean in both seasons. Drip irrigation was applied as needed. All other agronomic practices were don for all treatments as recommended for maize production in Toshka region, except the factors under study.

Studied traits:

A-Earliness and vegetative characteristics: flowering date, the time of tasseling was estimated as the number of days from sowing to 50% tasseling. Five guarded plants were taken randomly at 80 days after planting from each plot to determine number of green leaves $plant^{-1}$ and ear leaf area (dm^2). Ear leaf area was calculated from the following equation: Leaf area = leaf length × greatest width of ear leaf × 0.75, according to Gardner *et al*. (1985).

B-Yield and its attributes: At harvest ten guarded plants were taken out at random from the middle two ridges of each plot and the following yield traits were recorded: plant height (cm), ear length (cm) and number of ears $plant^{-1}$. All plants of each plot were harvested to estimate grain yield and converted to (ton fed^{-1}) adjusted to 15.5% moisture content.

C-Economic feasibility*:* was made using the inputs and outputs prices of local market by calculating all operations cost, net farm income, net farm return, and benefit to cost ratio. The economic evaluation was done using the method described by CIMMYT (1988).

Data analysis:

The collected data were subjected to analysis of variance (ANOVA) for the strip-split plot design according to Gomez and Gomez (1984) by using MSTAT computer program, LSD method was used to test the differences between treatment means at 5% level of probability as described by Sendecor and Cochran (1990).

Table 2. Structure of Amino Cat fertilizer and Nano-fertilizer (as the foliar application)

Element	N	P_2O_5	K_2O	Fe	Mg	Mn	Zn	B	Cu	Algal extract	Amino acids	OM	Mo ppm	Co ppm
Value %														
NPK Nano-fertilizer	19	19	19	0.48	0.80	0.24	0.35	0.05	0.08	0.52	1.1	-	100	100
Amino Cat fertilizer	3	1	1	-	-	-	-	-	-	-	10	18	-	-

RESULTS AND DISCUSSION

I- Earliness and vegetative characteristics:

Hybrid differences (M):

Results in Table 3 showed that the two yellow maize hybrids TWC 353 (M_1) and TWC 360 (M_2) were significantly differed in number of days from sowing to 50% tasseling, number of green leaves plant^{-1} and ear leaf area at 80 days after planting in the two seasons. Data revealed that maize hybrid TWC 353 produced the highest average values of number of green leaves plant^{-1} (12.77 and 12.71 leaves), ear leaf area (7.39 and 7.48 dm^2) and the shortest number of days from planting to 50 % tasseling (62.92 and 62.69 days) in 2018 and 2019 seasons, respectively. The hybrid differences in each of the above-mentioned characters may be attributed to their genetic make-up. El-Mekser *et al*. (2020) and Abd-Elaziz *et al*. (2020) they revealed that the three way cross 353 was the earliest hybrid for number of days to 50% tasseling (58.3 days) and (62.62 days), respectively. These results are in line with those reported by Zaki *et al*. (2016), Hassaan (2018), and El-Hosary *et al*. (2019) and Yasser *et al*. (2020).

Amino cat fertilizer (AA):

The illustrated data in Table 3 reveal that foliar spraying of amino acids significantly increased above mentioned traits of maize in both seasons. Foliar spraying of maize with 200 cm^3 fed^{-1} amino cat fertilizer gave the highest values of number of green leaves plant^{-1} (12.73 and 12.69 leaves), ear leaf area (7.28 and 7.39 dm^2), while, the same concentration gave the shortest period from sowing to 50% tasseling (63.63 and 63.46 days) in the two respective seasons. The increments in growth traits by foliar spraying with 200 cm^3 fed^{-1} might be attributed to their role in the synthesis of some hormones like auxins, increasing chlorophyll concentration, hence increasing photosynthesis, which is reflected in increases in number of leaves plant^{-1} and ear leaf area. Moreover, amino acids can directly or indirectly affect the physiological activities and development of plants (Ragheb, 2016), and increase the antioxidant content of the leaves (Ardebili *et al*., 2012). Many investigators recorded the beneficial influence of amino acids on growth parameters of maize (Zaki, 2014), on wheat (Kandil and Marie, 2017) on wheat (Al-juthery *et al*., 2019), on soybean (Abd El-Aal and Eid, 2018) and sorghum (Ahmed *et al*., 2019).

Fertilization treatments (F):

Obtained data in Table 3 revealed that the influence of combinations of mineral NPK and Nano fertilizer were significant on earliness and vegetative traits during 2018 and 2019 seasons. Application of 50% Nano NPK fertilizer (NP_S) + 50% mineral NPK fertilizer (F_6) recorded the highest mean values of number of days from sowing to 50% tasseling (62.96 and 62.75 days), number of green leaves plant^{-1} (13.33 and 13.29 leaves) and ear leaf area (7.85 and 7.95 dm^2) in 2018 and 2019 seasons, respectively, followed by (F_5) which include 75% Nano NPK + 25% mineral NPK as compared to other treatments. The impact of fertilization treatments on growth traits could be arranged in descending order of $F_6 > F_5 > F_3 > F_2 > F_4 > F_1$. The applied F_6, F_5, and F_3 treatments caused increases of growth parameters which may be due to the essential role of NPK mineral and Nano-fertilizers in physiological and biochemical processes of maize through increasing the availability of nutrients to the growing plant which consequently increases chlorophyll formation, photosynthesis rate, metabolic processes, promoting meristematic activities and increased vegetative growth rates and consequently increase in the number and size of leaves (Valizadeh and Milic 2016).

Reported similar results showed that foliar application of mineral fertilizers combined with Nano NPK increased the growth of wheat leaves, which was obtained by enhanced availability of nutrients by easy penetration of nano-formulation of NPK through stomata of leaves via gas uptake (Abdel-Aziz *et al*., 2018). Similar results were also reported by Manikandan and Subramanian (2016), Al-juthery *et al*., (2019), Gomaa *et al*., (2020) and Mehrez *et al*., (2020). Yasser et al. (2020) found that applying 75% N mineral along with 25% N nano significantly increased number of green leaves plant^{-1} and leaf area index.

Interaction effect:

Interaction between maize hybrids and amino cat fertilizer (M×AA):

Results in Table 3 showed significant effects of (M×AA) on number of green leaves plant^{-1} and ear leaf area, except number of days from sowing to 50% tasseling in the two seasons. Highest number of green leaves plant^{-1} (12.91 and 12.85 leaves) and ear leaf area (7.80 and 7.90 dm^2) was obtained from $M_1 \times AA_2$ (T.W. C. 353 × 200 cm^3 fed^{-1}) in 2018 and 2019 seasons, respectively. Similarly, Zaki *et al*. (2014) also showed that the effective treatments for growth characters were obtained from spraying maize SC 10 with 200 cm^3 fed^{-1} amino cat fertilizer in both seasons. Ahmed *et al.* (2019) support these results.

Interaction between maize hybrids and fertilization treatments (M×F):

Results in Table 3 pointed out that the influence of interaction among (M×F) had a significant effect on growth characters in the two seasons. When TWC hybrid maize 353 (M_1) fertilized by F_6: 50% Nano plus 50% mineral NPK recorded the highest values of number of green leaves plant^{-1} (13.59 and 13.52 leaves) and ear leaf area (8.50 and 8.59 dm^2), shortest number of days from sowing to 50% tasseling (61.90 and 61.81 days), respectively.

El-Hosary *et al.* (2019) found that number of days to 50% tasseling and number of green leaves plant^{-1} not significantly affected by the interaction among N fertilizer rates and maize hybrids in both seasons.

Interaction between amino cat fertilizer and fertilization treatments (AA×F):

For the interaction among (AA × F) illustrated in Table 3, disclosed that (AA_2 + F_6) achieved the highest values for number of days from sowing to 50% tasseling (62.58 days) in the 1st season, number of green leaves plant^{-1} (13.57 and 13.53 leaves) and ear leaf area (8.28 and 8.41 dm^2) in both seasons, followed by (AA_2 plus F_5). On the other hand, the lowest mean values for these traits were recorded by (AA_1 × F_1).

Interaction between three factors (M×AA×F):

The three-way interaction among maize hybrids, amino acids, and fertilization treatments (M×AA×F) showed significant effects on growth traits at 80 days after sowing Table 3. Maize hybrid T.W.C. 353 (M_1) gave the highest values for number of green leaves plant^{-1} (14.00 and 13.95 leaves), ear leaf area (9.19 and 9.32 dm^2) and the shortest number of days from sowing to 50% tasseling (61.80 and 61.60 days) under foliar spraying with 200 cm^3 fed^{-1} amino cat fertilizer (AA_2) combined with 50% Nano plus 50% mineral NPK fertilizers (F_6) in the 1st and 2nd seasons, respectively.

II- Yield and its attributes:

Hybrid differences (M):

Yield traits showed significant differences among the two tested hybrids in both seasons (Tables 4 and 5). Hybrid "T.W.C. 353" recorded the highest values for plant height (215.2 and 214.4 cm), ear length (17.45 and 17.35 cm), number of ears plant^{-1} (1.12 and 1.13 ear) and grain yield (3.21 and 3.26 ton fed^{-1}). Growing maize hybrid TWC 353 increased grain yield (kg fed^{-1}) by 20.67 and 21.19%, over that of TWC 360 hybrid in the 2018 and 2019 seasons, respectively. The superiority of T.W.C. 353 on T.W.C. 360 in yield and its components might be attributed to its superiority in growth traits (Table 3), yield components (Tables 4 and 5), or could be explained by the fact that photosynthates translocate from the leaves to the storage organs (grain) were great enough to fill all the grains of TWC 353 hybrid which is reflected the final grain yield fed^{-1}. Moreover, these differences in hybrids may be due to the differences in growth habits and the response of each one to environmental conditions controlled by genetic factors. Yasser *et al*. (2020) explained that S.C.168 hybrid had the highest grain yield and its components followed by SC 176, then TWC 321 maize hybrid. These results are in harmony with those reported by Zaki *et al*. (2016), Gomaa *et al*.(2017), Hassaan (2018), Ahmed *et al*. (2019), El-Hosary *et al*.(2019) Ali and Abdelaal (2020), El-Mekser *et al.* (2020) and Casimir *et al*. (2020).

Amino cat fertilizer (AA):

Concerning the influences of the foliar application by amino cat fertilizer on yield and yield components, data in Tables 4 and 5 indicated that foliar application of AA significantly increased plant height (212.7 and 212.8 cm), ear length (17.74 and 17.67 cm), number of ears plant^{-1} (1.09 and 1.10 ear) and grain yield of maize (3.02 and 3.06 ton fed^{-1}) by increasing AA concentrations up to 200 cm^3 fed^{-1} in the 2018 and 2019 seasons, respectively. The superiority of 200 cm^3 fed^{-1} over 100 cm^3 fed^{-1} from amino cat fertilizer on maize plants might be attributed to its greatest positive effect on growth traits (Table 4), and more dry matter accumulation and stimulated the building of metabolic products that translocated to grains. Moreover, the advantageous influences of amino cat in improving original ultrastructure of cell especially the plastids in mesophyll tissue consequently, improving photosynthetic efficiency leading to the production of more assimilates needed for formation of new cell reflected to increase plant height, leaf area as well as yield and its components. Amino acids play a positive role on plant growth by increasing chlorophyll concentration leading to a higher degree of photosynthesis, and consequently increased yield (Kasraie *et al*., 2012 and Seadh *et al*., 2015). Many results are in harmony with these results are obtained by Zaki (2014), Ragheb (2016), Abd El-Aal and Eid (2018) Al-juthery *et al*. (2019), and Ahmed *et al*. (2019).

Fertilization treatments (F):

The differences among fertilization treatments on plant height, ear length, number of ears plant^{-1} and grain yield were significant in both seasons (Tables 4 and 5).

The increases in previous traits in maize plants which fertilized by F_6 (50% NPK mineral + 50% NPK nano-fertilization) more than control (F_1) by (7.01 and 6.92%), (7.54 and 7.45%), (12.87 and 12.75%) and (22.81 and 22.64%) in 2018 and 2019 seasons, respectively. These increments may be due to the improving role of NPK mineral and NPK nano-fertilizers for encouraging biosynthesis, cell division, and cell enlargement and finally reflected in dry matter accumulation as well as enhance the rate of the photosynthesis which results in more production and translocation of photosynthates to different parts of plant.

Table 3. Mean of earliness and vegetative traits as influenced by two maize hybrids, fertilization treatments, and amino cat fertilizer during the 2018 and 2019 seasons

Traits		Earliness and vegetative traits																	
		Number of days to 50% tasselling						Number of green leaves plant^{-1}						Ear leaf area (dm^2)					
M: Maize hybrids	F: Fertilization treatments	AA: Amino acids			AA: Amino acids			AA: Amino acids			AA: Amino acids			AA: Amino acids			AA: Amino acids		
		AA_1	AA_2	Mean	AA_1	AA_2	Mean	AA_1	AA_2	Mean	AA_1	AA_2	Mean	AA_1	AA_2	Mean	AA_1	AA_2	Mean
		Season 2018		M×F	Season 2019		M×F	Season 2018		M×F	Season 2019		M×F	Season 2018		M×F	Season 2019		M×F
M_1: TWC 353	F_1: 0.0 control	64.67	63.77	64.22	63.70	63.27	63.49	11.94	11.98	11.96	11.89	11.93	11.91	6.04	6.50	6.27	6.11	6.60	6.36
	F_2: 100 Mineral	63.00	62.70	62.85	62.83	62.40	62.62	12.64	13.00	12.82	12.55	12.92	12.73	7.05	7.57	7.31	7.09	7.71	7.40
	F_3: 100 Nano	62.90	62.50	62.70	62.77	62.27	62.52	12.86	13.08	12.97	12.84	13.02	12.93	7.30	8.04	7.67	7.36	8.10	7.73
	F_4: 75 Min.+25 Nano	64.00	63.20	63.60	63.87	63.00	63.44	12.07	12.17	12.12	12.02	12.13	12.08	6.56	7.17	6.87	6.70	7.26	6.98
	F_5: 75 Nano.+25 Min.	62.50	62.00	62.25	62.60	62.01	62.31	13.01	13.2	13.11	13.00	13.18	13.09	7.15	8.32	7.74	7.20	8.42	7.81
	F_6: 50 Min.+50 Nano	62.00	61.80	61.90	62.01	61.60	61.81	13.17	14.00	13.59	13.10	13.95	13.52	7.80	9.19	8.50	7.86	9.32	8.59
	Mean of M × AA	63.18	62.66	62.92	62.96	62.42	62.69	12.62	12.91	12.77	12.57	12.85	12.71	6.98	7.80	7.39	7.06	7.90	7.48
M_2: TWC 360	F_1: 0.0 control	66.70	65.90	66.30	66.00	65.53	65.77	11.71	11.70	11.71	11.62	11.67	11.65	5.79	6.17	5.98	6.00	6.25	6.13
	F_2: 100 Mineral	65.00	64.93	64.97	64.99	64.40	64.70	12.53	12.60	12.57	12.45	12.56	12.51	6.15	6.40	6.28	6.28	6.50	6.39
	F_3: 100 Nano	64.77	64.40	64.59	64.73	64.67	64.70	12.71	12.75	12.73	12.67	12.73	12.70	6.48	7.00	6.74	6.58	7.08	6.83
	F_4: 75 Min.+25 Nano	65.70	65.02	65.36	65.00	65.00	65.00	12.01	12.11	12.06	12.00	12.09	12.05	6.04	6.41	6.23	6.11	6.60	6.36
	F_5: 75 Nano.+25 Min.	64.80	64.00	64.40	64.60	64.01	64.31	12.97	13.00	12.98	12.89	13.00	12.94	6.98	7.20	7.09	7.06	7.29	7.18
	F_6: 50 Min.+50 Nano	64.67	63.37	64.02	64.00	63.40	63.70	13.00	13.13	13.07	13.00	13.11	13.06	7.07	7.37	7.22	7.13	7.50	7.31
	Mean of M × AA	65.27	64.60	64.94	64.89	64.50	64.70	12.49	12.55	12.52	12.44	12.53	12.49	6.42	6.76	6.59	6.53	6.87	6.70
(AA) × (F)	F_1: 0.0 control	65.68	64.83	65.26	64.85	64.40	64.63	11.83	11.84	11.83	11.75	11.80	11.78	5.92	6.33	6.13	6.06	6.43	6.24
	F_2: 100 Mineral	64.00	63.82	63.91	63.91	63.40	63.66	12.59	12.80	12.69	12.50	12.74	12.62	6.60	6.98	6.79	6.69	7.11	6.90
	F_3: 100 Nano	63.83	63.45	63.64	63.75	63.47	63.60	12.79	12.92	12.85	12.76	12.88	12.82	6.89	7.52	7.21	6.97	7.59	7.28
	F_4: 75 Min.+25 Nano	64.85	64.11	64.48	64.43	64.00	64.22	12.04	12.14	12.09	12.01	12.11	12.06	6.30	6.79	6.55	6.41	6.93	6.67
	F_5: 75 Nano.+25 Min.	63.65	63.00	63.33	63.60	63.01	63.31	12.99	13.10	13.04	12.94	13.09	13.02	7.07	7.76	7.41	7.13	7.86	7.49
	F_6: 50 Min.+50 Nano	63.33	62.58	62.96	63.01	62.50	62.75	13.09	13.57	13.33	13.05	13.53	13.29	7.43	8.28	7.85	7.50	8.41	7.95
	Mean of Amino (AA)	64.23	63.63	------	63.93	63.46	------	12.55	12.73	------	12.50	12.69	------	6.70	7.28	------	6.79	7.39	------
LSD at 0.05		M = 0.26			M = 0.02			M = 0.02			M = 0.02			M = 0.01			M = 0.01		
		AA = 0.24			AA = 0.15			AA = 0.03			AA = 0.03			AA = 0.34			AA = 0.007		
		F = 0.13			F = 0.10			F = 0.01			F = 0.03			F = 0.04			F = 0.009		
		M × AA = NS			M × AA = NS			M × AA = 0.05			M × AA = 0.06			M × AA = 0.10			M × AA = 0.02		
		M × F = 0.18			M × F = 0.14			M × F = 0.016			M × F = 0.04			M × F = 0.05			M × F = 0.01		
		AA × F = 0.18			AA × F = NS			AA × F = 0.016			AA × F = 0.04			AA × F = 0.05			AA × F = 0.01		
		M × AA × F = 0.26			M × AA × F = 0.20			M × AA × F = 0.023			M × AA × F = 0.06			M × AA × F = 0.07			M × AA × F = 0.02		

100%NPK mineral fertilizer = (120:30:24 kg fed^{-1})

100% NPK Nano-fertilizer (Hyper feed motawazen fertilizer) = (10 kg fed^{-1})

Gomaa *et al.* (2017) illustrated that foliar application of KP Nano- fertilizers and KP mineral fertilization in soil increased yield and its components of maize crop. Applying 75% N mineral along with 25% N nano significantly increased growth, yield, and yield components of maize in both seasons (Yasser *et al*., 2020). These results had the same trend with those reported by Gomaa *et al*. (2018), Khalil *et al*. (2019) and Gomaa *et al*. (2020) who revealed that the application of 50% mineral NPK fertilizer plus 50% NPK nano-fertilizer increased all traits of sorghum in both seasons. The same trend was resulted by Yasser *et al*. (2020)

Interaction effect:

Interaction between maize hybrids and amino acids (M×AA):

Results in Tables (4 and 5) showed that significant effect of interaction between maize hybrids and amino cat fertilizer were obtained for ear length, number of ears plant^{-1} and grain yield in both seasons, while plant height was not significantly influenced by the same interaction in both seasons. Maize hybrid TWC 353 treated with 200 cm^3 fed^{-1} amino cat fertilizer is distinguished by its superiority in all studied characters while maize hybrid TWC 360 gave the lowest values for yield and its attributes under foliar spraying of 100 cm^3 fed^{-1}. Zaki et al. (2014) indicated that spraying maize hybrid SC 10 with amino cat fertilizer at 200 cm^3 fed^{-1} increased yield and yield components. Also, Ahmed *et al*. (2019) showed that sorghum shandawell cultivars sprayed with 400 cm^3 fed^{-1} amino cat fertilizer out yielded the greatest mean values for yield and yield components in two growing seasons.

Interaction between maize hybrids and fertilization treatments (M×F):

The interaction between maize hybrids and fertilization treatments had a significant effect on plant height, ear length, number of ears plant^{-1} and grain yield in both seasons as shown in Tables 4 and 5.

Significant increase in yield and its attributes were realized by the interaction between maize TCW 353 and 50% N mineral +50% N nano fertilization. This result may be due to the increased growth traits and positive effect on yield characters under combination of mineral and nano-fertilizers. Similar results have been reported by Khalil *et al*. (2019) who noted that fertilized single hybrid maize by 75% mineral plus 25% nano N fertilizers gave the highest values for plant height, ear length, and grain yield. Likewise, Gomaa *et al*. (2017) found that the application of mineral fertilizer in the soil combined with foliar application of nano-fertilizer gave the highest mean values of number of grains row^{-1}, number of grains ear^{-1}and 100-grain weight for single maize hybrid. Yasser *et al*. (2020) supported these results.

Interaction between amino cat fertilizer and fertilization treatments (AA×F):

Significant interaction between each of the amino act fertilizer and fertilization treatments was obtained for all studied traits in both seasons, except plant height in 2018 (Tables 4 and 5). Maximum values of these traits were obtained from spraying maize plants by 200 cm^3 fed^{-1} of amino cat fertilizer and fertilized with 50% NPK mineral plus 50% nano NPK fertilizers (AA_2×F_6). While applied lowest amino cat level without fertilization treatments (AA_1×F_1) resulted the lowest values of all studied characters in 2018 and 2019 seasons.

Interaction between three factors (M×AA×F):

Plant height, ear length, number of ears plant^{-1}, and grain yield were significantly affected by the interaction between maize hybrids, amino cat fertilizer levels, and fertilization treatments in the two seasons Tables (4 and 5). The highest values of the corresponding data were (224.8 and 223.5 cm), (19.01 and 18.95 cm), (1.22 and 1.23 ears) and (3.73 and 3.80 ton fed^{-1}) were recorded by foliar spraying TWC 353 hybrid with 200 cm^3 fed^{-1} amino cat fertilizer and combined with 50% NPK mineral plus 50% nano NPK fertilizers (M_1×AA_2×F_6) in 2018 and 2019 seasons, respectively.

Table 4. Means of plant height and ear length as influenced by two maize hybrids, fertilization treatments, and amino cat fertilizer during the 2018 and 2019 seasons

Yield attributes													
Traits		Plant height (cm)						Ear length (cm)					
M: Maize hybrids	F: Fertilization treatments	AA: Amino acids			AA: Amino acids			AA: Amino acids			AA: Amino acids		
		AA_1	AA_2	Mean M×F	AA_1	AA_2	Mean M×F	AA_1	AA_2	Mean M×F	AA_1	AA_2	Mean M×F
		Season 2018			Season 2019			Season 2018			Season 2019		
M_1: TWC 353	F_1: 0.0 Control	200.5	207.1	203.8	198.9	206.2	202.6	16.13	17.25	16.69	16.07	17.17	16.62
	F_2: 100 Mineral	211.9	218.5	215.2	211.8	218.6	215.2	16.80	18.12	17.46	16.72	18.01	17.36
	F_3: 100 Nano	213.7	220.4	217.1	213.3	220.1	216.7	17.03	18.21	17.62	16.94	18.11	17.52
	F_4: 75 Min.+25 Nano	210.8	218.1	214.5	210.2	217.8	214.0	16.43	17.80	17.11	16.31	17.65	16.98
	F_5: 75 Nano.+25 Min.	215.6	223.7	219.7	215.0	222.5	218.8	17.00	18.10	17.55	16.80	18.05	17.43
	F_6: 50 Min.+50 Nano	216.9	224.8	220.9	215.3	223.5	219.4	17.45	19.01	18.22	17.36	18.95	18.15
	Mean of M × AA	211.6	218.7	215.2	210.7	218.1	214.4	16.81	18.08	17.45	16.70	17.99	17.35
M_2: TWC 360	F_1: 0.0 Control	191.5	199.3	195.4	192.4	200.1	196.3	15.88	17.03	16.45	15.83	17.01	16.42
	F_2: 100 Mineral	199.4	207.4	203.4	200.1	208.3	204.2	16.12	17.31	16.72	16.05	17.26	16.66
	F_3: 100 Nano	200.1	208.9	204.0	201.1	209.2	205.2	16.40	17.55	16.98	16.33	17.51	16.92
	F_4: 75 Min.+25 Nano	198.7	206.4	202.6	199.5	206.1	202.8	16.11	17.21	16.66	16.01	17.17	16.59
	F_5: 75 Nano.+25 Min.	201.4	208.5	205.0	202.0	209.5	205.8	16.21	17.34	16.77	16.11	17.26	16.68
	F_6: 50 Min.+50 Nano	202.4	210.5	206.5	202.9	211.5	207.2	16.92	17.95	17.54	16.76	17.93	17.35
	Mean of M × AA	198.9	206.6	202.8	199.3	207.4	203.4	16.27	17.40	16.84	16.18	17.36	16.77
(AA) × (F)	F_1: 0.0 Control	196.0	203.2	199.6	195.7	203.2	199.5	16.01	17.14	16.58	15.95	17.09	16.52
	F_2: 100 Mineral	205.6	210.9	209.3	205.9	213.4	209.7	16.46	17.72	17.09	16.38	17.64	17.01
	F_3: 100 Nano	206.9	214.2	210.5	207.2	214.7	211.0	16.72	17.88	17.30	16.63	17.81	17.22
	F_4: 75 Min.+25 Nano	204.8	212.3	208.5	204.9	211.9	208.4	16.27	17.51	16.89	16.16	17.41	16.79
	F_5: 75 Nano.+25 Min.	208.5	216.1	212.3	208.5	216.0	212.3	16.61	17.72	17.16	16.46	17.66	17.06
	F_6: 50 Min.+50 Nano	209.7	217.6	213.6	209.1	217.5	213.3	17.18	18.48	17.83	17.06	18.44	17.75
	Mean of Amino (AA)	205.2	212.7	------	205.2	212.8	------	16.54	17.74	------	16.44	17.67	------
LSD at 0.05		M = 0.79 AA = 0.64 F = 0.32 M × AA = NS M × F = 0.45 AA × F = NS M × AA × F = 0.64			M = 0.44 AA = 0.18 F = 0.23 M × AA = NS M × F = 0.33 AA × F = 0.33 M × AA × F = 0.47			M = 0.02 AA = 0.02 F = 0.03 M × AA = 0.03 M × F = 0.05 AA × F = 0.05 M × AA × F = 0.06			M = 0.01 AA = 0.06 F = 0.03 M × AA = 0.03 M × F = 0.05 AA × F = 0.05 M × AA × F = 0.07		

100%NPK mineral fertilizer = (120:30:24 kg fed^{-1})

100% NPK Nano-fertilizer (Hyper feed motawazen fertilizer) = (10 kg fed^{-1})

Table 5. Means of number of ears plant-1 and grain yield as influenced by two maize hybrids, fertilization treatments, and amino cat fertilizer during the 2018 and 2019 seasons

Yield attributes													
Traits		Number of ears plant^{-1}						Grain yield (ton fed^{-1})					
M: Maize hybrids	F: Fertilization treatments	AA: Amino acids			AA: Amino acids			AA: Amino acids			AA: Amino acids		
		AA_1	AA_2	Mean M×F	AA_1	AA_2	Mean M×F	AA_1	AA_2	Mean M×F	AA_1	AA_2	Mean M×F
		Season 2018			Season 2019			Season 2018			Season 2019		
M_1: TWC 353	F_1: 0.0 Control	1.01	1.02	1.02	1.02	1.03	1.03	2.79	2.82	2.81	2.81	2.84	2.83
	F_2: 100 Mineral	1.11	1.14	1.13	1.12	1.14	1.13	3.02	3.35	3.19	3.05	3.41	3.23
	F_3: 100 Nano	1.13	1.20	1.17	1.14	1.21	1.18	3.23	3.59	3.41	3.25	3.61	3.43
	F_4: 75 Min.+25 Nano	1.06	1.10	1.05	1.09	1.12	1.11	2.93	3.18	3.06	3.00	3.20	3.10
	F_5: 75 Nano.+25 Min.	1.10	1.16	1.13	1.11	1.18	1.15	3.15	3.43	3.29	3.19	3.49	3.34
	F_6: 50 Min.+50 Nano	1.16	1.22	1.19	1.17	1.23	1.20	3.40	3.73	3.57	3.41	3.80	3.61
	Mean of M × AA	1.10	1.14	1.12	1.11	1.15	1.13	3.09	3.35	3.21	3.12	3.39	3.26
M_2: TWC 360	F_1: 0.0 Control	1.00	1.00	1.00	1.00	1.01	1.01	2.45	2.44	2.45	2.47	2.46	2.47
	F_2: 100 Mineral	1.03	1.04	1.04	1.04	1.05	1.05	2.60	2.63	2.62	2.62	2.66	2.64
	F_3: 100 Nano	1.04	1.05	1.05	1.05	1.07	1.06	2.74	2.82	2.78	2.77	2.85	2.81
	F_4: 75 Min.+25 Nano	1.02	1.03	1.03	1.03	1.04	1.04	2.51	2.58	2.55	2.54	2.62	2.58
	F_5: 75 Nano.+25 Min.	1.04	1.06	1.05	1.05	1.08	1.07	2.56	2.77	2.67	2.68	2.82	2.75
	F_6: 50 Min.+50 Nano	1.07	1.10	1.09	1.07	1.10	1.09	2.86	2.93	2.90	2.89	2.90	2.90
	Mean of M × AA	1.03	1.05	1.04	1.04	1.06	1.05	2.62	2.70	2.66	2.66	2.72	2.69
(AA) × (F)	F_1: 0.0 Control	1.00	1.01	1.01	1.01	1.02	1.02	2.62	2.63	2.63	2.64	2.65	2.65
	F_2: 100 Mineral	1.07	1.09	1.08	1.08	1.10	1.09	2.81	2.99	2.90	2.84	3.04	2.94
	F_3: 100 Nano	1.09	1.12	1.11	1.10	1.14	1.12	2.99	3.21	3.10	3.01	3.23	3.12
	F_4: 75 Min.+25 Nano	1.04	1.07	1.06	1.06	1.08	1.07	2.72	2.88	2.80	2.77	2.91	2.84
	F_5: 75 Nano.+25 Min.	1.07	1.11	1.09	1.08	1.13	1.11	2.86	3.10	2.98	2.94	3.16	3.05
	F_6: 50 Min.+50 Nano	1.12	1.16	1.14	1.12	1.17	1.15	3.13	3.33	3.23	3.15	3.35	3.25
	Mean of Amino (AA)	1.06	1.09	------	1.07	1.10	------	2.86	3.02	------	2.89	3.06	------
LSD at 0.05		M = 0.007 AA = 0.004 F = 0.006 M × AA = 0.006 M × F = 0.006 AA × F = 0.006 M × AA × F = 0.01			M = 0.002 AA = 0.004 F = 0.006 M × AA = 0.01 M × F = 0.008 AA × F = 0.008 M × AA × F = 0.01			M = 0.03 AA = 0.02 F = 0.02 M × AA = 0.05 M × F = 0.03 AA × F = 0.03 M × AA × F = 0.05			M = 0.007 AA = 0.007 F = 0.01 M × AA = 0.01 M × F = 0.02 AA × F = 0.02 M × AA × F = 0.03		

100%NPK mineral fertilizer = (120:30:24 kg fed^{-1})

100% NPK Nano-fertilizer (Hyper feed motawazen fertilizer = (10 kg fed^{-1})

III- Correlation among traits:

Correlation coefficient values among most studied parameters i.e. growth, yield, and yield components (over the tested amino cat fertilizer, maize hybrids, and fertilization treatments), as of the two growing seasons, are presented in Table 6. The interrelationship among mean performances was positive and highly significant for the following traits, number of days to 50% tasseling, number of green leaves plant^{-1}, ear leaf area, plant height, ear length, number of ears plant^{-1} and grain yield in both seasons. Reversely, number of days to 50% tasseling had high significant and negative correlation coefficients with each of number of green leaves plant (r= -0.729** and -0.670**), ear leaf area (r= -0.873**and -0.833**), plant height (r= -0.944** and -0.892**), ear length (r= -0.731**and -0.683**), number of ears plant^{-1}(r= -0.904**and -0.894**) and grain yield (r= -0.909**and -0.954**) in the 2018 and 2019 seasons, respectively. Grain yield also exhibited positive and highly significant linear relationship of all studied traits, except for number of days to 50% tasseling which was negatively correlated in both seasons.

IV- Economic feasibility:

Sustainable agriculture involves maximizing net return which farmer, receives from agricultural production. When estimating the total of cultivation costs, net farm income, net farm return, and benefit: cost ratio for the two maize hybrids treated with amino cat fertilizer foliar application and using fertilization treatments (presented in Table 7). Data showed that total costs of maize production fed^{-1} as influenced by applied different treatments as an average of the two seasons.

The combination between treatments that included $M_1AA_2F_2$ and $M_2AA_2F_2$ (TWC 353 or TWC 360, 200 cm^3 amino cat fertilizer and 100% mineral NPK fertilizer) gave maximum total costs which were 6691 L.E fed^{-1}. Whereas, maize hybrid under study which received foliar application with 100 cm^3 amino cat fertilizer or the control treatment exhibited the lowest costs 6040 L.E fed^{-1} ($M_1AA_1F_1$) and ($M_2AA_1F_1$). Results in Table 7 indicated that the foliar application of TWC 353 hybrid with 200 cm^3 amino fertilizer ($M_1AA_2F_6$), beside fertilization by 50% mineral NPK + 50% NPK nano-fertilizers, recorded the highest values for net farm income (12926 L.E fed^{-1}), net farm return (6360 L.E fed^{-1}) and BCR (1.97) as well as, the economic efficiency (net farm return / total costs = 0.97). This result is due to the highest grain yield productivity under this treatment (3.77 ton fed^{-1}) as an average of the two seasons compared with the other treatments.

Table 6. Simple correlation coefficients (r) for 7 characteristics of two maize hybrids grown under foliar application of amino cat fertilizer and fertilization treatments during 2018 and 2019 seasons

Traits	(NT)	(NGL)	(ELA)	(PH)	(EL)	(NE)	(GY)
No. of days to 50% tasseling (NT)		-0.729**	-0.873**	-0.944**	-0.731**	-0.904**	-0.909**
No. of green leaves plant^{-1} (NGL)	-0.670**		0.874**	0.669**	0.645**	0.799**	0.547**
Ear leaf area (ELA)	-0.833**	0.866**		0.884**	0.845**	0.942**	0.785**
Plant height (PH)	-0.892**	0.690**	0.885**		0.849**	0.903**	0.886**
Ear length (EL)	-0.683**	0.638**	0.841**	0.879**		0.778**	0.649**
Number of ears plant^{-1} (NE)	-0.894**	0.775**	0.932**	0.925**	0.759**		0.871**
Grain yield (GY)	-0.954**	0.550**	0.795**	0.871**	0.635**	0.899**	

Season 2018 (above diagonal) Season 2019 (below diagonal)

Table 7. The total cost of cultivation, *net farm income, **net farm return, and ***benefit: cost ratio of maize production as influenced by different treatments (average of the two successive seasons)

Treatments		An economic evaluation of maize production											
M: Maize hybrids	F: Fertilization treatments	Total costs L.E fed^{-1}			Net farm income L.E fed^{-1}			Net farm return L.E fed^{-1}			BCR		
		Amino acids AA		Mean	Amino acids AA		Mean	Amino acids AA		Mean	Amino acids AA		Mean
		AA_1	AA_2	M×F	AA_1	AA_2	M×F	AA_1	AA_2	M×F	AA_1	AA_2	M×F
M_1: TWC 353	F_1:	6040	6080	6060	9600	9703	9652	3560	3623	3592	1.59	1.60	1.60
	F_2:	6651	6691	6671	10423	11589	11006	3772	4898	4335	1.57	1.73	1.65
	F_3:	6400	6440	6420	11109	12343	11726	4709	5903	5306	1.74	1.92	1.83
	F_4:	6589	6629	6609	10183	10937	10560	3594	4308	3951	1.55	1.65	1.60
	F_5:	6463	6503	6483	10869	11863	11366	4406	5360	4883	1.68	1.82	1.75
	F_6:	6526	6566	6546	11691	12926	12309	5165	6360	5763	1.79	1.97	1.88
Mean of M × AA		6445	6485	6465	10646	11560	11103	4201	5075	4638	1.65	1.78	1.72
M_2: TWC 360	F_1:	6040	6080	6060	8434	8400	8417	2394	2320	2357	1.40	1.38	1.39
	F_2:	6651	6691	6671	8949	9086	9018	2298	2395	2347	1.35	1.36	1.36
	F_3:	6400	6440	6420	9463	9737	9600	3063	3297	3180	1.48	1.51	1.50
	F_4:	6589	6629	6609	8674	8914	8794	2085	2285	2185	1.32	1.34	1.33
	F_5:	6463	6503	6483	8983	9600	9292	2520	3097	2809	1.39	1.48	1.44
	F_6:	6526	6566	6546	9874	10011	9943	3348	3445	3397	1.51	1.52	1.52
Mean of M × AA		6445	6485	6465	9063	9291	9177	2618	2807	2713	1.41	1.43	1.42
(AA) × (F)	F_1:	6040	6080	6069	9017	9052	9035	2977	2972	2975	1.50	1.49	1.50
	F_2:	6651	6691	6671	9686	10338	10012	3035	3647	3341	1.46	1.55	1.51
	F_3:	6400	6440	6420	10286	11040	10663	3886	4600	4243	1.61	1.72	1.67
	F_4:	6589	6629	6609	9429	9926	9678	2840	3297	3069	1.44	1.50	1.47
	F_5:	6463	6503	6483	9926	10732	10329	3463	4229	3846	1.54	1.65	1.60
	F_6:	6526	6566	6546	10783	11469	11126	4257	4903	4580	1.65	1.75	1.70
Mean of (AA)		6445	6485	-------	9855	10426	-------	3410	3941	-------	1.53	1.61	-------

F_1: 0.0 Control F_2: 100 Mineral F_3: 100 Nano-fertilizer F_4: 75 Min.+25 Nano F_5: 75 Nano.+25 Min. F_6: 50 Min.+50 Nano

*Net farm income=Price (L.E ton^{-1}) × grain yield (ton fed^{-1}) **Net farm return=Net farm income – Total costs ***RCB=Net farm income / Total costs

To calculate the total return and the average of maize grain price presented by Bulletin of agriculture Statistical Cost Production and Net Return, 2018.

CONCLUSION AND RECOMMENDATIONS

From this study, it could be concluded that spraying maize hybrid TWC 353 with 200 cm^3 amino cat fertilizer and added 50% mineral NPK + 50% NPK nano-fertilizers led to improve its performance, increased grain yield fed^{-1} and net economic return as well as maximizing productivity per unit area and reduce production costs and environmental pollution under Toshka conditions.

REFERENCE

Abdel-Aziz, H. M. M., M. N. A. Hasaneen and O.M. Aya. 2018. Foliar application of nano chitosan NPK fertilizer improves the yield of wheat plants grown on two different soils. The Egyptian J. of Experimental Biology (Botany).14(1): 63-72.

Abd-Elaziz, M. A. A., H. A. Darwish, H. M. El-Shahed, H. A. A. Mohamed and R. H. A. Alsebaey. 2020. Evaluation of some maize hybrids under water stress conditions. J. of Plant Production, Mansoura Univ. 11(12):1625 – 1631.

Abd El-Aal, M. M. and E. S. M. Rania. 2018. Effect of foliar spray with lithovit and amino acids on growth, bioconstituents, anatomical and yield features of soybean plant. 4th Int. Confe. Biotech. App. Agric. (ICBAA), Moshtohor Benha Univ. Hurghada. 4-7 April.

Ahmed, M.A., G. A.Amal and A.E. Ebtesam. 2019. Alleviating adverse effect of water stress on some grain sorghum (*Sorghum bicolor* L. Moench) cultivars by foliar application with amino cat fertilizer. Plant Archives. 19(2):2237- 2252.

Al-juthery, H. W. A., H. M. Hardan, F. G.A. Al-Swedi, M. H. Obaid and Q. M. N. Al-Shami. 2019. Effect of nano-fertilizers and amino acids on growth and yield of wheat. IOP Conf. Series: Earth and Environmental Sci. 388.

Ali, O.A.M. and M.S.M. Abdelaal. 2020. Effect of irrigation intervals on growth, productivity and quality of some yellow maize genotypes. Egypt. J. Agron. 42(2): 105-122.

Ardebili, Z.O., A.R.L. Moghadam, N.O. Ardebili and A.R. Pashaie. 2012. The induced physiological changes by foliar application of amino acids in Aloe vera L. plants. Plant Omics. 5: 279-284.

Awadalla, A. and A. S. M. Morsy. 2016. Response of some yellow maize crosses to N- fertilizer rates and plant densities at Toshka region. Egypt. J. Agron. 38(3):337-354

Bulletin of Agriculture Statistical. 2018. Summer & Nile Crops. Agriculture Statistical and Economic Sector. Ministry of Agriculture and Land Reclamation, Part (2). Egypt.

Casimir, L. A. S., H. K. V. Kouame, L. F. Coulibaly and K. Kouame. 2020. Effect of rainfall on growth parameters and yield of four varieties of maize (*Zea Mays*), grown in Korhogo Commune, northern Cote d'Ivoire. J. Agric. Crop Res. 8(4):82-89.

CIMMYT. 1988. “From Agronomic Data to Farmer Recommendation: An Economic Work Book” D.F: pp. 31-33.

El-Hassanin, A.1, A. El-Ganayni, E. Ola, A. A. Maboud, A. Khalifah and M. Shousha. 2015. Interaction effect of both soil and foliar application of NPK on response of corn varieties in Egypt and Morocco. J. Plant Production, Mansoura Univ. 6 (4): 481-491.

El-Hosary, A. A., G. Y. Hammam, E. M. El-Gedwy, A.A.A. El-Hosary and M. E. Sidi. 2019. Response of white maize hybrids to various nitrogen fertilizer rates in Qalyubia, Egypt. Bioscience Research. 16 (3): 2475-2485.

El-Mekser, K. A. Hoda, O. M. Dewidar and M. M. B. Darwich. 2020. Response of 3-way crosses hybrids of corn (*Zea mays* L.) to different fertilizer levels and its effect on growth, yield, physicochemical and technological characteristics. Egypt. J. Agric. Res. 98 (1): 23-39

Eyasu, E., D. Shanka, D.Dalga and E. Elias. 2018. Yield response of maize (*Zea mays*, L.) varieties to row spacing under irrigation at Geleko, Ofa Woreda, Wolaita Zone, and Southern Ethiopia. J. Exp. Agric. Inter. 20 (1): 1-10.

FAOSTAT. 2019. Statistical Information. http://www.faostat.com.

Gardner, F. P., R. B. Pearce and R. L. Mithchel. 1985. Physiology of crop plants. The IOWA state Univ. Press, IOWA 50010, Pp 156-186.

Gomaa, M. A., F. I. Radwan, E. E. Kandil and D. H. H. Al-Challabi. 2017. Comparison of some new maize hybrids response to mineral fertilization and some nanofertilizers. Alexandria Sci. Exchange J. 38(3)506-514.

Gomaa, M. A., F. I. Radwan, E. E. Kandil and M.A.F. Al-Msari. 2018. Response of some Egyptian and Iraqi wheat cultivars to mineral and nano-fertilization. Egypt Acad. J. Biolog. Sci. 9(1) 19-26.

Gomaa, M.A., I. F. Rehab, A. M. Kordy and M. A. S. Bilkess. 2020. Assessment of sorghum (*Sorghum bicolor* L.) productivity under different weed control methods, mineral and nano Fertilization. Egypt. Acad. J. Biolog. Sci. 11(1):1-11.

Gomez, K.A. and A.A. Gomez. 1984. Statistical procedures for agriculture Research. A Wiley-Inter Science publication, john Wiley and sons, Inc. New York, USA.

Hassaan, M. A. 2018. Response of some yellow maize hybrids (*Zea mays* L.) to sowing date under Toshka conditions. J. Plant Production, Mansoura Univ. 9 (6): 509-514.

Kandil, E.E. and A. O. E. Marie. 2017. Response of some wheat cultivars to Nano-, mineral fertilizers and amino acids application. Alexandria Sci. Exchange J. 38(1):53-68.

Kannan, R.L., M. Dhivya, D. Abinaya, R.L. Krishna and S.K. Kumar. 2013. Effect of integrated nutrient management on soil fertility and productivity in maize. Bull. Environ. Pharmac. Life Sci. 2(8): 61-67.

Kasraie, P., M. Nasri and M. Khalatbari. 2012. The effects of time spraying amino acid on water deficit stress on yield, yield component and some physiological characteristics of grain corn (TWC 647). Annals of Biol. Res. 3 (9):4282-4286.

Khalil, M.H., A.F. Abou-Hadid, R.Th. Abdrabou, S.H.Abd Al-halim and M.Sh. AbdEl-Maaboud. 2019. Response of two maize cultivars (*zea mays* L.) to organic manure and mineral nano nitrogen fertilizer under Siwa oasis conditions. AUJAS, Ain Shams Univ., Cairo, Egypt. Special Issue, 27(1):299-312.

Kopittke, P. M., E. Lombi, P. Wang, J. K. Schjoerringd and S. Hustedd. 2019. Nano-materials as fertilizers for improving plant mineral nutrition and environmental outcomes. Environ. Sci. Nano. 6:3513-3524.

Manikandan, A. and K. S. Subramanian. 2016. Evaluation of zeolite-based nitrogen Nano-fertilizers on maize growth, yield and quality on inceptisols and alfisols. Int. J. of Plant & Soil Sci. 9(4): 1-9.

Mehrez, E. E., N. R. Abdelsalam, M.M.G. Fouda, M. I. Mackled, M. A.M. Al-Jaddadi, H. M. Ali, M. H. Siddiqui and E. E. Kandil. 2020. Soil Application of Nano silica on maize yield and its insecticidal activity against some stored Insects after the post-harvest. Nanomaterials. 10:739.

Miransari, M. 2011. Soil microbes and plant fertilization. Appli. Microb. Biotec. 92:875-885.

Page, A.L., R.H. Miller and D.R. Keeney. 1982. Methods of soil Analysis. Part 2: chemical and microbiological properties. 2nd ed. Amer. Soc. Agron. Inc. Soil. Sci. Soc. Of Am., Madison, Wisconsin, USA.

Pratelli, R. and G. Pilot. 2014. Regulation of amino acid metabolic enzymes and transporters in plants. J. Exp. Bot. 65: 5535-5556.

Entsar, E. R. 2016. Sweet corn as affected by foliar application with amino and humic acids under different fertilizer sources. Egypt. J. Hort. 43(2): 441-456.

Shang, Y., Md. K. Hasan, G. J. Ahammed, M. Li, H. Yin and J. Zhou. 2019. Applications of nanotechnology in plant growth and crop protection: A Review. Molecules. 24, 2558:1-24.

Seadh, S.E., W.A.E. Abido and D.R. Abdulrahman. 2015. The role of foliar application in reducing maize nitrogen requirements. J. Plant Production, Mansoura Univ. 6(7): 1168-1180.

Sendecor, G. W. and W. G. Cochran. 1990. Statistical methods 7th Ed-Iowa State Univ. Press, Ames Iowa USA. pp.507.

Singh, M. D., C. Gautam, O. P. Patidar, H. M. Meena, G. Prakasha and Vishwajith. 2017. Nano-Fertilizers is a new way to increase nutrients use efficiency in crop production. International J. Agric. Sci. 9(7) 3831-3833.

Tajul, M.I., M.M. Alam, S.M.M. Hossain, K. Naher, M.Y. Rafii and M.A. Latif. 2013. Influence of plant population and nitrogen fertilizer at various levels on growth and growth efficiency of maize. The Scientific World J. 1-9.

Valizadeh, M. and V. Milic. 2016. The effects of balanced nutrient managements and nano-fertilizers effects on crop production in semi-arid areas. Current Opinion in Agriculture. 5(1):31-38.

Yasser, E. E., E. A.Amira and K. A. El-Douby. 2020. Influence of intercropping cowpea with some maize hybrids and N nano-mineral fertilization on productivity in salinity soil. Egypt. J. Agron. 42(1): 63-78.

Nabila, M.Z., A. G.Amal, M.S. Hassanein, F.M. Manal and M.M. Tawfik. 2014. Yield and yield components of two maize hybrids as influenced by water deficit and amino cat fertilizer. Middle East J. Applied Sci. 4(3): 648-654.

Nabila, M.Z., M.S. Hassanein, A. G.Amal, M.A. Ahmed and M. Hozayn. 2016. Impact of urea and potassium foliar application on yield and yield components of two maize hybrids. International J. of ChemTech Research. 9(7): 300-307.

الملخص العربي

إستجابة هجينين من الذرة الشامية الصفراء للأحماض الأمينية والتسميد المعدنى والنانو تحت ظروف منطقة توشكا

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أجريت هذه الدراسة خلال موسمي ٢٠١٨ و ٢٠١٩ بالمزرعة البحثية بمجمع الدراسات والبحوث المائية بتوشكى بهدف دراسة تأثير إستخدام تركيزين من الأحماض الأمينية (١٠٠ و ٢٠٠ سم٣/فدان) و ٦ معدلات مختلفة من NPK المعدنية والأسمدة النانوية (م١=كنترول ، م٢=١٠٠٪ من الأسمدة المعدنية الكلية، م٣=١٠٠٪ من سماد النانو تكنولوجى، م٤=٧٥٪ معدنى + ٢٥٪ نانو، م٥=٧٥٪ نانو + ٢٥٪ معدنى و م٦=٥٠٪معدنى + ٥٠٪ نانو) على النمو والإنتاجية وصافي العائد الإقتصادي لأثنين من هجين الذرة الشامية الصفراء (هجين ثلاثى ٣٥٣ و ٣٦٠). وقد إستخدم تصميم القطاعات كاملة العشوائية بترتيب الشرائح المنشقة بثلاث مكررات. الصفات التي تمت دراستها هي عدد الأيام من الزراعة حتى ظهور ٥٠٪ من النورات المذكرة ، عدد الأوراق الخضراء لكل نبات، مساحة ورقة الكوز، إرتفاع النبات، طول الكوز، عدد الكيزان/نبات، ومحصول الحبوب.

أظهرت النتائج التي تم الحصول عليها أن هجن الذرة ، وسماد الأمينو كات ، معاملات التسميد، وتفاعلاتها أثرت معنوياً على معظم الصفات محل الدراسة في الموسمين.

الهجين الثلاثى TWC 353 حقق أعلى متوسطات لجميع الصفات السابقة في كلا الموسمين . أرتبط الرش الورقي بسماد الأمينو كات عند تركيز ٢٠٠ سم٣ إرتباطًا معنوياً بالزيادات المقابلة لجميع الصفات محل الدراسة خاصة محصول الحبوب (٣.٠٢ و ٣.٠٦ طن/فدان) في الموسمين الأول والثاني على التوالي. أدى التسميد بـ ٥٠ ٪ من التسميد المعدني + ٥٠ ٪ من التسميد النانو إلى زيادة كل الصفات خلال موسمي النمو.

كما كانت التفاعلات الثنائية والثلاثية معنوية لمعظم الصفات تحت الدراسة. سجل التفاعل الثلاثى (هجين الذرة الثلاثى ٣٥٣ × ٢٠٠سم٣ من سماد الأمينو كات × التسميد المعدنى بـ ٥٠٪ والنانو بـ ٥٠٪) أعلى القيم لكلاً من صافى دخل المزرعة (١٢٩٢٦ جنية لكل فدان) و صافى عائد المزرعة (٦٣٦٠ جنيه لكل فدان) و نسبة الفائدة للتكلفة (١,٩٧) والكفائة الإقتصادية (٠,٩٧) كما سجل نفس التفاعل أعلى إنتاجية لمحصول الحبوب (٣,٧٧ طن للفدان) كمتوسط للموسين بالمقارنة بالمعاملات الأخرى.

التوصية: توصى الدراسة بزارعة الهجين الثلاثى TWC 353 وتسميده ورقياً بسماد الأمينو كات بتركيز ٢٠٠ سم٣ بالإضافة إلى التسميد بـ ٥٠٪ من التسميد المعدني الموصى به + ٥٠٪ من سماد النانو للحصول على أعلى نمو وإنتاجية لوحدة المساحة وكذلك أعلى دخل وأربحية تحت ظروف منطقة توشكا.