Effect of Foliar Application with Growth Promoters and Mixture of Fe, Zn and Mn on Growth and Yield of Corn under Different Nitrogen levels

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ABSTRACT

In the summer of 2020 and 2021, two field experiments were conducted at the Sakha Agricultural Research Station in Kafr el-Sheikh, Egypt. The primary aim of the research was to optimize the growth characteristics and yields of hybrid TWC.360 corn by applying nitrogen fertilizer rates and foliar application. Experiment was conducted in a split-plot design with four replication. The results indicated that in all seasons, grain production, protein percentage, growth parameters, and yield attributes all greatly outperformed other study levels (80 and 100 kg N/fed) when nitrogen fertilizer was administered at a rate of 120 kg N/fed. In corn, foliar application of amino total, melagrow, and combinations (Fe+Zn+Mn) produced the highest values for grain protein percentage and growth parameters in both seasons. However, in both seasons, the maximum values of yield and its constituents were obtained with foliar application of Amino complete. In general, based the results obtained in from study, this resulted in reducing the costs of nitrogen fertilization while obtaining the same yield value / average costs it can be concluded that to maximize the growth and productivity of corn under environmental conditions in the North Delta location of Egypt.

Keywords: Corn, foliar nutrition, growth promoters Nitrogen rates.

INTRODUCTION

Corn (Zea mays L.) is a major cereal and versatile grain crop in the grass family. It is used in industry to make dextrose, corn starch, corn syrup, and corn flakes, as well as for human consumption and animal and poultry feed. (Gulet et al. 2021). Additionally, it thrives in a variety of climates and soil types. It can gain more from certain nutrients than other crops such grain legumes and cereals. A variety of uses exist for corn cultivation, such as grain and silage for cattle feed, grain for poultry and swine feed, and grain and sweet corn for human use. After wheat and rice, it is one of the most significant food crops in Egypt in terms of both cultivated area and production. 1.03 million hectares, or roughly 25.2% of Egypt's total cultivated land, are planted with corn, and FAOSTAT (2020) estimates that the crop produces 8.3 tons of grain per hectare. The Egyptian government aims to improve the production of grains per unit area of agricultural land. For maize plants, nitrogen (N) is a crucial nutrient.

It is a crucial component of several metabolic processes that are vital to photosynthetic activity and agricultural output. The availability of nitrogen influences maize grain output and plant growth. An effective of radiation interception, nitrogen partitioning to reproductive organs, and other physiological parameters can be used to quantify the effect of nitrogen availability on maize grain output. (Sandhu et al.2021). Effects of nitrogen fertilizer on maize plants, including how it affects the growth, maintenance, and photosynthetic efficiency of leaf area (Shah et al. 2021a), (Habtegebrial et al. 2007), and (Kaur et al. 2012). High nitrogen application to corn improved plant elongation and yield as well as maximum germination rate (Keskin et al., 2005) and (Siddiqui et al., 2006). (Ogola et al., 2002).

It was stated that higher rates of nitrogen caused higher in dry matter (25-42%) and corn grain output (43-68%). Additionally, nitrogen is necessary for metabolism and physiological processes (Vijayalakshmi et al. 2013). Spraying varied amounts of N, P, and K increased the amount of protein in the grain and changed the proportions of different amino acids in the grain protein of corn (Ali et al. 2011). (El-Azab 2012) discovered applying Maringa loafer leaf extracts, a natural source of cytokinin, to maize enhanced its leaf area, grass height, and root fresh and dry weight. Additionally, he discovered that using Melagrow topically improved corn's yield and characteristics while producing the highest yields. On the other hand, control (water) showed the lowest values. According to (Kasrai et al., 2012) the number of grains per row, number of rows per ear, weight of 1000 grains, yield of corn grains, and protein content of grains were all impacted by the number of times an amino acid was sprayed. Prior to water deficiency stress, foliar application of amino acids produced maximum number of ears per plant, number of grains per row, number of rows per ear, 1000 grain weight, and number of rows per hectare of grain yield. When safflower plants were treated with Melagrow is an organic growth enhancer, twice, 30 and 70 days after seeding, (Seadh et al. 2012) reported the highest grain yield and its characteristics. In contrast, the lowest yield and component levels were seen in the control treatment, which was without any spraying. A variety of amino acids play key roles in the production of hormones like auxin, increase environmental chlorophyll levels, promote photosynthesis, and function as chelating agents to facilitate the uptake and transfer of micronutrients.

Therefore, the purpose of this study was to ascertain the optimal amount of mineral nitrogen fertilizer, foliar
application of growth promoter and mixture of micronutrients to maximize the productivity of three way cross (TWC 360) under environmental conditions in the Egypt's North Delta region.

**MATERIALS AND METHODS**

This Investigation was conducted in the Sakha Agricultural Research Station, Egypt during the two summer seasons of 2020 and 2021. The experimental site is located at 31.07 North Latitude, 30.05 East Longitude with an elevation of about 6 meters above sea level. The study was to maximize productivity of corn triple (TWC.360) through determination of optimal nitrogen fertilizer levels and foliar application of growth promoter and mixture of Fe+Zn+Mn treatments. Experiment was conducted in a split-plot design in four replication. For the main - plots, three different nitrogen fertilizer amounts were applied: N1=80 kg N/fed, N2=100 kg N/fed, and N3=120 kg N/fed. Applying urea (46.5% N) as the mineral nitrogen fertilizer to the soil in two equal portions before the first irrigation and the second irrigation was the first step in the process. Urea was the basic formula of physiological attributes studied was used according to Radford (1967).

**Photosynthetic pigments contents of leaves:**

One hundred days after planting, ten guarded plants were selected at random from each plot to determine the following growth traits. Chlorophyll a, chlorophyll b, and carotenoids were determined from five disks collected from corn harvests. Disks were extracted by pounding in 85% aqueous acetone (20 ml), and sometime after pounding, the CaCO3 squeeze was included in acetone. After filtration, the volume of acetone was reduced to 20 ml. The overall chlorophyll color was determined by measuring the wavelengths at 662 nm and 644 nm, while 470 nm for carotenoids in a spectrophotometer and computed the photosynthetic pigment concentration based on the parameters of Lichtenthaler and Buschmann (2001). Chl a =11.24 (0.D) 662-2.04 (0.D)644= (mg/dm F.W) Chl b =20.13 (0.D) 644-4.19 (0.D)662= (mg/dm F.W)Car. =1000 (0.D) 470- 1.90 chl a -63.14 chl b/214= (mg/dm F.W)

**Table 1. Chemical composition to Aminototal as foliar growth promoter.**

<table>
<thead>
<tr>
<th>Aminototal Content</th>
<th>Concentrate (%)</th>
<th>Aminototal content</th>
<th>Concentrate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspartic</td>
<td>3.20-3.45</td>
<td>Leucine</td>
<td>0.23-0.31</td>
</tr>
<tr>
<td>Threonine</td>
<td>3.05-3.56</td>
<td>Valine</td>
<td>2.80-3.10</td>
</tr>
<tr>
<td>Glutamic</td>
<td>7.24-9.12</td>
<td>Phenylalanine</td>
<td>1.26-1.70</td>
</tr>
<tr>
<td>Serein</td>
<td>3.76-4.49</td>
<td>Isoleucine</td>
<td>1.98-2.80</td>
</tr>
<tr>
<td>Glycine</td>
<td>1.87-2.43</td>
<td>Arginine</td>
<td>0.42-0.90</td>
</tr>
<tr>
<td>Proline</td>
<td>2.23-3.50</td>
<td>Histidine</td>
<td>1.03 -1.78</td>
</tr>
<tr>
<td>Cystine</td>
<td>1.87-2.45</td>
<td>Methionine</td>
<td>0.48-1.02</td>
</tr>
<tr>
<td>Alanine</td>
<td>2.16-2.20</td>
<td>Tyrosine</td>
<td>5.20 -6.30</td>
</tr>
<tr>
<td>Lysine</td>
<td>1.39-2.30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Each plot was 14.7 m², 7 rows, 3.0 m long and 0.7 m wide. The experimental sites were preceded by wheat in the both seasons. Corn grown was sown on May 19th and 15th in 2020 and 2021 seasons, respectively, at 25 cm spacing. Six irrigations were performed on the plots; the first irrigation took place 21 days after seeding, and the others happened every 14 days. The experimental plots were plowed, levelled, compacted, and ridged twice and divided into experimental units (14.7 m²). Hills were spaced 25 cm, at a rate of 15 kg grains /fed.in the both seasons 150 kg of calcium superphosphate (15.5% P2O5) was added to the soil throughout the amendment process. Harvesting took place on September 8th and 6th in 2020 and 2021 seasons, respectively. The physical and chemical properties of the experimental soils are shown in Table 2. Except for the factors under study, other farming practices were applied is recommended Table 1 according to the method described by Klute. (1986).

**Table 2. Soil analysis at the experimental sites during the two growing seasons of 2020 and 2021.**

<table>
<thead>
<tr>
<th>Soil analysis</th>
<th>2020 season</th>
<th>2021 season</th>
</tr>
</thead>
<tbody>
<tr>
<td>A- Physical properties</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silt %</td>
<td>24.35</td>
<td>25.76</td>
</tr>
<tr>
<td>Clay %</td>
<td>47.04</td>
<td>47.40</td>
</tr>
<tr>
<td>Texture</td>
<td>Clayey</td>
<td>Clayey</td>
</tr>
<tr>
<td>B- Chemical properties</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic matter %</td>
<td>1.94</td>
<td>1.87</td>
</tr>
<tr>
<td>Available N (ppm)</td>
<td>29.6</td>
<td>31.04</td>
</tr>
<tr>
<td>Available P (ppm)</td>
<td>11.5</td>
<td>18.34</td>
</tr>
<tr>
<td>Exchangeable K (ppm)</td>
<td>291.3</td>
<td>314.5</td>
</tr>
<tr>
<td>pH</td>
<td>7.85</td>
<td>7.94</td>
</tr>
<tr>
<td>EC m. mohs/cm</td>
<td>0.59</td>
<td>0.62</td>
</tr>
</tbody>
</table>

**Table 2. Soil analysis at the experimental sites during the two growing seasons of 2020 and 2021.**

**Studied Characters:**

- **A- Physiological parameters:**
  - Characters related to crop growth rate and net assimilation rate were estimated for the 45-60 and 60–75 days after sowing (DAS) growth phases.
  - **1-crop growth rate (CGR):**
    \[ W_{2}-W_{1}/T_{2}-T_{1}= (g/m²)/week. \]
  - **2-Net assimilation rate (NAR):**
    \[ W_{2}(W_{2}-W_{1})/(log_{e}A_{1}-log_{e}A_{2})/(T_{2}-T_{1}) = (g/m²)/week \]
  - Where: \( W_{1} \) and \( W_{2} \) differences on dry matter accumulated between the successive simples, respectively.
  - \( A_{1} \) and \( A_{2} \) difference on leaf area/plant “cm²” between the successive simples, respectively.
  - Loge = logarithm to the base “e” where is the base of natural logarithm (2.71828), \((t_{1}-t_{1})\) member of weeks esteem two successive samples. The basic formula of physiological attributes studied was used according to Radford (1967).

- **B- Yield and its components:**
  - During harvest (120 days after planting), ten guarded plants and ears were randomly picked from each plot, and the following yields and their constituent parts were measured.
  - **1-Plant height (cm):**
    - Length of ear (cm).
    - Ear diameter of the ear (cm).
  - **4- Weight of ears (g):**
    - Weight of ear grain (g).
    - Shelling (%).
    - 100-grain weight (g).
  - **8- Grain yield (tons/fed.) 9-stover yield (tons/fed.):** calculated by...
converting the weight of grain per kilogram to tons per feddan, adjusted to 15.5% moisture content in each plot.

C- Grain quality:
1- Crude protein of grains (%): A tiny Kjeldahl device was used to digest a known weight of the finely ground seeds (about 0.1g). The total nitrogen was multiplied by 5.85 to determine the crude protein AOAC. (A.O.A.C. 2007).
2- Total carbohydrates of grains (%): Determined by applying the Enthorne technique, as detailed by Sodasivam and Manickam (1996).
3-Oil content of grains (%): According to the procedures of (A.O.A.C 2007), the oil of the seeds was extracted using a Soxhlet's extractor and petroleum ether (60-80°C). The extractions took at least eight hours, with a siphoning rate of 6-7 per hour.
4-Ash (%): To calculate the grain ash content, take 2.0 g of each sample, weigh it in a crucible, and burn it for 8 hours at 600 degrees Celsius in a muffle furnace as described by (A.O.A.C 2007).
5-Crude fiber of grains %: was ascertained using the conventional method outlined in (A.O.A.C 2007).

D-Economic evaluation:
1- Total yield (EGP/fed.):
Total yield was estimated using the following formula with the main product of corn (grain).
Total harvest = grain yield (tons/fed.) x price of 1 ton (9871EGP.)
2-Total cost of production (EGP/fed.): A-Cost of tested mineral fertilizer = rate of urea fertilizer used/fed. x price of 1 kg of urea fertilizer. Here, 1 kg of urea is equivalent to 6.60 kg of mineral fertilizer = rate of urea fertilizer used/fed. x price of 1 kg of urea fertilizer. D-Cost of the tested applying foliar spray using a mixture of (Fe, Zn, Mn). Aminototal and Melagrow: calculated on the basis of 400 g of the tested foliar spraying is equivalent to 600 EGP. C-Other costs include land preparation, seed, planting, pest control, other fertilizers, irrigation, weed control, land rent, harvesting, labor wages, machinery, and other expenses. Production costs were calculated from data presented in the preliminary agricultural machinery, and preparation, seed, planting, pest control, other expenses. Production costs were calculated from data presented in the preliminary agricultural machinery, and preparation, seed, planting, pest control, other expenses.
3-Net return (EGP/fed.) = total return on production/fed.- total cost of production. 4-change in total return (%) = (Total of returns treatments – total return of control) / Total return of control x 100

5-Benefit/cost ratio (EGP return/EGP cost): It was estimated by the following described by John and Frank (1987).

Benefit/cost ratio = Total return of production/Total costs of production.

Statistical analysis: Individual analysis of variance (ANOVA) of split plot design, as described by (Gomez and Gomez 1984), was used to the data collected throughout the two seasons. The (Snedecor and Cochran 1982) analysis of variance was used, and treatment means were compared using (LSD) at the probability threshold of 0.05. Using the "MSTAT-C" (1990) computer software package, the analysis of variance technique was used for all statistical studies.

RESULTS AND DISCUSSION

Growth parameters:
The Data in Table (3) indicated the effects of different levels form nitrogen fertilizer and foliar application of physiological growth parameters as well as mixture of (Fe, Zn, Mn). Results showed that nitrogen fertilizer rates and foliar application with growth promoters and microelements mixture significantly affected impacted the net assimilation rate (NAR) and crop growth rate (CGR). Findings indicated that increasing nitrogen application from 80 to 120 kgN/fed. significantly increased CGR and NAR in two growth periods in both seasons. These results are agree with (Rong and Xuefeng 2011), (Asif et al., 2013) (Vishuddha. 2015) (Wasaya et al., 2017) and (Hu et al.,2020) they showed that improvising nitrogen rate increases progressively and positively affected average yield. Furthermore, many researchers have found that increased nitrogen utilization has a positive impact on maize productivity. The foliar application by a mixture of Aminototal, Melagrow, and (Fe, Zn and Mn) was observed at two growth stages in both seasons which Aminototal + Melagrow + mixture of (Fe, Zn and Mn) resulted in higher CGR and NAR as well as foliar application of Aminototal+ mixture of (Fe, Zn and Mn) was next. On the other hand, the lowest effective was foliar application with water (control). The interaction between nitrogen levels and foliar spray treatments was significant for CGR and NAR at the two periods in both seasons. This result agree with the results obtained by (Badawi et al., 2012) and (Ibrahim et al., 2014) and (Vishuddha 2015).

Table 3. Effect of mineral nitrogen levels and foliar spraying with growth promoters and (Fe, Zn, Mn) on some physiological attributes of maize plant at periods of 45-60 and 60-75 days after sowing in 2020 and 2021 seasons.

<table>
<thead>
<tr>
<th>Characters Treatments</th>
<th>Crop growth rate (g/m²/week)</th>
<th>Net assimilation rate (g/m²/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>45-60 (DAS)</td>
<td>60-75 (DAS)</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td>2021</td>
</tr>
<tr>
<td>A- Nitrogen fertilizer levels:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80 kg N/fed.</td>
<td>N1</td>
<td>6.02</td>
</tr>
<tr>
<td>120 kgN/fed.</td>
<td>N3</td>
<td>7.61</td>
</tr>
<tr>
<td>F-test</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>L S D at 0.05</td>
<td>0.49</td>
<td>0.69</td>
</tr>
<tr>
<td>B- Foliar spraying with growth promoter:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1- spraying with water (control)</td>
<td>5.23</td>
<td>5.27</td>
</tr>
<tr>
<td>2- spraying by mixture (Fe+Zn+Mn)</td>
<td>5.77</td>
<td>5.77</td>
</tr>
<tr>
<td>3- spraying by Aminototal</td>
<td>6.24</td>
<td>6.25</td>
</tr>
<tr>
<td>5- spraying by mixture (Fe+Zn+Mn)+ Aminototal</td>
<td>7.45</td>
<td>7.74</td>
</tr>
<tr>
<td>6- spraying by mixture (Fe+Zn+Mn)+ melagrow</td>
<td>7.97</td>
<td>8.12</td>
</tr>
<tr>
<td>7- spraying by mixture (Fe+Zn+Mn)+ Aminototal+ melagrow</td>
<td>8.60</td>
<td>8.75</td>
</tr>
<tr>
<td>F-test</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>L S D at 0.05</td>
<td>0.21</td>
<td>0.23</td>
</tr>
<tr>
<td>C- interaction : A*B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**Photosynthetic pigment content in leaves:**

Table (4) shows the effect of nitrogen fertilizer rates and growth promoters on Photosynthetic pigment of maize leaves. The data reflect that chlorophyll a, b and total chlorophyll concentration increase with increasing nitrogen fertilizer rates. The highest nitrogen fertilizer application (120 kg N/fed.) recorded the highest mean pigment values. These results perhaps due to the role of nitrogen in improving and increasing leaf area and photosynthetic pigment content in leaves. As a result, photosynthesis levels increased Hafez et al., (2014). In this respect, these results are certain with Hafez and Abdelaal (2015), Woldesenbet and Haileyesus (2016) and Ali and Anjum (2017).

<table>
<thead>
<tr>
<th>Characters</th>
<th>Treatments</th>
<th>Chlorophyll a (mg/dm F.W)</th>
<th>Chlorophyll b (mg/dm F.W)</th>
<th>Carotenoids (mg/dm F.W)</th>
<th>Total Photosynthetic pigments contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-Nitrogen fertilizer levels:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80 kg N/fed.</td>
<td>N1.</td>
<td>4.739</td>
<td>4.017</td>
<td>2.214</td>
<td>1.975</td>
</tr>
<tr>
<td>100 kg N/fed.</td>
<td>N2.</td>
<td>4.812</td>
<td>4.023</td>
<td>2.624</td>
<td>2.245</td>
</tr>
<tr>
<td>F-test</td>
<td>***</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>L S D at 0.05</td>
<td></td>
<td>0.024</td>
<td>0.019</td>
<td>0.011</td>
<td>0.016</td>
</tr>
<tr>
<td>B- foliar spraying with growth promoter:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1- spraying with water (control)</td>
<td></td>
<td>4.497</td>
<td>3.806</td>
<td>2.138</td>
<td>1.874</td>
</tr>
<tr>
<td>2- spraying by mixture (Fe+Zn+Mn)</td>
<td></td>
<td>4.679</td>
<td>3.915</td>
<td>2.273</td>
<td>1.973</td>
</tr>
<tr>
<td>4- spraying by melagrow</td>
<td></td>
<td>4.837</td>
<td>4.051</td>
<td>2.496</td>
<td>2.174</td>
</tr>
<tr>
<td>5- spraying by mixture (Fe+Zn+Mn)+ Aminototal</td>
<td></td>
<td>4.929</td>
<td>4.203</td>
<td>2.619</td>
<td>2.270</td>
</tr>
<tr>
<td>6- spraying by mixture (Fe+Zn+Mn)+ melagrow</td>
<td></td>
<td>5.203</td>
<td>4.339</td>
<td>2.723</td>
<td>2.374</td>
</tr>
<tr>
<td>7- spraying by mixture (Fe+Zn+Mn)+ Aminototal+ melagrow</td>
<td></td>
<td>5.257</td>
<td>4.408</td>
<td>2.863</td>
<td>2.548</td>
</tr>
<tr>
<td>F-test</td>
<td>***</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>L S D at 0.05</td>
<td></td>
<td>0.088</td>
<td>0.091</td>
<td>0.135</td>
<td>0.192</td>
</tr>
<tr>
<td>C-interaction : A*B</td>
<td></td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
</tbody>
</table>

Thus, foliar applied growth promoters and mixture (Fe, Zn, Mn) increased the maize plants' ability to photosynthesize. (Al-Shaheen and Soh 2016) (Alam et al., 2016) and (Baddour et al., 2017). Indicating that metabolic disorders are the main limit vector of photosynthesis, as many reports. The chlorophyll content of maize leaves shown in Table (4) indicated that foliar application of Aminototal+ Melagrow+ mixture of (Zn, Fe and Mn) gave the higher mean values. This could be as a result of broader leaves increasing the amount of chlorophyll in leaves during photosynthesis. Both the wide leaves and high chlorophyll content led to increase photosynthetic processes to dry matter accumulation. This study supports( Shafi et al., 2012)and (Lihiang and Lumingkewas 2017).The results showing the interaction of N-fertilizer in the absence and presence of growth promoters on chlorophyll concentration content (a, b and total) revealed that using 120 kg N/fed. and (Fe, Zn and Mn) fertilizer in the presence of foliar application of a mixture of amino total + (Fe, Zn and Mn) found the highest average values of the previous parameters at the highest average values of the previous parameters were found using 120 kg N/fed. in the presence of spraying with aminototal+ (Fe, Zn and Mn). On the other hand, the lowest value was recorded by spraying with water (control treatment). These results are consistent with (Abo Elzz and Hafez 2019).

**Yield and its components**

Table (5) shows the impact of growth promoters and nitrogen levels on yield and its components. It’s clearly that increasing nitrogen fertilizer levels caused increased length of ear, ear diameter, and weight of ear. However, the highest values of this parameter were found to be highest at the recommended application of 120 kg N/fed. The increase in ear diameter could be attributed to the supply of sufficient nitrogen. These results may be due to the effect of nitrogen fertilizers on plant vigor and photosynthetic assimilate accumulation, and microelements resulting in higher to length of ear, ear diameter, ear weight increased yield attributes such and grain yield under highly fritters (120kg N/fed.) gave the highest increased automatically with increasing nitrogen levels. The increase in plant height due to high N may have been due to better vegetation development and increased mutual shading and beam extension. The application of high concentrations of N increased cell division, cell elongation, nucleation, leaf green color, and therefore chlorophyll content, increased the rate of photosynthesis, as well as increased stem elongation, resulting in increased plant height. Was fanned by (Hafez and Abdelaal 2015) (Woldesenbet and Haileyesus 2016) and (Ali and Anjum 2017) Feeding maize plants to improve growth traits and nutritional efficiency with the help of foliar spraying. These results are agree with (Alam et al. 2016) and (Al-Shaheen and Soh 2016). The highest plant height (cm), ear length (cm), ear diameter (cm), and ear weight (g) were obtained from the aminototal + mixture of zinc, iron, and magnesium. Nevertheless, the water spraying treatment (control treatment) yielded the lowest value.

This result may be attributed to the fact that as soil moisture decreases, the mobility of nutrients in the soil increases and the rate at which nutrients enter the zone of absorption for roots decreases. Furthermore, calculations of the collected data revealed that the above content values varied significantly within the irrigation treatment. Comparable outcomes were attained by (Alam et al., 2016) and (Baddour et al., 2017).
Table 5. Plant height, ear length, ear diameter and ear weight as affected by nitrogen fertilizer levels, foliar spraying with growth promoters, mixture of (Zn, Fe and Mn) on 2020 and 2021 seasons.

<table>
<thead>
<tr>
<th>Characters Treatments</th>
<th>Plant height (cm) 2020</th>
<th>Plant height (cm) 2021</th>
<th>Plant height (cm) 2020</th>
<th>Plant height (cm) 2021</th>
<th>Plant height (cm) 2020</th>
<th>Plant height (cm) 2021</th>
<th>Plant height (cm) 2020</th>
<th>Plant height (cm) 2021</th>
<th>Plant height (cm) 2020</th>
<th>Plant height (cm) 2021</th>
<th>Plant height (cm) 2020</th>
<th>Plant height (cm) 2021</th>
<th>Plant height (cm) 2020</th>
<th>Plant height (cm) 2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>N0</td>
<td>293.4</td>
<td>304.7</td>
<td>23.5</td>
<td>24.2</td>
<td>6.48</td>
<td>7.31</td>
<td>304.9</td>
<td>310.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N1</td>
<td>315.6</td>
<td>322.3</td>
<td>26.2</td>
<td>27.4</td>
<td>7.4</td>
<td>7.98</td>
<td>327.5</td>
<td>342.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N2</td>
<td>348.5</td>
<td>353.9</td>
<td>28.6</td>
<td>30.6</td>
<td>8.19</td>
<td>8.64</td>
<td>361.6</td>
<td>379.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-test</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>L S D at 0.05</td>
<td>1.63</td>
<td>1.74</td>
<td>0.50</td>
<td>0.76</td>
<td>0.03</td>
<td>0.05</td>
<td>0.67</td>
<td>0.77</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Concerning the effect of nitrogen fertilization levels up to 120kg N/fed. And foliar application by growth promoter and mixture of (Fe, Zn and Mn) on yield and its components in Tables (6 and 7). Data clearly show that increased nitrogen fertilization levels increased 100-grain weight, number kernel/ear, ear grains weight, shelling % total grain yield, Stover yield and nitrogen use efficiency in the absence or presence of growth promoter. However, the greatest average values of these characteristics are discovered to be utilized 120 kgN /fed. from the recommended presence of foliar Aminototal, Melagrow, mixture of (Fe, Zn and Mn). In the absence of nitrogen fertilizer, the values of this parameter increased with increasing levels of nitrogen fertilizer on 100-kernel weight, number of kernels, ear-kernel weight, capsular fruit percentage, Stover yield, and nitrogen use efficiency.

Table 6. 100-kernel weight, kernel number/ear, ear grains weight, shelling % as affected by applying nitrogen fertilizer levels and foliar spraying with growth promoters in 2020 and 2021 seasons.

| Characters Treatments | 100-kernel weight (g) 2020 | 100-kernel weight (g) 2021 | Kernel Number /ear 2020 | Kernel Number /ear 2021 | Ear grains weight (g) 2020 | Ear grains weight (g) 2021 | Shelling (%) 2020 | Shelling (%) 2021 |
|-----------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| N0                   | 29.3                   | 31.2                   | 535.2                 | 545.4                 | 157.4                 | 167.9                 | 55.95                 | 59.34                 |
| N1                   | 31.5                   | 33.4                   | 596.0                 | 618.2                 | 190.8                 | 201.5                 | 59.83                 | 62.25                 |
| N2                   | 34.0                   | 36.5                   | 657.1                 | 671.4                 | 220.6                 | 236.5                 | 63.38                 | 71.32                 |
| F-test               | **                     | **                     | **                    | **                    | **                     | **                    | **                     | **                    |
| L S D at 0.05        | 0.18                   | 0.16                   | 1.98                  | 2.21                  | 7.29                  | 7.12                  | 0.84                  | 0.61                  |

Concerning the effect of nitrogen fertilization levels up to 120kg N/fed. And foliar application by growth promoter and mixture of (Fe, Zn and Mn) on yield and its components in Tables (6 and 7). Data clearly show that increased nitrogen fertilization levels increased 100-grain weight, number kernel/ear, ear grains weight, shelling % total grain yield, Stover yield and nitrogen use efficiency in the absence or presence of growth promoter. However, the greatest average values of these characteristics are discovered to be utilized 120 kgN /fed. from the recommended presence of foliar Aminototal, Melagrow, mixture of (Fe, Zn and Mn). In the absence of nitrogen fertilizer, the values of this parameter increased with increasing levels of nitrogen fertilizer on 100-kernel weight, number of kernels, ear-kernel weight, capsular fruit percentage, Stover yield, and nitrogen use efficiency.

Table 7. Effects of nitrogen fertilizer levels and foliar spraying with a combination of growth promoters (Fe, Zn, and Mn) on grain yield, stockpile yield, and nitrogen, along with how they interacted in the 2020 and 2021 seasons.

| Characters Treatments | Grain yield (t/fed) 2020 | Grain yield (t/fed) 2021 | Stover (t/fed) 2020 | Stover (t/fed) 2021 | Nitrogen used 2020 | Nitrogen used 2021 |
|-----------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| N0                   | 2.053                 | 2.143                 | 4.328                 | 4.458                 | 25.66                 | 26.79                 |
| N1                   | 2.538                 | 2.625                 | 5.061                 | 5.252                 | 25.38                 | 26.25                 |
| N2                   | 2.681                 | 2.709                 | 5.383                 | 6.928                 | 22.34                 | 22.58                 |
| F-test               | **                    | **                    | **                   | **                   | **                    | **                    | **                    | **                    |
| L S D at 0.05        | 0.176                 | 0.189                 | 0.113                 | 0.140                 | 0.155                 | 0.197                 |

Concerning the effect of nitrogen fertilization levels up to 120kg N/fed. And foliar application by growth promoter and mixture of (Fe, Zn and Mn) on yield and its components in Tables (6 and 7). Data clearly show that increased nitrogen fertilization levels increased 100-grain weight, number kernel/ear, ear grains weight, shelling % total grain yield, Stover yield and nitrogen use efficiency in the absence or presence of growth promoter. However, the greatest average values of these characteristics are discovered to be utilized 120 kgN /fed. from the recommended presence of foliar Aminototal, Melagrow, mixture of (Fe, Zn and Mn). In the absence of nitrogen fertilizer, the values of this parameter increased with increasing levels of nitrogen fertilizer on 100-kernel weight, number of kernels, ear-kernel weight, capsular fruit percentage, Stover yield, and nitrogen use efficiency.
These results may be due to the effect of nitrogen on vigor. Plant growth and photosynthetic assimilate accumulation produce higher grain number/row and grain/ear and maize plant meristematic activity and increase yield attributes as final grain yield. These results are consistent with both Hafez and Abdelaal (2015), Woldemariam and Haileyesus (2014) and Ali and Anjum (2017). With a little assistance from Aminotal applied topically, Melagrow and Haileyesus (2016) and Ali and Anjum (2017). Our results are similar to those of Shrestha et al., (2018), who also reported that as nitrogen dosage increased grain yield of corn. This increase in corn grain yield at higher nitrogen levels may be attributed to less competition for nutrients, more plant canopy, higher photosynthetic activity, and accumulation of more biomass in the thicker grain. High concentrations of significant interactions between N-fertilizers in the absence of growth promoters as affected by concentration at which the highest average yield attributes of corn plants were realized.

Nitrogen rates 120N/kg/fed with the foliar application with growth promoters, mixture of (Fe, Zn and Mn) camed nitrogen 80N kg/fed. The maize crop is of interest to farmers because it is the backbone of life for feeding livestock resulting from chopping corn stalks and using them as silage to feed livestock on it (Table 8).

### Table 8. The interaction between nitrogen fertilizer levels and foliar spraying with growth promoters, mixture of (Fe, Zn and Mn) on grain yield, Stover during 2020 and 2021 seasons

<table>
<thead>
<tr>
<th>Nitrogen rates</th>
<th>Treatments</th>
<th>Grain yield (t/fed)</th>
<th>Stover (t/fed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 kg N/fed.</td>
<td>1- spraying with water (control)</td>
<td>1.757</td>
<td>4.071</td>
</tr>
<tr>
<td></td>
<td>2- spraying by mixture (Fe+Zn+Mn)</td>
<td>1.857</td>
<td>4.161</td>
</tr>
<tr>
<td></td>
<td>3- spraying by Aminotal</td>
<td>1.960</td>
<td>4.229</td>
</tr>
<tr>
<td></td>
<td>4- spraying by melagrow</td>
<td>2.030</td>
<td>4.406</td>
</tr>
<tr>
<td></td>
<td>5- spraying by mixture (Fe+Zn+Mn) + Aminotal</td>
<td>2.182</td>
<td>4.548</td>
</tr>
<tr>
<td></td>
<td>6- spraying by mixture (Fe+Zn+Mn) + melagrow</td>
<td>2.251</td>
<td>4.509</td>
</tr>
<tr>
<td></td>
<td>7- spraying by mixture (Fe+Zn+Mn) + Aminotal + melagrow</td>
<td>2.333</td>
<td>4.559</td>
</tr>
<tr>
<td>100 kg N/fed.</td>
<td>1- spraying with water (control)</td>
<td>2.060</td>
<td>4.751</td>
</tr>
<tr>
<td></td>
<td>2- spraying by mixture (Fe+Zn+Mn)</td>
<td>2.363</td>
<td>4.891</td>
</tr>
<tr>
<td></td>
<td>3- spraying by Aminotal</td>
<td>2.487</td>
<td>4.731</td>
</tr>
<tr>
<td></td>
<td>4- spraying by melagrow</td>
<td>2.552</td>
<td>5.062</td>
</tr>
<tr>
<td></td>
<td>5- spraying by mixture (Fe+Zn+Mn) + Aminotal</td>
<td>2.688</td>
<td>5.144</td>
</tr>
<tr>
<td></td>
<td>6- spraying by mixture (Fe+Zn+Mn) + melagrow</td>
<td>2.771</td>
<td>5.381</td>
</tr>
<tr>
<td></td>
<td>7- spraying by mixture (Fe+Zn+Mn) + Aminotal + melagrow</td>
<td>2.845</td>
<td>5.467</td>
</tr>
<tr>
<td>120 kg N/fed.</td>
<td>1- spraying with water (control)</td>
<td>2.333</td>
<td>5.464</td>
</tr>
<tr>
<td></td>
<td>2- spraying by mixture (Fe+Zn+Mn)</td>
<td>2.479</td>
<td>5.423</td>
</tr>
<tr>
<td></td>
<td>3- spraying by Aminotal</td>
<td>2.595</td>
<td>5.641</td>
</tr>
<tr>
<td></td>
<td>4- spraying by melagrow</td>
<td>2.706</td>
<td>5.350</td>
</tr>
<tr>
<td></td>
<td>5- spraying by mixture (Fe+Zn+Mn) + Aminotal</td>
<td>2.810</td>
<td>5.257</td>
</tr>
<tr>
<td></td>
<td>6- spraying by mixture (Fe+Zn+Mn) + melagrow</td>
<td>2.906</td>
<td>5.317</td>
</tr>
<tr>
<td></td>
<td>7- spraying by mixture (Fe+Zn+Mn) + Aminotal + melagrow</td>
<td>2.938</td>
<td>5.229</td>
</tr>
</tbody>
</table>

**L S D at 0.05**

1.52 1.09 1.43 1.28

### Grain quality

The data in Table 9 indicate that the effect of different nitrogen fertilizer levels with growth promoters on grain quality of the maize. Increasing nitrogen fertilizer from 80 KgN/fed. to 120 KgN/fed. increased both of crude protein, ash% and crude fiber as both total carbohydrate and oil decreased in the both seasons. The improvement in corn grain quality could be explained by the rise in nutrients that are now available. Nitrogen is important in the production of proteins and is present in the root zone, which enhances the plant’s supply of nitrogen when fertilizer levels are high. These results are agreement with those obtained by (Hafez and Abdelaal 2015) (Woldemariam and Haileyesus 2016) and (Ali and Anjum 2017).

### Table 9. Total Carbohydrates %, Crude protein %, oil %, ash% and crude fiber %, as affected by nitrogen fertilizer levels and foliar spraying with growth promoters, (Fe, Zn , Mn) as well as their interaction during 2020 and 2021 seasons.

<table>
<thead>
<tr>
<th>Characters</th>
<th>Treatments</th>
<th>Total carbohydrates %</th>
<th>Crude protein %</th>
<th>Oil %</th>
<th>Ash %</th>
<th>Crude fiber %</th>
</tr>
</thead>
<tbody>
<tr>
<td>A- Nitrogen fertilizer levels:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80 kg N/fed.</td>
<td>N1</td>
<td>83.01</td>
<td>82.04</td>
<td>7.94</td>
<td>8.43</td>
<td>5.75</td>
</tr>
<tr>
<td>100 kgN/fed.</td>
<td>N2</td>
<td>82.13</td>
<td>81.09</td>
<td>8.90</td>
<td>9.52</td>
<td>5.52</td>
</tr>
<tr>
<td>120 kgN/fed.</td>
<td>N3</td>
<td>81.65</td>
<td>80.31</td>
<td>9.22</td>
<td>9.85</td>
<td>5.11</td>
</tr>
<tr>
<td>F-test</td>
<td></td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>L S D at 0.05</td>
<td></td>
<td>0.20</td>
<td>0.18</td>
<td>0.80</td>
<td>0.98</td>
<td>0.07</td>
</tr>
<tr>
<td>B- foliar spraying with growth promoters:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1- spraying with water (control)</td>
<td>84.65</td>
<td>82.06</td>
<td>7.49</td>
<td>8.45</td>
<td>6.92</td>
<td>7.63</td>
</tr>
<tr>
<td>2- spraying by mixture (Fe+Zn+Mn)</td>
<td>83.18</td>
<td>81.52</td>
<td>7.73</td>
<td>8.72</td>
<td>6.73</td>
<td>7.39</td>
</tr>
<tr>
<td>3- spraying by Aminotal</td>
<td>82.77</td>
<td>81.04</td>
<td>7.97</td>
<td>8.99</td>
<td>6.60</td>
<td>7.22</td>
</tr>
<tr>
<td>4- spraying by melagrow</td>
<td>82.63</td>
<td>80.87</td>
<td>8.39</td>
<td>9.46</td>
<td>6.42</td>
<td>7.00</td>
</tr>
<tr>
<td>5- spraying by mixture (Fe+Zn+Mn) + Aminotal</td>
<td>82.09</td>
<td>80.24</td>
<td>8.57</td>
<td>9.87</td>
<td>6.34</td>
<td>6.76</td>
</tr>
<tr>
<td>6- spraying by mixture (Fe+Zn+Mn) + melagrow</td>
<td>81.79</td>
<td>79.89</td>
<td>8.75</td>
<td>9.67</td>
<td>6.02</td>
<td>6.48</td>
</tr>
<tr>
<td>7- spraying by mixture (Fe+Zn+Mn) + Aminotal + melagrow</td>
<td>80.72</td>
<td>78.66</td>
<td>8.99</td>
<td>10.14</td>
<td>5.68</td>
<td>6.04</td>
</tr>
<tr>
<td>F-test</td>
<td></td>
<td>*</td>
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<td>*</td>
<td>*</td>
<td>**</td>
</tr>
<tr>
<td>L S D at 0.05</td>
<td></td>
<td>0.39</td>
<td>0.45</td>
<td>0.18</td>
<td>0.19</td>
<td>0.17</td>
</tr>
<tr>
<td>C-interaction : A*B</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>
Spraying by mixture \((\text{Fe} + \text{Zn} + \text{Mn}) + \text{Aminototal}\) Melagrow gave the highest crude protein, ash% and fiber% in both seasons. These results are consistent with Al-Shaheen and Soh 2016 (Baddour et al., 2017) and (Gheit et al. 2022).

The results aligned with the findings of Al-Shaheen and Soh 2016 (Baddour et al., 2017), and (Gheit et al. 2022) regarding the impact of growth promoters.

**Economic evaluation**

Table 10 shows the economic evaluation values (gross revenue and production cost/feed, net revenue/feed, gross revenue change, and profit/cost ratio) of corn as affected by foliar application of nitrogen fertilizer levels and growth promoter inoculation for the 2020 and 2021 seasons. From an economic point of view, corn with 120 kg nitrogen and foliar application of a mixture of Aminototal, Melagrow, \((\text{Zn}, \text{Fe}, \text{Mn})\) was optimized to 15438 and 17580 EGP/feed in the first and second seasons, respectively (not considering Stover yield prices). The price of Stover yield was compared to other foliar spray treatments, mixing alone or with another compound was affected by different nitrogen fertilizer rates in the study. Corn plant treatments with water and foliar spray as control treatments (control) for other spray treatment inoculations presented, compared to 11636 and 10883 EGP/feed.

In both seasons, the results showed that in both the seasons, the total return and benefit/cost ratios were 26.18% and 42.53% and 3.004 and 3.132 (EGP revenue/EGP cost) higher than to the control treatment, respectively. However, as averages for both seasons, foliar applications of 100 kg N and mixtures of aminototal, melagrow, and \((\text{Zn}, \text{Fe}, \text{Mn})\) took first and second place. The foliar application mixture was in second place after the addition of a high amount of nitrogen fertilizer. While it can be said that corn plants respond to high levels of nitrogen fertilizer, nitrogen fertilizer rates ranged from 80, 100, and 120 N of nitrogen with amino total, melagrow, and a mixture of \((\text{Zn}, \text{Fe}, \text{Mn})\) compounds. This means that the above two treatments produced revenue effects (benefit/cost ratio) of approximately the same value. From these results, we can recommend that foliar application of the mixture of aminototal, melagrow, and \((\text{Zn}, \text{Fe}, \text{Mn})\) can reduce the recommended rate of nitrogen levels by 80 kg N. Environmental pollution in this concern, many investigators previously reported that grain inoculation with growth promoter (Aminototal, Melagrow, mixture of \((\text{Zn}, \text{Fe}, \text{Mn})\) caused an increase in productivity and/or reduced nitrogen fertilizer and production costs of maize as reported by (Morris et al., 2018) and (Yesuf et al., 2022) reported.

**Table 10. Economic evaluation of maize as affected by nitrogen levels and growth promoter 2020 and 2021 seasons.**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Grain yield (ton/fed)</th>
<th>Total return of yield (EGP/fed)</th>
<th>Total costs of production (EGP/fed)</th>
<th>Net return (EGP/fed)</th>
<th>Change in total return %</th>
<th>Benefic cost ratio (EGP) return/EGP cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>J. of Plant Production, Mansoura Univ., Vol. 15 (3), March, 2024</strong></td>
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</tr>
</tbody>
</table>

CONCLUSION

In based on the study’s conclusions, it can be said that high grain productivity and good quality can be achieved by using foliar spraying of a mixture of Amino Total, Melagrow, \((\text{Fe}, \text{Zn}, \text{Mn})\) to increase nitrogen concentrations is effective in maintaining and improving green and dry matter forage corn yields. Therefore, it is advised that the adding of 120 kg N/fed. or foliar application of Aminototal, Melagrow, and mixture of \((\text{Fe}, \text{Zn}, \text{Mn})\) is the most economical strategy to obtain the highest quality grain corn yield.

REFERENCES


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Abo-Marzoka, E. A. et al.

أثير الرش الورقي بمنشطات النمو ومخلوط (الحديد والزنك والمنجنيز) على نمو ومحصول الذرة الشامية تحت معدلات مختلفة من السماد النيتروجيني

السيد عبد المقصود ابومرزوقة

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المستقبل

تم إجراء تجربة حقلية في محطة البحوث الزراعية في سخا، كفر الشيخ، مصر خلال موسمين 2020 و2021. الأهداف الرئيسية من هذه الدراسة هو الوصول إلى أعلى إنتاجية من هجين الذرة الشامية (TWC.360) من خلال اضافة معدلات مختلفة من السماد النيتروجيني ورش الورقي لمختلف منشطات النمو والمخلوط من الحديد والزنك والمنجنيز. تم استخدام تصميم مختصر من المحاكاة ذاتية للمحاور المختلفة (الذرة الشامية، نباتات الذرة الشامية، النباتات التي اضيف اليها 120 كجم نيتروجين/فدان) بالإضافة إلى النباتات التي رشت بالماء...


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