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Research Article
Reducing Pollution due to Maize Nitrogen Fertilization by using Foliar Application Treatments

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Abstract

Background: Using foliar fertilization treatments is very important for improving maize yield and its components of maize hybrid single cross 131 (SC 131). **Methods:** Two field experiments were conducted at the Experimental Station Farm, Faculty of Agriculture, Mansoura University, Egypt, during 2014 and 2015 summer seasons, a strip-plot design with 4 replications was used. The vertical plots were assigned with five foliar fertilization treatments. While, the horizontal plots were occupied with three mineral nitrogen fertilizer levels. **Results:** Highest averages of all studied characters in both seasons were recorded from foliar spraying 3 times with the mixture of gibberellic acid (GA_3) at the rate of 50 mL+amino acids (AA) at the rate of 500 mL+yeast extract (YE) at the rate of 2000 mL/200 L water/fed. Highest means of all studied characters were resulted from using 100% of the recommended dose (120 kg N/fed) in the in both seasons. **Conclusion:** It can be concluded that foliar fertilizing maize hybrid SC 131 with the mixture of GA3 at the rate of 50 mL+AA at the rate of 500 mL+YE at the rate of 2000 mL/200 L water/fed 3 times after 30, 37 and 44 days from sowing in addition mineral fertilizing with 80% of the recommended dose 96 kg N/fed in order to increasing yield and its components as well as reducing nitrogen pollution under the environmental conditions of Dakahlia Governorate, Egypt.

Key words: Maize, foliar spraying, nitrogen levels, growth, yield and quality

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Maize (*Zea mays* L.) is the most important cereal grain in the world as well as in Egypt and is consider a major source of carbohydrate which used as food, in livestock diet, in the textile industry and also in the pharmaceutical industry. Therefore, a great attention should be paid to raise maize productivity either by increasing the cultivated area or maximizing yield/unit area in order to reduce the gap between its production and consumption. Whereas, maize is well known for its high demand for nutrients and other production inputs. Thereby, among factors that enhance maize productivity via foliar fertilization with growth regulators such as gibberellic acid (GA_3) and natural growth promoters i.e., amino acids and yeast extract as a modern trends in fertilizing maize as well as mineral nitrogen fertilization.

Foliar fertilizers exhibit a secondary fertilizing role, which determines a significant increase in the productive consumption for soil elements and soil-applied elements without substituting root fertilization methods, where foliar fertilizers are supplementary in balancing and optimizing the fertilization system applied to crops[1].

Plant growth regulators for example gibberellics (GA_3) play a good role in stimulates cell division and elongation, encourages plant growth, increases the economic yield and to enable the plant to adapt the adverse conditions[2-4].

Amino acids are a well known as bio-stimulant which has positive effects on plant productivity by increasing chlorophyll concentration leading to higher degree of photosynthesis, consequently its increment yield and significantly reduce the harms caused by a biotic stress[5,6]. El-Moursy Rasha[7] indicated that foliar spraying maize plants with amino total as a source of amino acids twice after 25 and 35 days from sowing (DFS) resulted in the highest values of studied yield and its components.

Yeast extract is natural source of cytokinins and has stimulatory effects on plants such as cell division and enlargement, protein and nucleic acid synthesis and chlorophyll formation[8-10].

Mineral nitrogen fertilizer plays a good role in plant nutrition. It is the element that required in the greatest quantity by cereal crop plants especially maize. Thus, increasing application of nitrogen fertilizer levels led to significant increases in growth, yield and its components and quality characters of maize crop[11-15]. In spite of mineral fertilizers have a good effect on plant productivity, nevertheless it's also have a pollutant effect on the environment especially dissolved ones like as nitrogen fertilizer. Whereas, it is more rapidly leaching to ground water, which affects human and animal health[16].

In general, this investigation was conducted to study the effect of foliar fertilization treatments, mineral nitrogen fertilizer levels and their interactions on yield and its components and grain quality of maize grains hybrid single cross 131 under the environmental conditions of Dakahlia Governorate, Egypt.

MATERIALS AND METHODS

Two field experiments were laid out at the Experimental Station Farm, Faculty of Agriculture, Mansoura University, Egypt, during the two successive summer seasons of 2014 and 2015 to determine the effect of foliar fertilization treatments, mineral nitrogen fertilizer levels and their interactions on yield and its components of maize plants hybrid single cross 131 (SC 131). In addition, reduce mineral nitrogen requirements by using foliar fertilization treatments as a new trend in fertilizing maize.

The experiment design was carried out in a strip-plot design with four replications. The vertical plots were allocated with the following five foliar fertilization treatments: (a) Without (control treatment), (b) Foliar spraying with gibberellic acid (GA_3) at the rate of 50 mL/200 L water/fed (feddan = fed = 4200 m^2), (c) Foliar spraying with amino acids (AA) at the rate of 500 mL/200 L water/fed, (d) Foliar spraying with yeast extract (YE) at the rate of 2000 mL/200 L water/fed, (e) Foliar spraying with the mixture of gibberellic acid (GA_3) at the rate of 50 mL+amino acids (AA) at the rate of 500 mL+yeast extract (YE) at the rate of 2000 mL/200 L water/fed.

Foliar fertilization treatments were carried out three times at the aforementioned rates after 30, 37 and 44 days from sowing (DFS). Gibberellic acid (GA_3) in the form of Gibbro-S (which contain 4% gibberellic acid EC) was manufactured by Firmsea Industrial Co., LTD and obtained from Gaara Establishment for Import and Export Co. Amino acids (AA) in the form of Amin-Zn (which contain 15% amino acids and 5.5% zinc) was manufactured by Prosber Way Group and obtained from Gaara Establishment for Import and Export Co. Yeast extract (YE) as natural biostimulants was prepared by using a technique allowed yeast cells (pure dry yeast) to be grown and multiplied efficiently during conducive aerobic and nutritional conditions. Thus, method allowed to produce

denovo beneficial bioconstituent (carbohydrates, sugars, proteins, amino acids, fatty acids, hormones, etc.), then these constituents could release out of yeast cells in readily form. Active dry yeast was dissolved in water at rate 1 g L^{-1} followed by adding sugar at ratio 1:1 and kept overnight for activation and reproduction of yeast and two cycles of freezing and thawing for disruption of yeast cells and releasing their content. Such technique for yeast preparation was modified by Spencer *et al.*[17].

The horizontal plots were occupied with three mineral nitrogen fertilizer levels i.e., 60, 80 and 100% of the recommended dose which were (72, 96 and 120 kg N/fed).

Mineral nitrogen fertilizer in the form of urea (46.0% N) was added at the formerly mentioned levels in two equal portions, one half after thinning (before the first irrigation) and the second half before the second irrigation.

Each experimental basic unit (sub-plot) included five ridges, each of 60 cm width and 3.5 m length, resulted an area of 10.5 m^2 (1/400 fed). The preceding winter crop was Egyptian clover in the first and second seasons.

The soil of experimental site was characterized as a Clayey loam soil as shown in Table 1, which cleared some physical and chemical properties.

The experimental field well prepared for each experiment through two ploughing, leveling, ridging and then divided into the experimental units (10.5 m^2).

Calcium superphosphate (15.5% P_2O_5) was applied during soil preparation at the rate of 150 kg/fed. Potassium sulphate (48% K_2SO_4) at the rate of 50 kg/fed was applied with the first dose of nitrogen fertilizer.

Maize grains were hand sown in hills 25 cm apart at the rate of 2-3 grains/hill using dry sowing method (Afir) on one side of the ridge during the first week of May in 2014 and 2015 seasons. The plants were thinned to one plant/hill before the first irrigation. The first irrigation was applied after 21 days from sowing and the following irrigations were applied at 15 days intervals during the growing seasons. The other agricultural practices were kept the same as normally practiced in maize fields according to the recommendations of Ministry of Agriculture and Land Reclamation, except for the factors under study.

Studied characters

Yield and its attributes: (1) Ear length (cm), (2) Ear diameter (cm), (3) Ear grains weight (g), (4) 100 grain weight (g), (5) Grain yield (ardab/fed). It was determined by the weight of grains per kg adjusted to 15.5% moisture content of each plot, then converted to ardab/feddan (ardab = 140 kg) and (6) Stover yield (t/fed). The stover resulted from all plants of each plot was weighted in kg/plot, then it was converted to t/fed.

Statistical analysis: All obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the strip-plot design as published by Gomez and Gomez[18] by using "MSTAT-C" computer software package. Least significant of difference (LSD) method was used to test the differences between treatment means at 5% level of probability as described by Snedecor and Cochran[19].

RESULTS AND DISCUSSION

Effect of foliar fertilization treatments: There was significant effect on yields and its attributes (ear length and diameter, ear grains weight, 100 grain weight, grain and stover yield/fed) due to foliar fertilization treatments in the two seasons (Table 2). There were substantial differences in yields and its attributes among all foliar fertilization treatments and control treatment in 2014 and 2015 seasons. Foliar spraying 3 times with the mixture of GA_3 at the rate of 50 mL+AA at the rate of 500 mL+YE at the rate of 2000 mL/200 L water/fed produced the highest values of yields and its attributes in the two growing seasons. This treatment followed by foliar spraying three times with YE alone at the rate of 2000 mL/200 L water/fed with significant differences between them in both seasons. However, foliar spraying with GA_3 at the rate of 50 mL/ 200 L water/fed ranked as the third best treatment and followed by foliar spraying with AA as the forth best treatment in both seasons. On the other hand, maize plants grown without foliar spraying gave the lowest values of yields and its attributes in the first and second seasons of this

Table 1: Some physical and chemical properties of the experimental site during 2014 and 2015 seasons

								Available PPM		
Seasons	Sand	Silt (%)	Clay (%)	$CaCO_3$ (%)	EC (Ds m^{-1})	pH (%)	OM (%)	K	P	N
2014	20.65	27.25	49.25	3.73	1.93	7.75	1.65	145.5	7.75	22.25
2015	20.55	27.65	48.95	3.67	1.88	7.66	1.72	173.5	9.45	31.45

investigation. The desirable effect of spraying maize plants three after 30, 37 and 44 days from sowing with the mixture of GA_3+AA+YE as a modern trend in fertilization maize might have been due to its effective role in improving early maize growth, more dry matter accumulation and stimulated the building of metabolic products which translocated to grains. Furthermore, the advantageous effects of gibberellic acid and amino acids generally and yeast extract particularly in improving plant growth characters such as plant height, stalk diameter, number of leaves/plant and ear leaf area which reflected on increasing the different yield components such as number of ears/plant, ear length and diameter, ear grains weight and 100 grain weight, which consequently increasing grain yield per unit area. These findings are coincidence with those recorded by Kasraie *et al.*[6].

Effect of nitrogen fertilizer levels: Regarding to the effect of nitrogen fertilizer levels on yields and its attributes (ear length and diameter, ear grains weight, 100 grain weight, grain and stover yield/fed) was significant in the two seasons of this study (Table 2). Overall, yields and its attributes were significantly increased as nitrogen fertilizer levels increased from 60 of the recommended dose (72 kg N/fed) to 80 of the recommended dose (96 kg N/fed) and 100 of the recommended dose (120 kg N/fed) and the differences among nitrogen fertilizer levels were significant in the two growing seasons. Maize plants fertilized with 100% of the recommended dose resulted in the highest means of yields and its attributes in the first and second seasons of this study. On the contrary, the lowest values of maize yields and its attributes were obtained from fertilizing with 60% of the recommended dose (72 kg N/fed) in both seasons. This increments in yields and its attributes resulting from increasing nitrogen fertilizer levels can be easily ascribed to the role of nitrogen in activating growth of plants, consequently enhancement yield components (ear dimension, number and weight of grains/ear as well as 100 grain weight) and accordingly increasing grain. These results are in compatible with those found by Seadh and El-Zehery[11] and Khan *et al.*[13].

Effect of interaction: Regarding the effect of interaction, there are many significant effects of the interaction between both studied factors (foliar application treatments and mineral nitrogen fertilizer levels) on the studied characters (Table 2). We present only the effect of significant interactions on grain yield.

Maximum values of grain and Stover yield/fed were produced from plants that foliar sprayed three times during growth stage with the mixture of GA_3+AA+YE at the recommended rate of them in addition mineral fertilizing with 100 of the recommended dose (120 kg N/fed), followed by plants that foliar sprayed three times with the mixture of GA_3+AA+YE at the

Table 2: Means of ear length and diameter, ear grains weight, 100 grain weight, grain and stover yields/fed as affected by foliar application treatments and nitrogen fertilizer levels as well as their interactions during 2014 and 2015 seasons

	Characters seasons											
	Ear length (cm)		Ear diameter (cm)		Ear grains weight (g)		100 grain weight (g)		Grain yield (ardab/fed)		Stover yield (t/fed)	
Treatments	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Foliar application treatments												
Without	21.25	20.58	4.41	4.39	204.7	171.4	41.33	40.08	22.85	22.85	4.931	4.880
Gibberellic acid (GA_3)	23.00	23.16	4.85	4.78	277.2	247.1	49.14	48.63	29.58	29.28	6.562	6.687
Amino acids (AA)	22.58	22.58	4.70	4.63	263.5	227.0	45.41	45.68	27.95	27.86	5.852	5.825
Yeast extract (YE)	23.83	23.75	4.92	4.86	289.8	265.1	53.77	54.24	31.95	31.96	7.091	7.052
Mixture of GA_3+AA+YE	24.66	24.33	5.25	5.10	317.3	291.0	64.02	59.09	34.31	35.03	8.290	8.163
F-test	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00
LSD at 5%	0.63	0.78	0.14	0.12	8.6	9.0	3.80	4.15	1.45	1.41	0.648	0.523
Nitrogen fertilizer levels												
60% of RD (72 kg N/fed)	22.60	22.45	4.72	4.67	256.0	226.1	48.81	48.48	27.81	27.82	6.207	6.183
80% of RD (96 kg N/fed)	23.20	22.95	4.86	4.75	273.7	239.9	50.75	49.19	29.58	29.45	6.583	6.388
100% of RD (120 kg N/fed)	23.40	23.25	4.91	4.84	281.8	255.0	52.63	50.97	30.59	30.92	6.844	6.992
F-test	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00
LSD at 5%	0.25	0.31	0.07	0.09	3.3	3.6	1.27	1.57	0.61	0.71	0.439	0.586
Interaction (F-test)												
A×B	0.00	0.00	NS	NS	0.0	0.0	NS	NS	0.00	0.00	0.00	0.00

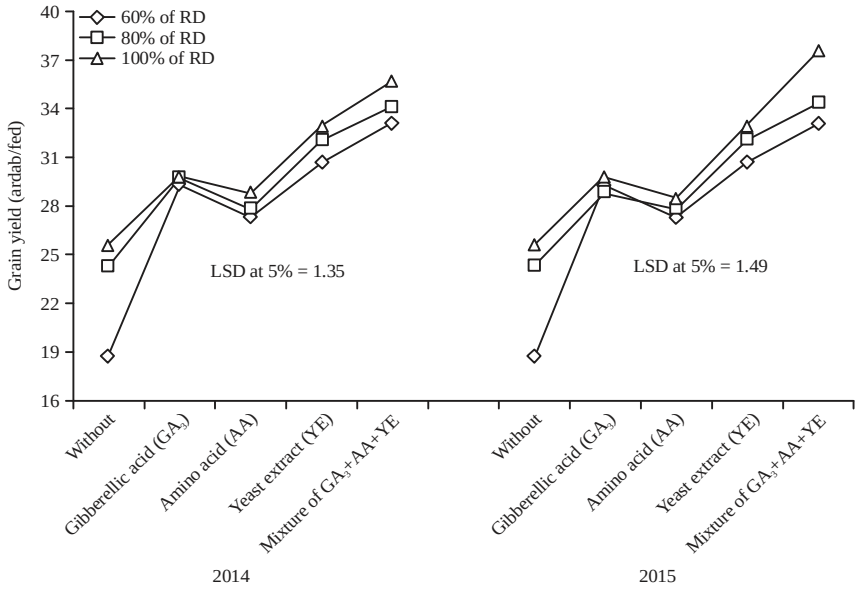

Fig. 1: Grain yield (ardab/fed) of maize as affected by the interaction between foliar application treatments and nitrogen fertilizer levels during 2014 and 2015 seasons

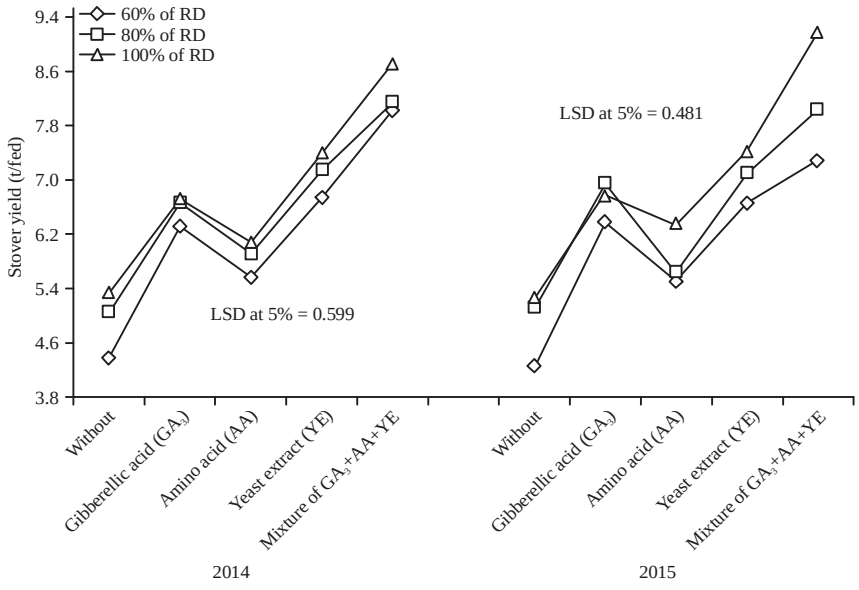

Fig. 2: Stover yield (t/fed) of maize as affected by the interaction between foliar application treatments and nitrogen fertilizer levels during 2014 and 2015 seasons

recommended rate of them plus mineral fertilizing with 80 of the recommended dose (96 kg N/fed) and plants that foliar sprayed 3 times with the mixture of GA_3+AA+YE at the recommended rate of them and mineral fertilizing with 60 of the recommended dose (72 kg N/fed) during 2014 and 2015 seasons as graphically demonstrated in Fig. 1 and 2. While, fertilizing with 60 of the recommended dose (72 kg N/fed) without foliar fertilization resulted in the lowest values of grain yield/fed in both seasons.

CONCLUSION

It can be concluded that foliar fertilizing maize hybrid SC 131 with the mixture of GA_3 at the rate of 50 mL+AA at the

rate of 500 mL+YE at the rate of 2000 mL/200 L water/fed 3 times after 30, 37 and 44 days from sowing in addition mineral fertilizing with 96 kg N/fed in order to maximizing productivity at the same time reduce production costs and environmental pollution under the environmental conditions of Dakahlia Governorate, Egypt.

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