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Response of some new maize hybrids to some nano fertilizers under water stress conditions

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ABSTRACT

Two field trials were conducted during the two successive summer growing seasons of 2019 and 2020, at the Experimental Farm, Faculty of Agriculture, Fayoum University Fayoum Governorate, Egypt. A split- split design with three replicates was used. The main plots were assigned three water stress treatments (skipping of some irrigations) as follows: normal irrigation (7 irrigations), i.e., control treatment, missing the 4th irrigation (64 days after planting; DAP), and missing the 6th irrigation (78 DAP). The sub-plots were restricted to three yellow single cross hybrids of maize, i.e., single cross hybrid 2055, single cross hybrid 2066 and single cross hybrid 2088, and the sub-sub plots received three concentrations Calcium carbonate nanoparticles i.e., 500, 750 and 100 g feddan^{-1} (fed^{-1}; feddan= 4200 m^2). The results showed that irrigation treatment reflected positive significant influences on growth parameters, normal irrigation resulted in the best mean values of plant height in both seasons at 65 and 80 DAP. Also, yellow single cross hybrids of maize were significantly differed in almost mean values of maize growth, under study in both seasons. Maize hybrid of S.C. 2088 was significantly surpassed S.C. 2055 and S.C. 2066 in mean values of all growth characters. Calcium carbonate nanoparticles concentrations had a significant effect on growth parameters, i.e., plant height in both seasons at 65 and 80 DAS. Data revealed that ear characters, i.e., ear height, ear length, ear diameter, ear weight, no. of row/ear, no. of grain/row significantly affected by different irrigation treatments. Normal irrigation produced the highest ear characters, i.e., ear height, ear length, ear diameter, ear weight, no. of row/ears, number of grain/row) between different yellow single cross hybrids of maize. S.C. 2088 was significantly surpassed S.C. 2055 and S.C. 2066 in mean values of all ear characters. Application of calcium carbonate nanoparticles as nano-fertilizers was pioneer and significantly resulted in characters, i.e., ear height, ear length, ear diameter, ear weight, number of row/ear, number of grain/row, high rate of calcium carbonate nanoparticles produced the highest values.

Keywords: Maize, Water stress, Calcium carbonate nanoparticles, yield and its components.

1. INTRODUCTION

Maize (Zea mays L.) is one of the most important strategic cereal crops in Egypt and the world. In Egypt, it is used as human food, livestock, and poultry feed as

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well as a row material for industrial products such as oil and starch. The cultivated area of maize in world was 193,733,586 hectares with annual production of 1,147,621,938 tones and average productivity equal 5.92 ton/ha. Total area under cultivation of maize in Egypt reached about 994818 hectares producing 7.45 million ton, thus the average production of maize is 7.489 ton/hectare (FAO, 2019).

The local production of maize dose not sufficient to meet the excessive demand especially the yellow grains. Therefore, any attempts for raising maize production are considered a matter of utmost importance. Such attempts could be achieved either by increasing its cultivated area or by the productivity of unit area using high yielding hybrids as well as improving the culture practices. One of the most important factors limiting crop production in arid and semi-arid regions is water shortage at different stages of growth (Harrison et al., 2014). Many reports indicated that maize plants are highly oversensitive to water deficiency conditions (Zafar-Ul-Hye et al., 2014). It is well known that maize crop had high irrigation requirements as well as it is sensitive crop to water stress during some growth stages (Khattab et al., 2015).

2. MATERIALS AND METHODS

Experimental site and plant materials

Two field experiments were conducted at Experimental Station Farm, Faculty of Agriculture, Fayoum University, Fayoum Governorate Egypt, during the two successive summer seasons of 2019 (SI) and 2020 (SII). The representative soil samples (0-30 cm depth) were taken before adding fertilizers and during soil preparation for assessing physical and chemical properties of the experimental soil (table 1).

Table 1 The Mechanical and chemical analysis of the experimental soil in both growing seasons of 2019 and 2020.

2019				2020			
Mechanical analysis							
Sand, %	Silt, %	Clay, %	Texture Class	Sand, %	Silt, %	Clay, %	Texture Class
21.83	35.50	42.67	Clay loam	21.63	35.21	43.16	Clay loam
Chemical analysis							
Organic M %	CaCo3 %	PH	EC (ds/m)	Organic M %	CaCo3 %	PH	EC (ds/m)
2.07	7.10	7.26	1.86	1.99	6.97	7.48	1.98

Layout and experimental design

The experiments were laid-out in a split–split plot design, having three replications. The treatments of the experimental factors were allocated as follows:

Three skipping Irrigation treatments, i.e., Normal irrigation, receiving seven irrigations at 15 days interval, skip irrigation at the 4^{th} irrigation (64DAP), and skip irrigation at the 5^{th} irrigation (78DAP) in the main plots, while three yellow single cross hybrids of maize, i. e. S.C.2055, S. C. 2066 and S. C. 2088 in the sub – plots, and three calcium carbonate nanoparticles concentrations, i.e., 500, 750 and 1000 g fed^{-1} in the sub-sub-plots. The net size of plot unit was 3×3.5 m, resulted an area of 10.5 m^2 (1/400 fed). Maize grains three hybrids were obtained from Egyptian Agricultural Company for Seed Production Agaseed. Maize hybrids seeds (12kg/fed.) were hand planted into rows 70 cm apart into digs spaced 25 cm. apart, at the rate of 2 grains/dig using dry methods (Afeer) on one side of the ridge.

Cultural practices

The preceding winter crop was wheat (*Triticum aestivum L.*) in both seasons. N fertilizer was added on the form of ammonium nitrate (33.5% N) at rate of 120 kg N/fed., splitted into two equal doses, one half after thinning (before 1st irrigation, and the other half (before 2nd irrigation), 200 kg calcium super-phosphate; (15.5% P2O5) was added during the soil preparation. Potassium fertilizer was applied before sowing (during seedbed preparation) at rate of 50 kg/fed., in the form of potassium sulphate (48% K2O). The first irrigation was applied at 21 days after sowing then plants were irrigated every 15 days till the dough stage. All other agricultural treatments for maize production were carried out as recommended by the Ministry of Agriculture and Land Reclamation, except for the factors under study.

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Data recorded

Yield and yield component

At harvest time (after 120 days from planting), samples of five plants were taken at random from each sub–sub plot and, the middle two rows from each sub plot were harvested to determine the following characters:

Plant height (cm)
Ear height (cm)
Ear length (cm)
Ear diameter (cm)
Ear weight (g)
No. of row/ear
No. grains/row
Ear grain weight (g)
100-grain weight
Biological yield (ton/fed)
Grain yield (ton/fed): it was determined by the weight of grains per kilograms adjusted 15.5 % moisture content of each plot.

All data obtained in both seasons were subjected to analysis using of variance (ANOVA) by GenStat Statistical computer software (edition12). Treatment means were compared using the least significant difference (LSD) test according to (Gomez and Gomez, 1984) at the 5% level of significance.

3. RESULTS AND DISCUSSION

Results of the main effects of skipping Irrigation, yellow single cross hybrids of maize, calcium carbonate nanoparticles concentrations and their interactions (first and second orders) will be elicited and discussed under following topics:

Maize characters at harvest

Plant and ear height (cm)

Results presented in Table (2) revealed that Plant height and ear height of maize plants were significantly affected by skip irrigation, maize hybrids, nanoparticles and their interactions. The normal irrigation had more increased plant and ear height of maize than skip irrigation treatments. The results were agreement with those obtained by Chattha et al. (2017). Among the three tested yellow single cross hybrids of maize on plant and ear height S. C. 2088 maize hybrid gave the tallest one recording (252.85and 97.30 cm) and (244.76 and 94.01 cm), in the first and second seasons, respectively. These results in good accordance with those reported by Bamuaafa et al. (2010) and Khan et al., (2014). Also, the results show that a significant differences among three rates of calcium carbonate nanoparticles on plant and ear height. The tallest plants were obtained from maize plants which treated with 1000 g/fed calcium carbonate nanoparticles (253.85 and 97.64 cm) and (246.54 and 95.31 cm) in the first and second seasons, respectively. While the shortest plants were obtained by maize plants which treated with 500 g/fed. Some workers came to the same trends as Yugandhar and Savithramma (2013) and Sabir et al., (2014).

Yield components

Results presented in Tables (2 and 3) reveled that ear characters (length, diameter, weight, No. of row/ear, No. of grains/row and ear grains weight) and 100- grain weight were significantly affected by skip irrigation, maize hybrids, nanoparticles and their interactions. Normal irrigation had more increased all ear characters means as well as 100- grain weight. Among the three tested yellow single cross hybrids of maize on ear characters and 100- grain weight S. C. 2088 maize hybrid gave the highest values of these traits. Also the results show that a significant differences among three rates of calcium carbonate, maize plants which treated with 1000 g/fed calcium carbonate nanoparticls gave the highest values of ear characters and 100- grain weight, i.e. 19.57 cm, 4.0 cm, 235.65g, 13.89, 45.49, 120.68g , 28.86g in ear characters (length, diameter, weight, No. of row/ear, No. of grains/row and ear grains weight) and 100- grain weight, respectively in the first season and i.e. 19.16 cm, 3.93 cm, 220.78g, 13.84, 44.58, 115.61g , 27.29g in ear characters (length, diameter, weight, No. of row/ear, No. of grains/row and ear grains weight) and 100- grain weight, respectively in the second season.

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Table 2 Effect of skip irrigation, Single cross hybrids, calcium carbonate nanoparticles and their interactions on plant height and some ear characters.

Trait	Plant height (cm)		Ear height (cm)		Ear length (cm)		Ear diameter (cm)		Ear weight (g)	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
A- Irrigation levels (I)										
I_0	269.64	261.68	110.84	109.09	20.77	20.43	4.47	4.35	262.95	250.73
I_1	251.73	243.55	93.03	89.33	19.95	19.55	3.71	3.80	225.38	214.41
I_2	230.53	223.78	82.77	79.95	16.51	16.11	3.35	3.24	180.79	170.06
B- Yellow single cross hybrids										
S. C. 2055	248.74	241.11	93.92	91.67	18.62	18.28	3.68	3.64	212.98	202.00
S. C. 2066	250.99	243.15	95.42	92.68	19.12	18.74	3.83	3.81	224.22	212.95
S. C. 2088	252.85	244.76	97.30	94.01	19.50	19.06	4.00	3.94	231.91	220.24
C- Calcium carbonate nanoparticles (g/fed)										
500	247.21	239.34	93.63	90.47	18.62	18.11	3.67	3.66	206.92	196.26
750	250.84	243.13	95.38	92.57	19.05	18.82	3.84	3.80	226.55	215.16
1000	253.85	246.54	97.64	95.31	19.57	19.16	4.00	3.93	235.65	220.78
L.S.D at 5%										
A	1.35	1.30	3.30	1.90	0.09	0.25	0.13	0.21	6.21	6.29
B	0.72	0.18	0.85	0.53	0.10	0.07	0.04	0.05	0.35	0.59
C	0.16	0.24	0.28	0.67	0.10	0.08	0.04	0.02	0.28	0.51
A×B	n. s	n. s	n. s	0.92	n. s	0.13	0.07	0.09	0.60	1.03
A×C	0.27	0.43	0.48	n. s	n. s	0.14	n. s	n. s	0.50	0.89
B×C	0.27	0.44	0.48	n. s	n. s	n. s	0.07	n. s	0.50	0.89
A×B×C	0.48	0.74	0.84	n. s	n. s	n. s	n. s	n. s	0.86	1.55

Table 3 Effect of skip irrigation, single cross hybrids, calcium carbonate nanoparticles and their interactions on grain yield components.

Trait	No. of row/ear		No. of grains/row		Ear grains weight (g)		100-grain weight (g)	
	2019	2020	2019	2020	2019	2020	2019	2020
A- Irrigation levels (I)								
I_0	14.81	14.75	48.56	47.18	143.79	138.71	29.70	28.34
I_1	13.47	13.42	44.14	43.16	117.42	112.38	27.90	26.63
I_2	12.64	12.84	40.63	40.36	88.93	84.40	26.93	25.70
B- Yellow single cross hybrids								
S. C. 2055	13.41	13.38	43.69	42.65	109.99	105.39	27.87	26.61
S. C. 2066	13.65	13.59	44.35	43.47	116.45	111.58	28.16	26.88
S. C. 2088	13.89	13.79	45.33	44.58	123.71	118.52	28.48	27.19
C- Calcium carbonate nanoparticles (g/fed)								
500	13.39	13.36	43.13	42.22	111.72	107.08	27.61	26.36
750	13.63	13.57	44.74	43.89	117.74	112.80	28.31	27.03
1000	13.89	13.84	45.49	44.58	120.68	115.61	28.86	27.29
L.S.D at 5%								
A	0.01	0.02	0.29	1.04	1.44	2.22	0.12	0.01
B	0.00	0.07	0.11	0.25	0.72	0.62	0.01	0.01
C	0.01	0.06	0.08	n. s	0.59	0.56	0.01	0.01
A×B	0.01	n. s	0.20	0.24	1.25	1.08	0.02	0.02
A×C	0.01	0.10	0.14	0.42	1.02	0.97	0.02	0.02

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B×C	0.01	n. s	0.14	0.42	1.02	0.97	0.02	0.02
A×B×C	0.03	n. s	0.24	n. s	1.77	1.69	0.03	0.03

Table 4 Effect of skip irrigation, Single cross hybrids, calcium carbonate nanoparticles and their interactions on Biological, grain yield (ton/fed [1]) and Harvest index.

Trait	Biological yield (ton/fed)		Grain yield (ton/fed)		Harvest index (%)	
	2019	2020	2019	2020	2019	2020
A- Irrigation levels (I)						
I_0	8.68	8.41	4.11	3.64	47.31	43.22
I_1	7.94	7.68	3.64	3.19	45.81	41.50
I_2	6.12	5.91	2.32	1.94	37.78	32.62
B- Yellow single cross hybrids						
S. C. 2055	7.09	6.86	3.06	3.20	42.51	37.79
S. C. 2066	7.63	7.39	3.36	2.93	43.52	39.04
S. C. 2088	8.02	7.76	3.65	2.64	44.87	40.91
C- Calcium carbonate nanoparticles (g/fed)						
500	6.85	6.62	2.94	2.53	42.10	37.18
750	7.70	7.46	3.40	2.96	43.64	39.25
1000	8.19	7.93	3.74	3.28	45.15	40.91
L.S.D at 5%						
A	0.11	0.09	0.05	0.07	0.23	0.18
B	0.01	0.01	0.01	0.01	0.03	0.02
C	0.01	0.01	0.01	0.01	0.04	0.02
A×B	0.03	0.02	0.01	0.02	0.05	0.04
A×C	0.02	0.02	0.01	0.01	0.08	0.03
B×C	0.02	0.02	0.01	0.01	0.08	0.03
A×B×C	0.04	0.04	0.02	0.03	0.14	0.05

Biological and grain yield (ton/fed)

Data presented in Table (4) show that biological and grain yield (ton/fed) were significantly affected by skip irrigation, maize hybrids, nanoparticles and their interactions. Normal irrigation had more increased both biological and grain yield (ton/fed). Among the three tested yellow single cross hybrids of maize on biological and grain yield (ton/fed) S. C. 2088 maize hybrid gave the highest values of these traits, i. e. (8.02 and 3.65 ton/fed) and (8.41 and 3.64 ton/fed) in biological and grain yield in the first and second, respectively. These results are in harmony with those reported by Ahmad et al., (2018).

Biological and grain yield (ton/fed) were increased by increasing calcium carbonate nanoparticles rates in both seasons. the highest values of these traits, were obtained from maize plants which treated with 1000 g/fed calcium carbonate nanoparticles (8.19 and 3.74 ton/fed) and (7.93and 3.28 ton/fed) in biological and grain yield in the first and second, respectively. These results are agreement with those reported by (Nassar et al., 2018).

Harvest index

Results presented in Tables (4) indicated that, irrigation withholding was significant affecting of harvest index %. The highest mean values of harvest index (47.31 and 43.22 % in the respective two seasons). Missing the 4rd and 5th irrigation detected a significant decrease in harvest index. Whereas, the lowest mean values of harvest index which were (37.78 and 32.62 %) in the first and second seasons, respectively. These results refer to a decrease in the current and stored photosynthates available for ear growth. These results are agreement with those reported by El-Sobky and El-Naggar (2017). The differences among the three yellow single cross hybrids of maize, in harvest index were significant in both seasons, as shown in Table (4). Maize hybrid of S. C. 2088 significantly surpassed the other two hybrids in harvest index this hybrid followed by maize hybrids of S. C. 2066 and S. C. 2055, in a descending order, with significant differences among them. Results showed that increasing calcium carbonate nanoparticles rates from 500 to 750 and 1000 g/fed caused significant increase for harvest index in the 2019 and 2020 seasons. The highest mean values of harvest index were (45.15 and 40.91%) recorded from applying 1000 g/fed in the first and second seasons, respectively. These results are agreement with those reported by (Nassar et al., 2018).

4. CONCLUSION

Application of calcium carbonate nanoparticles as nano-fertilizers was pioneer and significantly resulted in characters, i.e., ear height, ear length, ear diameter, ear weight, number of row/ear, number of grain/row, high rate of calcium carbonate nanoparticles produced the highest values.

Ethical approval

Not applicable.

Funding

The study has not received any external funding.

Informed consent

Not applicable.

Conflicts of interests

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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