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Effect of some Nano fertilizers on vegetative growth parameters of some new maize hybrids under water stress conditions

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ABSTRACT:

Two field experiments were conducted at the Experimental Farm, Faculty of Agriculture, Fayoum University at "Dar-El- Ramed" Fayoum Governorate, Egypt during the two successive seasons of 2019 and 2020. The study was conducted in order to investigate the effect of withholding one irrigation at two stages as growth and three rates of Calcium carbonate nanoparticles as nano-fertilizers on growth parameters of some yellow single cross hybrids of maize under the environmental conditions of the experimentation area.

The experimental layout was a split-split plot arranged in randomized complete block design with three replications where water stress treatments (skipping of some irrigations) were considered as the main plot, three yellow single cross hybrids of maize arranged in the sub-plot and the sub-sub plot occupied by three concentrations calcium carbonate nanoparticles treatments.

Results indicated that irrigation treatment reflected positive significant influences on growth parameters, normal irrigation resulted in the best mean values of plant height, maximum number of leaves plant^{-1} , largest leaf area plant^{-1} and heaviest dry weight plant^{-1} in both seasons 65 and 80 (DAS). Irrigation treatments had a significant effect on number of days from sowing to 50% tasseling in the two growing seasons. The maximum number of days from sowing to 50% tasseling due to irrigation were produced from the normal irrigation compared with the other irrigation treatments {(Withholding the 4th irrigation (65 DAP) and Withholding the 5th irrigation (80 DAP)}.While the minimum number of days from sowing to 50% tasseling were resulted from Withholding the 5th irrigation (80 DAP).

Results showed that yellow single cross hybrids of maize were significantly differed in almost mean values of maize growth, under study in the 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, number of leaves/plant^{-1}, dry weight plant^{-1}, and total dry weight of plant in both seasons at 65 and 80 DAS. Application of high rate of calcium carbonate nanoparticles produced the highest values.

KEYWORDS: Maize, water stress, calcium carbonate nanoparticles, vegetative growth.

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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 well as a row material for industrial products such as oil and starch. The cultivated area of maize in world was 193,733,586 hectare 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 hectare 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 **(Khatab et al., 2015).**

The present study was conducted to evaluate of some maize yellow single cross hybrids in growth parameter under three irrigation regimes and Calcium carbonate nanoparticles as nano-fertilizers rates.

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 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 in (table 1).

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

2019 (SI)				2020(SI)			
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 4th irrigation (65DAP), and skip irrigation at the 5th irrigation (80 DAP) 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. 500g fed-1, 750 g fed-1 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 m2 (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.

Data recorded:

A. Number of days from sowing to 50% tasseling:

This character was determined as the number of days from planting to 50% tasseling of each sub-sub plot plants.

B. Vegetative measurements were taken to study the growth characteristics. Two samples were taken during the growth period (65 and 80 days from sowing), where five guarded plants were chosen at random from outer ridges of each sub-sub plot. The following growth attributes was determined:

1. Plant height (cm).
2. Number of leaves/plant.
3. Total leaf area/plant (cm2).
4. Total dry weight per plant (g).

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 DESCUSSION:

Results of the main effects of skipping irrigation, nanoparticles, hybrids of maize and their interaction will be elicited and discussed under following topics:

A- Number of days from sowing to 50% tasseling:

Table (2) display the main and interaction impacts of skipping irrigation, nanoparticles, hybrids of maize and their interactions on number of days from planting to 50% tasseling. The maximum mean values of No. of days from planting to 50 % tasseling was found under normal irrigation treatment (61.30 and 60.34 days) in the two growing seasons, respectively. Missing the 4rd and 5th irrigation detected a significant decrease in No. of days from planting to 50 % tasseling. Whereas, the minimum No. of days from planting to 50 % tasseling (47.78 and 47.03 days) in the first and second seasons, respectively. These results are in agreement with those of **Saleem et al., (2011)** they reported that decreased in days to 50% tasseling under drought conditions. The differences among the three yellow single cross hybrids of maize, (S. C. 2055, S. C. 2066 and S. C. 2088) in No. of days from planting to 50% tasseling were significant in 2019 and 2020 seasons, as shown in Table (2). Maize hybrid of S.C.2088 significantly surpassed the other two hybrids in No. of days from planting to 50% tasseling this hybrid followed by maize hybrids of S.C.2066 and S.C.2055, in a descending order, with significant differences among them. Planting maize hybrid of S.C.2088 significantly gave maximum mean values of No. of days from planting to 50% tasseling were 55.63 and 54.76 days, in the first and second seasons, respectively. These results are in harmony with those reported by **Kinfe et al., 2016**.

Regarding nano-fertilizers rates, the maximum mean values of No. of days from planting to 50% tasseling (56.13 and 55.25 day) recorded from applying 1000 g/fed in the first and second seasons, respectively. On the other hand, the minimum No. of days from planting to 50% tasseling, (52.51 and 51.69 day) were obtained from added 500 g/fed in the two seasons, respectively.

Effects of decomposition of calcium carbonate ($CaCO_3$) breaks down to calcium oxide (CaO) and carbon dioxide (CO_2) in clears out stomata, and this CO_2 increase the rate of photosynthesis, leading to increased carbon take-up and assimilation of carbon, thus enhancing plant development. The results were agreement with those obtained by **(Nassar et al.,2018).**

B- Vegetative measurements:

1- Plant height (cm):

Table (3 and 4) displays the main and interaction effects of skip irrigation with Calcium carbonate nanoparticles as nano-fertilizers rates, and their interaction on plant height of three yellow single cross hybrids of maize at 65 and 80 DAS in 2019 and 2020 seasons. Normal irrigation produced significantly higher plant height at 64 and 78 DAS, 197.26 and 235.91 cm in the first season and 189.42 and 213.13 cm in the second season at 65 and 80 DAS, respectively. On the other hand, the shortest plants were obtained by the skip irrigation at milk stage (174.79 and 209.03 cm) in the first season and 172.86 and 189.08 cm in the second seasons, at 65 and 80 DAS, respectively. The results were agreement with those obtained by **Chattha et al., (2017**). Maize hybrid of S. C. 2088 significantly surpassed the other two hybrids in plant height (cm) this hybrid followed by maize hybrids of S. C. 2066 and S. C. 2055, in a descending order, with significant differences among them. Planting maize hybrid of S. C. 2088 significantly gave the tallest plants were 188.48 and 225.40 cm in the first season and 183.29 and 203.63 cm in the second seasons, at 65 and 80 DAS, respectively. These results are in harmony with those reported by **Adeniyan (2014).** Regarding nano-fertilizers rates, increasing calcium carbonate nanoparticles rates from 500 to 750 and 1000 g/fed caused significant increase for plant height cm at 65 and 80DAS in the 2019 and 2020 seasons. The highest plants were found by calcium carbonate nanoparticles at a concentration of 1000 g/fed, (189.58 and 225.40 cm) in the first season and (183.96 and 204.89 cm) in the second seasons, at 65 and 80 DAS, respectively. These results are agreement with those reported by **(Nassar et al., 2018).**

2- Number of leaves/plant.

Results tabulated in Table (5 and 6) revealed that the average of number of leaves/plant was significantly affected by skipping irrigation, nanoparticles, hybrids of maize in the two growing seasons.

Normal irrigation produced significantly highest No. of leaves/plant which were (14.95 and 18.02) in the first season and (14.39 and 17.08) in the second seasons, at 65 and 80 DAS, respectively. On the other hand, the lowest No. of leaves/plant were obtained by the skip irrigation at milk stage (12.61 and 15.27) in the first season and (12.20 and 14.48) in the second seasons, at 65 and 80 DAS, respectively. The results were agreement with those obtained by **Chattha et al., (2017).** Concerning the varietal differences on **number of leaves/plant** with three yellow single cross hybrids of maize. Maize hybrid of S. C. 2088 significantly surpassed the other two hybrids in number of leaves per plant this hybrid followed by maize hybrids of S. C. 2066 and S. C. 2055, in a descending order, with significant differences among them. Planting maize hybrid of S. C. 2088 significantly gave highest number of leaves/plants were (14.01 and 16.94) in the first season and (13.52 and 16.06) in the second seasons, at 65 and 80 DAS, respectively. These results are in harmony with those reported by **Majid et al., (2017).** The highest number of leaves/plants were found by calcium carbonate nanoparticles at a concentration of 1000 g/fed, (14.06 and 16.99) in the first season and (13.57 and 16.11) in the second seasons, at 65 and 80 DAS, respectively. On the other hand, the lowest number of leaves/plants were obtained by applying 500 g/fed (13.36 and 16.14) in the first season and (12.89 and 15.30) in the second seasons, at 65 and 80 DAS, respectively. calcium carbonate (CaCO3) breaks down to calcium oxide (CaO) and carbon dioxide (CO2) in clears out stomata, and this CO2 increase the rate of photosynthesis, leading to increased carbon take-up and assimilation of carbon, thus enhancing plant development. These results are agreement with those reported by **(Nassar et al., 2018).**

3- Total leaf area/plant (cm^2).

Data in Table (7 and 8) show that the effect of skipping irrigation, nanoparticles, hybrids of maize and their interactions on total leaf area/plant (cm2) at 65and 80 days after sowing (DAS) in the two growing summer seasons of 2019 and 2020. Normal irrigation produced significantly maximum leaf area/plant (cm^2) which were 9568.50 and 9104.80 cm^2 in the first season and 8772.75 and 8467.02 in the second seasons, at 65 and 80 DAS, respectively. On the other hand, the minimum leaf area/plant (cm^2) were obtained by the skip irrigation at milk stage (6915.40 and 6617.30 cm^2) in the first season and (6375.98 and 6153.78 cm^2) in the second seasons, at 65 and 80 DAS, respectively. The results were agreement with those obtained by **Chattha et al., (2017).** Varietal differences in total leaf area/plant (cm^2), Maize hybrid of S. C. 2088 significantly surpassed the other two hybrids in leaf area/plant (cm^2) this hybrid followed by maize hybrids of S. C. 2066 and S. C. 2055, in a descending order, with significant differences among them. Planting maize hybrid of S. C. 2088 significantly gave the maximum leaf area/plant (cm2) were 8559.30 and 8168.70 cm^2 in the first season and 7870.80 and 7596.51 cm^2 in the second seasons, at 64 and 78 DAS, respectively. On the other hand, S.C. 2055 maize hybrid produced the minimum leaf area/plant (cm^2) which were 7667.90 and 7318.40 cm^2 in the first season and 7051.49 and 6805.75 cm^2 in the second seasons, at 64 and 78 DAS, respectively. The results agree with those reported by **Hafez and Abdelaal 2015.**

Regarding nano-fertilizers rates, the maximum leaf area/plant (cm^2) were found by calcium carbonate nanoparticles at a concentration of 1000 g/fed, were 8643.60 and 8249.40 cm^2 in the first season and 7948.54 and 7671.53 cm^2 in the second seasons, at 65 and 80 DAS, respectively. On the other hand, the minimum leaf area/plant (cm^2) were obtained by applying 500 g/fed (7575.30 and 7230.00 cm^2) in the first season and 6966.30 and 6723.52 cm^2 in the second seasons, at 65 and 80 DAS, respectively. Calcium carbonate ($CaCO_3$) breaks down to calcium oxide (CaO) and carbon dioxide (CO_2) in clears out stomata, and this CO_2 increase the rate of photosynthesis, leading to increased carbon take-up and assimilation of carbon, thus enhancing plant development. These results are agreement with those reported by **(Nassar et al., 2018).**

4-Total dry weight /plant (g).

Table (10 and 11) displays the main and interaction impact of skipping irrigation, nanoparticles, hybrids of maize and their interactions on total dry weight /plant (g) at two growth ages. Results showed that Normal irrigation produced significantly maximum total dry weigh/plant which were 75.08 and 86.51 g in the first season and 74.11 and 81.13g in the 2^{nd} seasons, at 65 and 80 DAS, respectively. On the other hand, the minimum total dry weigh/plant were obtained by the skip irrigation at milk stage (65.07 and 70.92 g) in the 1st season and 47.78 and 47.03 g in the 2nd seasons, at 65 and 80 DAS, respectively. The results were agreement with those obtained by **Chattha et al., (2017).**

The differences among the three yellow single cross hybrids of maize, (S. C. 2055, S. C. 2066 and S. C. 2088) in total dry weigh/plant were significant in 2019 and 2020 seasons, as shown in Table (10 and 11). Maize hybrid of S. C. 2088 significantly surpassed the other two hybrids in total dry weigh/plant this hybrid followed by maize hybrids of S. C. 2066 and S. C. 2055, in a descending order, with significant differences among them. Planting maize hybrid of S. C. 2088 significantly gave the maximum total dry weigh/plant were 71.33 and 81.76 g in the first season and 68.98 and 76.91 g in the second seasons, at 65 and 80 DAS, respectively. These results are in harmony with those reported by **Adeniyn (2014).**

The maximum total dry weigh/plant were found by calcium carbonate nanoparticles at a concentration of 1000 g/fed, (71.90 and 82.42 g) in the first season and 70.98 and 77.53 g in the second seasons, at 65 and 80 DAS, respectively. On the other hand, the minimum total dry weigh/plant were obtained by applying 500 g/fed (69.02 and 79.14 g) in the first season and 68.13 and 74.49 g in the second seasons, at 65 and 80 DAS, respectively. Calcium carbonate ($CaCO_3$) breaks down to calcium oxide (CaO) and carbon dioxide (CO_2) in clears out stomata, and this CO_2 increase the rate of photosynthesis, leading to increased carbon take-up and assimilation of carbon, thus enhancing plant development. These results are agreement with those reported by **(Nassar et al., 2018).**

Table 2. Number of days from sowing to 50% tasseling of maize as affected by Irrigation regimes, some maize hybrids, Nano - fertilizers, and their interactions during 2019 and 2020 seasons.

Irrigation (I)	Maize hybrids (V)	2019				2020			
		Nano (N)				Nano (N)			
		N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
I1	V_1	59.17	60.34	2	60.46	58.24	59.39	60.90	59.51
	V_2	59.94	60.90	62.45	61.09	59.00	59.94	61.47	60.14
	V_3	60.82	62.75	63.47	62.35	59.87	61.76	62.48	61.37
Mean		59.97	61.33	62.60	61.30	59.04	60.37	61.62	60.34
I_2	V_1	51.61	52.18	54.98	52.93	50.81	51.37	54.12	52.10
	V_2	52.05	53.91	55.79	53.92	51.23	53.07	54.12	53.07
	V_3	52.67	55.53	57.89	55.36	51.84	54.66	56.99	54.50
Mean		52.11	53.88	56.22	54.07	51.29	53.03	55.34	53.22
I_3	V_1	44.54	55.53	57.89	46.28	43.84	45.63	47.20	45.56
	V_2	45.67	48.64	49.34	47.88	44.96	47.88	48.57	47.13
	V_3	46.16	49.97	51.39	49.17	45.44	49.19	50.58	48.40
Mean		45.46	48.32	49.56	47.78	44.75	47.57	48.79	47.03
Means of (V)		51.77	52.96	54.93	53.22	50.96	52.13	54.07	52.39
		52.55	54.48	55.86	54.30	51.73	53.63	54.99	53.45
		53.22	56.08	57.58	55.63	52.38	55.21	56.68	54.76
Means of hybrids (N)		52.51	54.51	56.13		51.69	53.66	55.25	
$L.S.D_{(0.05)}$									
I		1.31 0.54							
V		0.10 0.04							
N		0.09 0.03							
I x V		0.18 0.07							
I x N		0.15 0.06							
V x N		0.15 0.06							
I x V x N		0.27 0.11							

Table 3. Plant height (cm) at 65 and 80 days after sowing of maize as affected by Irrigation regimes, some maize hybrids, Nano - fertilizers, and their interactions during 2019 season.

Irrigation (I)	Maize hybrids (V)	65 DAS				80 DAS			
		Nano (N)				Nano (N)			
		N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
I_1	V_1	187.46	191.87	194.26	191.20	224.19	229.46	232.32	228.66
	V_2	189.75	195.49	204.28	196.51	226.92	233.79	244.30	235.00
	V_3	193.07	200.91	218.25	204.08	230.90	240.27	261.01	244.06
Mean		190.09	196.09	205.60	197.26	227.34	234.51	245.87	235.91
I_2	V_1	179.17	181.69	184.45	181.77	214.28	217.29	220.59	217.38
	V_2	180.83	184.23	185.31	183.46	216.26	220.32	221.62	219.40
	V_3	182.25	185.58	187.03	184.96	217.96	221.94	223.67	221.19
Mean		180.75	183.84	185.60	183.39	216.16	219.85	221.96	219.32
I_3	V_1	169.78	174.01	176.06	173.28	203.04	208.10	210.55	207.23
	V_2	171.33	175.86	176.83	174.67	204.89	210.31	211.47	208.89
	V_3	172.73	176.71	179.76	176.40	206.57	211.33	214.98	210.96
Mean		171.28	`75.53	177.55	174.79	204.84	209.92	212.33	209.03
Means of hybrids (V)		178.81	182.52	184.92	182.08	213.84	218.28	221.15	217.76
		180.64	185.19	188.81	184.88	216.02	221.48	225.80	221.10
		182.69	187.73	195.01	188.48	218.48	224.51	233.22	225.40
Means of (N)		180.71	185.15	189.58		216.11	221.42	226.72	
L.S.D$_{(0.05)}$									
I		0.92 0.98							
V		0.14 0.15							
N		0.11 0.11							
I x V		0.25 0.26							
I x N		0.19 0.20							
V x N		0.19 0.20							
I x V x N		0.33 0.35							

Table 4. Plant height (cm) at 65 and 80 days after sowing of maize as affected by Irrigation regimes, some maize hybrids, Nano - fertilizers, and their interactions during 2020 season.

Irrigation (I)	Maize hybrids (V)	65 DAS				80 DAS			
		Nano (N)				Nano (N)			
		N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
I_1	V_1	180.57	184.17	186.47	183.74	202.73	207.89	210.05	206.89
	V_2	182.14	187.65	196.08	188.62	204.52	211.35	220.65	212.17
	V_3	185.33	192.85	209.50	195.89	208.38	217.42	235.21	220.34
Mean		182.68	188.22	197.35	189.42	205.21	212.22	221.97	213.13
I_2	V_1	171.99	174.40	177.05	174.48	193.54	196.52	199.40	196.49
	V_2	173.58	176.84	177.88	176.10	195.64	199.15	200.30	198.36
	V_3	174.94	178.14	179.53	177.54	196.71	200.40	202.22	199.77
Mean		173.50	176.46	178.15	176.04	195.29	198.69	200.64	198.21
I_3	V_1	166.36	170.51	172.51	169.79	183.57	188.14	190.36	187.36
	V_2	167.88	172.32	176.85	172.35	185.58	190.19	191.48	189.08
	V_3	172.76	176.74	179.79	176.43	186.67	191.39	194.31	190.79
Mean		169.00	173.19	176.38	172.86	185.28	189.90	192.05	189.08
Means of hybrids (V)		172.97	176.36	178.68	176.00	193.28	197.52	199.93	196.91
		174.53	178.94	183.61	179.02	195.25	200.23	204.14	199.87
		177.68	182.58	189.60	183.29	197.25	203.07	210.58	203.63
Means of (N)		175.06	179.29	183.96		195.26	200.27	204.89	
$L.S.D_{(0.05)}$									
I		4.27 0.95							
V		1.08 0.27							
N		0.67 0.25							
I x V		3.20 0.48							
I x N		1.16 0.44							
V x N		1.16 0.44							
I x V x N		2.01 0.77							

Table 5. Number of leaves per plant at 65 and 80 days after sowing of maize as affected by Irrigation regimes, some maize hybrids, Nano - fertilizers, and their interactions during 2019 season.

Irrigation (I)	Maize hybrids (V)	65 DAS				80 DAS			
		Nano (N)				Nano (N)			
		N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
I_1	V_1	14.03	14.47	15.10	14.53	16.90	17.43	18.20	17.51
	V_2	14.38	14.82	15.49	14.90	17.32	17.86	18.66	17.95
	V_3	14.91	15.44	15.93	15.43	17.96	18.60	19.20	18.59
Mean		14.44	14.91	15.51	14.95	17.40	17.96	18.69	18.02
I_2	V_1	13.10	13.39	13.56	13.35	15.86	16.21	16.40	16.16
	V_2	13.45	13.58	13.82	13.62	16.28	16.44	16.73	16.48
	V_3	13.48	13.75	14.00	13.74	16.31	16.64	16.94	18.59
Mean		13.34	13.57	13.79	13.57	16.15	16.43	16.69	16.42
I_3	V_1	12.07	12.39	12.55	12.33	14.62	15.01	15.20	14.94
	V_2	12.32	12.67	12.84	12.61	14.93	15.36	15.55	15.28
	V_3	12.47	12.90	13.24	12.87	15.11	15.64	16.04	15.60
Mean		12.29	12.65	12.88	12.61	14.89	15.33	15.60	15.27
Means of hybrids (V)		13.07	13.41	13.74	13.41	15.79	16.21	16.60	16.20
		13.38	13.69	14.05	13.71	16.18	16.55	16.98	16.57
		13.62	14.03	14.39	14.01	16.46	16.96	17.39	16.94
Means of (N)		13.36	13.71	14.06		16.14	16.57	16.99	
$L.S.D_{(0.05)}$									
I		0.093 0.127							
V		0.012 0.016							
N		0.008 0.010							
I x V		0.021 0.028							
I x N		0.013 0.018							
V x N		0.013 0.018							
I x V x N		0.023 0.031							

Table 6. Number of leaves per plant at 65 and 80 days after sowing of maize as affected by Irrigation regimes, some maize hybrids, Nano - fertilizers, and their interactions during 2020 season.

Irrigation (I)	Maize hybrids (V)	65 DAS				80 DAS			
		Nano (N)				Nano (N)			
		N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
I_1	V_1	13.50	13.92	14.53	13.98	16.02	16.52	17.25	16.60
	V_2	13.83	14.26	14.90	14.33	16.42	16.93	17.69	17.01
	V_3	14.43	14.86	15.33	14.84	17.03	17.63	18.20	17.62
Mean		13.89	14.34	14.92	14.39	16.49	17.03	17.71	17.08
I_2	V_1	12.66	12.94	13.10	12.90	15.03	15.36	15.55	15.31
	V_2	13.00	13.13	13.36	13.16	15.43	15.58	15.86	15.62
	V_3	13.02	13.28	13.53	13.28	15.46	15.77	16.06	15.76
Mean		12.89	13.12	13.33	13.11	15.31	15.57	15.82	15.57
I_3	V_1	11.68	11.98	12.14	11.93	13.86	14.22	14.41	14.17
	V_2	11.92	12.26	12.42	12.20	14.15	14.56	14.74	14.48
	V_3	12.07	12.48	12.81	12.45	14.32	14.82	15.21	14.78
Mean		11.89	12.24	12.46	12.20	14.11	15.53	14.79	14.48
Means of hybrids (V)		12.61	12.95	13.26	12.94	14.97	15.37	15.74	15.36
		12.92	13.22	13.56	13.23	15.33	15.69	16.10	15.71
		13.14	13.54	13.89	13.52	15.60	16.08	16.49	16.06
Means of (N)		12.89	13.23	13.57		15.30	15.71	16.11	
$L.S.D_{(0.05)}$									
I		1.11 0.12							
V		0.01 0.01							
N		0.01 0.01							
I x V		0.02 0.02							
I x N		0.01 0.01							
V x N		0.01 0.01							
I x V x N		0.02 0.03							

Table 7. Leaf area per plant (cm2) at 65 and 80 days after sowing of maize as affected by Irrigation regimes, some maize hybrids, Nano - fertilizers, and their interactions during 2019 season.

Irrigation (I)	Maize hybrids (V)	65 DAS				80 DAS			
		Nano (N)				Nano (N)			
		N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
I_1	V_1	8284.0	9003.8	9598.9	8962.2	7882.5	8567.4	9133.7	8527.9
	V_2	8741.0	9451.4	10230.7	9474.4	8317.4	8993.3	9734.9	9015.2
	V_3	9536.9	10337.6	10932.7	10269.1	9074.7	9836.6	10402.8	9771.4
Mean		8854.0	9597.6	10254.1	9568.5	8424.9	9123.4	9757.1	9104.8
I_2	V_1	7187.4	7558.9	7815.6	7520.6	6869.0	7224.1	7469.3	7187.5
	V_2	7537.0	7780.5	8252.2	7856.6	7203.2	7708.7	8595.8	7508.5
	V_3	7465.4	8066.0	8994.2	8175.2	7134.7	7708.7	8595.8	7813.0
Mean		7396.6	7801.8	8354.0	7850.8	7069.0	7456.2	7983.9	7503.0
I_3	V_1	6252.8	6486.0	6823.9	6520.9	5983.3	6206.5	6529.8	6239.8
	V_2	6471.5	7151.5	7352.1	6991.7	6192.6	6843.2	7035.2	6690.4
	V_3	6701.3	7207.0	7792.4	7233.5	6412.5	6896.3	7456.5	6921.8
Mean		6475.2	6948.2	7322.8	6915.4	6196.1	6648.7	7007.2	6617.3
Means of hybrids (V)		7241.4	7682.9	8079.4	7667.9	6911.6	7332.7	7710.9	7318.4
		7583.2	8127.8	8611.7	8107.6	7237.7	7757.5	8218.9	7738.0
		7901.2	8536.8	9239.7	8559.3	7540.6	8147.2	8818.4	8168.7
Means of (N)		7575.3	8115.8	8643.6	8111.6	7230.0	7745.8	8249.4	7741.7
$L.S.D_{(0.05)}$									
I		128.99 249.72							
V		25.32 40.49							
N		16.51 26.10							
I x V		43.85 70.13							
I x N		28.60 45.21							
V x N		28.60 45.21							
I x V x N		49.53 78.31							

Table 8. Leaf area per plant (cm2) at 65 and 80 days after sowing of maize as affected by Irrigation regimes, some maize hybrids, Nano - fertilizers, and their interactions during 2020 season.

Irrigation (I)	Maize hybrids (V)	65 DAS				80 DAS			
		Nano (N)				Nano (N)			
		N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
I_1	V_1	7595.03	8254.96	8800.57	8216.85	7330.34	7967.27	8493.87	7930.49
	V_2	8014.06	8665.34	9379.81	8686.41	7734.77	8363.35	9052.93	8383.68
	V_3	8743.73	9477.84	10023.45	9415.01	8439.01	9147.54	9674.13	9086.89
Mean		8117.61	8799.38	9401.28	8772.75	7834.71	8492.72	9073.64	8467.02
I_2	V_1	6618.53	6960.61	7196.93	6925.36	6387.87	6718.03	6946.12	6684.01
	V_2	6940.45	7164.55	7599.02	7234.70	6698.57	6914.96	7334.19	6982.57
	V_3	6874.47	7427.53	8282.26	7528.09	6634.89	7168.68	7993.62	7265.73
Mean		6811.15	7065.23	7429.71	7229.38	6573.78	6933.89	7424.64	6977.44
I_3	V_1	5765.08	5980.12	6291.61	6012.27	5564.17	5771.72	6072.35	5802.75
	V_2	5966.76	6593.64	6778.67	6446.35	5758.82	6363.85	6542.43	6221.70
	V_3	6178.60	6644.82	7184.54	6669.32	5963.27	6413.24	6934.16	6436.89
Mean		5970.15	6406.19	6751.61	6375.98	5762.09	6182.94	6516.31	6153.78
Means of hybrids (V)		6659.55	7065.23	7429.71	7051.49	6427.46	6819.01	7170.78	6805.75
		6973.76	7474.54	7919.17	7455.82	6730.72	7214.05	7643.18	7195.99
		7265.60	7850.06	8496.75	7870.80	7012.39	7576.49	8200.64	7596.51
Means of (N)		6966.30	7463.28	7948.54	7459.37	6723.52	7203.18	7671.53	7199.41
$L.S.D_{(0.05)}$									
I		241.56 246.79							
V		39.16 40.01							
N		25.25 25.79							
I x V		67.84 69.30							
I x N		43.73 44.68							
V x N		43.73 44.68							
I x V x N		75.75 77.39							

Table 9. Total dry weight of Plant (g) at 65 and 80 days after sowing of maize as affected by Irrigation regimes, some maize hybrids, Nano - fertilizers, and their interactions during 2019 season.

Irrigation (I)	Maize hybrids (V)	65 DAS				80 DAS			
		Nano (N)				Nano (N)			
		N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
I_1	V_1	73.24	73.97	75.63	74.28	84.40	85.24	87.14	85.59
	V_2	73.95	74.81	76.39	75.05	85.22	86.20	88.01	86.48
	V_3	74.59	75.84	77.32	75.91	85.95	87.38	89.07	87.47
Mean		73.93	74.87	76.45	75.08	85.19	86.27	88.07	86.51
I_2	V_1	68.62	69.77	70.62	69.67	78.72	80.03	81.00	79.91
	V_2	68.94	70.45	71.29	70.23	79.09	80.81	81.77	80.56
	V_3	68.94	71.96	73.41	71.25	78.44	82.53	84.18	81.72
Mean		68.64	70.73	71.77	70.38	78.75	81.12	82.32	80.73
I_3	V_1	63.37	64.58	66.79	64.96	72.33	73.56	76.07	73.99
	V_2	65.07	65.67	67.18	65.97	74.12	74.80	76.51	75.14
	V_3	64.94	67.01	68.49	66.82	73.97	76.32	78.00	76.10
Mean		64.50	65.75	67.49	65.91	73.47	74.89	76.86	75.08
Means of hybrids (V)		68.45	69.44	71.01	69.93	78.48	79.61	81.40	79.83
		69.32	70.31	71.62	70.42	79.48	80.60	82.10	80.73
		69.30	71.60	73.07	71.33	79.45	82.08	83.75	81.76
Means of (N)		69.02	70.45	71.90		79.14	80.76	82.42	
$L.S.D_{(0.05)}$									
I		0.64 2.17							
V		0.02 0.08							
N		0.02 0.07							
I x V		0.50 0.14							
I x N		0.04 0.13							
V x N		0.04 0.13							
I x V x N		0.08 0.23							

Table 10.Total dry weight of Plant (g) at 65 and 80 days after sowing of maize as affected by Irrigation regimes, some maize hybrids, Nano - fertilizers, and their interactions during 2020 season.

Irrigation (I)	Maize hybrids (V)	65 DAS				80 DAS			
		Nano (N)				Nano (N)			
		N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
I_1	V_1	72.29	73.01	74.66	73.32	79.21	79.90	81.79	80.30
	V_2	73.00	73.85	75.40	74.08	79.91	80.87	82.43	81.07
	V_3	73.63	74.86	76.32	74.93	80.63	81.87	83.56	82.02
Mean		72.97	73.91	75.46	74.11	79.92	80.88	82.59	81.13
I_2	V_1	67.73	68.86	69.70	68.77	74.13	75.30	76.23	81.13
	V_2	68.05	69.54	70.37	69.32	74.42	76.17	76.94	75.98
	V_3	67.49	71.03	72.46	70.33	73.88	77.66	79.08	76.87
Mean		67.76	69.81	70.85	69.47	74.14	76.38	77.42	75.98
I_3	V_1	62.68	63.75	65.94	64.12	68.33	69.56	71.86	69.92
	V_2	64.24	64.83	66.32	65.13	69.95	70.66	72.45	71.02
	V_3	64.10	66.16	67.62	65.96	69.97	72.10	73.44	71.84
Mean		63.68	64.91	66.63	65.07	69.42	70.77	72.58	70.92
Means of hybrids (V)		67.57	68.54	70.10	70.98	73.89	74.92	76.63	75.14
		68.43	69.41	70.70	69.54	74.76	75.90	77.27	75.98
		68.41	70.68	72.13	68.74	74.83	77.21	78.69	76.91
Means of (N)		68.13	69.54	70.98		74.49	76.01	77.53	
$L.S.D_{(0.05)}$									
I		0.28 1.60							
V		0.04 0.08							
N		0.03 0.10							
I x V		0.06 0.13							
I x N		0.06 0.18							
V x N		0.06 0.18							
I x V x N		0.11 0.32							

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الملخص العربي

تأثير بعض أسمدة النانو على خصائص النمو الخضري لبعض هجن الذرة الشامية تحت ظروف الإجهاد المائي

اجريت تجربتان حقليتان بالمزرعة التجريبية بكلية الزراعة جامعة الفيوم- بمنطقة دار الرماد محافظة الفيوم خلال موسمي 2019 و2020 لدراسة تأثير الرش الورقي بكربونات الكالسيوم النانونية كأسمدة ورقية على نمو بعض هجن الذرة الشامية تحت ظروف الإجهاد المائي. وقد تم اجراء التجارب في تصميم القطع المنشقة مرتين في ثلاث مكررات. حيث وضعت أنظمة الرى (الري العادى- اسقاط رية في مرحلة ما قبل التزهير- اسقاط رية في طور النضج اللبني) القطع الرئيسية اما القطع الفرعية فاحتوت على ثلاث هجن من الذرة الشامية (هجين ثلاثي 2055- هجين ثلاثي 2066 - هجين ثلاثى2088) وتركيزات النانو (500 جرام/ فدان، 750 جرام/فدان، 1000 جرام/فدان) تم توزيعها في القطع المنشقة الثانية. ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلي:

1- أظهرت النتائج أن معاملات الرى لها تأثير معنوى على خصائص النمو. وكان الرى العادى دون اسقاط رية أفضل النتائج حيث أعطت النبات الاعلى ارتفاعا وأقصى عدد لأوراق النبات وأكبر مساحة لأوراق النبات وأثقل وزن جاف للنبات عند عمر 65، 80 يوماً من الزراعة في كلا الموسمين.

2- كان لمعاملات الرى تأثير معنوى على عدد الأيام من الزراعة حتى ظهور 50% من النورات المذكرة. أدى عدم اسقاط رية في مراحل نمو الذرة الشامية (الرى العادى) إلى أطالة فترة النمو الخضري وتأخير المدة بالأيام من الزراعة حتى ظهور 50% من النورات المذكرة.

3- أوضحت النتائج أن الإختلاف بين الهجن الفردية الصفراء للذرة الشامية تحت الدراسة كانت معنوية في متوسط جميع صفات النمو. تفوق الهجين الفردي 2088 على كلاً من الهجين الفردي 2055 والهجين الفردي 2066 في متوسط ارتفاع النبات، عدد الأوراق الخضراء/نبات، مساحة أوراق النبات، والوزن الجاف للنبات عند عمر 65، 80 يوماً من الزراعة.

4- سجل الهجين الفدى 2055 أدنى متوسط في صفات ارتفاع النبات، مساحة أوراق النبات، عدد الأوراق الخضراء/نبات والوزن الجاف للنبات عند عمر 65، 80 يوماً من الزراعة.

5- زادت قيم جميع الصفات المدروسة للذرة الشامية المدروسة مثل ارتفاع النبات، وعدد الأوراق الخضراء/نبات، مساحة أوراق النبات، والوزن الجاف للنبات عند عمر 65، 80 يوماً من الزراعة. برش النباتات بكربونات الكالسيوم النانونية. استخدام 1000جم/الفدان من كربونات الكالسيوم النانونية اعطى اعلى الفيم للصفات المذكورة .