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Seed priming effect on yield and yield components of some bread wheat (*Triticum aestivum* L.) cultivars under rainfed conditions of Egypt

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Abstract

Low annual rainfall and long dry spells are the major reasons of wheat low yield in the North Western Coast of Egypt (NWCZ). The present study aims to improve the wheat productivity under rainfed conditions by evaluating the effectiveness of using osmo priming technique yield and yield components of some bread wheat cultivars. Three osmo-priming treatments of 0 ,30 and 60 $CaCl_2$ mg/L and four wheat cultivars were used in the first season of 2014/2015 i.e., Sakha 93, Misr 1 , Giza 168 and Gemmiza11, and two more cultivars i.e., Sakha 94 and Sids 12 were included in the second season (2015/2016). Results showed that there was a significant difference among the tested cultivars for most of the studied parameters. In the first season, Gemmiza 11 had the highest significant values of plant height, 1000 grain yield, grain, straw and biological yields. However, in the second season, Giza 168 produced the highest grain yield, biological yield, Osmo priming was more effective under the severe drought condition i.e. first season as compared to the moderate drought condition in the second season. Soaking the seeds in a solution of $CaCl_2$ at 60 Mg/L increased wheat grain yield by 33.73 % over the control in the first season .In the second season, the same treatment produced the highest values of 1000 grains weight (42.22 g), grain yield (860.18 Kg/ha), straw yield (1491 Kg/ha) and biological yield (2361.2Kg/h) as compared to the control .It can be concluded that osom-priming can be used to increase the productivity of wheat under low rainfall conditions.

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Introduction

Egypt now is known as the world's largest wheat importer country. According to the Food and Agriculture Organization of the United Nations (FAO, 2014), the total cultivated area of wheat in Egypt is 1,33 million hectares with a total production of 9 million tons. The total wheat consumption in Egypt is 19 million tons, this wide gap between consumption and actual production forces the country to import 10 million tons to close this gap. The North Western Coastal Zone (NWCZ) is an area of rainfed agriculture with 140 mm of annual precipitation. Crop production in that area is facing several serious threats i.e low rainfall, high rainfall spatial and temporal variability, low soil fertility and productivity. Wheat growth and yield is more affected by water shortage and soil fertility as compared to barley, moreover in many years wheat even couldn't reach the maturity stage to achieve an economic yield due to low precipitation (Gomaa, 2007). Many agricultural practices are implemented to minimize the drought impacts on wheat yield, these practices include adding supplemental irrigation during the critical growth periods of wheat in the NWCZ (Salem *et al .,* 2003;Attia and Barsoum, 2013; El-Sadek and Salem, 2015),or by applying water harvesting techniques to increase the water use efficiency in the area (Attia and Barsoum, 2013).

Seed priming is a pre-sowing treatment by soaking the seeds in a priming agent solution followed by drying of seeds (Ibrahim,2016). The most common priming methods are the hydropriming and osmopriming. In hydro-priming, seeds are soaked in pure water (Passam and Kakouriotis 1994 ; Cayuela *et al .,* 1996 ; Lee-suskoon *et al .,* 1998 ; Kaya *et al.,* 2002). While, Osmo priming is the treatment of soaking the seeds in low water potential solutions using various chemical agents such as KNO_3, KCL, K_3PO_4, KH_2PO_4, $MGSO_4$, $CaCl_2$ and NaCl (Farooq *et al.,* 2005). Many studies have reported the impact of seeds priming with $CaCl_2$ on wheat seedling, growth, vigor, yield and establishment (Abdulrahmani *et al.,* 2007; Jafar *et al.,* 2012; Khan *et al.,* 2014). Abdulrahmani *et al .,* (2007) stated that seed priming with $CaCl_2$ significantly improved seedling emergence and stand establishment, reduced the time to start emergence and time to 50% emergence. Results also revealed that seed priming with5 mM $CaCl_2$ had the greatest effect on Fe content of grain and resulted in the greatest Zn concentrations in the straw and grain, respectively. Grain yield increased by 29% over the control (dry seed) when the seeds were soaked in 5 mM $CaCl_2$ solution.

Most of the osmopriming studies were conducted under saline conditions either in laboratory and pot studies or the field conditions. Therefore, the main objectives of this study were 1) to evaluate the productivity of some bread wheat cultivars under rainfed conditions in the NWCZ of Egypt and 2) to examine the effectiveness of seed priming practice using $CaCl_2$ on the yield and its components of different wheat cultivars.

Materials and methods

Study area

The field experiments were conducted in a private farm at Sidi Barrani , Matrouh governorate, Egypt (31.60° N and 25.88° E) during the two seasons of 2014/2015 and 2015/2016 .Barrani is characterized by a typical Mediterranean climate with a mean daily maximum temperature of 28.18° C in August and a mean daily minimum. temperature of 13.83° C in February, while the mean annual maximum and minimum temperatures are 22.54 and 19.23° C, respectively. The mean annual rainfall is 143.65 mm. Soil is sand clay loam in texture with high calcium carbonate content.

Seed materials

Seeds of six bread wheat cultivars were brought from the Central Administration of Seeds Production (CASP) of the Egyptian Ministry of Agriculture and Land Reclamation. In the first season only 4 cultivars were sown i.e., Sakha 93, Misr 1 , Giza 168 and Gemmiza11,while in the second season two more wheat cultivars i.e., Sakha 94and Sids 12 were included. Table 1 presents the names, pedigree and year of release of the studied cultivars.

Seed priming treatment

The seeds of the six wheat cultivars were soaked in $CaCl_2$ solution at three different concentrations (0, 30 , 60 mg/L) for overnight (12 hours) as a pre sowing treatment then the seeds were washed three times with distilled water. For the control, seeds were soaked in distilled water.

Measurements

Number of yield-related measurements at the harvest time were recorded including plant height (cm), spike length (cm),number of spikes per m², number of grains per spike and1000 grains weight (g). The plants from 1 m ² were harvested and the following parameters were calculated; Biological yield (Kg/h), straw yield (Kg/ha),grain yield (Kg/ha), harvest index and crop index. Harvest and Crop indices were calculated as follows:

$$\text{Harvest index (HI\%)} = \frac{\text{Economic yield}}{biologicalyield} \times 100 \qquad (1)$$

$$\text{Crop index (CI\%)} = \frac{\text{Econmic yield}}{strawyield} \times 100 \qquad (2)$$

Field experiment

The experiment was laid out in a split plot design with three replications, where cultivars were allocated in the main plots and $CaCl_2$ priming treatments were in the sub plots. The plot size was 10.5 m² (3×3.5 m) and the seed rate was 96 kg/ha (96g/plot) . Seeds were sown after the first effective rain during the rainy seasons i.e., Dec. 23th and Nov. 7th in the first and second seasons, respectively. The seeds were broadcasted after one chisel plow then the seeds were covered manually. During the growing season, no fertilizers were applied as followed by the NWC farmers.

Statistical analysis

Data were subjected to statistical analysis using analysis of variance (ANOVA) to determine the significance of the main effects and their interaction . Least significant difference (LSD) was used to determine the significant differences between individual means using Crop Stat 7.2 statistical software package developed by IRRI (IRRI,2009).

Results and discussion

Precipitation data

It is clear from figure 1 that in the first season the rain started in Jan.14,2014 with a total precipitation of 74.61 mm. The highest daily precipitation for this season was 13.9 mm/day and was recorded in Jan. 14 . Only one event exceeded 10 mm of rain, and the rainy season ended in March. Although, the total precipitation was low and below the annual average, it was well distributed over the season. In the second season, the rain started as early as Oct. 23,2015 with a total amount of 239.43 mm/year. The highest daily rainfall of 139.76 mm/day was recorded in Dec.12. Most of the fallen precipitation was in November and December, almost 4 major events with a daily precipitation of more than 10 mm were recorded, and the season ended early in January.

Table 1. Name, pedigree and year of release for the studied cultivars.

Cultivar	Pedigree	Year of release
Giza 168	MRL/BUC//SERI. CM93046-8M-0Y-2Y-0B-0GZ	1999
Sakha 94	OPATA/RAYON//KAUZ. CMBW90Y3180-0TOPM-3Y-010Y-10M-015Y-0Y-0AP-0S.	2004
Sids 12	BUC//7C/ALD/5/MAYA74/ON//1160- 147/3/BB/GLL/4/CHAT"S"/6/MAYA/VUL//CMH74A. 630/4*SX. SD7096-4SD-1SD-1SD-0SD.	2007
Misr-1	OASIS/SKAUZ//4*BCN/3/2*PASTOR	2010
Gemmeiza 11	BOW"S"/KVZ"S"//7C/SER182/3/GIZA168/SAKHA61. GM7892-2GM-1GM-2GM-0GM.	2011
Sakha 93	SAKHA 92 /TR 810328 S8871-1S-2S-1S-0S	1999

Table 2. Analysis of variance for yield and its components at West Barrani in 2014/2015 and 2015/2016 growing seasons.

Sources of variation	df	PH (cm)	SL (cm)	NGS	1000GW (g)	GY (Kg/ha)	SY (Kg/ha)	BY (Kg/ha)	HI (%)	CI (%)
First season 2014/2015										
Replicates	2	1.75	0.28	1.13	1.10	19.15	39.49	104.66	2.32	22.62
Cultivar	3	225.82^{**}	3.99^{**}	26.27^{**}	241.33^{**}	359.79^{**}	1669.84^{**}	3349.77^{**}	90.52^{*}	330.58^{*}
Error A	6	3.33	0.17	1.84	3.35	8.94	42.55	45.75	12.57	62.53
CaCl2	2	76.27^{**}	1.48^{**}	92.86^{**}	2.33^{ns}	156.95^{**}	53.62^{ns}	31.73^{ns}	223.40^{**}	908.76^{**}
Cultivar*$CaCl_2$	6	10.38^{**}	1.82^{**}	26.45^{**}	15.03^{**}	63.64^{**}	112.08^{**}	220.63^{**}	54.94^{**}	188.94^{ns}
Error B	16	2.48	0.04	1.35	3.02	10.12	28.14	38.45	13.84	75.42
Second season 2015/2016										
Replicates	2	19.04	0.17	5.22	1.78	31.29	22.87	67.63	9.15	65.51
cultivar	5	118.97^{**}	2.75^{**}	271.80^{**}	123.94^{**}	4129.41^{**}	5432.15^{**}	15981.10^{**}	179.48^{**}	1280.82^{**}
Error A	10	6.49	0.14	12.22	6.34	177.58	177.59	654.96	4.71	24.43
CaCl2	2	3.18^{ns}	1.61^{**}	50.04^{**}	169.27^{**}	1165.67^{**}	6419.09^{**}	13055.60^{**}	25.05^{ns}	236.08^{ns}
Cultivar*$CaCl_2$	10	15.79^{**}	0.88^{**}	47.29^{**}	54.99^{**}	555.04^{**}	2106.21^{**}	4191.09	38.90^{**}	272.25^{**}
Error B	24	4.24	0.07	7.69	2.94	115.34	265.44	619.29	6.59	52.15

Table 3. yield and yield components of different wheat cultivars at Barrani location in the first and second season (2014/2015 and 2015/2016).

Cultivars	PH (CM)	SL (CM)	N GS	1000GW (g)	GY (Kg/ha)	SY (Kg/ha)	BY (Kg/ha)	HI (%)	CI (%)
First season 2014/2015									
Gemmiza 11	42.13	5.506	15.33	32.3	337.72	750.94	108.9	30.95	44.99
Misr 1	32.25	4.848	16.17	24.36	214.19	629.12	84.33	24.92	34.54
Giza 168	36.81	5.513	17.11	19.89	195.54	421.31	61.69	32.17	48.88
Sakha 93	31.13	4.113	13.11	24.11	257.5	612	86.95	29.59	42.44
LSD at 5%	2.105	0.473	1.562	2.111	34.473	75.213	77.99	4.088	9.118
Second season 2015/2016									
Gemmiza11	60.14	7.311	38.14	45.03	613.8	1026	1640	37.44	59.87
Misr1	64.84	8.278	49.49	39.35	675.6	1185	1860	36.85	59.29
Giza 168	64.72	7.244	40.56	38.18	1086	1538	2624	41.48	71.34
Sakha 93	56.63	7.033	33.67	33.55	777.0	1661	2438	31.49	46.41
Sakha94	64.63	7.583	44.6	38.47	1046	1408	2454	43.71	78.94
Sids 12	58.47	6.644	43.56	37.45	609.6	1159	1769	34.54	52.83
LSD at5%	2.675	0.386	3.672	2.645	140.0	140.0	268.8	2.280	5.191

Whereas PH plant height , SL spike length , NGS number of grains per spike ,1000GW 1000 grain weight GY grain yield , SY Straw yield BY biological Yield , HI harvest index and CI crop index.

The analysis of variance (ANOVA)

The analysis of Variance (ANOVA) in Table (2) showed a highly significant variation among the tested cultivars for all of the studied parameters in both seasons except for harvest index and crop index in the first season which were only significant at $P< 0.05$. Also, there was a strong significant difference among the $CaCl_2$ priming treatments for all the studied traits except for 1000-GW, straw yield and biological yield in the first season and for the harvest and crop indices in the second season which were insignificantly affected (Table 2). Likewise, the interaction between cultivars and $CaCl_2$ priming was highly significant for the yield and its related components except ($P< 0.05$)for the crop index in the first season.

Table 4. Effect of different $CaCl_2$ concentrations on the yield and yield component of wheat grown at west Barrani location in 2014/2015 and 2015/2016 growing seasons.

$CaCl_2$ (mg/L)	PH (cm)	SL (cm)	N G S.	1000GW (g)	GY (Kg/ha)	SY (Kg/ha)	BY (Kg/ha)	HI (%)	CI (%)
2014/2015 season									
0	34.00	4.705	13.54	25.51	214.83	621.42	836.25	25.19	34.74
30	34.25	4.895	14.13	24.67	251.73	608.52	860.24	29.20	41.39
60	38.49	5.385	18.63	25.32	287.16	580.1	867.26	33.81	51.99
LSD at5%	1.363	0.164	1.005	1.504	27.529	45.907	53.662	3.219	7.516
2015/2016 season									
0	61.87	7.61	43.17	37.68	712.89	1121.9	1834.8	38.94	65.47
30	61.09	7.02	39.87	36.22	821.11	1375.9	2197.0	37.02	60.41
60	61.76	7.42	41.97	42.11	870.18	1491.0	2361.2	36.79	58.46
LSD at 5%	1.417	0.188	1.908	1.180	73.884	112.08	171.2	1.766	4.968

Whereas PH plant height ,SLspike length , NGS number of grains per spike ,1000GW 1000 grain weight yield , SY Straw yield BY biolology Yield , HI harvest index and CI crop index.

Wheat cultivars performance

Data presented in Table (3) showed that the cultivars performed differently in both seasons In the first season, Gemmiza 11 recorded the highest significant values of plant height, 1000- grain weight ,grain ,straw and biological yields, while Giza 168 produced the highest significant values for number of grains per spike , harvest index and crop index. It is worth noting that Gemmiza 11 produced the highest grain yield as a result of producing the heaviest 1000-grain weight (32.3 g) and the second longest spike (5.50 cm) after Giza 168 with no significant difference. Since spike grain weight is a function of number of grains per spike and 1000-grain weight ,this explains the superiority of Gimmeza 11 to the other wheat cultivars in producing the highest grain yield. Same conclusion was drawn by Ibrahim *et al.,(*2011) and Abd El-Karim *et al.,(*2011).

Table 5. The influence of interaction between cultivars and $CaCl_2$ concentrations on yield and yield component of wheat grown at Barrani location in 2014/2015 season.

Cultivars	$CaCl_2$ (mg/L)	PH (cm)	SL (cm)	NGS	1000GW (g)	GY (Kg/ha)	SY (Kg/ha)	BY (Kg/ha)	HI (%)	CI (%)
Gemmiza 11	0	42.61	4.600	9.667	30.35	327.53	715.13	1042.7	31.21	45.79
	30	37.95	5.417	15	33.35	322.03	722.30	1044.3	30.81	44.55
	60	45.82	6.50	21.33	33.2	363.60	815.40	1179.0	30.82	44.62
Misr 1	0	30.5	5.5	16.5	25.6	105.20	641.40	746.6	14.48	17.03
	30	31.88	3.993	13.50	24.98	255.03	656.57	911.6	27.98	38.85
	60	34.37	5.05	18.5	22.5	282.33	589.40	871.7	32.30	47.72
Giza168	0	35.2	5.55	18.33	22.8	206.50	507.03	713.5	28.96	40.76
	30	36.07	5.8	14	17.25	181.53	430.70	612.2	29.42	41.83
	60	39.15	5.19	19.00	19.63	198.60	326.20	524.8	38.12	64.06
Sakha 93	0	27.68	3.170	9.667	23.3	220.10	622.10	842.2	26.13	35.38
	30	31.1	4.37	14	23.1	248.30	624.50	872.8	28.60	40.35
	60	34.6	4.80	15.67	25.93	304.10	589.40	893.5	34.03	51.58
LSD at5%		2.727	0.327	2.009	3.008	55.06	91.81	107.3	6.438	15.03

Whereas PH plant height , SL spike length , NGS number of grains per spike ,1000GW 1000 grain weight, GY grain yield ,SY Straw yield , BY biological Yield,, HI harvest index and CI crop index.

In the second season, Misr 1 produced the highest values of plant height, spike length and number of grains per spike with no significant difference from Sakha 94 and Giza 168 for the plant height (Table 3). Giza 168 recorded the highest grain yield and biological yield while Sakha 94 recorded the highest harvest index and crop index. By comparing the two growing seasons, it is quite clear that all the cultivars performed better under high rainfall conditions. Although Misr 1 produced the tallest spike length and the second highest 1000-grain weight after Gemmiza 11, while it came after Giza 168, Sakha94 and Sakha 93 in grain yield. Same results was reported by Abd El Ghany *et al.*,(2016)under both full irrigation and water stress conditions at the NWCZ of Egypt.

Table 6. Effect of interaction between cultivars and $CaCl_2$ concentrations on yield and yield component of wheat grown at west Barrani location in 2015/2016 season.

Cultivars	$CaCl_2$ (mg/L)	PH (cm)	SL (cm)	NGS	1000GW (g)	GY (Kg/ha)	SY (Kg/ha)	BY (Kg/ha)	HI (%)	CI (%)
Gemmiza 11	0	60.6	7.633	36.87	44.3	572.9	930.4	1503	38.07	61.49
	30	60.95	7.4	39.9	45.57	654.9	1085	1740	37.66	60.42
	60	58.87	6.9	37.67	45.21	613.7	1063	1677	36.57	57.69
Misr 1	0	66.33	8.933	54.13	40.53	640.2	874.6	1515	42.27	73.27
	30	61.8	7.6	44.67	38.45	630.1	1420	2050	30.77	44.59
	60	66.4	8.3	49.67	39.07	756.5	1260	2016	37.50	60.01
Giza168	0	62.27	6.933	40.67	32.6	826.3	1098	1924	42.93	76.11
	30	64.6	7.3	39	40.33	1401	1978	3379	41.34	70.57
	60	67.3	7.5	42	41.6	1031	1540	2571	40.17	67.33
Sakha 93	0	57.5	6.6	37.67	30.75	748.8	1718	2467	29.53	42.46
	30	55.4	6.9	32.67	28.8	669.5	1556	2226	30.16	43.27
	60	57	7.6	30.67	41.1	912.5	1709.3	2622	34.79	53.48
Sakha 94	0	66	8.15	46	41.9	970.1	1106	2076	46.69	87.60
	30	66.8	7.3	37	29.05	993.9	1160	2154	46.91	88.99
	60	61.1	7.3	50.8	44.45	1175.4	1957	3132	37.55	60.24
Sids 12	0	58.5	7.4	43.67	35.97	519.0	1005	1524	34.15	51.91
	30	57	5.633	46	35.15	577.7	1055	1633	35.31	54.61
	60	59.9	6.9	41	41.23	732.0	1417	2149	34.15	51.98
LSD at5%		3.471	0.459	4.674	2.890	181.0	274.5	419.4	4.326	12.169

Whereas PH plant height, SL spike length , NGS number of grains per spike ,1000GW 1000 grain weight Y grain yield , SY Straw yield BY biological Yield , HI harvest index and CI crop index.

Until 2014/2015 season, Sakha 93 was the most commonly grown high yielding variety in the NWCZ, and that was very clear from the performance of this cultivar under the severe drought condition of the first season as it came second after Gemmiza 11 for the traits of grain yield and biological yield .Starting from 2015/2016 season the Ministry of Agriculture replaced Sakha 93 by a new cultivar i.e. Sakha 94 (for this reason this cultivar was included in the second season). This new cultivar showed a high potential for grain yield and its associated yield components, moreover it produced the highest harvest index and crop index.

Seed priming

Data presented in Table (4) showed that, in the first season, seed priming increased most of the studied characteristics except for the straw yield. However, in the second season, seed priming treatments only improved the 1000-GW, grain, straw and biological yields. Grain yield was increased by 33.66 and 22.06% in the first and second seasons, respectively, by soaking the seeds in a solution of $CaCl_2$ at 60 Mg/L as compared to the control (hydro priming). Same results were found by Jafar *et al.*, 2012.

Increasing the final grain yield and its components as a result of osmopriming ($CaCl_2$) was also reported in rice (Rehman *et al.*, 2011). They concluded that primed seeds usually have earlier and uniform emergence , and that the increase of the straw and kernel yields is due to the fact that osmopriming increased the number of fertile tillers, number of kernels per panicle which increases the harvest index. Moreover, Ca improves the emergence as a result of its involvement in the carbohydrate metabolism and increases the activity of the α-amylase enzyme during the initial phase establishment (Farook *et al.*, 2008).

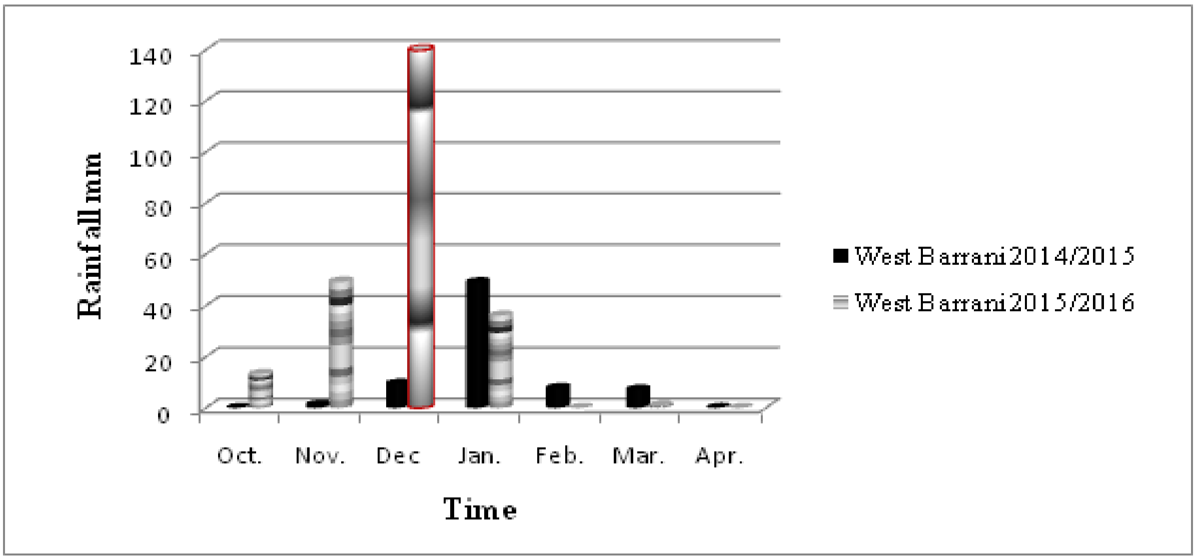

Fig. 1. Monthly rainfall distribution over the study area during the two growing seasons.

Secondary roots and the root dry weight (Khan *et al.*, 2014) which allows the roots to absorb water more efficiently. The increase of the straw yield and biological yield in case of osmoprimed seeds probably resulted from the high number of emerged seeds and the decrease of the mean germination time.

Interaction between cultivars and $CaCl_2$ treatments

Data in Table (5) showed that the grain yield of some cultivars was highly responsive to $CaCl_2$ osmopriming such as Misr 1 and Sakha 93. However, the grain yield of Giza 168 and Gemmiza 11 showed no significant change due to the osmopriming treatments (Table 5). All over the treatments, Gemmiza 11 with the highest $CaCl_2$ concentration of 60 mg/L produced the highest values of plant height ,spike length, number of grains per spike, grain yield ,straw yield and biological yield. However Giza 168 with 60 mg/L of $CaCl_2$ produced the highest values of harvest index and crop index. It could be concluded that Gemmiza 11 produced the highest grain yield under all the $CaCl_2$ osmo priming treatments, with the highest grain yield of 363.60Kg/ha at the level of 60mg/L which ranked this cultivar as first in regard to the mean grain yield as compared to the other cultivars.

In the second season, cultivars showed a different response to the osmo priming treatments as follow: 1) the low concentration of $CaCl_2$ i.e., 30 mg/L produced the highest grain yield in case of and Gemmiza 11, Misr 1 and Giza 168) the high concentration of $CaCl_2$ i.e., 30 mg/L recorded the highest grain yield in Sakha 93,sakha94 and Sids 12. the highest grain yield, biological yield, harvest index and crop index was obtained when the seeds of Giza 168and Sakha 94 were soaked in a solution of 30 mg/L from $CaCl_2$. Again, results showed that grain yield was highly correlated to the spike length and 1000-grain weight.

It can be concluded that the osmopriming interacts differently with cultivars and the availability of soil moisture.

Seed priming can be an effective method to enhance the crops productivity under harsh environments (Singh *et al.*,2015).Using $CaCl_2$ even at a low concentration of 30 mg/L increased the grain yield by (142.4 %) and (70%) in Misr1 and Giza 168 over the control in the first and second seasons ,respectively . Seed priming has proved to be more effective in reducing drought induced yield loss when combined with other agronomic practices e.g. row spacing (Hussain *et al.*, 2016) and ridge planting in maize (Khan *et al.*,2015). Based on the promising results of this study, we suggest that osmo priming can be used as an easy and cheap strategy to increase the crops yield under the rainfed conditions of the NWCZ, and we recommend testing more different seed priming agents and practices.

Conclusion

Under dry conditions, the selection of most suitable cultivars is one of the major strategies to obtain better yield under these conditions.

In this study, used cultivars performed differently under severe and moderate drought conditions. Gemmiza 11 and Giza 168 had higher potential yields as compared to the other tested cultivars under severe and moderate drought conditions, respectively. Seed priming with the $CaCl_2$ improved the drought tolerance in some wheat cultivars under the severe drought conditions by improving the germination and the seedling establishment.

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