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Combating Drought Using Yield Stabilizing Agents in Barley

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ABSTRACT

A field trial was conducted on six cultivars of barley (*Hordeum vulgare* L.), Giza 123, 125, 126, 129, 130 and 2000 to determine the effect of yield stabilizing agents (YSA), as magnesium carbonate and sodium salicylate under drought conditions. The interaction between irrigation treatment, yield stabilizing agents and barley cultivars, proved insignificant results for spike length and number of spikes per plant, but the use of sodium salicylate improved crop yield of Giza 129 and Giza 130 also magnesium carbonate application was so effective for improving growth and yield components of most of the chosen cultivars. Giza 126 surpassed other cultivars in plant height, grain yield and crop index, while Giza 125 overcame other cultivars in spike length and seed index, although Giza 129 overcome other cultivars in straw and biological yield, under different irrigation treatments. The highest N was recorded for cultivars grown under normal irrigation condition. Application of magnesium carbonate increased N in Giza 125, 126, 129 and 130 whereas P, K and Na percentages in all cultivars decreased, under water stress condition. Sodium salicylate was more effective in increasing K and P levels than $MgCO_3$, but didn't show pronounced effect on Na contents. Carbohydrate percentage increased under water stress. Application of $MgCO_3$ increased the carbohydrate level in Giza 123, 129 and 2000, while sodium salicylate increased it in Giza 125, 126 and 130. Results indicated that the highest reduction in yield as a result of skipping the last irrigation were obtained by Giza 126. Whereas the lowest reduction in grain, straw and biological yields were obtained by the two hull-less varieties. The application of magnesium carbonate had better effect on the yield of barley varieties than that of sodium salicylate under water stress condition.

Key Words: Water stress; Yield stabilizing agents (YSA); Magnesium carbonate; Sodium salicylate; Barley

INTRODUCTION

Barley (*Hordeum vulgare* L.) is one the most important cereal crops being used in making bread as it is mixed with flour, beverages, malting and brewing industry, animal feeding and many other uses. Water stress in crops changes patterns of plant growth and development. Depressed water potential suppresses cell division, organ growth, net photosynthesis, protein synthesis and alerts hormonal balances of major plants tissues (Gusta & Chen, 1987). It is possible to identify barley genotypes with high yield potential and with high average stability under severe drought stress (El-Bawab, 2002).

Tolerance implies relative stability of economic yield from barley crop in the presence of varying levels of water stress (Guttieri *et al.,* 2001). However, the stability of yield and yield components of barley grown under water stress could be achieved by using "yield stabilizing agents". These are substances involved in increase in drought resistance by tending to cause xermorphy or stabilization of cell structure or combination of both. Cell stabilizers include antitranspirants and antioxidants (Bergmann *et al.*, 1998).

In addition to the external supply with yield stabilizing agents barley plant is characterized by its higher accumulation of glycinebetaine in the chloroplasts, which plays an important role as a compatible solute in combating different environmental stresses (Sakamoto & Murata, 2002).

Therefore, the objectives of this study was to (a) characterize growth and yield of different barley cultivars' under water stress condition (b) evaluate the effect magnesium carbonate and sodium salicylate as a yield stabilizing agents on barley cultivars grown under water stress condition.

MATERIALS AND METHODS

A field experiment was conducted on six barley cultivars, four normal types (Giza 123, 125, 126, 2000) and two hull-less (Giza 129 & 130) during two successive seasons of 2002/2003 and 2003/2004 at the Agricultural Experimental Station of National Research Centre, Shalakan, Kalubia Governorate, Egypt.

The preceded crop was maize in both seasons and the soil texture was clay loam of the following characteristics 7.5% sand, 59.1% silt and 33.4% clay, pH, 7.55, Ec. 0.26 dsm^{-1}, Ca^{++} 1.1, Mg^{++}, 0.5, Na^{+}, 1.3, K^{+}, 0.8, HCO_3, 0.4, Cl^{-}, 2.6, SO_4^{--}, 0.58 (meq/L).

Two types of antitranspirants (YSA), reflectant (Magnesium carbonate) and stomatic type (sodium salicylate) were applied exogenously on six barley cultivars (*Hordeum vulgare* L.) under water stress conditions. The statistical design was split-split plot with three replicates. The cultivars were assigned in the main plots while the antitranspirants and irrigation treatments were distributed in the subplot.

Treatments were as follows:

1. Normal irrigation,
2. Water shortage at milk ripe stage (skipping one irrigation),
3. Normal irrigation in addition to foliar application of yield stabilizing agents,
4. Water shortage at milk ripe stage in addition to foliar application of YSA.

Barley seeds were sown on the third and fifth of December 2002/2003 and 2003/2004 respectively. Potassium fertilizer was added at the rate of 24 kg/fed (K_2SO_4), where nitrogen fertilizer as 45kg/fed which was divided into two equal doses, the first was added at tillering stage and the second at shooting stage. Plants were normally irrigated every twenty one days. One irrigation was skipped before harvest (at milk ripe stage). Antitranspirants (1g/L for each of magnesium carbonate and sodium salicylate were sprayed twice, once at the vegetative stage and another at milk ripe stage.

At harvest, ten plants were selected randomly from the three replicates of each treatment for estimating growth and yield parameters. Chemical analysis was carried out in barley grains for estimation of N, P, K and carbohydrate according to A.O.A.C (1970). Protein percentage was calculated by multiplying N% by 6.25 (constant).

The combined data of two successive seasons were statistically analyzed according to (Snedecor & Cochran, 1982) where treatment means were compared using L.S.D. test at 0.05 probability level.

RESULTS

Results obtained in Table I indicated the interactive effect of irrigation treatment and antitranspirant use on growth and yield parameters of six chosen barley cultivars. Under normal irrigation conditions, the use of $MgCO_3$ reflectant type of antitranspirant showed superiority for plant height, spike length, number of grains/spike, straw yield/fed, and biological yield/fed. While the use of sodium salicylate (stomatic) type of antitranspirant overcame the reflectant type in weight of grains/spike, seed index gm, grain yield/fed, ton and crop index%. The same trend was significantly observed under water stress and it was clear that the use of both types of antitranspirants was so effective compared to the control (NO YSA). However, the interaction between irrigation treatment and the six barley cultivars on growth and yield parameters were presented in Table II.

Table I. The interactive effect of irrigation treatment and antitranspirants use on growth and yield barley cultivars (2002/2003 and 2003/2004)

Parameters/ Treatments			Plant height (cm)	Pike length (cm)	No. of spikes/ plant	No. of grains/ spike	Weight of grains/ spike (g)	Weight of grains/ plant (gm)	Seed index (g)	No. of spikes/m^2	Grain yield/fed. ton	Straw yield/fed. ton	Biological yield/fed. Ton	Crop index %
Normal Irrigation	Yield stabilizing	No anti.	105.1	7.4	3.2	51.3	3.13	10.46	53.37	284.0	2.849	4.825	7.674	37.8
		Sod. Salc	104.1	8.7	4.9	59.1	3.24	11.74	56.89	305.5	3.459	5.022	8.481	41.0
		$MgCO_3$	111.9	9.3	6.3	62.8	3.22	12.41	55.39	299.2	3.192	6.139	9.33	34.5
Skipping one irrigation at milk ripe stage		No anti.	95.8	7.1	2.8	56.7	2.76	8.79	47.96	250.1	2.755	4.505	7.260	38.5
		Sod salc	102.0	8.3	4.2	56.2	3.14	10.08	54.94	264.7	3.187	4.715	7.902	40.8
		$MgCO_3$	106.3	8.2	5.2	59.6	3.02	10.52	53.01	266.9	2.941	4.881	7.822	38.1
L.S.D. at 5%			1.76	0.36	N.S	1.92	N.S	0.36	1.05	N.S	0.055	0.313	0.310	1.5

Table II. The interactive effect of irrigation treatment and cultivars on growth and yield of barley plant

Parameters/ Treatments			Plant height (cm)	Pike length (cm)	No. of spikes/ plant	No. of grains/ spike	Weight of grains/ spike (g)	Weight of grains/ plant (g)	Seed index (g)	No. of spikes/m^2	Grain yield/fed. ton	Straw yield/fed. ton	Biological yield/fed. ton	Crop index %
Irrigation	Cultivars	G123	116.1	8.8	4.9	58.1	3.33	13.29	57.75	321.8	3.420	5.343	8.763	39.1
		G125	100.1	9.4	4.2	52.4	3.45	11.65	64.83	263.4	3.384	5.620	9.003	37.6
		G126	117.9	8.5	4.4	59.3	3.52	11.88	61.02	287.9	3.771	4.943	8.714	43.4
		G 129	91.0	7.8	4.9	58.3	2.51	9.25	45.30	321.9	3.013	6.318	9.331	32.4
		G 130	109.1	8.6	5.2	60.1	3.07	11.05	48.62	297.4	2.752	5.190	7.943	35.8
		G 2000	106.4	9.0	5.4	60.6	3.06	11.89	56.29	308.4	3.148	4.632	7.780	40.8
Skipping one irrigation at milk ripe stage		G123	106.9	7.9	4.3	53.4	3.05	10.14	54.96	278.5	3.245	4.302	7.547	43.0
		G125	98.4	8.3	4.1	54.8	3.20	10.66	59.75	253.6	3.190	3.997	7.187	44.7
		G126	112.4	8.1	3.9	61.1	3.40	11.39	51.50	251.7	3.316	3.983	7.299	45.4
		G 129	88.3	7.5	4.2	53.5	2.25	7.88	44.15	250.6	2.350	6.799	9.149	25.7
		G 130	101.4	8.2	4.4	58.3	2.86	10.33	51.69	267.1	2.731	4.822	7.553	36.2
		G 2000	105.3	7.6	4.4	62.1	3.06	9.62	53.76	276.3	3.020	4.119	7.139	42.1
L.S.D. at 5%			2.33	0.39	N.S	2.38	N.S	0.45	1.21	9.40	0.074	0.244	0.225	1.4

Table III. The interactive effect of cultivars and antitranspirant use on growth and yield of barley plants (2002/2003 and 2003/2004 seasons)

Parameters/ Treatments			Plant height (cm)	Spike length (cm)	No. of spikes/ plant	No. of grains/ spike	Weight of grains/ spike (g)	Weight of grains/ plant (g)	Seed index (g)	No. of spikes/m^2	Grain yield/fed. ton	Straw yield/fed. ton	Biological yield/fed. ton	Crop index %
Cultivars	No Antitranspirant	G123	108.9	7.0	3.4	52.4	3.10	10.42	53.73	291.4	3.085	4.700	7.785	39.8
		G125	95.1	8.0	2.6	53.6	3.17	9.11	55.56	243.6	2.975	4.726	7.701	39.2
		G126	113.6	7.1	2.6	58.3	3.28	10.74	54.53	253.6	3.113	4.486	7.600	41.2
		G 129	83.6	6.8	3.0	53.8	2.44	7.49	43.04	264.8	2.363	6.312	8.675	27.3
		G 130	99.1	7.4	3.5	52.0	2.71	10.20	47.64	270.1	2.503	3.986	6.489	39.1
		G 2000	102.4	7.2	2.9	53.6	2.97	9.81	49.49	278.8	2.775	3.777	6.552	42.3
	Sod. Sole	G123	106.9	8.6	3.9	54.8	3.18	10.79	58.75	293.8	3.375	4.593	7.968	42.5
		G125	96.0	8.9	4.1	52.6	3.57	11.87	65.19	254.6	3.219	4.816	8.035	40.5
		G126	112.0	8.6	3.9	61.5	3.71	11.58	59.58	272.6	4.013	4.103	8.116	49.4
		G 129	89.5	8.0	4.6	55.0	2.34	9.42	44.79	288.9	2.719	6.469	9.188	29.6
		G 130	107.8	8.5	5.5	59.1	2.93	10.61	50.91	295.9	2.925	4.837	7.763	37.7
		G 2000	106.3	8.4	5.3	62.9	3.39	11.16	56.28	305.0	3.686	4.392	8.078	45.7
	$MgCO_3$	G123	116.5	8.9	6.1	62.1	3.20	13.01	56.49	309.3	3.316	5.091	8.407	39.7
		G125	108.3	9.0	5.4	56.6	3.45	12.14	63.47	271.3	3.434	5.284	8.718	39.5
		G126	120.8	8.7	5.8	61.4	3.36	12.64	56.44	276.8	3.456	4.769	8.226	42.3
		G 129	94.6	7.8	5.6	57.6	2.44	8.66	45.80	280.0	2.557	7.103	9.661	26.4
		G 130	105.6	9.1	5.5	63.9	3.04	10.90	49.35	276.6	2.709	5.758	8.467	32.7
		G 2000	108.6	8.9	6.0	65.8	3.24	11.45	53.67	284.4	2.926	5.054	7.980	36.9
L.S.D. at 5%			3.3	0.5	0.8	3.4	0.26	0.64	1.71	13.2	0.105	0.346	0.319	2.0

Sod. Salc : Sodium salicylate; $MgCO_3$: magnesium carbonate; G : Giza

Table IV. The interactive effect of irrigation treatment, antitranspirant and cultivars on growth and yield of barley (2002/2003 and 2003/2004)

Parameters Treatments			Plant height (cm)	Spike length (cm)	No. of spikes/ plant	No. of grains/ spike	Weight of grains/ spike	Weight of grains/ spike (g)	Seed index (g)	No. of spikes/m^2	Grain yield/fed. ton	Straw yield/fed. ton	Biological yield/fed. ton	Crop index %
Normal Irrigation	No Anti.	G123	114.8	7.1	3.5	53.0	3.25	12.02	55.5	309.5	3.019	5.237	8.255	36.6
		G125	96.8	8.1	2.8	50.0	3.31	9.34	62.59	246.5	2.918	5.645	8.563	31.1
		G126	117.8	7.4	3.0	53.5	3.38	11.20	60.32	264.5	3.226	4.966	8.192	39.5
		G 129	89.3	6.9	3.5	54.8	2.63	8.39	42.43	293.3	2.525	6.226	8.750	28.9
		G 130	106.3	6.9	3.8	47.5	2.98	10.82	46.61	286.3	2.346	3.192	5.538	42.4
		G 2000	105.8	8.2	2.8	48.8	3.22	11.03	52.42	303.8	3.063	3.683	6.746	45.4
	Sod. Salc .	G123	109.3	8.7	4.0	57.0	3.36	12.60	61.14	311.3	3.526	5.030	8.556	41.3
		G125	93.8	9.4	4.3	51.8	3.47	13.15	64.53	257.0	3.126	5.478	8.604	36.5
		G126	114.0	8.6	4.3	62.3	3.76	11.92	63.68	295.0	4.273	4.277	8.551	50.0
		G 129	86.0	8.1	4.8	59.0	2.54	10.24	44.96	327.0	2.96	6.204	9.110	31.9
		G 130	111.5	8.9	6.5	62.3	2.95	10.56	51.03	323.0	3.465	4.374	7.838	44.2
		G 2000	110.0	8.3	5.8	62.3	3.35	11.96	56.01	320.0	3.459	4.767	8.227	42.1
	$MgCO_3$	G123	122.8	9.5	7.0	66.0	3.35	15.04	57.58	335.3	3.321	5.753	9.074	36.7
		G125	110.8	9.3	5.5	57.0	3.49	13.24	64.36	273.8	3.762	5.807	9.568	39.4
		G126	123.3	9.0	6.3	61.3	3.43	13.22	60.94	286.0	3.816	5.409	9.225	41.7
		G 129	97.5	7.9	6.0	58.3	2.43	8.82	47.35	318.8	2.768	7.336	10.103	27.4
		G 130	109.8	9.9	6.0	67.5	3.29	11.78	47.88	287.8	2.491	6.910	9.400	26.6
		G 2000	107.3	10.3	7.0	67.0	3.33	12.39	54.26	293.8	2.993	5.617	8.610	34.9
Skipping one irrigation at milk-ripe stage	No Anti.	G123	103.0	6.9	3.3	51.8	2.95	8.82	51.62	273.3	3.151	4.164	7.314	43.1
		G125	93.5	7.9	2.5	57.3	3.03	8.88	48.53	240.8	3.031	3.808	6.839	44.3
		G126	109.5	6.9	2.3	63.0	3.1	10.28	48.75	242.8	3.001	4.007	7.008	42.8
		G 129	78.0	6.6	2.5	53.0	2.25	6.60	43.64	236.3	2.201	6.398	8.599	45.6
		G 130	92.0	7.9	3.3	56.5	2.45	9.58	48.67	254.0	2.660	4.780	7.439	35.8
		G 2000	99.0	6.3	3.0	58.5	2.73	8.60	46.57	253.8	2.487	3.871	6.358	39.1
	Sod. Salc.	G123	104.5	8.5	3.8	52.5	2.99	8.99	56.35	276.3	3.25	4.155	7.380	43.6
		G125	98.3	8.4	4.0	53.5	3.67	10.59	65.85	252.3	3.312	4.154	7.466	44.4
		G126	110.0	8.5	3.5	60.8	3.66	11.25	55.49	250.3	3.753	3.929	7.681	48.9
		G 129	93.0	7.9	4.5	51.0	2.15	8.61	44.61	250.8	2.232	6.734	9.266	27.3
		G 130	104.0	8.1	4.5	56.0	2.92	10.66	50.79	268.8	2.386	5.301	7.688	31.1
		G 2000	102.5	8.6	4.8	63.5	3.44	10.37	56.54	290.0	3.913	4.016	7.929	49.4
	$MgCO_3$	G123	110.3	8.3	5.3	58.3	3.05	10.98	55.40	283.3	3.311	4.428	7.739	42.8
		G125	105.8	8.8	5.3	56.3	3.40	11.04	62.58	268.8	3.106	4.761	7.867	39.5
		G126	118.3	8.4	5.3	61.5	3.30	12.06	51.94	267.5	3.097	4.130	7.226	42.9
		G 129	91.8	7.6	5.3	57.0	2.44	8.50	44.25	241.3	2.347	6.871	9.218	25.5
		G 130	101.8	8.4	5.0	60.3	2.79	10.02	50.83	265.5	2.926	4.607	7.534	38.8
		G 2000	110.0	7.6	5.0	64.5	3.16	10.51	53.07	275.0	2.860	4.491	7.350	38.9
L.S.D. at 5%			4.7	0.8	N.S	N.S	0.37	0.90	2.41	18.7	0.054	0.489	0.451	2.8

C.V. = Cultivars; Anti : Antitranspirant; Sod Salc : Sodium salicylate; $MgCO_3$: magnesium carbonate

Four cultivars were normal type (Giza 123, 125, 126 & 2000) and two were hull-less trends under normal and water shortage conditions. Giza 126 surpassed other cultivars in plant height, grain yield and crop index, under different irrigation treatments, while Giza 125 overcame, other cultivars in spike length and seed index. Moreover, Giza 129 overcame other cultivars in straw and biological yields. Although Giza 2000 showed an increase in number of grains/spike and number of spike/m^2.

The interaction between barley cultivars and antitranspirants were listed in Table III, which indicated that using reflectant and stomatic types of antitranspirants significantly induced an increase in most of the growth and yield parameters compared to the control (antitranspirants not used) on comparing between the effect of the two types of antitranspirants (YSA) $MgCO_3$ seemed to be more effective than sodium salicylate.

Wereas the increase in plant height ranged between 89.5 and 106.9 cm in different cultivars on using sodium salicylate, while ranged between 94.6 and 120.8 cm on using $MgCO_3$. For spike length (cm), the highest record was for Giza 125, 8.0 cm under control, which increased by 11.25% on using sodium salicylate and by 12.5% on using $MgCO_3$. While, Giza 130 showed the highest number of spikes per plant and increased by 57.1% on using sodium salicylate and by 71.4% when $MgCO_3$ was used. Also, the best record for number of grains per spike, weight of grains per spike, weight of grains. plant, grain yield and crop index were observed by Giza 126 without the use of antitranspirant compared to other cultivars, but when using sodium salicylate Giza 2000 gave higher records than the control and for $MgCO_3$ most of the cultivars showed higher values than the control compared to that of the control.

Tri-interaction between irrigation treatment, (YSA) antitranspirant use and six barley cultivars were presented in Table IV where insignificant results were indicated by spike length and number of spikes per plant. Under normal irrigation condition the use of sodium salicylate increased the crop index percentage for all cultivars except for Giza 2000 which was decreased by 7.2%, also the use of $MgCO_3$ showed a decrease in crop index % Giza 129, 130 and 2000. Although, the use of reflectant type $MgCO_3$ under water stress condition (withholding irrigation at milk ripe stage) was so effective for most of the cultivars crop index %, but sodium salicylate was so effective for Giza 129 and Giza 130.

The highest record for nitrogen percentage was under normal irrigation condition while under water stress (Fig. 1 a&b) Giza 129 showed a decrease by 10% and Giza 130 by 3%. Application of sodium salicylate showed a slight increase in N%, 2.2% for Giza 129 and 2.31% for Giza 130. Although $MgCO_3$ application increased N% for Giza 125, 126, 129 and 130. Protein percentage showed the same trend for all treatments and cultivars (Fig. 2 a&b). A clear decrease was recognized for P%, particularly under water stress condition (Fig. 3a&b). Application of antitranspirants, under water stress increased P%, only for Giza 2000.

For all chosen cultivars, a decrease in K% potassium percentage was observed under water shortage compared to normal irrigation. The use of sodium salicylate was more effective in increasing potassium level than the application of $MgCO_3$ under water stress condition (Fig. 4a&b). Also, sodium percentage decreased under water stress and antitranspirant use didn't show a clear effect on Na% neither under normal nor water stress condition (Fig. 5a&b).

For carbohydrate percentage, a different trend was observed, whereas the percentage increased under water stress. Application of sodium salicylate increased carbohydrate percentage under water stress by 7.2%, 12.4%, 12.5%, 0.1%, 10.3% and 6.7% in Giza 123, 125, 126, 129, 130 and 2000 respectively. While the use of $MgCO_3$ increased carbohydrate percentage by 12%, 8.6%, 10.3%, 13.2%, 7.4% and 21.5% in Giza 123, 125, 126, 129, 130 and 2000 respectively. So, each cultivar was affected differently by the use of antitranspirants. $MgCO_3$ affected Giza 123, 129 and 2000 more than sodium salicylate in increasing carbohydrate reserve, while sodium salicylate led to an increase in carbohydrate in Giza 125, 126 and 130 more than the use of $MgCO_3$ (Fig. 6 a&b).

DISCUSSION

The differences in plant height between different barley cultivars may be due to genetical differences, also fluctuated values of spikes number/m^2 reflects the vertical difference response to environmental conditions. Similar observations were reached by (Sharaan & Abd El-Samei, 1999). However, (Nagaz *et al.*, 2001), found that the reduction in grain yield under water stress was attributed to the reduction in number of spikes/m^2 number of grains/spike and grain weight.

Substances involved in increase in drought resistance or act as cell stabilizers or stress diminishing factors are classified into antitranspirants. (Bergmann *et al.*, 1994). The use of yield stabilizing agents such as antitranspirants, increased growth and yield of barley cultivars under water stress conditions. (Solanki *et al.*, 1987), supported previous mentioned results and found that two sprays of 6% Kaolin increased barley yield. Also (Bergmann *et al.*, 1994) found that ethanolamine increased barley yield by 10% in which plants were subjected to water stress. Moreover, (Georgiev & Ichev, 1991) found that application of antitranspirants at tillering or the appearance of flag leaf decreased transpiration by 30-50%, increased leaf area and retarded leaf senescence during vegetative growth.

Bergmann *et al.* (1994) used acetylsalicylic acid as a stress diminishing substances, which significantly increased yield and water use efficiency of barley up to 20% and sugar beet up to 10%.

On the contrary, the effect of (YSA) yield stabilizing agents was not so clear on barley grain chemical constituents under water stress condition. (Yadav & Singh,

Fig. (1-6). Changes in chemical constituents of barley grain grown under water stress in addition to antitranspirant application

Fig. (1a)

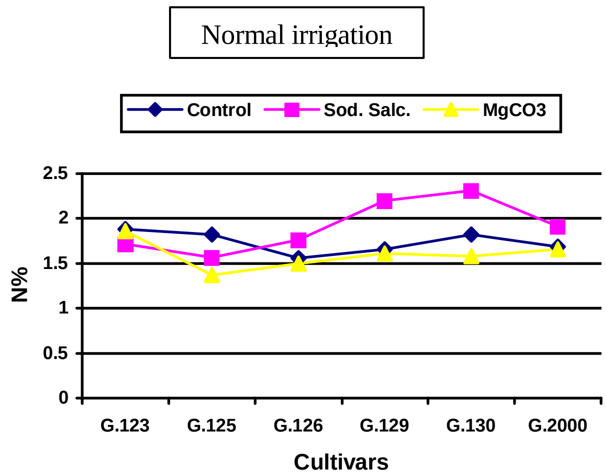


Fig. (1b)

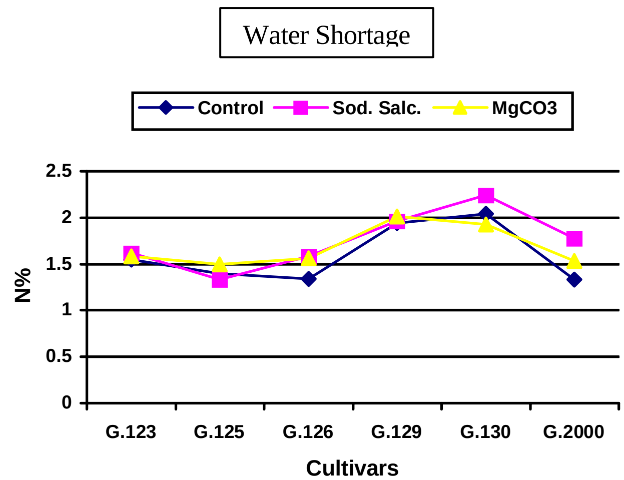


Fig. (2a)

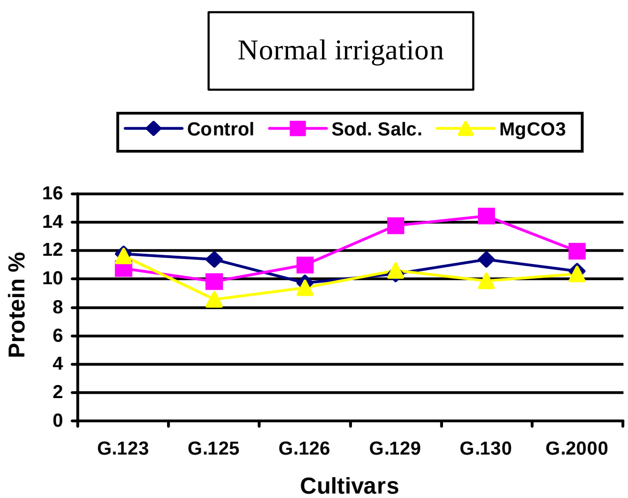


Fig. (2b)

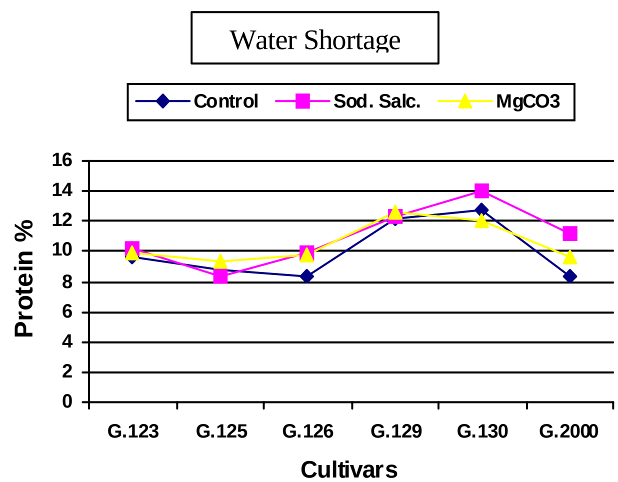


Fig. (3a)

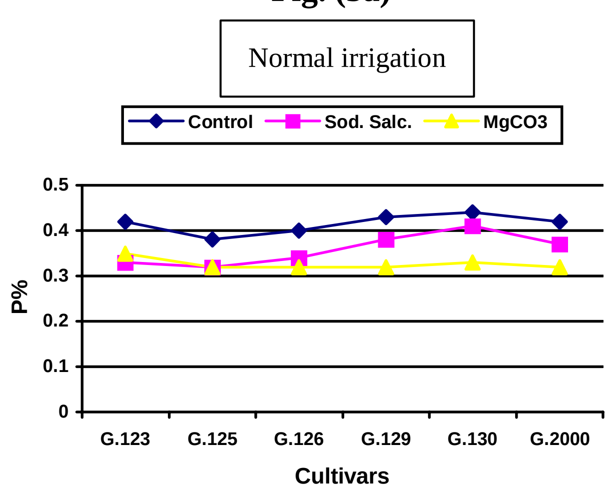
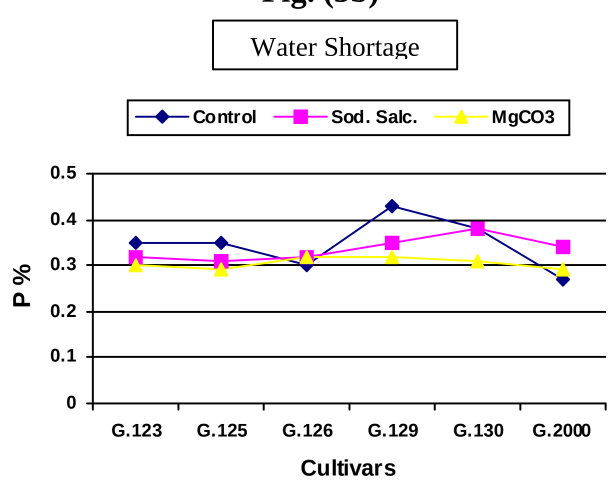


Fig. (3b)



Continue

Continued

Fig. (4a)

Normal irrigation

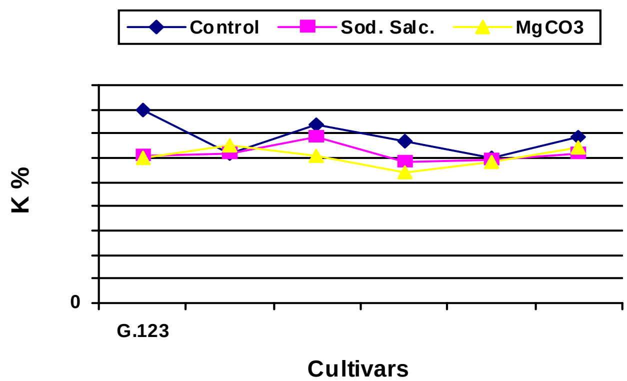


Fig. (4b)

Water Shortage

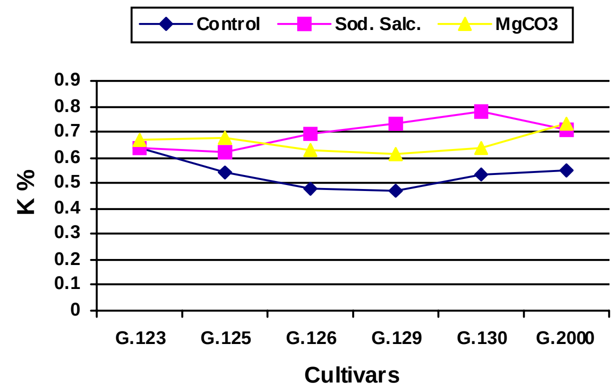


Fig. (5a)

Normal irrigation

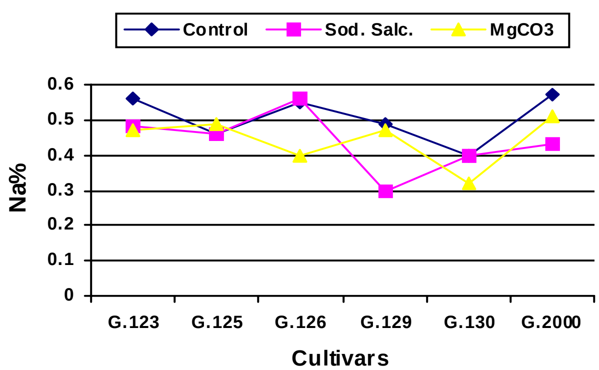


Fig. (5b)

Water Shortage

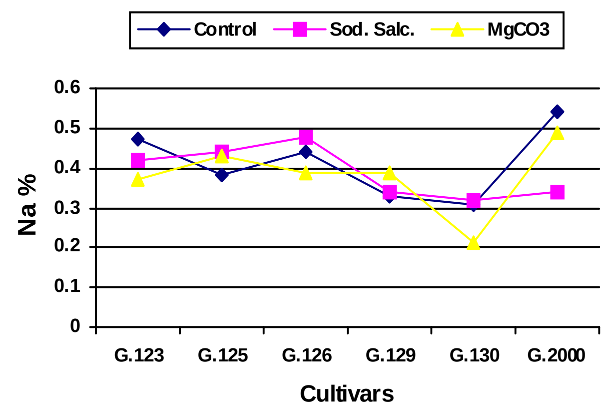


Fig. (6a)

Normal irrigation

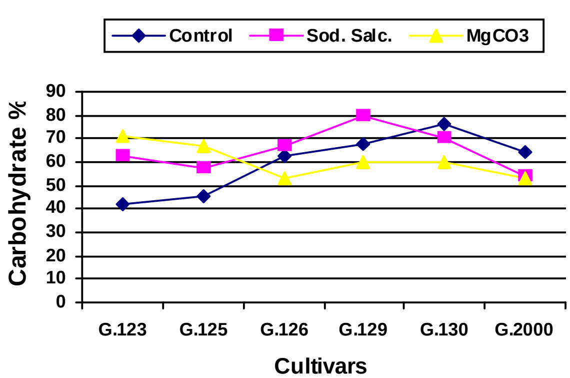
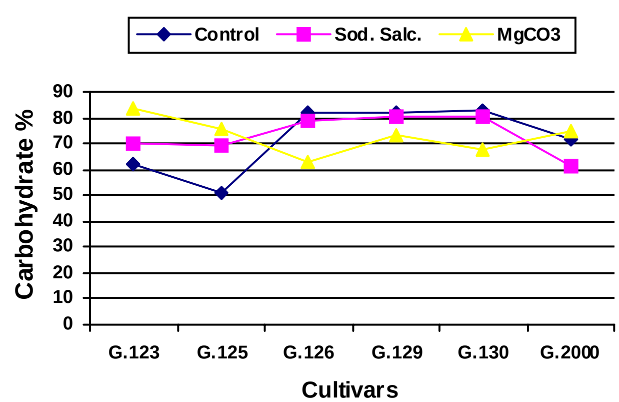


Fig. (6b)

Water Shortage



1985), found that antitranspirants had no significant effect on nitrogen N content. Also, (Marimuthu *et al.,* 1996) found that antitranspirant application had no effect on carbohydrate reserves. On the other hand, (Anjum *et al.,* 2003) and (Aldesuquy *et al.,* 1999) a clear reduction in Na^+ and K^+ contents of shoot and root dry matter and an increase in chlorophyll content by progressive drought and also (Aldesuquy *et al.*, 1999) approved that the use sodium salicylate and ABA reduced Na^+ content in developed grains of water stressed plant. However, (El-Kholy & Gaballah, 2005), proved that reflectant application ($MgCO_3$) increased wheat plant yield under water stress condition, although growth parameters and nutrient content did not show a pronounced effect.

El-Seidy and Khattab (2000), appointed that the reduction in grain yield/plant could be attributed to incomplete development of some grains/spike due to the lack of water in the soil.

McMaster (1997) reported that under water stress condition, mobilization of stem nonstructural reserve increase. Gardner *et al.* (1985) also found that the use of antitranspirants for stomatal closure and the reduction of carbon exchange rate for photosynthesis at the grain developmental stage could be overcome by mobilization of stem reserve and the decrease in rate of transpiration may affect nutrients absorption by the plant.

CONCLUSIONS

The application of yield stabilizing agents and ability of barley hull-less cultivar to tolerate water stress during grain premature stage were the two reasons for lowering yield losses. Therefore it is recommended to plant either Giza 129 or Giza 130 and use magnesium carbonate as a yields.

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