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Mitigating Global Warming Impact on Wheat Productivity in Egypt

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Abstract: Global warming is already changing the world around us in ways that researchers can measure and quantify. Wheat yield in Egypt may decrease as per the above global warming forecast, which may be further affected by water scarcity or drought. One approach to dealing with these heat-related constraints is to use α-amino acid as an effective way to promote agricultural production during periods of unexpected weather and temperature variations. To achieve the aforementioned objectives, two field experiments was carried out in the two successive winter seasons of 2005/06 and 2006/07 at Agricultural Research Station of National Research Centre located in Shalkan Province, Kaluobia Governorate, Egypt. This study was designed to explore the impact of soaking wheat grains in arginine (0.0, 0.3 and 0.6 mM) to increase the tolerance of wheat cultivar (sakha-93) to two late sowing dates (23/12 and 23/1) as compared with optimum sowing date (23/11). Delayed sowing caused marked reduction in biological and economic yield, through reduction in the spike length and weight, spike grain weight, spike no per square meter, and 100-grains weight. The reduction in grain yield fed^{-1} reached to17.28% and 31.98% when delay sowing wheat to 23/12 and 23/1 respectively. Pre-treating wheat grains with arginine with 0.3 and 0.6 mM on normal or delayed sowing wheat exhibited significant increment in yield and its components in comparison to untreated plants. The magnitude of increments was much more pronounced in response to 0.3 mM of arginine which induce 12.35%, 25.87% and 16.84% increases in grain yield per fadden (fed = 4200 m^2) at normal, 30 and 60 days delay, respectively. As well as results show that, 0.3 mM arginine treatment could reduce the reduction percent in grain yield from17.28% to 1.65% and from 31.98 to 20.66% at 23/12 and 23/1 sowing date, respectively. From this study it could be concluded that, pre-treating wheat grains with arginine could alleviate the adverse impact of high temperature stress during late sowing of wheat and reduce expected reduction of economic yield in semi aired region under irrigated agriculture.

Key words: Wheat – Arginine – Sowing dates – Global warming – Economic yield.

INTRODUCTION

Wheat is considered to be one of the main crops in Egypt as well as in the world. Enormous efforts were carried out to maximize wheat crop yield under the current conditions to reduce the vast gap between production and consumption of wheat under the reduced environmental recourses due to climate change, global warming and growth of population.

Optimum sowing date plays an important role in yield production. Planting wheat in its optimum sowing date would realize optimum season length and achieve high grain yield as a result of suitable whether conditions prevailing through different wheat growth stages (Ouda *et al*., 2005). In Egypt, wheat is grown mostly after harvesting of summer crops. Sowing wheat usually gets delayed beyond November due to late harvesting of rice, cotton or sugarcane etc. In such case, wheat growth and yield are adversely affected due to high temperature during growth and reproductive phases. Delay of wheat sowing date reduced wheat yield as a result of exposure to high temperature, which reduce season length (McCeur *et al*. 1997; Abd El-Monem, 2007 and Mostafa *et al*., 2010). Yield reduction in wheat under heat stress could be caused by accelerated phases development; accelerated senescence; increased respiration; reduced photosynthesis and inhibition of starch synthesis in developing kernels (Hamam and Khaled 2009). The rise in daily average temperature up to 30^{o}C or more during anthesis causes pollen sterility (Rayan *et al*., 1999).

Arginine is one member of the essential amino acid. It considered the main precursor of the polyamines group. It is also act as a source of nitrogen due to the huge number of nitrogen atom in their structure. The stimulative effect of arginine as polyamine precursor on growth and yield component may be as protective agents in plants adapted to extreme environment (Kuhen *et al*., 1990 and Abd El Monem, 2007). Pascalidis and Roubelakis-Angelakis (2005) reported that, PAS, their precursor arginine and their biosynthetic enzymes are involved in stimulation of cell division, expansion and differentiation and vascular development in tobacco plant. Hassanein *et al*. (2008) found that, arginine at 2.5 mM was the most effective in improving growth and

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yield of wheat plant exposed to high temperature stress. Moreover, Abd El –Monem (2007) and Mostafa *et al*. (2010) concluded that, foliar application of arginine (1.25 and 2.5 mM) on normal or delayed sowing wheat exhibited significant increments in the growth and all yield parameters in comparison to the late sowing plants or the untreated control sown at normal date. The objectives of this study were to determine the impact of pre-treatment wheat grain with arginine in tolerating high temperature stress in delayed sowing wheat under agriculture Egyptian condition.

MATERIALS AND METHODS

Two field experiments were carried out in the two successive winter seasons of 2005/06 and 2006/07 at Agricultural Research Station of National Research Centre located in Shalkan Province, Kaluobia Governorate, Egypt to explore the role of soaking wheat grains in arginine (0.0, 0.3 and 0.60 mM) for 12 hours before sowing to increasing the tolerance of wheat cultivar (Sakha-93) to two late sowing (23/12 and 23/1) dates, beside the normal sowing date (23/11) as control. Experiment was quadruplicated in split plot design with a net plot size of 3.0 x 3.5 meter. Sowing dates and arginine were allocated in main and sub plots, respectively.

The soil was ploughed twice and divided into plots. Wheat grains sown by drilling seed manually in the rows at 15-cm apart at the rate of 60 kg/fed (fed=4200 m^2). 100 kg calcium super phosphate (15.5 P_2O_5)/fed and 50 kg potassium sulphate (48% K_2O)/fed were added during seedbed preparation. Nitrogen fertilizers was applied at the rate of 40 kg N/fed as Urea (46% N) in two equal doses before the first and second irrigation. All agronomic practices for wheat cultivation were kept normal and uniform. Wheat plants were manually harvested on the last week of May.

At harvest, wheat plants in one square meter from each plot were cut and counted to determine number of spikes/m^2. Also, data on wheat plants i.e., plant height, number of spikelets and grain per spike, length and weight of spike, grains weight of spike and 100-grains weight were determined from randomly selected 20 tillers. Wheat was threshed manually to determine grain, straw and biological yield per plot (3.0 x 3.5m) to calculate grain, straw and biological yields per fed.

Analysis of variance (ANOVA) for split plot design and LSD to compare mean were used by M-STAT-C statistical analysis program (MSTAT, 1988). Since the trend was similar in both seasons, Bartlett's test and the combined analysis of the two growing seasons were done.

Weakly and daily maximum and minimum temperatures data were obtained for Shebeen El- Kanater region as representative of Shalakan region through the 2005/06 and 2006/07 growing seasons (Fig 1&2).

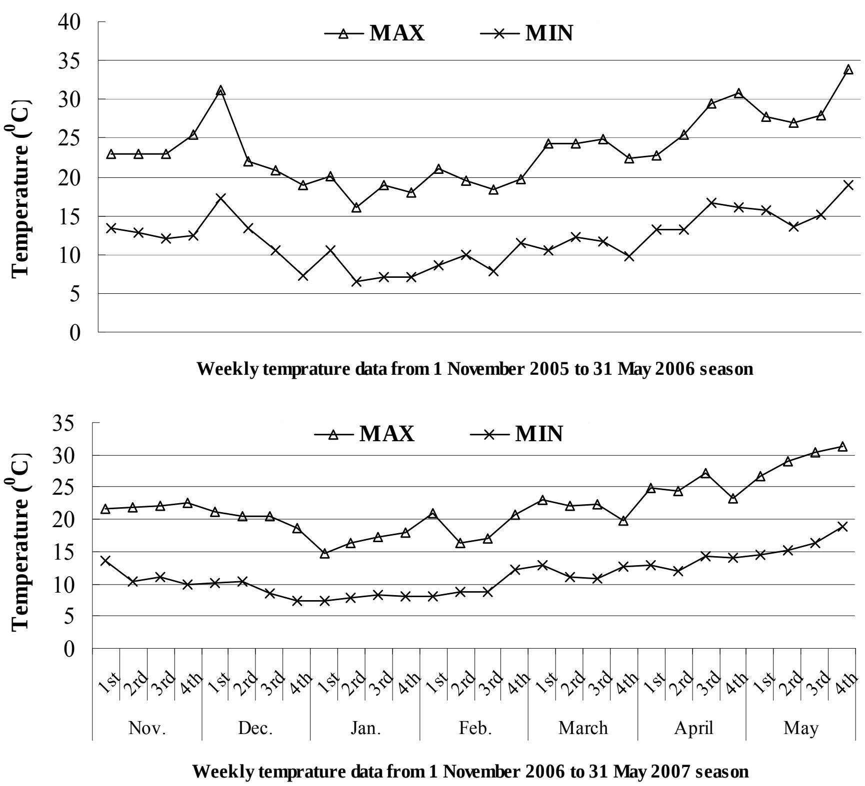

Fig. 1: Weekly temperature data during wheat growing at 2005/06 and 2006/07 seasons.

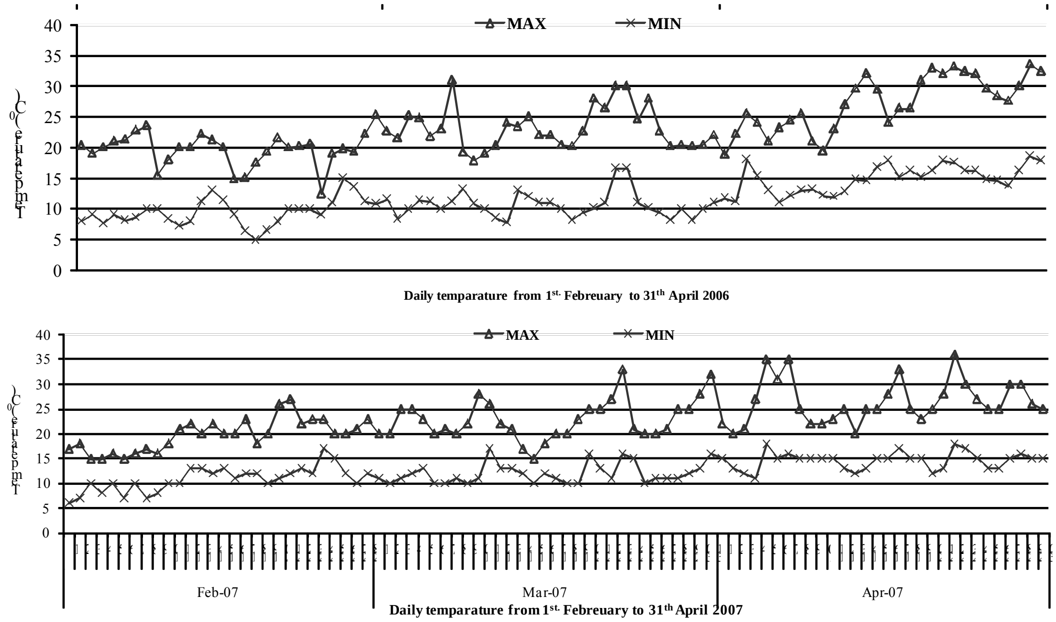

Fig. 2: Daily temperature from 1th February to 31th April (grain filling stage) at 2005/06 and 2006/07 seasons.

RESULTS AND DISCUSSION

1. Wheat Yield Components:

Data in Table (1) showed that, wheat yield was affected significantly by different sowing dates. The crop sown at the last week of November (23/11) induced the maximum yield traits at harvest i.e., plant height, spike length, spike weight, spike grain weight, spike number, spikelets number and grain spike ratio. These results could be attributed to the appropriate weather conditions prevailing during growth season (fig 1 and 2), which in turn increased yield components. This result was in agreement with those obtained by Ouda *et al*. (2005), who reported that, planting wheat in mid November or early December increased season length through increasing number of days to anthesis and consequently number of days to physiological maturity. Hamam and Khaled (2009) concluded that, sowing at favourable date where heat units and metabolites stored in favourable sowing date caused taller plants, vigorous growth and taller spikes. All measured yield components were significantly decreased by delaying sowing date (Table 1). These reductions could be attributed to the shortening in the total growth duration and exposing plant to high temperature stress in delaying sowing dates (fig 1&2). The same results are obtained by several studies (Mohanty 2003, Singh and Pal 2003and Mostafa *et al*. 2010). In this concern, Menshawy, (2007) reported that, high reduction in kernel weight was found under late planting, it could be fully accounted by the reduction in grain filling period. Delaying sowing date reduced kernel weight due to high temperatures affecting the grain maturity which resulted in shrinked kernels.

Results also indicated that, pre-treatment of wheat grains with two arginine concentration (0.3 and 0.6 mM) before sowing, exhibited significant increments in all yield parameters under normal or late dates of sowing with superiority to 0.3 mM arginine treatment which increased plant height by 6.34% and 11.86%, spikes number./m^2 by 15.84% and 6.43%, spike length by 9..84% and 7.03%, spike weight by 9.50% and 11.21%, spike grain weight 16.19% and 18.67%, spikelets number/spike by 9.86% and 4.92%, grain spike ratio by 6.11% and 6.71% and 1000-grain weight by 11.57% and 11.07% at sowing date delayed for 30 and 60 days, respectively as compared with corresponding controls sown at delayed dates without treatment. The positive increase in the yield components of wheat in response to arginine is in agreement with those obtained by Iqbal and Ashraf (2005), El–Bassiouny *et al*. (2008). Moreover, Abd-El-Monem (2007) and Mostafa *et al*., (2010) proved that, the positive increase in the yield components of wheat in response to arginine treatment may be due to the stimulatory effects of arginine in increasing vegetative growth, growth promoters, antioxidant enzymes, endogenous polyamines and endogenous amino acids under normal or high temperature stress.

2. Wheat Yield (ton fed^{-1}):

Results in Table (2) indicated that, sowing wheat plant at 23 November is the optimum date for inducing the maximum grain, straw and biological yields fed^{-1} as compared to the other sowing dates (Table 2). Similar results were reported by several investigations (Ouda *et al*. 2005, Abd El-Monem 2007, Mostafa *et al*. 2010 and Hamam and Khaled 2009).

Table 1: Yield components of wheat as affected by soaking of arginine at different sowing dates.(combined date over both seasons).

Treatment		Plant height (cm)	Spike (s)				Spikelets number/ spike	Grain spike ratio	1000-grains wt. (g)
Sowing date	Arginine (mml)		No/ 1 m^2	Length (cm)	Weight (g)	Grains wt (g)			
23./11	0.0	93.75	446.00	9.75	3.68	2.37	16.50	0.64	4.90
	0.3	82.75	525.00	10.13	4.38	2.78	20.50	0.63	5.13
	0.6	87.75	519.00	9.88	3.86	2.63	17.25	0.68	5.10
23./12	0.0	93.75	404.00	9.25	3.37	2.10	17.75	0.62	4.54
	0.3	88.00	689.00	10.38	4.46	2.81	18.50	0.63	4.83
	0.6	87.50	598.00	10.13	3.84	2.20	18.00	0.57	4.69
23./1	0.0	70.75	393.00	9.50	2.29	1.56	15.25	0.68	3.71
	0.3	68.25	573.00	10.25	2.65	1.97	15.75	0.74	3.95
	0.6	63.25	472.00	9.75	2.40	1.79	15.50	0.75	3.84
LSD 5%		1.67	55.94	0.63	0.37	0.24	1.25	0.02	0.07
Mean of Main effects:									
Sowing date	23./11	88.08	496.67	9.92	3.97	2.59	18.08	0.65	5.04
	23./12	89.75	563.67	9.92	3.89	2.37	18.08	0.61	4.68
	23./1	67.42	479.33	9.83	2.45	1.77	15.50	0.72	3.83
LSD 5%		1.87	62.44	0.48	0.30	0.24	1.23	0.01	0.08
Soaking Arginine (mml)	0.0	86.08	414.33	9.50	3.11	2.01	16.50	0.65	4.38
	0.3	79.67	595.67	10.25	3.83	2.52	18.25	0.67	4.64
	0.6	79.50	529.67	9.92	3.36	2.21	16.92	0.67	4.54
LSD 5%		0.97	32.30	0.36	0.22	0.14	0.72	0.01	0.04

Table 2: Yield of wheat as affected by spraying of arginine at different sowing dates. (combined date over both seasons).

Treatment		Yield (ton fed $^{-1}$)*			HI (%)	CI (%)
Sowing date	Arginine (mml)	Grains	Straw	Biological		
23./11	0.0	3.01	4.27	7.28	41.34	70.60
	0.3	3.73	6.60	10.34	36.10	56.51
	0.6	3.59	6.25	9.84	37.41	61.53
23./12	0.0	3.43	4.57	8.00	42.90	75.25
	0.3	3.53	8.08	11.60	30.40	43.68
	0.6	3.52	8.49	12.00	29.30	41.56
23./1	0.0	1.65	3.19	4.84	34.42	52.97
	0.3	1.93	4.25	6.18	31.20	45.92
	0.6	1.84	3.93	5.77	31.87	47.04
LSD $_{5\%}$		0.36	1.03	1.08	5.71	14.09
Mean of Main effects:						
Sowing date	23./11	3.44	5.71	9.15	38.29	62.88
	23./12	3.49	7.04	10.53	34.20	53.50
	23./1	1.81	3.79	5.59	32.50	48.64
LSD $_{5\%}$		0.20	0.80	0.83	3.36	8.32
Soaking arginine (mM)	0.0	2.70	4.01	6.70	39.56	66.27
	0.3	3.06	6.31	9.37	32.57	48.70
	0.6	2.98	6.22	9.20	32.86	50.04
LSD $_{5\%}$		0.21	0.59	0.62	3.30	8.13

*Fed.= 4200 m^2

Sowing wheat in late dates (23/12 and 23/1) significantly decreased grain, straw and biological yields fed^{-1} as compared with plants sowing at suitable date (23/11). The reduction percentage reached to 17.28% and 31.98% for grain yield, 6.56% and 30.31% for straw and 10.29% and 30.89% for biological yield fed^{-1} when sowing date was delayed for 30 and 60 days, respectively (Table 1). The decrease in yields of wheat plant at late both sowing dates can be attributed to decline in spike weight, grain spike weight, 1000- grains weight and spike noumber/m^2 and other yield components (Table1). These results are in good harmony with those obtained by Singh and Pal (2003), who found that, late sowing caused shortening in the total growth duration and significant reduction in the biological and economic yields through reduction in the number of spikes per pot, number of grains per spike, weight of 100-grain and grain dry weight per shoot. Ouda *et al*. (2005) reported that, sowing wheat in late dates reduced season length, resulted in a reduction in grain, straw and biological yields. Abd El- Monem (2007) and Mostafa *et al*. (2009) concluded that, exposure of wheat plants of high temperature stress due to late cultivation (15/12) cold be led to reducing the vegetative and reproductive phases in wheat consequently reduced grain, straw and biological yields compared to plants sown at normal date (15/11). Moreover, Hamam and Khaled (2009) reported that, the wheat grain yield was greatly affected by the main yield components like kernel weight. Reducing flag leaf area, spike length and kernel weight caused great reduction in grain yield.

Soaking wheat grain in 0.3 or 0.6 mM exhibited significant increment in wheat yield per fed in comparison to untreated plants sowing. The magnitude of increments was much more pronounced in response to 0.3 mM of arginine which induces 6.58%, 18.91% and 16.64% increases in grain yield fed^{-1} compared with corresponding control at normal, 30 and 60 days delay, respectively. Results also, show that, 0.3 mM arginine treatment decreases the reduction percent in grain yield from 17.28% to 1.65% and from 31.98% to 20.66% in plants delayed for 30 or 60 days from sowing. At the same time, increase the straw yield by 22.54% and decrease the reduction from 30.31% to 6.94% and increase the biological yield to 14.14% and decrease the reduction from 30.89% to 11.70% at 23/12 and 23/1 sowing dates respectively. At normal date the percent of increase due to application of 0.3 mM arginine in grain yield was 6.58%; straw yield was 19.42% and biological yield was 15.00% compared to untreated plant. These results may be due to the stimulatory effect of arginine in increasing yield components under normal or late sowing dates which serves as specific protective agents in plants exposed to extreme environment. The same results were obtained on wheat by Abdel-Moneim (2007) and El-Bassiouny *et al*. (2008) under normal condition, Hassanein *et al*., (2008) under high temperature stress and Mostafa *et al*. (2010) under late sowing conditions. They concluded that, arginine stimulate the growth and yield of wheat through increasing vegetative growth, grain weight per plant, 1000-grain weight, straw and biological yield per plant, endogenous polyamines, endogenous amino acids and their translocation to the produced grains.

3. Nutritional Values of Wheat Grains:

Delaying sowing date of wheat for 30 or 60 days produced poor grains quality (decrease in carbohydrate, amino acids and protein contents) as compared with optimum sowing date (23/11) (Table 2). The reduction percentage reached to 2.31% and 6.23% in total carbohydrate, to 9.66% and 14.08% in total protein and to 2.92% and 6.13% in total amino acid of wheat grains sowing at 23/12 and 23/1,respectively. The delay of sowing date led to exposing plant to high temperature stress during different developmental processes as compared with those sown at normal date (Fig 1). These results may be attributed to the reduction in grain weight which associated with the reduction of starch accumulation and the disruption of normal protein synthesis under high temperature stress. These results are in agreement with those obtained by Stone and Nicolas (1998) who reported that, protein content in grains of wheat significantly reduced by any duration of heat treatment. They also demonstrated that, the reduction in the carbohydrate content in the produced wheat grains after the exposure to high temperature stress may be attributed to a reduction in endosperm cell size (Radley, 1978); a truncated duration of grain filling (Weir *et al*.1984); reducing the activity of soluble starch synthase (Hawker & Jenner, 1993) or impaired initiation of β – type starch granules (Nicolas *et al*.1984) which may be related to the reduced duration of grain filling.

Table 3: Nutritional values of wheat grains as affected by soaking of arginine at different sowing date.

Treatment		Nutritional values of grains		
Sowing date	Arginine (mM)	Carbohydrate (%)	Protein (%)	Total amino acid (mg/100g dry weight)
23/11	0.0	45.11	18.33	522.13
	0.3	56.43	24.12	583.63
	0.6	48.64	18.75	536.18
23/12	0.0	45.16	16.56	506.88
	0.3	52.73	21.43	564.14
	0.6	45.75	17.21	515.81
23/1	0.0	42.33	15.75	490.14
	0.3	48.87	18.45	536.44
	0.6	43.11	16.37	496.11
LSD 5%		0.17	0.20	0.23
Mean of Main effects:				
Sowing date	23/11	50.06	20.40	547.31
	23/12	47.88	18.40	528.94
	23/1	44.77	16.86	507.56
LSD 5%		0.15	0.20	0.19
Soaking arginine (mM)	0.0	44.20	16.88	506.38
	0.3	52.68	21.33	561.40
	0.6	45.83	17.44	516.03
LSD 5%		0.10	0.12	0.14

Concerning the effect of arginine treating on wheat grains sown at late dates, the results indicated that, all concentrations used of arginine induced significant increases in the carbohydrate, protein and amino acid contents of wheat grains as compared with that of the corresponding plants sowing at late date without treatments, and in some cases over the untreated control plants sowing at normal date. The magnitude of increments was much more pronounced in response to 0.3 mM of arginine. These results may be attributed to the role of arginine in antagonizing the harmful effect of high temperature stress during late sowing by manifesting assimilate accumulation in wheat treated plant. The same observations were detected by El-Bassiouny (2004) who found that, the increase in protein % of the yielded pea seeds may be due to the increase in the protein synthesis and the translocation of amino acids from shoots to seeds. Moreover, Abd El-Monem (2007) and Mostafa *et al*. (2010) concluded that arginine has a protective role for grain quality against high temperature stress induced under late sowing conditions.

Conclusion:

From this study it could be concluded that, soaking wheat grains in 0.3 mM arginine could alleviate the adverse impact of climate change particularly high temperature stress due to late sowing dates of wheat and reduce expected reduction of economic wheat yield under agriculture Egyptian condition.

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