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Physiological role of arginine on wheat (*Triticum aestivum* L.) cultivars grown under water drought condition

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ABSTRACT

Background and Objective: Two field experiments were conducted at, Agricultural Experimental Station Research Centre of National Research Centre, Nubaria, El-Behera Governorate, Egypt, during two successive seasons; 2017/2018 and 2018/2019. Each experiment was arranged in split- split plot design with four replicates. The present study investigated the effect of arginine (Ar) as amino acid priming agent, applied as foliar application spray, on growth, yield and its components, some chemical constituents of yielded grains of two wheat (*Triticum aestivum* L.,) cv., Gemiza-9 and Misr-2 under drought. Moreover, the study aims to determine suitable concentrations of (Ar) as exogenous treatment to enhance wheat tolerance to drought. Methods: Foliar application spray with three levels of arginine (0, 2 and 4 mM/l) were applied twice after 50 and 60 days from sowing to increase the tolerance drought of wheat cultivars which irrigated with four treatments from water stress (Normal irrigation as a control, Once irrigation at tillering, germination and ripening stages) on two wheat cultivars (Gemiza-9 and Misr-2). Results: The obtained results clearly indicated the role of Ar increasing the tolerance of wheat plants to drought. The highest rates of arginine led to significant increase in growth, yield and its components as well as chemical constituents of the wheat grains in both growing seasons. Conclusion: The magnitude of increments was pronounced in response to wheat cultivar Misr-2 and 4 mM/l of arginine as a foliar spray which led to positive changes in all studied parameters under normal irrigation. All treatments were effective in alleviating the harmful effect of drought.

Keywords: Wheat, Cultivars, Foliar application, Arginine, Drought

Introduction

World agriculture is facing a lot of challenges like producing 70% more food for an additional population of 2.3 billion by 2050, while at the same time fighting with poverty and hunger, consuming scarce natural resources more efficiently and adapting to climate change (FAO, 2009). The importance of wheat for human main food is the well-known fact, overall the world as well as Egypt, extensive.Effects on wheatare continuously paid for increasing its productivity by means of vertical and/or horizontal planting. In Egypt wheat crop covers about 3.10 million feddan distributed mainly in the old land and partially in the new land (Egypt stat. Agric. Rep. 2011). In the light of present national water policy using wheat cultivars that produce high yielding under suitable water regime.Egyptian wheat plants are sometimes exposed to drought stress at different period of growth. A possible approach to minimize drought stress that induces crop losses is the foliar application with arginine on wheat plant (Abdul Qados, 2010 and Ahmed *et al*., 2015).

In recent years, growth regulating substances played an important role in controlling seed germination, vegetative growth, flowering and yield of several crop plants (Abd El-Monem, 2007). Arginine is one of the essential amino acids, considered the main precursor of polyamines which produced by decarboxylation of arginine via arginine decarboxylase to form putrescine (Bouchereau *et al.,* 1999).

Polyamines and their precursor arginine have been implicated as vital modulators in a variety of growth, physiological and developmental processes in higher plants (Galston and Kaur Sahney, 1990). Polyamines are involved in the control of cell cycle, cell division, morphogenesis in phytochrome and

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plant hormone mediated process and the control of plant senescence, as well as in plant response to various stress factors(El-Shintinawy and Hassanein, 2001).

The application of arginine significantly promoted the growth and increased the fresh and dry weights, certain endogenous plant growth regulators, chlorophylls a and b and carotenoids in wheat (Abd El-Monem, 2007 and El-Bassiouny *et al*., 2008). Moreover Hassanein *et al*., (2008) showed the positive role of arginine in alleviating the inhibition occurs as the result of exposing plants to stress.

Therefore, the objective of the physiological role of foliar treatment with arginine on some wheat cultivars (*Triticum aestivum* L.) under water stress condition in the newly cultivated in sandy soil and to investigate the role of arginine in alleviating the harmful effects of drought.

Materials and Methods

Two field experiments were carried out at Agricultural Experimental Station Research Centre of National Research Centre, Nubaria, El-Behera Governorate, Egypt, during two successive seasons; 2017/2018 and 2018/2019. Each experiment was arranged in split- split plot design with four replicates. Each experiment was arranged in split-split plot design with four replicates. Cultivars of wheat (*Triticum aestivum* L) cv., Gemiza-9 and Misr-2, were used which obtained from the Ministry of Egyptian Agriculture.

Foliar application spray with three levels of arginine (0, 2 and 4 mM/L) were applied twice after 50 and 60 days from sowing and irrigated with four treatments from water stress (Normal irrigation as a control which irrigated with one-week intervals up to maturity stage (140 days after sowing), Once irrigation at tillering at 49 days after sowing, germination at 98 days after sowing and ripening stage at 105 days after sowing.).

Cultivars were allocated to main plots, while the water treatments ones were allocated to sub-plot and arginine application treatments were distributed in sub-sub plots. The chemical used in the present work was arginine (one of the essential amino acids). The structure formula of this compound is: NH_2 – COOH – CH (CH_2) NH_3 – C – NH – NH_2. This experiment was carried out to investigate the physiological role of foliar application by arginine on alleviating the harmful effect of drought on wheat cultivars. Table (1), presented the physical and chemical analysis of the soil that determined according to Richards (1954).

Table 1: Physical and chemical analyses of the experimental site

	Chemical				Mechanical			
Depth (cm)	**O.M (%)**	**pH (1:2.5)**	**E.C. (0.5 m^{-1})**	**$CaCO_3$ (%)**	**Course Sand**	**Fine Sand**	**Silt & Clay**	**Texture**
0-20	0.65	8.70	0.35	7.01	47.46	49.79	2.49	
20-40	0.40	8.80	0.33	2.37	56.72	39.57	3.74	**Sandy**
40-60	0.25	9.30	0.45	4.71	36.76	59.39	3.85	
Depth (cm)	**SP** (%)	**FC** (%)	**WP** (%)	**AW** (%)	**Hydraulic conductivity** (cm/hr)			
0-20	21.00	10.10	4.68	5.41	22.50			
20-40	19.00	13.50	5.61	7.89	19.00			
40-60	22.00	14.49	4.63	7.89	21.00			

Notes: the data of two growing seasons were combined

The area of experimental unit consisted of 10 rows each of 2.5 m in length at 20 cm apart. Grains were sown in November at the last week for both seasons at grain rates of 40 kg/fad. The recommended cultural practices of growing wheat plant were followed by harvest date as recommended by Wheat Research Department, Agricultural Research Center.

Samples of guarded plants were often taken randomly from each plot for the four replications to measure growth parameters after 110 and 120 days of sowing, where, plant height, number and dried weight of each tiller blades, spikes/plant, flag leaf blade area cm^2, and blade area cm^2/plant were determined according to Bremner and Taha (1966). LAI was estimated according to the method described by Watson (1952).

At harvest date, guarded plants were taken randomly from the middle rows of each plot to determine the number of spikesper plant, dry weight of spike (g/plant), grain index (weight of 1000 grain/g), straw, biological biomass (above ground) and yields per plant.

In addition, a migration coefficient (i.e. dry weight of spikes/plant/above ground biomass per plant) was estimated according to Abdel-Gawad *et al*., (1987).Moreover, grains (ton/fed); straw(ton/fed) and above ground biomass in ton/fed were collected from the whole area of each experimental unit and then converted to yield per feddan.

Chemical analysis

Samples were chosen for some chemicals composition, photosynthetic pigments contentsin wheat blades (mg/g dry wt.) were extracted by aqueous solution of 85% acetone and calculated using Van Wetistein formula (Van Wettstein, 1957) after 110 and 120 days of sowing. The dried grains were finally grounded and kept for carbohydrates and protein determinations. The total carbohydrates percentages were determined using a phenol sulfuric acid method as described by (Duois *et al*., 1956) whereas, N % in dry grains was determined according the method of Pregl (1945), also, crude protein percentages in dry grains were calculated by multiplying N content by 5.75. Phosphorus was extracted and using spectrophotometer according to Jackson (1973), whereas, potassium was assayed using flamephotometer according to Allen *et al*., (1984).

Statistical analysis

Data were statistically analyzed by using analysis of variances according to Snedecor and Cochran (1990) and means were grouped by LSD test at the 5% probability level. Furthermore, combined analysis was made for the data of the two growing seasons as the results were followed a similar trend.

Results and Discussion

1. Effect of cultivars

Results in Table (2), showed that significant differences were found between the two wheat cultivars Gemiza-9 and Misr-2 in allgrowth parameters after 110- and 120- days of two growing seasons. Gemiza-9 cultivar significantly surpassed Misr-2 cultivar in plant height, number of blades/plant and tillers dry weight/plant after 110 and 120 days of sowing, whereas, Misr-2 cultivar gave the highest significant values at number of tillers/plant, number of spikes/plant, blades dry weight/plant, spikes dry weight/plant, flag leaf blade area, blades area/plant and LAI after110 and 120 dayscompared with Gemiza-9 cultivar.

It is worthy, plant height, number of tillers/plant, the number of blades/plant, dry weight of tillers/plant, dry weight of blades/plant, blades area/plant and LAI were decreased with advancing plant age to110 and 120 days however, number of spikes/plant, dry weight of spikes/plant and the flag leaf blade area seemed to be increased with advancing plant age to 110 and 120 days after sowing.

Regarding, chemical concentration of wheat plant Gemiza-9 and Misr-2 cultivars, table (3) indicated that the cultivars significantly differed in photosynthetic pigment content per wheat blade (i.e. Chl a, Chl b, Chl(a+b) and carotenoids) as well as, total carbohydrates % and crude protein % per grains were significant. Also, photosynthetic pigment content per green wheat blades was decreased after 110 days from sowing. Also, from table (3) Msir-2 in photosynthetic pigments as compared to other wheat cultivars after 110 and 120 days of sowing and total carbohydrates % per grains at harvest date. On the contrary, Gemiza-9 cultivar produced the greatest mean values from crude protein % per grains at harvest date compared with Misr-2 cultivar.

Table (4) showed clearly that Gemiza-9 and Misr-2 cultivars were significantly differed in yield and its components (i.e. Number of spikes/plant, spikes dry weight/plant, mean of spike length, grain index, grains, straw and above ground biomass yields per plant and/or per fed., migration coefficient, crop index and harvest index. Data in the same table clearly indicated that Misr-2 was significantly out weight of Gemiza-9 cultivar in all previous yield and its components except straw yield per plant and/or per fed where Misr-2 cultivar characterized by significant decrease in straw yield compared with Gemiza-9 cultivar

It is worthy to mention that the differences between wheat cultivars might be attributed to the differences between wheat genotype for mineral elements concentration and to the differences in photosynthetic partitioning and migration photosynthetic among wheat plant organs. Generally, the significant cultivar differences between wheat cultivars in this study are in full agreement with previous results obtained by Hassanain *et al*., (2014) and El-Metwally *et al*., (2015).

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Table 2: Effect of cultivars, water stress and arginine concentrations on growth parameters of wheat plant (Average of 2017/2018 and 2018/2109 seasons).

Cultivars	Water stress treats.	ArConcen (mM/l)	Plant height (cm)	No./plant Tiller	No./plant Blades	No./plant Spikes	Dry weight (g/plant) Tiller + shoots	Dry weight (g/plant) Blades	Dry weight (g/plant) Spikes	Flag leaf blade area	Blades area (cm^2)/ plant	LAI
			110 days after sowing									
Gemiza-9			156.29	6.03	40.86	5.17	8.23	5.64	8.09	35.58	958.73	6.39
Misr-2			151.09	6.80	40.58	5.77	7.82	5.83	8.56	40.68	1005.91	6.71
	LSD $_{0.05}$		**1.53**	**0.29**	**0.14**	**0.30**	**Ns**	**0.15**	**0.18**	**1.27**	**11.64**	**0.20**
	Control		160.69	6.94	44.33	6.29	8.62	6.02	8.91	43.58	1026.30	6.85
	Tillering		141.35	5.93	36.52	4.78	7.50	5.42	7.50	31.88	932.37	6.22
	Germinating		149.92	6.14	40.14	5.21	7.82	5.67	8.22	36.70	968.31	6.47
	Ripening		157.58	6.63	43.11	5.70	8.11	5.83	8.68	40.74	1000.30	6.67
	LSD $_{0.05}$		**2.88**	**0.15**	**1.51**	**0.23**	**0.27**	**0.13**	**0.60**	**0.63**	**1.46**	**0.06**
		0.00	147.61	6.05	38.17	5.08	7.41	5.50	7.81	34.32	940.50	6.27
		2.00	154.95	6.47	40.60	5.59	8.04	5.70	8.25	38.00	983.73	6.58
		4.00	158.55	6.70	43.39	5.81	8.64	6.00	8.93	42.10	1022.80	6.82
	LSD $_{0.05}$		**1.44**	**0.10**	**2.01**	**0.15**	**0.35**	**0.16**	**0.22**	**2.24**	**27.46**	**0.08**
			120 days after sowing									
Gemiza-9			148.20	5.77	38.70	5.68	7.98	5.08	8.63	38.92	902.30	6.02
Misr-2			141.89	6.36	39.05	6.24	7.38	5.28	9.37	44.32	995.07	6.63
	LSD $_{0.05}$		**3.12**	**0.25**	**ns**	**ns**	**0.22**	**0.11**	**0.36**	**2.03**	**17.52**	**0.41**
	Control		151.71	6.66	42.40	6.55	8.43	5.58	9.78	46.05	1010.05	6.73
	Tillering		137.00	5.29	34.95	5.03	6.67	4.88	8.44	37.13	893.76	5.96
	Germinating		145.51	6.07	38.05	6.00	7.51	5.12	8.81	39.88	927.38	6.18
	Ripening		148.51	6.40	40.10	6.27	7.93	5.25	9.17	43.46	963.52	6.42
	LSD $_{0.05}$		**1.06**	**0.08**	**0.01**	**0.13**	**0.08**	**0.04**	**0.31**	**0.82**	**9.97**	**0.08**
		0.00	140.29	5.70	36.33	5.61	7.11	4.91	8.61	38.20	910.73	6.07
		2.00	142.36	6.00	39.00	5.98	7.67	5.18	8.98	41.67	946.70	6.31
		4.00	149.60	6.48	41.28	6.31	8.27	5.45	9.43	45.00	988.14	6.59
	LSD $_{0.05}$		**2.01**	**0.16**	**1.64**	**0.20**	**0.27**	**0.11**	**0.12**	**1.56**	**30.61**	**0.14**

Table 3: Effect of cultivars, water stress and arginine concentrations on chemical constituents of wheat plant (Average of 2017/2018 and 2018/2019 seasons).

Cultivars	Water stress treats.	ArConcen. (mM/l)	Photosynthetic pigments content per blades (mg/g) dry weight 110 days after sowing				120 days after sowing				Total Carb. (%)	Crude protein (%)
			Chl a	Chl b	Chl(a+b)	Car.	Chl a	Chl b	Chl(a+b)	Car.		
Gemiza-9			2.78	1.10	3.88	1.88	2.63	0.96	3.59	1.75	84.79	11.95
Misr-2			2.89	1.22	4.11	1.95	2.72	1.04	3.76	1.84	85.54	11.75
LSD $_{0.05}$			0.07	0.03	0.09	0.05	0.02	0.04	0.08	0.06	0.11	0.10
	Control		3.06	1.35	4.41	2.17	2.89	1.16	4.05	2.01	86.19	11.67
	Tillering		2.61	0.98	3.59	1.70	2.49	0.82	3.31	1.64	83.69	12.31
	Germinating		2.77	1.12	3.89	1.82	2.61	0.95	3.56	1.72	85.13	11.73
	Ripening		2.91	1.19	4.10	1.96	2.73	1.07	3.80	1.83	85.66	11.70
LSD $_{0.05}$			0.11	0.08	0.14	0.09	0.12	0.06	0.17	0.13	0.03	0.21
		0.00	2.70	1.08	3.78	1.83	2.55	0.91	3.46	1.68	84.79	11.48
		2.00	2.82	1.14	3.96	1.93	2.68	0.99	3.67	1.83	85.16	11.80
		4.00	2.95	1.28	4.25	1.98	2.80	1.10	3.90	1.90	85.44	11.89
LSD $_{0.05}$			0.08	0.07	0.19	0.04	0.10	0.06	0.18	0.04	0.25	0.08

2. Effect of drought

Results in Table (2) showed that skipping irrigation at certain developmental stages of growth for wheat plant caused significant decrement in growth parameters, i.e. plant height, number and dried weight of tillers, blades and spikes/plant, flag leaf blade area, blade area/plant and LAI at 110 and 120 days after sowing date (Table 2), photosynthetic pigment content (i.e Chl a, Chl b, Chl (a+b) and carotenoids) per green blades at 110 and 120 days after sowing. In addition, total carbohydrates % and crude protein % per dried grains at harvest date (Table 3), as well as, yield and its components, i.e. number of spikes/plant, dry weight of spike per plant, mean of spike length, grain index, grain, straw and above ground biomass, yields per plant and/or per feddan, migration coefficient, harvest index and crop index (Table 4).

Data collected indicated that plant height, number and the dry weight of tillers + sheats and blades, blades area/plant and LAI were decreased with advancing plant age after 110 and 120 days of sowing (Table 2), as well as, photosynthetic pigment content (Table 3). On the contrary, the number and dried weight of spikes/plant, flag leaf blade area was increased with advancing plant age after110- and 120-days. Noticeably, the damaging effect of the harmful effect of drought stress on growth character (Table 2), chemical constituents of wheat plant (Table 3) with yield and its components (Table 4), may be explained on the basis of turgidity loss with effect of cell expansion cute and ultimate cell size, the loss of turgidity is probably the most sensitive processes to water stress, thus caused decrement in growth rate, stem elongation and enlargement which has been carefully discussed by Kramer and Boyer (1995). As a result, yield and its components were decreased consequently. Our results in Tables (2, 3 and 4) clearly indicated that wheat plants were more sensitive to drought stress at tillering stage, followed by germinating stage, whereas, skipping one irrigation at ripening stage showed the lowest damaging effect on each of growth characters (Tables 2), chemical constituents (Tables 3) and, yield and its components (Tables 4). On the other hand, water stress for wheat plant even water afterward did not recover to their normal behavior to compensate for the adverse effect caused by the exposure to drought conditions (Magda *et al*., 2014).

Generally, irrigation is recommended due to the highest effect on tillersurvival and this included that development and physiological processes in determining final grain yield and the water stress should be avoided at this growth stage. Therefore, the damage in growth characters (Tables 2), chemical constituents (Tables 3), and yield with its components (Tables 4) attributed to water stress at tillering stage was more pronounced, because every plant was subjected to soil moisture at tillering stage and their effect might be attributed to the lack of absorbed water, inadequate uptake of chemical elements, inhibition of meristematic activity and/or reduction in photosynthetic capacity under such unfavorable conditions (Magda, *et al*., 2018).

Moreover, assimilates translocation to the new developing tillers and to the spike primordial were recorded which were not enough to mention or develop these organs from plants (Magda, *et al*., 2018). Finally, our results are in good harmony with those obtained by Abdel Salam *et al*., (2016).

3. Effect of foliar spray by arginine

Data illustrated in Table(2) indicated that the growth attributes of wheat plants to the concentration of arginine were significant, where; plant height, number and dried weight/plant of each one of tillers + shoots, blades and spikes/plant, flag leaf blade area and blade area/plant and LAI were significantly affected by foliar application with arginine. In addition, foliar spray with 2.0mM/l caused a significant increment in all growth parameters after 110 and 120 days of sowing compared to control treatment (Tap water treatment). On the other hand, increasing concentration of arginine from 2.0 to 4.0 mM/l caused another significant increase in growth parameters after 110 and 120 days compared to control treatment and 2.0 mM/l treatment only, respectively.

Furthermore, a significant response of photosynthetic pigment contents after 110 and 120 days of sowing were found due to the foliar application with arginine. Also, carbohydrates % and crude protein % per dry grains at harvest date, where, the application with 2.0 mM/l arginine significantly enhanced the previous chemical composition of wheat plant compared to control plant after 110 and 120 days of sowing, where, increasing arginine concentration from 2.0 to 4.0 mM/l caused further increases in Chl a, Chl b, Chl(a+b) and carotenoidsper wheat blades after 110 and 120 days of sowing plus in carbohydrates and crude protein % per dried grains at harvest date compared to 2.0 mM/l concentration.

On the other hand, each to plant height, number of tillers/plant, number of blades/plant, tillers + shoots, dry weight/plant, dried weight of blade/plant, blade area/plant and LAI, as well as, Chl a, Chl b, Chl(a+b) and carotenoids at seemed to be decreased with advancing plant age (110 and 120) days, whereas, the number and dry weight of spikes/plant, as well as, flag leaf blade area were increased with advancing plant age (110 and 120) days.

The effect of arginine concentration on yield and its components of wheat plant were respected significantly at level (5%) in Table (4). Results showed clearly that foliar spray with 2.0 mM/l arginine significantly enhanced the number of spikes/plant; dry weight of spike/plant, the mean of spike length, grain index, grain, straw and above ground biomass/plant, above ground biomass/feddan, migration coefficient, harvest index and crop index compared with control treatment, except the increase in grain and straw yield/fed. were not reaching the significant level at 5%.

Moreover, foliar spraying with 4 mM/l arginine on wheat plant caused significant increment in all the yields and its component except the differences in grains and straw yield/feddan, harvest index and crop index between 2 and 4 mM/l arginine that were not in significant level at 5 %.

These results may be attributed to the role of PAs (the main group of arginine products), application in alleviating the adverse effect of drought and salt stress by increasing the endogenous PAs contents in wheat plants and proved that arginine treatments significantly increased grains weight per plant, the weight of 1000-grain, straw and biological yields per plant and harvest index in wheat plants (El-Shintinawy and Hassanein, 2001)

It is notable that our results are confirmed with results obtained by Nasibi *et al*., (2014); Ahemd *et al*., (2015); Magda *et al*., (2018) for the connection the main role of arginine products (putrescine, spermidine and spermine) in the stressed plants for the long run, which was to maintain a cation-anion balance in plant tissue by stabilizing membrane of high external stress (El-Bassiouny *et al*., 2008). Foliar spraying with polyamine (end product of arginine to several plant species have been shown to promoting the cell division, cell differentiation and general growth promotion. The arginine can also help in stabilizingthe membrane and cell properties (Velikova *et al*., 2000) and protecting the plant against environmental stress (Mo and Pua, 2002).

Furthermore, the positive effect of arginine on yield and its components may be attributed tothe positive effect of arginine on growth characters (Table 2) and photosynthetic pigment content per wheat green blades (Table 3). Thus, application of arginine can be used to decrease harmful effect of drought stress and wear. The arginine treatment can help in solving the problems produced by environmental drought stress. The positive effect of arginine products (putrescine, spermidine and spermine) used in our study is in a good harmony with those obtained by Ahmed *et al*., (2015); Akladious and Hanafy, (2018).

However, the disappearance of some protein bands under stress may be due to the suppression of the genes responsible for protein synthesis as a result of stress. Then, the developed tissues had lost their ability to synthesize these proteins under stress conditions (Akladious and Abbas, 2014).

Table 4: Effect of cultivars, water stress and arginine concentrations on yield and its components of wheat plant (Average of 2017/2018 and 2018/2019 seasons).

Cultivars	Water stress treats.	Ar Concen. (mM/l)	No of spikes/ plant	Spikes dry weight (g/plant)	Main spikes length (cm)	Grain index (g)	Grain yield g/plant)	Straw yield g/plant)	Above ground biomass (g/plant)	Grain yield (ton/fed)	Straw yield (ton/fed)	Above ground biomass (ton/fed)	Migration coefficient	Harvest index	Crop index
Gemiza-9			5.79	19.97	15.69	32.93	14.40	21.44	35.84	2.83	3.34	6.17	0.56	0.85	0.46
Misr-2			6.44	21.74	17.15	35.11	15.81	20.49	36.30	3.01	3.21	6.22	0.60	0.94	0.48
	LSD $_{0.05}$		**0.61**	**0.16**	**0.13**	**0.35**	**0.30**	**0.86**	**0.27**	**0.12**	**0.07**	**0.03**	**0.02**	**0.05**	**0.01**
	Control		6.68	24.57	24.57	37.52	18.44	24.01	42.45	3.20	3.49	6.69	0.58	0.92	0.48
	Tillering		5.13	17.46	13.69	31.39	12.19	17.36	29.55	2.55	3.15	5.70	0.59	0.81	0.45
	Germinating		6.12	19.66	15.92	32.66	13.97	20.32	34.29	2.90	3.20	6.10	0.57	0.91	0.48
	Ripening		6.37	21.75	17.38	34.52	15.83	22.18	38.01	3.04	3.26	6.30	0.57	0.93	0.48
	LSD $_{0.05}$		**0.13**	**0.18**	**0.49**	**0.85**	**0.55**	**0.55**	**0.41**	**0.03**	**0.15**	**0.07**	**0.01**	**0.01**	**ns**
		0.00	5.71	18.24	14.23	31.95	13.39	19.11	32.50	2.81	3.35	6.16	0.56	0.84	0.46
		2.00	6.08	20.03	16.39	33.87	14.83	20.83	34.83	2.96	3.39	6.25	0.58	0.90	0.47
		4.00	6.43	24.32	18.61	36.27	17.11	22.97	40.08	3.11	3.44	6.55	0.61	0.90	0.47
	LSD $_{0.05}$		**0.31**	**1.82**	**1.25**	**0.26**	**0.22**	**0.18**	**0.86**	**0.09**	**0.08**	**0.03**	**0.02**	**0.01**	**0.01**

Table 5: Effect of interaction between cultivars and water stress on growth characters of wheat plant (during 2017/2018 and 2018/2019 seasons).

Cultivars	Water stress treats.	Plant height (cm)	No./plant			Dry weight (g/plant)			Flag leaf blade area	Blades area (cm^2) / plant	LAI
			Tiller	Blades	Spikes	Tiller + shoots	Blades	Spikes			
		110 days after sowing									
Gemiza-9	**Control**	167.77	6.77	44.43	6.00	8.87	5.89	8.75	40.82	1003.2	6.69
	Tillering	143.77	5.49	36.63	4.56	7.59	5.30	7.11	29.19	921.60	6.14
	Germinating	153.11	5.57	40.58	4.83	8.04	5.58	8.08	34.90	939.35	6.26
	Ripening	160.43	6.25	41.77	5.28	8.31	5.77	8.36	38.39	970.73	6.47
Misr-2	**Control**	153.60	7.11	44.22	6.50	8.37	6.14	9.07	46.53	1049.40	7.00
	Tillering	138.93	6.31	36.40	5.00	7.41	5.54	7.83	34.57	943.14	6.29
	Germinating	146.73	6.64	39.70	5.58	7.60	5.75	8.35	38.90	1000.26	6.67
	Ripening	154.73	7.00	42.00	6.12	7.91	5.88	9.00	43.09	1029.87	6.87
LSD $_{0.05}$		**4.55**	**0.24**	**2.38**	**0.37**	**0.42**	**0.20**	**0.10**	**0.99**	**23.00**	**0.10**
		120 days after sowing									
Gemiza-9	**Control**	153.60	6.42	42.40	6.33	8.69	5.42	9.26	42.40	965.49	6.44
	Tillering	140.70	5.07	35.20	4.78	6.91	4.73	8.18	34.65	855.39	5.70
	Germinating	147.93	5.84	37.70	5.70	7.75	5.02	8.55	38.50	877.23	5.85
	Ripening	150.58	6.10	39.60	5.93	8.19	5.15	8.93	40.20	911.04	6.07
Misr-2	**Control**	149.82	6.90	42.40	6.77	8.16	5.72	10.30	49.70	1054.60	7.04
	Tillering	133.27	5.50	34.70	5.28	6.42	5.02	8.69	39.60	932.13	6.21
	Germinating	142.56	6.30	38.40	6.30	7.26	5.22	9.06	41.25	977.53	6.52
	Ripening	146.43	6.70	40.60	6.60	7.67	5.34	9.41	46.72	1016.00	6.37
LSD $_{0.05}$		**1.68**	**0.12**	**0.02**	**0.21**	**0.12**	**0.06**	**0.49**	**1.29**	**15.75**	**0.13**

4. Effect of the interaction between cultivars X skipping irrigation

Table (5), indicated that the interaction between wheat cultivars X skipping irrigation at certain developmental stages on growth character after 110 and 120 days of sowing (Table 5), chemical constituents except crude protein per dried grain (Table 6), and yield and its components (Table 7) was significant, where Misr-2 cultivar surpassed Gemiza-9 in all pervious determined characters except plant height after 110 and 120 days of sowing, Gemiza-9 was producing the tallest wheat plant.

Furthermore, the collected data indicated that wheat plants were more sensitive to skipping irrigation at tillering stage followed by germinating stage, while the skipping irrigation at ripening stage was at the end of list. These results are in agreement with the findings obtained by Magda *et al*., (2014).

Table 6: Effect of interaction between cultivars and water stress on chemical constituents of wheat plant (Average of 2017/2018 and 2018/2019 seasons).

Cultivars	Water stress treats.	Photosynthetic pigments content per blades (mg/g) dry weight								Total Carb. (%)	Crude protein (%)
		110 days after sowing				120 days after sowing					
		Chl a	Chl b	Chl(a+b)	Car.	Chl A	Chl B	Chl(a+b)	Car.		
Gemiza-9	Control	3.01	1.31	4.32	2.11	2.84	1.14	3.98	1.96	86.02	11.64
	Tillering	2.55	0.88	3.43	1.67	2.42	0.77	3.19	1.58	82.92	12.80
	Germinating	2.68	1.05	3.73	1.79	2.55	0.90	3.45	1.68	84.79	11.69
	Ripening	2.87	1.17	4.04	1.94	2.70	1.02	3.72	1.78	85.44	11.66
Misr-2	Control	3.11	1.38	4.49	2.22	2.94	1.18	4.12	2.05	86.32	11.69
	Tillering	2.66	1.08	3.74	1.73	2.55	0.86	3.41	1.69	84.48	11.82
	Germinating	2,85	1.19	4.04	1.85	2.66	0.99	3.65	1.76	85.47	11.77
	Ripening	2.95	1.21	4.16	1.98	2.75	1.11	3.86	1.87	85.87	11.73
LSD $_{0.05}$		**0.17**	**0.13**	**0.22**	**0.14**	**0.19**	**0.10**	**0.27**	**0.20**	**0.05**	**ns**

With respect of the interaction of wheat cultivars X arginine concentration, data observed that the interaction was significant on growth characters (Table 8), on chemical constituents (Table 9) and the yield associated with its components (Table 10).
Furthermore, data obtained from the previous table, explained that the most effective treatment was Misr-2 cultivar sprayed with 4 mM/lof arginine. These results are in harmony with those obtained by El-Bassiouny *et al*., (2008).

Regarding the interaction between skipping irrigation at certain developmental stages of growth and arginine concentration treatments on growth characters after 110 and 120 days of sowing (Table 11) chemical constituents of the wheat plant (Table 12) and the yield accompanied with its components except for the crop index and harvest index (Table 13) was significant. Also, the most favorable treatment for all the pervious characters was the traditional irrigation (without skipping) under foliar spraying with 4 mM/l arginine followed by normal irrigation under spraying with 2 mM/l arginine. These results are in agreement with those obtained by Ahmed *et al*., (2015) and Magda *et al*., (2018).

The three-ways interaction among wheat cultivars X drought stress treatment X foliar spraying with arginine clearly showed that the effect on growth characters (Table 14), chemical constituents of the wheat plant, except crude protein per dried grains (Table 15), as well as, yield and its components, except the crop index and harvest index (Table 16) were significant. Generally, the most effective treatment for increasing wheat plant yield and quality are Misr-2 cultivar under normal irrigation using the foliar spraying with 4 mM/l arginine followed by Misr-2 under normal using the foliar spraying with 2 mM/l arginine. It is evidenced to state that these results are in harmony with those obtained by Ahmed *et al*., (2015). Also, it can be concluded that the damaging of water stress to wheat plants can be alleviated by using foliar application with 4 mM/l arginine**.**

Table 7: Effect of interaction between cultivars and water stress on yield and its components of wheat plant (Average of 2017/2018 and 2018/2019 seasons).

Cultivars	Water stress treats.	No of spikes/ plant	Spikes dry weight (g/plant)	Main spikes length (cm)	Grain index (g)	Grain yield g/plant)	Straw yield g/plant)	Above ground biomass (g/plant)	Grain yield (ton/fed)	Straw yield (ton/fed)	Above ground biomass (ton/fed)	Migration coefficient	Harvest index	Crop index
Gemiza-9	Control	6.45	23.46	18.05	36.33	17.70	24.92	42.62	3.11	3.56	6.67	0.56	0.87	0.47
	Tillering	4.87	16.67	12.98	30.46	11.41	17.94	29.35	2.45	3.23	5.68	0.57	0.76	0.43
	Germinating	5.81	18.92	14.99	31.12	13.21	20.16	33.37	2.81	3.26	6.07	0.57	0.86	0.46
	Ripening	6.04	20.81	16.71	33.79	15.27	22.73	38.00	2.95	3.30	6.25	0.55	0.89	0.47
Misr-2	Control	6.90	25.67	19.31	38.70	19.17	23.09	42.26	3.28	3.42	6.70	0.61	0.96	0.49
	Tillering	5.38	18.24	14.39	32.31	12.97	16.77	29.74	2.65	3.06	5.71	0.61	0.87	0.46
	Germinating	6.42	20.39	16.85	34.19	14.72	20.48	35.20	2.98	3.14	6.12	0.58	0.95	0.49
	Ripening	6.69	22.69	18.04	35.24	16.38	21.63	38.01	3.12	3.22	6.34	0.60	0.97	0.49
LSD $_{0.05}$		**0.20**	**0.28**	**0.77**	**1.35**	**0.87**	**0.87**	**0.65**	**0.04**	**0.14**	**0.11**	**0.03**	**0.03**	**0.01**

Table 8: Effect of interaction between cultivars and arginine concentrations on growth characters of wheat plant (Average of 2017/2018 and 2018/2019 seasons).

Cultivars	ArConcen. (mM/l)	Plant height (cm)	No./plant			Dry weight (g/plant)			Flag leaf blade area	Blades area (cm²) / plant	LAI
			Tiller	Blades	Spikes	Tiller + shoots	Blades	Spikes			
110 days after sowing											
Gemiza-9	0.00	149.71	5.72	37.94	4.75	7.58	5.39	7.42	32.02	918.90	6.13
	2.00	157.40	6.03	40.33	5.25	8.33	5.57	8.11	35.21	957.78	6.39
	4.00	161.75	6.33	44.30	5.50	8.77	5.95	8.75	39.52	999.50	6.66
Misr-2	0.00	145.61	6.38	38.40	5.40	7.23	5.61	8.20	36.61	962.05	6.41
	2.00	152.30	6.90	40.86	5.80	7.74	5.80	8.38	40.76	1009.67	6.73
	4.00	155.35	7.06	42.48	6.11	8.50	6.08	9.10	44.66	1046.00	6.97
LSD $_{0.05}$		**2.24**	**0.16**	**3.14**	**0.23**	**0.55**	**0.25**	**0.35**	**3.50**	**42.84**	**0.13**
120 days after sowing											
Gemiza-9	0.00	143.00	5.40	36.12	5.29	7.30	4.83	8.25	35.56	878.90	5.86
	2.00	148.67	5.58	38.64	5.65	7.95	5.08	8.55	38.50	891.70	5.98
	4.00	152.93	6.32	41.35	6.11	8.70	5.33	9.10	42.71	931.30	6.21
Misr-2	0.00	137.57	6.00	36.54	5.92	6.91	4.98	8.96	40.84	942.55	6.28
	2.00	141.84	6.44	39.40	6.30	7.38	5.28	9.40	44.83	996.70	6.64
	4.00	146.26	6.64	41.20	6.50	7.84	5.57	9.75	47.28	1045.97	6.97
LSD $_{0.05}$		**3.14**	**0.25**	**2.56**	**0.31**	**0.42**	**0.17**	**0.19**	**2.44**	**47.75**	**0.17**

Table 9: Effect of interaction between cultivars and arginine concentrations on chemical constituents of wheat plant (Average of 2017/2018 and 2018/2019 seasons).

Cultivars	Arginine Concen. (mM/l)	Photosynthetic pigments content per blades (mg/g) dry weight								Total Carb. (%)	Crude protein (%)
		110 days after sowing				120 days after sowing					
		Chl a	Chl b	Chl(a+b)	Car.	Chl a	Chl B	Chl(a+b)	Car.		
Gemiza-9	**0.00**	2.63	1.00	3.63	1.78	2.51	0.87	3.38	1.64	84.32	11.45
	2.00	2.77	1.08	3.85	1.89	2.64	0.96	3.60	1.76	84.77	11.80
	4.00	2.92	1.22	4.14	1.97	2.72	1.07	3.79	1.85	85.28	11.83
Misr-2	**0.00**	2.77	1.16	3.93	1.88	2.59	0.95	3.54	1.71	85.26	11.51
	2.00	2.87	1.19	4.06	1.96	2.72	1.02	3.74	1.89	85.55	11.80
	4.00	3.02	1.34	4.36	2.01	2.88	1.13	4.01	1.94	85.79	11.94
LSD 0.05		**0.12**	**0.09**	**0.29**	**0.04**	**0.13**	**0.08**	**0.24**	**0.06**	**0.36**	**0.10**

Table 10: Effect of interaction between cultivars and arginine concentrations on yield and its components of wheat plant (Average of 2017/2018 and 2018/2019 seasons).

Cultivars	Ar Concen. (mM/l)	No of spikes/ plant	Spikes dry weight (g/plant)	Main spikes length (cm)	Grain index (g)	Grain yield g/plant)	Straw yield g/plant)	Above ground biomass (g/plant)	Grain yield (ton/fed)	Straw yield (ton/fed)	Above ground biomass (ton/fed)	Migration coefficient	Harvest index	Crop index
Gemiza-9	**0.00**	5.39	17.56	13.22	30.92	12.68	19.39	32.07	2.61	3.19	5.80	0.55	0.82	0.45
	2.00	5.75	19.07	15,93	32.75	14.29	21.32	35.61	2.87	3.34	6.21	0.54	0.86	0.46
	4.00	6.23	23.27	17.91	35.16	16.23	23.61	39.84	3.01	3.50	6.51	0.58	0.86	0.46
Misr-2	**0.00**	6.03	18.92	15.25	32.97	14.09	18.82	32.91	2.78	3.01	5.79	0.57	0.92	0.48
	2.00	6.41	20.98	16.84	34.99	15.36	20.33	35.69	3.05	3.23	6.28	0.59	0.94	0.49
	4.00	6.63	25.36	19.35	37.38	17.99	22.33	40.32	3.21	3.38	6.59	0.63	0.95	0.49
LSD 0.05		**0.32**	**2.84**	**1.95**	**0.40**	**0.35**	**0.28**	**1.34**	**0.46**	**0.11**	**0.05**	**0.04**	**0.01**	**0.02**

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Table 11: Effect of interaction between water stress and arginine concentrations on growth characters of wheat plant (Average of 2017/2018 and 2018/2019 seasons).

Cultivars	ArConcen. (mM/l)	Plant height (cm)	No./plant			Dry weight (g/plant)			Flag leaf blade area	Blades area (cm^2) /plant	LAI
			Tiller	Blades	Spikes	Tiller + shoots	Blades	Spikes			
110 days after sowing											
Control Treat. (No skipping) stage	**0.00**	159.59	6.58	41.04	5.67	8.02	5.62	8.57	39.05	972.73	6.42
	2.00	167.94	6.98	44.38	6.31	8.65	5.88	8.72	44.44	1034.60	6.90
	4.00	170.48	7.33	47.66	6.75	9.21	6.54	9.45	47.25	1086.90	7.25
Skipping one irrig. tillering stage	**0.00**	137.00	5.67	33.50	4.46	7.00	5.23	6.45	28.71	909.41	6.06
	2.00	141.67	5.94	36.70	4.75	7.48	5.43	7.18	31.37	931.23	6.21
	4.00	145.54	6.17	38.83	5.05	8.02	5.60	7.45	35.60	956.26	6.38
Skipping one irrig. Germinating stage	**0.00**	143.60	5.93	37.80	4.96	7.11	5.48	7.40	33.22	939.87	6.27
	2.00	151.90	6.30	40.30	5.23	7.81	5.63	8.04	35.70	967.14	6.45
	4.00	154.87	6.45	42.50	5.44	8.56	5.88	8.84	41.20	1002.40	6.68
Skipping one irrig. Ripening stage	**0.00**	150.90	6.10	39.78	5.27	7.49	5.64	8.20	37.50	949.86	6.33
	2.00	158.44	6.75	41.20	5.81	8.23	5.80	8.49	40.43	1001.86	6.68
	4.00	163.43	7.02	44.66	6.04	8.64	6.04	9.23	44.33	1049.17	6.99
LSD $_{0.05}$		**2.62**	**0.19**	**3.69**	**0.29**	**0.66**	**0.29**	**0.41**	**4.11**	**50.40**	**0.15**
120 days after sowing											
Control Treat. (No skipping) stage	**0.00**	146.75	6.12	39.29	6.12	7.83	5.15	9.39	43.24	949.05	6.33
	2.00	151.90	6.56	42.23	6.52	8.59	5.43	9.93	45.76	1003.75	6.69
	4.00	156.38	6.85	45.25	7.12	8.95	5.82	10.03	50.23	1050.30	7.00
Skipping one irrig. tillering stage	**0.00**	129.20	4.93	32.82	4.64	6.24	4.66	7.96	34.68	876.37	5.84
	2.00	134.70	5.40	35.10	5.04	6.55	4.91	8.47	36.67	888.00	5.92
	4.00	140.60	5.67	37.30	5.41	7.21	4.82	8.88	39.38	921.24	6.14
Skipping one irrig. germinating stage	**0.00**	140.83	5.50	35.83	5.77	7.05	4.85	8.24	36.80	894.82	5.97
	2.00	146.10	5.77	38.18	6.04	7.54	5.12	8.91	39.50	925.02	6.17
	4.00	148.90	6.12	40.18	6.21	7.94	5.40	9.27	43.30	962.31	6.42
Skipping one irrig. ripening stage	**0.00**	144.30	5.77	37.70	5.90	7.30	5.02	8.81	39.20	922.56	6.15
	2.00	149.30	6.21	40.50	6.31	8.10	5.28	9.20	44.00	970.00	6.47
	4.00	152.53	6.58	42.40	6.64	8.42	5.56	9.50	47.10	998.01	6.65
LSD $_{0.05}$		**3.69**	**0.29**	**3.00**	**0.37**	**0.55**	**0.20**	**0.23**	**2.87**	**51.62**	**0.21**

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Table 12: Effect of interaction between cultivars and water stress on growth and arginine concentrations on chemical constituents of wheat plant (Average of 2017/2018 and 2018/2109 seasons).

Water stress treats.	Ar Concen (mM/l)	Photosynthetic pigments content per blades (mg/g) dry weight								Total Carb. (%)	Crude protein (%)
		110 days after sowing				120 days after sowing					
		Chl a	Chl b	Chl (a+b)	Car.	Chl A	Chl b	Chl(a+b)	Car.		
Control Treat. (No skipping) stage	**0.00**	2.90	1.22	4.12	2.10	2.78	1.09	3.87	1.91	82.63	11.90
	2.00	3.04	1.34	4.38	2.16	2.86	1.17	4.03	2.00	82.87	12.21
	4.00	3.25	1.47	4.72	2.23	3.04	1.23	4.27	2.09	83.17	12.27
Skipping one irrig. tillering stage	**0.00**	2.49	0.89	3.38	1.61	2.35	0.75	3.10	1.45	80.17	12.04
	2.00	2.59	0.96	3.55	1.72	2.48	0.80	3.28	1.71	80.62	12.31
	4.00	2.74	1.09	3.83	1.78	2.62	0.92	3.54	1.76	80.72	12.41
Skipping one irrig. Germinating stage	**0.00**	2.66	1.02	3.68	1.76	2.51	0.87	3.38	1.58	81.39	11.94
	2.00	2.77	1.08	3.85	1.83	2.62	0.95	3.57	1.79	81.87	12.29
	4.00	2.85	1.25	4.1	1.87	2.69	1.04	3.73	1.80	82.41	12.37
Skipping one irrig. ripening stage	**0.00**	2.77	1.09	3.86	1.85	2.57	0.93	3.50	1.75	82.04	11.87
	2.00	2.87	1.16	4.03	1.99	2.75	1.08	3.83	1.83	81.86	12.25
	4.00	3.05	1.32	4.37	2.07	2.86	1.21	4.07	1.91	82.81	12.32
LSD $_{0.05}$		**0.12**	**0.11**	**0.31**	**0.06**	**0.16**	**0.09**	**0.28**	**0.07**	**0.40**	**0.12**

Table 13: Effect of interaction between water stress on growth characters and arginine concentrations on yield and its components of wheat plant (Average of 2017/2018 and 2018/2019 seasons).

Water stress treats.	ArConcen(mM/l)	No of spikes/ plant	Spikes dry weight (g/plant)	Main spikes length (cm)	Grain index (g)	Grain yield g/plant)	Straw yield g/plant)	Above ground biomass (g/plant)	Grain yield (ton/fed)	Straw yield (ton/fed)	Above ground biomass (ton/fed)	Migration coefficient	Harvest index	Crop index
Control Treat. (No skipping) stage	**0.00**	6.24	22.47	16.45	35.45	16.65	21.69	38.34	2.98	3.35	6.33	0.59	0.89	0.47
	2.00	6.68	23.79	19.14	37.59	18.17	23.27	41.54	3.23	3.51	6.74	0.57	0.92	0.48
	4.00	6.97	27.46	20.46	39.51	20.50	26.70	47.20	3.38	3.64	7.02	0.58	0.93	0.48
Skipping oneirrig. tillering stage	**0.00**	5.03	14.93	11.68	29.37	10.53	15.67	26.20	2.43	2.98	5.41	0.55	0.82	0.45
	2.00	5.50	16.78	13.31	31.03	11.76	17.69	29.45	2.57	3.18	5.75	0.57	0.81	0.45
	4.00	5.78	21.21	16.06	33.76	14.29	18.93	33.22	2.66	3.27	5.93	0.64	0.81	0.45
Skipping oneirrig. germinating stage	**0.00**	5.60	16.83	13.76	30.36	12.24	18.68	30.82	2.61	3.07	5.68	0.54	0.85	0.46
	2.00	5.87	18.85	15.51	31.92	13.83	20.43	34.26	2.96	3.19	6.15	0.55	0.93	0.48
	4.00	6.24	23.29	18.51	34.91	15.83	21.84	37.67	3.12	3.36	6.48	0.62	0.93	0.48
Skipping oneirrig. ripening stage	**0.00**	5.87	19.25	15.08	32.34	14.11	20.38	34.49	2.76	3.02	5.78	0.56	0.91	0.48
	2.00	6.33	20.77	15.78	34.46	15.56	21.53	37.09	3.06	3.26	6.32	0.56	0.94	0.48
	4.00	6.70	25.31	19.47	36.76	17.81	24.63	42.44	3.26	3.50	6.76	0.60	0.93	0.48
LSD $_{0.05}$		**0.37**	**3.34**	**2.29**	**0.29**	**0.40**	**1.58**	**0.54**	**0.32**	**0.16**	**0.29**	**0.01**	**ns**	**ns**

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Table 14: Effect of three way interaction cultivars X water stress X arginine concentrations on growth characters of wheat plant (Average of 2017/2018and 2018/2019 seasons).

Cultivars	Water stress treats	ArConcen (mM/l)	Plant height (cm)	No./plant			Dry weight (g/plant)			Flag leaf blade area	Blades area (cm^2)/ plant	LAI
				Tiller	Blades	Spikes	Tiller + shoots	Blades	Spikes			
110 days after sowing												
Gemiza-9	Control Treat. (No skipping) stage	0.00	161.25	6.32	40.50	5.40	8.27	5.47	8.40	36.51	932.52	6.21
		2.00	159.00	6.66	44.50	6.12	8.94	5.65	8.55	40.70	1005.48	6.71
		4.00	173.10	7.29	48.33	6.50	9.40	6.55	9.32	44.66	1070.47	7.14
	Skipping one irrig. tillering stage	0.00	138.25	5.30	34.22	4.30	6.81	5.12	5.82	25.96	901.37	6.00
		2.00	144.10	5.40	36.90	4.50	7.73	5.29	6.81	28.96	926.64	6.18
		4.00	148.90	5.67	38.70	4.90	7.91	5.49	6.96	32.67	936.36	6.24
	Skipping one irrig. Germinating stage	0.00	146.50	5.60	37.80	4.50	7.24	5.34	6.89	32.34	914.76	6.16
		2.00	154.60	5.80	40.00	4.90	8.18	5.57	7.99	33.22	934.20	6.23
		4.00	158.20	5.90	44.00	5.17	8.68	5.82	8.55	39.16	949.64	6.46
	Skipping one irrig. Ripening stage	0.00	152.90	5.90	39.25	4.90	7.67	5.61	7.73	35.67	926.91	6.18
		2.00	161.80	6.50	40.00	5.42	8.47	5.77	8.14	37.95	963.68	6.43
		4.00	166.60	6.80	46.12	5.60	8.81	5.91	9.20	41.58	1020.70	6.81
Misr-2	Control Treat. (No skipping) stage	0.00	157.90	6.84	41.60	5.95	7.76	5.78	8.75	41.58	992.95	6.62
		2.00	166.10	7.29	44.30	6.50	8.34	6.11	8.88	48.18	1062.72	7.08
		4.00	167.80	7.40	46.80	7.00	9.01	6.53	9.58	49.83	1103.33	7.35
	Skipping one irrig. tillering stage	0.00	135.80	5.90	33.80	4.60	6.88	5.35	7.07	31.46	917.46	6.11
		2.00	139.20	6.50	36.50	5.04	7.22	5.58	7.55	33.77	935.82	6.24
		4.00	141.80	6.67	38.90	5.25	8.12	5.70	7.93	38.50	976.17	6.51
	Skipping one irrig. Germinating stage	0.00	139.90	6.25	37.80	5.40	6.96	5.61	7.90	34.10	964.98	6.43
		2.00	148.80	6.80	40.20	5.60	7.44	5.70	8.08	38.17	1000.08	6.66
		4.00	151.50	7.00	41.00	5.75	8.41	5.94	9.12	43.23	1035.72	6.90
	Skipping one irrig. ripening stage	0.00	148.90	6.50	40.30	5.67	7.31	5.66	8.65	39.27	972.81	6.49
		2.00	155.10	7.00	42.50	6.20	7.97	5.81	8.84	42.90	1040.04	6.93
		4.00	160.20	7.20	44.30	6.50	8.46	6.17	9.26	47.08	1076.76	7.18
$LSD_{0.05}$			**2.97**	**0.22**	**4.18**	**0.31**	**0.74**	**0.32**	**0.47**	**4.66**	**57.02**	**0.17**
120 days after sowing												
Gemiza-9	Control Treat. (No skipping) stage	0.00	148.40	5.80	39.70	5.80	8.10	5.11	8.84	39.18	926.32	6.18
		2.00	154.00	6.30	42.30	6.20	8.79	5.37	9.41	41.80	949.75	6.33
		4.00	158.50	6.70	45.20	7.00	9.18	5.78	9.54	46.20	1020.60	6.93
	Skipping one irrig. tillering stage	0.00	132.60	4.70	32.80	4.40	6.33	4.55	7.60	31.90	840.24	5.61
		2.00	141.70	5.00	35.00	4.70	6.78	4.75	8.40	34.67	861.95	5.75
		4.00	147.70	5.40	37.80	5.25	7.60	4.88	8.55	37.18	872.64	5.82
	Skipping one irrig. Germinating stage	0.00	144.50	5.40	34.70	5.40	7.21	4.76	7.91	34.32	859.14	5.72
		2.00	147.90	5.60	37.80	5.60	7.82	5.01	8.68	37.62	868.86	5.79
		4.00	151.50	5.80	40.60	5.90	8.24	5.27	9.04	43.45	903.69	5.64
	Skipping one irrig. ripening stage	0.00	146.60	5.60	37.50	5.60	7.53	4.88	8.62	36.85	890.11	5.93
		2.00	151.10	5.90	39.50	5.90	8.40	5.20	8.91	39.60	906.12	6.04
		4.00	154.00	6.50	41.90	6.25	8.65	5.38	9.25	44.00	936.90	6.24
	Control Treat. (No skipping) stage	0.00	145.00	6.50	38.90	6.50	7.54	5.19	9.94	45.10	972.00	6.48
		2.00	150.00	6.80	42.10	6.80	8.20	5.50	10.43	49.72	1057.75	6.84
		4.00	151.00	7.00	45.40	7.20	8.71	5.87	10.52	54.26	1080.00	7.20

Misr-2	**Skipping one irrig. tillering stage**	**0.00**	126.00	5.20	32.50	4.90	6.15	4.75	8.31	37.40	912.49	6.08
		2.00	128.00	5.80	35.10	5.40	6.31	5.06	8.55	39.82	914.04	6.09
		4.00	135.00	5.90	36.70	5.60	6.81	5.70	9.22	41.58	969.84	6.47
	Skipping one irrig. germinating stage	**0.00**	137.20	5.58	36.90	6.17	6.89	4.92	8.55	39.27	930.50	6.20
		2.00	144.40	5.90	38.60	6.30	7.26	5.23	9.13	41.36	981.18	6.54
		4.00	146.00	6.50	40.00	6.50	7.64	5.51	9.50	43.12	1020.92	6.80
	Skipping one irrig. ripening stage	**0.00**	142.00	5.90	37.90	6.20	7.06	5.04	9.03	41.58	955.00	6.37
		2.00	147.00	6.50	41.10	6.67	7.76	5.37	9.48	48.40	1033.88	6.89
		4.00	151.00	6.70	43.00	7.00	8.18	5.74	9.74	50.16	1059.10	7.06
	LSD $_{0.05}$		**4.18**	**0.33**	**3.40**	**0.41**	**0.55**	**0.23**	**0.26**	**3.25**	**63.55**	**0.24**

Table 15: Effect of three way interaction cultivars X water stress X arginine concentrations on chemical constituents of wheat plant (Average of 2017/2018 and 2018/2019 seasons).

Cultivars	Water stress treats.	ArConcen (mM/l)	Photosynthetic pigments content per blades (mg/g) dry weight								Total Carb. (%)	Crude protein (%)
			110 days after sowing				120 days after sowing					
			Chl a	Chl b	Chl(a+b)	Car.	Chl A	Chl b	Chl(a+b)	Car.		
Gemiza-9	**Control Treat. (No skipping) stage**	**0.00**	2.85	1.19	4.04	2.04	2.76	1.07	3.83	1.89	85.70	11.43
		2.00	2.99	1.29	4.28	2.08	2.82	1.13	3.95	1.93	86.03	11.73
		4.00	3.20	1.44	4.64	2.21	2.91	1.23	4.14	2.05	86.32	11.76
	Skipping one irrig.tilleringstage	**0.00**	2.44	0.81	3.25	1.56	2.29	0.71	3.00	1.42	82.33	11.56
		2.00	2.53	0.88	3.41	1.69	2.45	0.77	3.22	1.63	83.13	11.83
		4.00	2.68	0.96	3.64	1.77	2.53	0.86	3.39	1.69	83.21	11.87
	Skipping one irrig. germinating stage	**0.00**	2.57	0.95	3.52	1.72	2.47	0.81	3.28	1.56	84.16	11.45
		2.00	2.71	1.00	3.71	1.77	2.56	0.90	3.46	1.74	84.71	11.81
		4.00	2.75	1.18	3.93	1.85	2.61	0.99	3.60	1.75	85.48	11.82
	Skipping one irrig. ripening stage	**0.00**	2.69	1.08	3.77	1.80	2.54	0.89	3.43	1.68	85.05	11.34
		2.00	2.85	1.12	3.97	1.97	2.73	1.02	3.75	1.76	85.18	11.78
		4.00	3.08	1.30	4.38	2.02	2.81	1.17	3.98	1.89	86.08	11.86
Misr-2	**Control Treat. (No skipping) stage**	**0.00**	2.94	1.25	4.19	2.17	2.79	1.11	3.90	1.94	86.09	11.45
		2.00	3.08	1.38	4.46	2.23	2.89	1.19	4.08	2.07	86.27	11.76
		4.00	3.31	1.50	4.81	2.26	3.16	1.22	4.38	2.13	86.59	11.86
	Skipping one irrig.tillering stage	**0.00**	2.54	0.99	3.53	1.64	2.42	0.78	3.20	1.49	84.36	11.59
		2.00	2.65	1.02	3.67	1.74	2.51	0.82	3.33	1.77	84.48	11.84
		4.00	2.80	1.21	4.01	1.79	2.72	0.97	3.69	1.82	84.61	12.01
	Skipping one irrig. germinating stage	**0.00**	2.76	1.09	3.85	1.80	2.56	0.94	3.50	1.61	85.05	11.51
		2.00	2.84	1.14	3.98	1.85	2.70	0.98	3.68	1.84	85.51	11.82
		4.00	2.93	1.32	4.25	1.88	2.75	1.07	3.82	1.85	85.85	11.97
	Skipping one irrig. ripening stage	**0.00**	2.85	1.10	3.95	1.89	2.59	0.95	3.54	1.80	85.35	11.47
		2.00	2.89	1.18	4.07	2.01	2.76	1.12	3.88	1.88	85.96	11.79
		4.00	3.01	1.34	4.35	2.10	2.89	1.25	4.14	1.94	86.10	11.92
	LSD $_{0.05}$		**0.16**	**0.12**	**0.36**	**0.06**	**0.17**	**0.10**	**0.31**	**0.08**	**0.47**	**ns**

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Table 16: Effect of three way interaction cultivars X water stress X arginine concentrations on yield and its components of wheat plant (Average of 2017/2018 and 2018/2019 seasons).

Cultivars	Water stress treats.	ArConcen. (mM/L)	No of spikes/ plant	Spikes dry weight (g/plant)	Main spikes length (cm)	Grain index (g)	Grain yield g/plant)	Straw yield g/plant)	Above ground biomass (g/plant)	Grain yield (ton/fed)	Straw yield (ton/fed)	Above ground biomass (ton/fed)	Migration coefficient	Harvest index	Crop index
	Control Treat.	**0.00**	5.86	21.57	15.54	34.24	16.21	22.37	38.58	2.89	3.47	6.36	0.56	0.83	0.45
	(No skipping)	**2.00**	6.33	22.51	18.59	36.22	17.75	24.90	42.65	3.14	3.55	6.69	0.53	0.88	0.47
	stage	**4.00**	7.15	26.20	20.02	38.52	19.14	27.50	46.64	3.29	3.68	6.97	0.56	0.89	0.47
Gemiza-9	**Skipping**	**0.00**	4.51	13.79	11.00	28.78	9.51	16.11	25.62	2.34	3.07	5.41	0.54	0.76	0.43
	oneirrig. tillering	**2.00**	4.76	16.14	13.09	29.96	10.86	18.38	29.24	2.46	3.28	5.72	0.55	0.75	0.43
	stage	**4.00**	5.34	20.02	14.85	32.64	13.88	19.36	33.24	2.56	3.33	5.86	0.60	0.77	0.44
	Skipping	**0.00**	5.50	16.31	12.65	29.15	11.53	18.25	29.78	2.55	3.14	5.69	0.55	0.81	0.45
	oneirrig.	**2.00**	5.86	17.90	14.74	30.03	13.32	20.18	33.50	2.89	3.21	6.10	0.53	0.90	0.47
	germinating stage	**4.00**	6.05	22.55	17.60	33.17	14.78	22.05	36.83	2.99	3.43	6.42	0.61	0.87	0.47
	Skipping	**0.00**	5.69	18.43	13.71	31.51	13.47	20.84	34.31	2.67	3.08	6.75	0.54	0.87	0.46
	oneirrig.	**2.00**	6.05	19.76	17.27	33.81	15.23	21.81	37.04	2.97	3.28	6.25	0.53	0.91	0.48
	ripening stage	**4.00**	6.38	24.24	19.14	36.06	17.10	25.54	42.64	3.20	3.54	6.64	0.57	0.90	0.47
	Control Treat.	**0.00**	6.60	23.35	17.34	36.65	17.09	21.02	38.11	3.07	3.22	6.29	0.61	0.95	0.49
	(No skipping)	**2.00**	6.96	25.07	19.69	38.95	18.57	22.37	40.94	3.32	3.46	6.78	0.61	0.96	0.49
	stage	**4.00**	7.34	28.70	20.90	40.50	21.85	25.89	47.74	3.46	3.60	7.06	0.60	0.96	0.49
	Skipping	**0.00**	4.95	14.97	12.35	29.96	11.55	15.23	26.78	2.52	2.89	5.41	0.56	0.87	0.47
	oneirrig. tillering	**2.00**	5.50	17.40	13.53	32.10	12.65	17.01	29.66	2.68	3.07	5.75	0.59	0.87	0.47
	stage	**4.00**	5.69	22.34	17.27	34.83	14.70	18.07	32.77	2.75	3.21	5.96	0.68	0.86	0.46
	Skipping	**0.00**	6.24	17.37	14.86	32.10	12.95	19.10	32.05	2.67	2.98	5.65	0.54	0.90	0.47
	oneirrig.	**2.00**	6.44	19.80	16.28	33.81	14.33	20.69	35.02	3.02	3.15	6.17	0.56	0.96	0.59
Misr-2	**germinating stage**	**4.00**	6.60	24.01	19.42	36.65	16.88	21.63	38.51	3.24	3.28	6.52	0.62	0.99	0.50
	Skipping	**0.00**	6.33	20.08	16.45	33.17	14.75	19.91	34.66	2.85	2.97	5.82	0.58	0.96	0.49
	oneirrig.	**2.00**	6.79	21.63	17.88	35.10	15.89	21.25	37.14	3.14	3.24	6.38	0.58	0.97	0.49
	ripening stage	**4.00**	7.15	26.38	19.80	37.45	18.50	23.73	42.23	3.36	3.45	6.81	0.63	0.97	0.49
	LSD $_{0.05}$	**0.42**	**3.78**	**2.59**	**0.52**	**0.45**	**1.12**	**0.61**	**0.37**	**0.08**	**0.31**	**0.05**	**ns**	**ns**	**0.42**

Conclusion

Drought reduced all yield parameters so, the application of foliar application with arginine (Ar) improved productivity of wheat plants and its components and increasing some chemicals composition of wheat grains under drought stress conditions. The Arginine foliar spray with 4.00 mM is the most effective treatment to enhance yield of wheat cv., Misr-2 plants and improve the grain quality under common irrigation compared with the other treatments. Results also indicated that treatment of wheat (*Triticum aestivum* L.) cv., Misr-2 with foliar plant with arginine as an amino acid was the most suitable significant material used to alleviate the harmful effect under drought conditions.

Conflict of interest

The authors declared that present study was performed in absence of any conflict of interest.

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