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Productivity of Wheat Cultivars as Affected by Seeding Methods and Reflectant Application under Water Stress Condition

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Abstract: A field experiment was executed on two wheat varieties (Sakha 93 and Giza 168) grown in clay loam soil under limited water condition at the agricultural experimental station of National Research Centre, Shalakan, Kalubia Governorate, for improving water stress tolerance of wheat plant, using a reflectant ($MgCO_3$), during plant growth. Water shortage had a drastic effect on plant growth, yield and nutrient content, however reflectant treatment under limited water condition and different cultivation methods (ridges, drilling and hills) at milky and maturity stages showed great variations. It was proved that reflectant application increased plant yield to match with normal irrigation condition although growth parameters and nutrient contents did not show a clear significant improvement. Sakha 93 wheat variety surpassed Giza 168 in resisting water stress. The drilling cultivation method surpassed ridges and hills, also a clear increase in K^+ content was observed in cultivation under water shortage condition and reflectant application.

Key words: Wheat varieties, water shortage, reflectant, cultivation method, growth, yield, nitrogen, potassium, phosphorus

INTRODUCTION

In the physiological mechanism of drought avoidance. Levitt[1] recognized maintenance of favourable water status in plants through either efficient stomatal regulation (water savers) or high root activity (water spenders). Plant water relation research on drought and other abiotic stresses has shifted emphasis from the monitoring of durnal and temporal oscillations to the identification of yield-related traits[2]. Since the recognition of the analytical approach to crop improvement under water-limiting conditions, the use of physiological traits has been extensively advocated[3].

Water stress in wheat changes patterns of plant growth and development. Depressed water potential suppresses cell division, organ growth, net photosynthesis, protein synthesis and alters hormonal balances of major plants tissues[4]. Tolerance implies relative stability of economic yield from the wheat crop in the presence of varying levels of water stress. Although stress typically depresses grain yield[5], stress can elevate the value of other components of economic yield, such as quantity of grain protein[6].

Wheat plant may react against drought stress by increasing pubescence on the leaves. If the hairs are shiny and reflective they help to reduce the heat load on the leaves and hence the transpiration rate. So, natural plant defensive mechanism sprouted out the idea of using reflectants.

Dusting or spraying plants with reflectants might be advantageous to try to breed or select plants with a higher leaf albedo as a natural mean of reducing transpiration.

Also the reflected light may penetrate the interior of the plant canopy where normally the leaves are too shaded for maximum photosynthesis[7].

Hagras[8] and El-Kholy[9] found that drilling seeding method at 30 cm between rows gave the highest values of the most yield components of wheat cultivars.

Thus the aim of the present investigation was to improve water stress tolerance of wheat plant, using a reflectant ($MgCO_3$) and studying its effect on wheat varieties growth, yield and chemical composition grown under different cultivation methods and water limited condition.

MATERIALS AND METHODS

A field experiment was conducted during two successive seasons of 2001/2002 and 2002/2003 at the Agricultural Experimental station of National Research Centre, Shalakan, Kalubia Governorate. The preceded

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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 dS m^{-1}, Ca^{++}, 1.1, Mg^{++}, 0.5, Na^{+}, 1.3, K^{+}, 0.8, HCO_3^{-}, 0.4, Cl^{-}, 2.0, SO_4^{--}, 0.58 (meq L^{-1}).

The statistical design was split-split plot with three replicates. The main plot included the irrigation treatment, while the cultivation methods, different varieties and reflectant (antitranspirant) application were distributed in subplots. Foliar spraying was conducted twice at 55 and 65 days after sowing.

The design of the experiment was as follows :

- Normal irrigation,
- Water shortage-at milky stage once and another at-maturity stage,
- Water shortage at milky stage + reflectant application ($MgCO_3$),
- Water shortage at maturity stage + reflectant application,
- Three cultivation methods (hills, ridges and lines),
- Two wheat varieties Sakha 93 and Giza 168

Wheat seeds (*Triticum aestivum* L.) Cv. Sakha 93 and Giza 168 were sown on December 12th K fertilizer was added at the rate of 50 kg/fed, calcium superphosphate (15.5% P_2O_5) was added at the rate of 100 kg/fed before planting, whereas nitrogen fertilizers as ammonium nitrate (33.5% N) at the rate of 80 kg N/fed divided equally before the first and second irrigation.

At harvest, ten plants were selected randomly from the three replicates for each treatment for estimating plant height, spikes number/m^2, grain yield ton/fed, grain weight/m^2, straw yield ton/fed, biological yield ton/fed, yield index (%), harvest index (%), 100 grain weight, spike length cm, grain weight/spike and grain weight/plant (g). Chemical analysis was carried out for estimation of N, P, K and protein according to AOAC[10].

Also Nitrogen, phosphorus and potassium contents were determined according to the methods described in AOAC[10] and protein calculated by multiplying nitrogen % by 5.7 (constant).

The combined data of two successive seasons were statistically analyzed according to Snedecor and Cochran[11]. Means of various treatments were compared by Duncan's Multiple Range test[12] at 5% probability level.

RESULTS

From Table 1 it was clear that variety Sakha 93 surpassed variety Giza 168 regarding the following characteristic (spikes number/m^2, grain wt./m^2, grain yield ton/fed, straw yield and biological yield, 100 grain weight, grain weight/spike and grain weight/plant at the milky stage. On the other hand variety Giza 168 overcame variety Sakha 93 for plant height, spike number/plant and spike length (cm). Moreover it was found that no significant differences were recorded between the two varieties for crop index and harvest index. At maturity stage it was found that variety Sakha 93 overcame variety Giza 168 in grain wt./m^2, straw yield ton/fed and biological yield, while Giza 168 showed superiority for plant height, spike number/plant and crop index. It is worthy to mention that both parameters of grain yield and harvest index were not significant between the two varieties.

Table 1 indicated the effect of different seeding methods at milky stage the cultivation of wheat on ridges surpassed the other methods of seeding (i.e. drilling and hills) for spike number/m^2.

With respect to grain wt./m^2 no significant differences were recorded between the two other cultivated methods (ridges and drilling). On the other hand drilling cultivation method surpassed the two other methods in 100 grain weight. For biological yield it was observed that there were no significant differences between the three cultivation methods for most of growth and yield parameters.

Of maturity stage no significant variations were recorded between the diverse cultivation methods regarding plant height, spike number/plant, tillers number/plant, straw and grain yield ton/fed (Table 1). On the other hand significant differences were found among the three seeding methods for grain weight/m^2, biological yield ton/fed, crop index and harvest index percentages, where the superiority was for the drilling cultivation method. Moreover no significant differences were found between ridges and drilling for grain weight/m^2 and biological yield.

The effect of water shortage and reflectant application in comparison to normal irrigation on different growth and yield parameters of wheat at milky stage was presented in Table 1. It is worthy to mention that the normal irrigation achieved the highest values for all tested parameters, except for straw yield ton/fed. Water shortage affected negatively various growth and yield parameters.

Inclusion the addition of antitranspirant improved significantly the water shortage treatment. No significant difference were recorded for grain yield ton/fed and straw yield ton/fed. between the three studied irrigation methods.

As to spikes number/m^2, (variety Sakha 93) the application of antitranspirant ($MgCO_3$) under water shortage condition gave similar results as that of normal

Table 1: Effect of seeding methods and irrigation on growth and yield components of wheat cultivars

	Treatments									
	Cultivar				Seeding methods					
	Giza 168		Sakha 93		Ridges		Durilling		Hills	
	Milky	Maturity	Milky	Maturity	Milky	Maturity	Milky	Maturity	Milky	Maturity
Plant height (cm)	100.91a	100.83a	96.13b	96.78b	98.31	98.78	98.86	99.14	98.39	98.50
Spike length (cm)	12.19a	11.91a	11.07b	10.92b	11.75a	11.73a	11.26b	10.03b	11.88a	11.49a
No. of spike/plant	3.52a	3.73a	3.13b	2.83b	3.38	3.19	3.33	3.31	2.26	3.33
No. of grains/spike	69.20	70.00a	68.30	66.50b	69.80	69.20	67.00	67.20	69.40	68.40
Spike grains weight (g)	2.18b	2.17b	2.32a	2.26a	2.26	2.26	2.26	2.21	2.23	2.17
100-grains weight (g)	3.13b	3.12b	3.39a	3.39a	3.24b	3.24b	3.34a	3.32a	3.20b	3.21b
Grains weight/plant (g)	8.17b	8.17b	8.70a	8.59a	8.54	8.48	8.41	8.33	8.35	8.33
No. of spikes/m^2	266.60b	267.50b	280.60a	278.80a	277.60a	274.00ab	271.3b	276.00a	272.00b	269.50b
Grains weight/m^2 (g)	581.20b	853.10b	665.70a	657.90a	631.90a	624.20a	623.2ab	631.80a	615.30b	605.40b
Grains yield fed/ton	2.32b	2.33b	2.62a	2.59a	2.52	2.491	2.449	2.484	2.453	2.413
Straw yield fed/ton	2.836b	2.841b	3.31a	3.32a	3.124	3.081	3.075	3.099	3.021	3.069
Biological yield fed/ton	5.190b	5.195b	5.96a	5.95a	5.67a	5.60a	5.58ab	5.64a	5.48b	5.48b
Crop index (%)	44.70	44.80a	44.60	44.00b	44.50	44.40ab	44.70	44.80a	44.80	44.00b
Harvest index (%)	81.10	81.10	81.10	79.50	79.70	80.10b	81.90	82.00a	81.60	78.90b

	Treatments					
	Irrigation					
	Normal		Storage		Sotrage+Reflectant	
	Milky	Maturity	Milky	Maturity	Milky	Maturity
Plant height (cm)	101.42a	101.42a	96.89b	96.44c	97.25b	98.56b
Spike length (cm)	11.74a	11.74a	11.76a	11.25b	11.38b	11.26b
No. of spike/plant	3.55a	3.55a	3.45a	3.00c	2.98b	3.29b
No. of grains/spike	68.90	68.90	69.10	67.70	68.20	68.10
Spike grains weight (g)	2.33	2.33a	2.22	2.08b	2.20	2.22a
100-grains weight (g)	3.42a	3.42a	3.19b	3.09c	3.17b	3.25b
Grains weight/plant (g)	8.98a	8.99a	8.15b	7.72c	8.16b	8.44b
No. of spikes/m^2	284.00a	284.00a	266.20b	262.30c	270.70b	273.30b
Grains weight/m^2 (g)	691.60a	691.60a	583.20b	550.60c	595.60b	619.30b
Grains yield fed/ton	2.711a	2.71a	2.30b	2.20c	2.38b	2.47b
Straw yield fed/ton	3.109a	3.109	2.93b	3.017	3.176a	3.12
Biological yield fed/ton	5.92a	5.92a	5.25c	5.22c	5.56b	5.58b
Crop index (%)	46.70a	46.70a	44.30b	42.30c	43.00c	44.30b
Harvest index (%)	88.3a	88.3a	79.10b	73.30c	75.90c	79.50b

Table 2: The interaction between irrigation, seeding methods and wheat cultivars on growth yield of wheat plant at Milky Stage

	Treatments									
	Irrigation									
	Cultivars						Seeding methods			
	Normal		Shortage		Short.+Reflec.		Normal			Shortage
	Giza 168	Sakha 93	Giza 168	Sakha 93	Giza 168	Sakha 93	Ridge	Drilling	Hills	Ridge
Plant height (cm)	105.6	98.30	98.60	95.20	99.60	94.90	100.30	103.10	100.90	97.30
Spike length (cm)	12.2	11.20	12.00	11.10	11.90	10.80	11.90ab	11.40cd	11.90ab	12.00a
No. of spike/plant	3.5a	3.60a	3.50a	3.40a	3.60a	2.40b	3.60	3.60	3.40	3.50
No. of grains/spike	69.9	86.00	68.50	69.60	69.10	67.30	70.00	67.70	69.10	69.90
Spike grains weight (g)	2.26	2.41	2.17	2.27	2.12	2.27	2.38	2.306	2.26	2.20
100-grains weight (g)	3.13c	3.33b	3.01d	3.59a	3.25b	3.26b	3.36b	3.60a	3.29bc	3.21c-e
Grains weight/plant (g)	8.55	9.43	8.01	8.29	8.00	8.37	9.24	8.84	8.88	8.14
No. of spikes/m^2	284.8a	283.20a	253.90b	278.40a	262.80b	278.70a	283.50ab	286.40a	282.00a-c	276.30b-d
Grains weight/m^2 (g)	644.1	739.00	541.00	624.90	558.00	633.20	691.10b	712.10a	671.50c	599.50d
Grains yield fed/ton	2.325	2.84	2.16	2.49	2.23	2.52	2.74	2.71	2.67	2.39
Straw yield fed/ton	2.935c	2.28b	2.82c	3.06bc	2.76c	3.58a	2.91b-d	3.32a	3.08bc	3.12ab
Biological yield fed/ton	5.600b	2.24a	4.97c	5.53b	4.99c	6.12a	5.78b	6.22a	5.76b	5.48c
Crop index (%)	46.0ab	47.30a	43.50c	45.20bc	44.60bc	41.40d	47.40a	46.20ab	46.40a	43.80cd
Harvest index (%)	85.4b	91.20a	77.10c	81.10c	80.70c	71.00d	90.40a	87.80a	86.70a	75.40cd

Table 2: Continue

	Treatments										
			Cultivars								
	Seeding methods		Seeding methods								
	Shortage		Short.+Reflec.			Giza 168			Sakha 93		
	Drilling	Hills	Ridge	Drilling	Hills	Ridge	Drilling	Hills	Ridge	Drilling	Hills
Plant height (cm)	96.90	96.40	97.30	96.60	97.80	101.10	101.10	100.60	95.60	96.70	96.20
Spike length (cm)	11.10d	12.10a	11.30cd	11.20cd	11.60bc	12.00b	12.10b	12.50a	11.50c	10.40d	11.30c
No. of spike/plant	3.40	3.40	3.00	3.00	2.90	3.50	3.50	3.50	3.20	3.10	3.00
No. of grains/spike	65.00	72.30	69.40	68.40	67.00	70.20a	69.60a	67.70ab	69.40a	64.40b	71.10a
Spike grains weight (g)	2.22	2.23	2.19	2.20	2.19	2.18	2.20	2.16	2.34	2.32	2.29
100-grains weight (g)	3.25cd	3.12e	3.15de	3.16de	3.20c-e	3.10d	3.15d	3.14d	3.39b	3.53a	3.27c
Grains weight/plant (g)	8.22	8.09	8.25	8.17	8.06	8.19	8.20	8.12	8.89	8.62	8.57
No. of spikes/m^2	256.40f	256.90e	273.00c-e	271.10de	268.00de	275.80a	259.70b	264.30b	279.30a	282.90a	279.60a
Grains weight/m^2 (g)	561.20e	588.90d	605.10d	596.40d	585.40d	597.50c	571.10d	575.10d	666.30ab	675.40a	655.50b
Grains yield fed/ton	2.24	2.35	2.42	2.38	2.33	2.39	2.28	2.30	2.65	2.61	2.60
Straw yield fed/ton	2.81d	2.86cd	3.33a	3.07bc	3.11b	2.82	2.89	2.78	3.42	3.25	3.25
Biological yield fed/ton	5.06d	5.22d	5.75b	5.4605c	5.45c	5.29	5.18	5.09	6.05	5.98	5.86
Crop index (%)	44.30cd	45.00bc	42.30e	43.80cd	43.10de	45.00ab	44.00b	45.20a	43.90b	45.50a	44.50ab
Harvest index (%)	79.90bc	82.00b	73.40d	78.10b-d	76.20cd	82.00ab	78.70bc	82.50ab	77.50c	85.20a	80.70bc

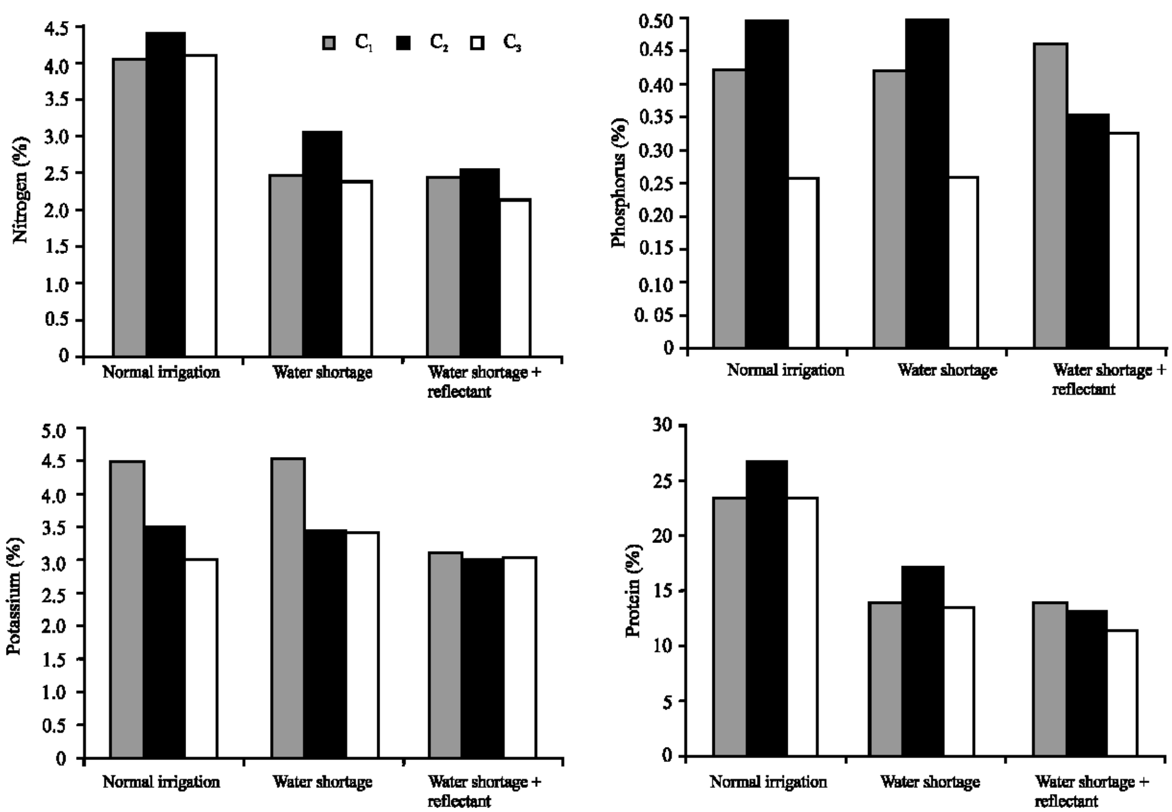

Fig. 1-4: Effect of water shortage and reflectant application on different nutrient content in wheat variety Giza 168 under different seeding methods, C_1 = Ridges, C_2 = Drilling, C_3 = Hills

irrigation method (Table 2). Also, variety Giza 168 cultivated in ridges or hills under water shortage condition and sprayed with the antitranspirant gave comparable insignificant results to the normal irrigation method. Table 2 regarding grain wt./m^2, variety Sakha 93 indicates that the antitranspirant application under water shortage condition resulted in similar results obtained by variety Giza 168 under normal irrigation method. On the other hand, variety Giza 168, did not give results similar to the normal irrigation method under the different cultivation methods where the differences between them were significant. For both straw yield and biological yield, Table 2 revealed that the antitranspirant application under water shortage conditions gave comparable results to that of the normal irrigation method for variety Sakha 93 where the differences between them were not significant. Also variety Giza 168, produced straw yield, under water shortage condition and antitranspirant application, matched the normal irrigation method. While for biological yield, cultivation of Giza 168 Var. on ridges gave a result similar to that cultivated on hills of the same variety under normal irrigation method.

Regarding yield index and harvest index, the antitranspirant application under water shortage treatment, variety Giza 168 produced results matched that obtained with the normal irrigation method, while variety Sakha 93 did not match the results of normal irrigation method (Table 2). On the other hand, variety Sakha 93 under water shortage and antitranspirant application induced results comparable to, with no significant differences, that obtained with the normal irrigation treatment for 100 grain weight. Moreover, for both characters of spiklet length and grains number/spike, Table 2 obtained results showed that the use of antitranpirant under water shortage condition produced similar results to that obtained by normal irrigation method for both varieties.

Table 3 indicated the impact of interaction between water sufficiency, antitranspirant, cultivation methods and wheat varieties on certain yield components at maturity stage. For spiklet length, it was found that variety Sakha 93 cultivated under water shortage and treated with the antiranspirant gave results similar to that obtained the normal water quantity especially those cultivated in drilling and hills where the differences were not significant. Similar results obtained by variety Giza 168 cultivated in ridges or hills under the previous mentioned conditions. Moreover, grains number/spike revealed the same previous trend, where the application of the antitranspirant under water shortage condition induced results, with no significant differences matched with that obtained by normal quantity of water for both varieties under different cultivation methods. Regarding spikes number/m^2, it was observed that variety Sakha 93 cultivated under water shortage and sprayed with the antitranspirant induced results matched with that of the normal irrigation. Furthermore, variety Giza 168 cultivated in drilling under water shortage and treated with the antitranspirant produced results similar to that irrigated with the normal quantity of water, while cultivation methods of ridges and hills gave results similar to that obtained by cultivation in hills and irrigated with the normal water quantity. As to the grain weight/m^2 and grain yield, it was found that significant differences in the favour of the normal irrigation was recorded for variety Sakha 93, while variety Giza 168 cultivated in ridges or drilling under water shortage and treated with the

Table 3: Tri-interaction between irrigation, wheat cultivars and seeding methods on growth and yield of wheat plant at Milky Stage

Treatments Irrigation Cultivar Seeding methods	Normal			Shortage			Shortage+Reflectant		
	Giza 168			Sakha 93			Giza 168		
	Ridge	Drilling	Hills	Ridge	Drilling	Hills	Ridge	Drilling	Hills
Plant height (cm)	103.20bc	106.50a	104.00ab	97.30e-I	99.70d-f	97.80d-h	99.30d-h	99.70d-f	96.80f-I
Spike length (cm)	12.00a-e	12.20a-d	12.50ab	11.80d-g	10.60h-j	11.30fg	12.50a	12.20a-d	12.40a-d
No. of spike/plant	3.50	3.60	3.40	3.70	3.60	3.40	3.60	3.40	3.40
No. of grains/spike	66.50cde	75.10ab	68.10a-e	73.50a-c	60.30e	70.00a-d	70.70a-d	66.50c-e	68.40a-d
Spike grains weight (g)	2.22	2.36	2.18	2.54	2.36	2.34	2.22	2.11	2.17
100-grains weight (g)	3.25c-f	3.27c-e	3.23c-f	3.48b	3.93a	3.35bc	3.09f-h	3.13eg	3.15d-g
Grains weight/plant (g)	8.62	8.56	8.46	9.85	9.13	9.30	7.84	8.16	8.02
No. of spikes/m^2	291.50a	282.00a-c	276.00b-d	275.50b-e	290.80a	289.00ab	273.00c-e	235.80g	253.00f
Grains weight/m^2 (g)	660.30c	665.00c	607.20e	722.00b	759.20a	735.80ab	574.10f	496.50g	553.80f
Grains yield fed/ton	2.64b-e	2.66b-d	2.42e-h	2.85ab	2.77a-c	2.91a	2.29g-I	1.98y	2.21hi
Straw yield fed/ton	2.83de	3.12cd	2.84de	2.99de	3.53b	3.32bc	2.83de	2.78de	2.81de
Biological yield fed/ton	5.72c	5.78c	5.29de	5.84c	6.66a	6.23b	5.12d-f	4.76g	5.02e-g
Crop index (%)	46.00bc	46.00bc	46.00bc	48.80a	46.40b	46.80b	44.80b-d	41.70fg	44.10c-e
Harvest index (%)	85.60b-d	85.30b-d	85.30b-d	95.20a	90.40ab	88.00bc	81.00c-e	71.40fg	78.80de

Table 3: Continue

	Treatments								
	Irrigation Cultivar Seeding methods								
	Shortage			Shortage+Reflectant					
	Sakha 93			Giza 168			Sakha 93		
	Ridge	Drilling	Hills	Ridge	Drilling	Hills	Ridge	Drilling	Hills
Plant height (cm)	95.30hi	94.20i	96.00g-I	100.70c-e	97.00f-I	101.00b-d	94.00i	96.20f-I	94.70hi
Spike length (cm)	11.50e-g	10.10j	11.90c-f	11.40fg	11.90b-f	12.50a-c	11.20gh	10.60ij	10.70fg
No. of spike/plant	3.40	3.40	3.40	3.60	3.60	3.60	2.40	2.40	2.30
No. of grains/spike	69.10a-d	63.60c-e	76.10a-d	73.30a-c	67.40b-e	66.70c-e	65.50c-e	69.30a-d	67.20b-e
Spike grains weight (g)	2.18	2.34	2.28	2.09	2.13	2.14	2.30	2.27	2.25
100-grains weight (g)	3.33bc	3.36bc	3.09f-h	2.96h	3.04gh	3.04gh	3.35b-c	3.29cd	3.35bc
Grains weight/plant (g)	8.43	8.28	8.106	8.11	7.88	7.87	8.39	8.406	8.25
No. of spikes/m^2	279.50a-c	277.00a-d	278.80a-c	263.00d-f	261.30ef	264.00d-f	283.00a-c	281.00a-c	272.00c-e
Grains weight/m^2 (g)	624.90de	626.00de	624.00de	558.10f	551.80f	564.30f	652.10f	641.00cd	606.60cd
Grains yield fed/ton	2.49d-g	2.50d-g	2.48d-g	2.23hi	2.207I	2.25hi	2.609c-f	2.56c-f	2.41f-I
Straw yield fed/ton	3.41bc	2.85de	2.92de	2.81de	2.780de	2.70e	3.86a	3.37bc	3.51b
Biological yield fed/ton	5.84c	5.35d	5.41d	5.04e-g	4.987fg	4.96fg	6.470ab	5.94c	5.95c
Crop index (%)	42.70ef	46.90b	45.90bc	44.20c-e	44.20c-e	45.50bc	40.30g	43.30d-f	40.30g
Harvest index (%)	69.80g	88.40a-c	85.10b-d	79.30de	79.40de	83.50b-e	67.60g	76.80ef	68.80g

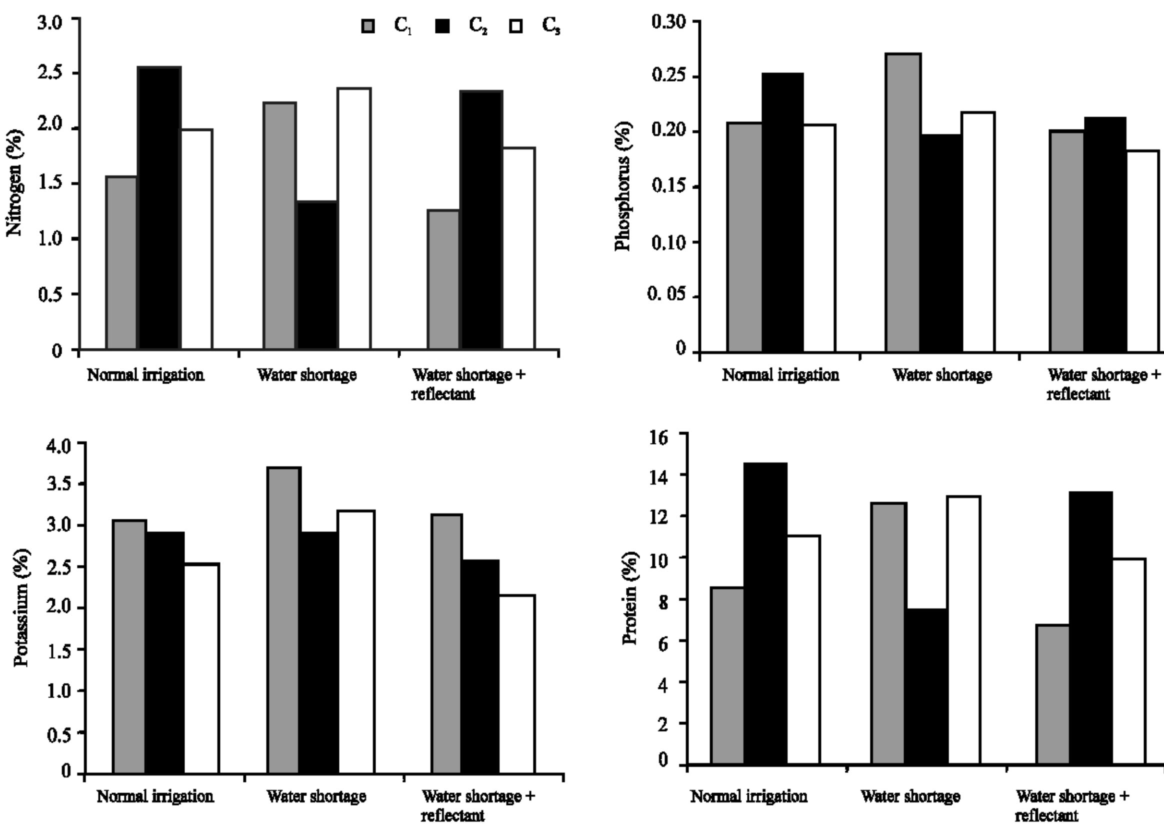

Fig. 5-8: Effect of water shortage and reflectant application on different nutrient content in wheat variety Sakha 93 under different seeding methods, C_1 = Ridges, C_2 = Drilling, C_3 = Hills

antitranspirant gave results similar to that obtained by cultivation in hills under normal irrigation.

Table 3 showed that variety Giza 168 of various cultivation methods and sprayed with the antitranspirant under water shortage condition produced grain yield similar to that obtained under normal irrigation and cultivated in hills. For biological yield, variety Sakha 93 cultivated under water stress and antitranspirant use gave results matched with that produced under normal irrigation and cultivated in either ridges or hills. While variety Giza 168, comparable results to that irrigated normally and cultivated in hills without significant differences. Also crop index for variety Sakha 93. Table 3 showed that cultivation in drilling under water stress and antitranspirant application gave similar results to cultivation under normal irrigation. Moreover, variety Giza 168 treated with antitranspirant and cultivated in drilling or hills matched that irrigated normally without significant differences. As for harvest index, variety Giza 168 treated with antitranspirant under water shortage condition and cultivated in hills was the only one that gave results comparable to normal irrigation and drilling or hills cultivation method, without significant variations.

Generally, the nutrient contents observed in Fig. 1-8 of both wheat varieties, did not show a definite increase in percentage under water shortage and reflectant application. The only recorded increase was for potassium as it showed a positive increase under water shortage condition.

DISCUSSION

Abo El-Kheir[13], Mossad *et al.*[14] and Naceur *et al.*[15] found that plant height, number of green leaves and tillers/plant as well as shoot d.w/plant were significantly decreased by decrease in water supply.

The reduction in growth parameters under low soil moisture conditions may be attributed to losses of tissue water which inhibit cell division and enlargement. Kramer[16] pointed out that water plays a central role in its cell division, enlargement and differentiation of plant organs and its availability often becomes limiting.

Abo El-Kheir[13] and Naceur *et al.*[15] found that the reduction in the yield and its related characters as a result of decreasing water supply may be attributed to the depression in the vegetative growth parameters. In this regard, it has been reported that water stress resulted in disturbance in most of the physiological processes e.g. photosynthesis, protein synthesis, enzyme activity etc. and these affect the metabolites transportation to the grains[16], reduced the number of reproductive tillers which limit their contribution to grain yield[14] and caused pollen sterility[17].

In addition, Thompson and Chase[18] concluded that water stress reduced yield of wheat through decrease in number of spikes/plant, no of grain/spike and individual grain weight.

Antitranspirant use increased the plant[19] explained that antitranspirant increased plant water status, chlorophyll content, biological yield and harvest index coupled with reduced values of water potential and transpiration rate.

The leaf-to-air temperature gradient was significantly and negatively correlated with grain and biological yields at the anthesis stage which indirectly suggests that stomatal closure, a decrease in transpiration and an increase in leaf temperature at anthesis are undesirable traits for higher yield. The reduction in number of tillers produced by water stress was non significant at boot stage, yield attributes caused significant reduction in plant height, grain number, weight, number, yield of tillers and leaves significantly related to grain and biological yields. Leaf turgor potential and rate of transpiration may be categorized as yield positive traits[20].

Importance of water during heading stage which may greatly affect anthesis, pollen viability, fertilization and consequently seed set[21].

The differences in plant height among wheat varieties may be due to their differences in number/or length of internodes and also spike length (genetical differences). Fluctuated values of spikes number/m^2 reflects the vertical difference response to environmental conditions. Sharaan and abd El-Samei[22] reached to similar conclusion.

Sharaan *et al.*[21] concluded that Giza 167 of a superior water use efficiency which may be attributed to its early completion of growth at dough-ripe stage, where it showed the shortest plant height and spike length with the lowest of spikes/m^2 compared to other tested varieties.

Wang and Chu[23] found that spraying antitranpirants increased yield by lowering water loss from plants.

Sarma *et al.*[24] reported that some of the plant antitranspirants have hydro regulatory and stomatal action by increasing K content.

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