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Effect of Iron Nutrient Care Sprayed on Foliage at Different Physiological Growth Stages on Yield and Quality of Some Durum Wheat (*Triticum durum* L.) Varieties in Sandy Soil

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ABSTRACT

The aim of this study is investigate the effect of iron foliar applications at different growth stages on wheat yield and quality in sandy soil. Field experiment was carried out during 2008/2009 and 2009/2010 seasons at the Agriculture Faculty Farm-Sebha University, Libya to study the effect of foliar application by iron nutrient added at various growth stages on the grain and protein yields of some hard wheat varieties in sandy soil under sprinkler irrigation system. Results indicated that durum wheat varieties, iron foliar application, application time and their interaction had a significant ($p \leq 0.05$) effect in plant height, spike length, 1000-grain weight, grain weight spike^{-1}, grain yield ha^{-1}, grain protein content (%) and protein yield ha^{-1} in the tow growing season. Thus, Baney-Suief 2 variety gained the maximum values of all mentioned traits except grain protein content. Otherwise, Karim variety recorded maximum values of grain protein content in both seasons. Application of iron nutrient as foliar treatment by the rates from 200 to 600 ppm enhanced the all above traits as compared to control (untreated treatment) and the superiority in this respect to 600 ppm concentration. Moreover, foliar application at ZGS31 (Zadoks Growth Stage 31) epitasis from other times of application in all studied traits except grain protein content which registered from application at ZGS55. The highest values of grain and protein yields ha^{-1} (6850.1 and 917.9 kg ha^{-1} in first season for grain and protein yields, respectively being 6810.0 and 939.8 kg ha^{-1} in second season in the same order) were obtained from Baney-Suief 2 variety fertilized by 600 ppm of iron nutrient as foliar application at ZGS31.

Key words: Sprinkler irrigation, durum wheat, varieties, iron foliar application, growth stages, grain and protein yields

INTRODUCTION

Wheat crop consider the most important cereal crop in the world with regard to cultivated area and total production. Increasing wheat production in order to reduce the gap between production and consumption are the strategic aim. Wheat genotypes varied significantly in grain yield, yield components, protein content and protein yield (Koc *et al*., 2000). Thus, choosing suitable genotype and sow it in suitable time with correct feeding by essential elements in time, method and amount resulted in higher yield and quality. Micronutrients supplied in optimal forms, amounts, timing and placement will encourage growth and yield. The total amount of micronutrients in variation soils don't usually reflect its availability to plants (McLaren *et al*., 1984).

Micronutrients are in general used in smaller amounts than the macronutrients, but are just as important for optimum yield. Foliar application is more benefits than top dressing in the soil surface. This is due to specific soil conditions where the nutrients can be lost by leaching or fixed by chemical reactions. Iron is one of the important essential micronutrients required for higher plants to complete hive cycle. Iron nutrient is critical for chlorophyll formation, photosynthesis, plant

enzyme systems and respiration (Havlin *et al.*, 1999) and or plays role in biological redox system, enzyme activation and oxygen carrier in nitrogen fixation (Romheld and Marschner, 1991). A symptom of iron reduction appears with high soil pH, free calcium carbonate and low organic matter. Foliar application of iron enhancement seed yield and its quality of wheat compared with non-application (Maralian, 2009; El-Magid *et al.*, 2000; Hekmat *et al.*, 2010; Zeidan *et al.*, 2010). Khan *et al.* (2010) stated that application of iron at different growth stages of wheat significantly improved the number of grains spike^{-1}, 1000-grain weight, grain yield, straw yield, biological yield and harvest index. Also, Seadh *et al.* (2009) found that foliar application by iron at 500 ppm enhanced grain yield, yield component and grain protein content over untreated (control). Foliar treatment of mixture Shelter micronutrients (Zn, Fe, Mn, Cu and B) at various growth stages increased plants height, grains per spike, 1000-grain weight, biological yield, harvest index, straw and grain yield in wheat. Increase the rates of Fe doses up to 12 kg ha^{-1} increased grain yield and its components (Abbas *et al.*, 2009).

The aim of this study is investigate the effect of iron foliar applications at different growth stages on wheat yield and quality in sandy soil.

MATERIALS AND METHODS

To study the effect of foliar application by iron nutrition added at various growth stages on the grain and protein yields of some hard wheat varieties in sandy soil under sprinkler irrigation system, an experiment was carried out at Agriculture Faculty Farm-Sebha University, Libya in 2008/2009 and 2009/2010 seasons. Sebha Co-ordinates are latitude: 27°01' N, longitude: 14°26' E and 432 m above sea level. The soil of the experimental site is sandy, comprising of 92.52% sand, 5.48% silt and 3.0% clay, with pH of 7.8 and EC. 1.2 dS m^{-1}. These experiments were layout in Randomization Completely Blocks Design (RCBD) using split-spilt-plot arrangement with three replicates. The wheat varieties (Baney-Suief 1, Baney-Suief 2 and Karim) were distributed in main plots, while iron concentration{ 0 (control plots were sprayed with distilled water), 200, 400 and 600 ppm} were arranged in sub plots, but the application at different Zadoks growth stages (ZGS21, ZGS31, ZDS55 and ZGS73 as described by Zadoks *et al.* (1974) in sub-sub-plots. Iron sulphate ($FeSO_4.H_2O$) was used a source of iron. The sub-sub-plot area was 10.5 m^{-2}. The grains of previous varieties were hand drill planting in 15 and 20th November in first and second seasons, respectively. Nitrogen, P and K used at 220, 75 and 120 kg ha^{-1} according to the recommendation, from sources of urea (with 46% N), triple super phosphate (with 46% P_2O_5) and potassium sulfate (with 50% K_2O), respectively, were added to all treatments (plots). All other cultural practices were carried out as recommended for wheat production in both seasons.

At harvest, random sample of ten guarded main stems for each experimental unit were taken and plant height (cm), spike length (cm), and grain weight spike^{-1} (g) were determined. 1000-kernel weight (g) and grain yield (kg ha^{-1}) were determined on plot basis. Kernel sample of 25 g from each sub-plot was milled using a 20 mesh laboratory Willy mil and nitrogen content was determined by the semi-micro-kjeldahl method to estimate crude protein percent (AOAC, 1980), then protein yield was calculated by multiplication of protein percentage by grain yield ha^{-1}.

All data collected were analyzed with analysis of variance (ANOVA) Procedures using the MSTAT-C Statistical Software Package (Michigan State University, 1983). Differences between means were compared by LSD at 5% level of significant (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Growth traits: The results showed that durum wheat varieties, iron concentration, time of application and their involved interactions had a significant ($p \leq 0.05$) effect on plant height and

Table 1: Plant height (cm) of some wheat varieties as affected by foliar application of iron nutrient added at different growth stages and their interaction involved

	Seasons									
	2009/2010					2008/2009				
	0	200	400	600	Mean	0	200	400	600	Mean
Varieties	(ppm)					(ppm)				
V1										
ZGS21	80.3	85.6	88.9	92.2	86.8	82.5	88.5	90.6	93.6	88.8
ZGS31	80.3	90.4	92.3	95.6	89.7	91.9	98.3	96.3	90.5	82.5
ZGS55	80.3	84.6	88.0	94.3	86.8	87.7	93.5	88.9	85.8	82.5
ZGS73	80.3	84.3	88.3	90.3	85.8	86.6	93.4	87.2	83.2	82.5
Mean	80.3	86.2	89.4	93.1	87.3	82.5	87.0	90.8	94.7	88.7
V2										
ZGS21	92.2	95.4	99.6	101.3	104.3	85.0	86.0	88.4	92.3	87.9
ZGS31	92.2	103.4	109.3	112.3	97.3	85.0	92.5	96.5	100.4	93.6
ZGS55	92.2	96.5	98.4	102.0	96.3	85.0	85.2	89.3	91.3	87.7
ZGS73	92.2	92.6	98.1	102.1	96.3	85.0	85.3	89.6	90.2	87.5
Mean	92.2	97.0	101.4	104.4	98.5	85.0	87.3	91.0	93.6	89.2
V3										
ZGS21	81.0	87.4	91.2	95.6	88.8	72.5	75.3	79.4	82.5	77.4
ZGS31	81.0	102.5	98.4	91.3	93.3	72.5	92.0	84.6	79.4	82.1
ZGS55	81.0	86.3	91.6	76.3	88.0	72.5	74.5	78.1	80.2	76.3
ZGS73	81.0	85.3	92.0	94.3	88.2	72.5	74.1	79.0	81.1	76.7
Mean	81.0	87.6	93.3	96.4	89.6	72.5	75.8	80.3	84.0	78.1
General mean	84.5	90.3	94.7	98.0	--------	80.0	83.4	87.3	90.7	------
A×C										
ZGS21	84.5	89.5	93.2	96.4	90.9	80.0	83.3	86.1	89.5	84.7
ZGS31	84.5	93.7	97.6	101.2	94.3	80.0	87.5	92.5	96.9	89.2
ZGS55	84.5	89.1	92.7	96.4	90.3	80.0	81.8	85.4	88.3	83.9
ZGS73	84.5	87.4	92.8	95.6	90.1	80.0	80.9	85.3	88.2	83.6
LSD 0.05 for V				1.8					1.5	
LSD 0.05 for C				2.5					2.3	
LSD 0.05 for A				2.4					2.0	
LSD 0.05 for V×C				3.6					3.0	
LSD 0.05 for V×A				3.6					3.3	
LSD 0.05 for C×A				5.0					4.6	
LSD 0.05 for V×C×A				8.6					7.9	

V: Varieties, A: Application time, C: Concentration , V1: Ban3y-Suief 1, , V2: Baney-Suief 2, V3: Karim varieties, ZGS21: Tillering stage (main shoot and one tiller), ZGS31: Stem elongation (first node detectable), ZGS55: Flowering stage (1/2 of inflorescence emerged) and ZGS73: Milk ripe stage (early milk)

spike length in the two growing seasons (Table 1, 2). Baney-Suief 2 variety gave the highest values of mentioned traits(89.2 and 6.4 cm for plant height and spike length in first and second seasons, respectively being 98.5 and 6.3 cm in second season in the same order). While, the lowest values of mentioned traits were obtained from Karim variety in first season (78.1 and 5.7 cm for plant height and spike length, respectively) whereas, the lowest values of mentioned traits in second season (87.3 and 5.9 cm for plant height and spike length, respectively) were obtained from Baney-Suief 1 variety. These differences may be due to the genetic behavior combination with

Table 2: Spike length (cm) of some wheat varieties as affected by foliar application of iron nutrient added at different growth stages and their interaction involved

	Seasons									
	2009/2010					2008/2009				
	0	200	400	600	Mean	0	200	400	600	Mean
Varieties	(ppm)					(ppm)				
V1										
ZGS21	5.0	5.5	5.9	6.3	5.7	5.2	5.7	5.9	6.2	5.8
ZGS31	5.9	6.3	6.8	7.5	5.0	5.2	6.1	6.5	7.0	6.2
ZGS55	6.0	6.8	6.2	5.8	5.0	5.2	5.6	6.0	6.4	5.8
ZGS73	5.0	5.4	5.9	6.4	5.7	5.2	5.4	5.8	6.1	5.6
Mean	5.0	5.7	6.2	6.8	5.9	5.2	5.7	6.1	6.4	5.8
V2										
ZGS21	5.4	5.9	6.5	6.9	6.2	5.6	5.6	6.5	6.9	6.3
ZGS31	5.4	6.5	7.3	8.1	6.8	5.6	6.6	7.2	7.9	6.8
ZGS55	5.4	5.9	6.4	6.8	6.1	5.6	6.0	6.4	6.8	6.2
ZGS73	5.4	5.7	6.6	7.0	6.2	5.6	6.0	6.6	6.9	6.3
Mean	5.4	6.0	6.7	7.2	6.3	6.4	6.2	6.7	5.6	7.1
V3										
ZGS21	5.2	5.6	6.1	6.9	6.0	4.9	5.3	5.9	6.3	5.6
ZGS31	5.2	6.0	6.6	7.5	6.3	4.9	5.8	6.6	7.1	6.1
ZGS55	5.2	6.6	5.9	5.6	5.8	4.9	5.2	5.8	6.4	5.6
ZGS73	5.2	5.5	6.0	5.9	5.9	4.9	5.3	5.8	6.4	5.6
Mean	5.2	5.6	6.2	6.9	6.0	4.9	5.4	6.0	6.6	5.7
General mean	5.2	5.8	6.4	6.9	------	5.2	5.8	6.3	6.7	----
A×C										
ZGS21	5.2	5.7	6.2	6.7	5.9	5.2	5.7	6.1	6.5	5.9
ZGS31	5.9	6.3	6.6	7.3	5.2	5.2	6.2	6.8	7.3	6.4
ZGS55	5.2	5.7	6.2	6.8	6.0	5.2	5.6	6.1	6.5	5.8
ZGS73	5.2	5.5	6.2	6.7	5.9	5.2		6.1	6.5	5.9
LSD 0.05 for V				0.3					0.2	
LSD 0.05 for C				0.4					0.3	
LSD 0.05 for A				0.3					0.3	
LSD 0.05 for V×C				0.6					0.4	
LSD 0.05 for V×A				0.4					0.4	
LSD 0.05 for C×A				0.6					0.6	
LSD 0.05 for V×C×A				0.9					0.9	

environment factors, which were suitable for Baney-Suief 2 variety than the other genotypes. These results are in harmony with those obtained by Koc *et al.* (2000) and Shalaby *et al.* (2006).

Application of iron nutrient at any growth stage by the concentration up to 600 ppm increased significantly plant height and spike length over the control (spray by distiller water). The men values of spike length were 5.2, 5.8, 6.3 and 6.7 cm for control, 200, 400 and 600 ppm of iron, respectively in first season being 5.2, 5.8, 6.4 and 6.9 cm in second season in the same order. Treated wheat plants by foliar iron application at ZGS31 enhanced plant height and spike length. These results might be due to the critical role of iron nutrient in crop growth, involving in photosynthesis processes, respiration and other biochemical and physiological activates (Zeidan *et al.*, 2010). The maximum values of plant height (96.9 and 101.2 cm in first and second

Table 3: 1000-kernel weight (g) of some wheat varieties as affected by foliar application of iron nutrient added at different growth stages and their interaction involved

	Seasons									
	2009/2010					2008/2009				
	0	200	400	600	Mean	0	200	400	600	Mean
Varieties	(ppm)					(ppm)				
V1										
ZGS21	56.2	57.1	58.9	60.9	58.3	55.5	57.3	59.0	61.0	58.2
ZGS31	56.2	58.6	63.1	64.4	60.6	55.5	58.4	62.2	64.0	60.0
ZGS55	56.2	56.8	60.1	62.1	58.8	55.5	56.9	60.0	60.6	58.3
ZGS73	56.2	56.7	58.9	59.2	57.8	55.5	56.0	57.5	58.2	56.8
Mean	56.2	57.3	60.3	61.7	58.9	55.5	57.2	59.7	61.0	58.3
V2										
ZGS21	57.6	58.9	60.1	62.3	59.7	57.0	58.6	59.9	63.2	59.7
ZGS31	57.6	60.2	63.3	65.3	61.6	57.0	59.8	63.2	65.5	61.4
ZGS55	57.6	59.1	60.0	62.2	59.7	57.0	58.3	60.1	61.5	59.2
ZGS73	57.6	58.8	59.1	60.0	58.9	57.0	58.1	60.0	61.0	59.0
Mean	57.6	59.3	60.6	62.5	60.0	57.0	58.7	60.8	62.8	59.8
V3										
ZGS21	55.0	56.5	58.5	60.5	57.6	53.2	56.4	58.9	60.0	57.1
ZGS31	55.0	58.5	60.0	62.4	59.0	53.2	57.8	61.2	62.0	58.6
ZGS55	55.0	57.3	58.0	60.2	57.6	53.2	55.4	57.5	59.0	56.3
ZGS73	55.0	56.8	57.5	58.9	57.1	53.2	55.0	56.6	57.8	55.7
Mean	56.4	58.0	59.9	61.6	59.0	53.2	57.4	59.8	61.3	58.5
General mean	56.4	58.0	59.9	61.6	------	55.4	57.4	59.8	61.3	------
A×C										
ZGS21	56.3	57.5	59.2	61.2	58.5	55.2	57.4	59.3	61.4	58.3
ZGS31	56.3	59.1	62.1	64.0	60.4	55.2	58.7	62.2	63.8	60.0
ZGS55	56.3	57.7	59.4	61.5	58.7	55.2	56.9	59.2	60.4	57.9
ZGS73	56.3	57.9	59.0	60.5	58.4	55.2	56.4	58.0	59.0	57.2
LSD 0.05 for V				0.5					0.4	
LSD 0.05 for C				0.6					0.5	
LSD 0.05 for A				0.6					0.5	
LSD 0.05 for V×C				0.9					0.8	
LSD 0.05 for V×A				0.7					0.7	
LSD 0.05 for C×A				1.2					1.0	
LSD 0.05 for V×C×A				2.0					1.7	

seasons, respectively) and spike length (7.3 cm in both seasons) were obtained from foliar application by 600 ppm iron nutrient added at ZGS31. Similar results were reported by Welch *et al.* (1991), Hall and Williams (2003) and Khan *et al.* (2010). Baney-Suief 2 treated with 600 ppm iron nutrients at ZGS31 gave the tallest plants (100.4 and 112.3 cm in first and second seasons, respectively) and longest spikes (7.9 and 8.1 cm in first and second seasons, respectively).

Yield components: Thousand kernel weight and kernel weigh spike^{-1} were significantly ($p \leq 0.05$) affected by durum wheat varieties, iron concentration, time of application and their involved interactions in both seasons of study (Table 3, 4). The highest values of 1000-kernel weight (59.8 and 60.0 g in first and second seasons, respectively) and kernel weight spike^{-1}

Table 4: Kernel weight spike $^{-1}$ (g) of some wheat varieties as affected by foliar application of iron nutrient added at different growth stages and their interaction involved

	Seasons									
	2009/2010					2008/2009				
	0	200	400	600	Mean	0	200	400	600	Mean
Varieties	(ppm)					(ppm)				
V1										
ZGS21	2.9	3.1	3.6	3.2	3.2	2.8	3.1	3.3	3.5	3.2
ZGS31	2.9	3.5	3.7	3.8	3.5	2.8	3.5	3.6	3.8	3.4
ZGS55	2.9	3.3	3.5	3.7	3.3	2.8	3.3	3.6	3.7	3.3
ZGS73	2.9	3.1	3.5	3.6	3.3	2.8	3.2	3.5	3.6	3.3
Mean	2.9	3.3	3.5	3.7	3.3	2.8	3.3	3.5	3.7	3.3
V2										
ZGS21	3.0	3.3	3.5	3.6	3.3	3.0	3.2	3.5	3.6	3.3
ZGS31	3.0	3.7	3.6	4.1	3.6	3.0	3.7	3.8	4.0	3.6
ZGS55	3.0	3.5	3.7	3.8	3.5	3.0	3.4	3.6	3.8	3.5
ZGS73	3.0	3.2	3.4	3.5	3.3	3.0	3.2	3.4	3.6	3.3
Mean	3.0	3.4	3.6	3.8	3.4	3.0	3.4	3.6	3.7	3.4
V3										
ZGS21	2.7	3.0	3.2	3.3	3.1	2.7	2.9	3.2	3.4	3.0
ZGS31	2.7	3.3	3.6	3.8	3.3	2.7	3.4	3.6	3.8	3.3
ZGS55	2.7	3.2	3.4	3.6	3.2	2.7	3.2	3.4	3.6	3.2
ZGS73	2.7	3.9	3.1	3.3	3.3	2.7	3.0	3.1	3.3	3.0
Mean	2.7	3.4	3.3	3.5	3.2	2.7	3.1	3.3	3.5	3.1
General mean	2.8	3.3	3.5	3.6	------	2.8	3.2	3.5	3.6	------
A×C										
ZGS21	2.8	3.1	3.3	3.5	3.2	2.8	3.1	3.3	3.5	3.2
ZGS31	2.8	3.5	3.7	3.9	3.5	2.8	3.5	3.7	3.9	3.5
ZGS55	2.8	3.3	3.5	3.7	3.4	2.8	3.3	3.5	3.7	3.3
ZGS73	2.8	3.4	3.4	3.6	3.3	2.8	3.1	3.3	3.5	3.2
LSD 0.05 for V					0.06					0.05
LSD 0.05 for C					0.08					0.07
LSD 0.05 for A					0.05					0.04
LSD 0.05 for V×C					0.12					0.1
LSD 0.05 for V×A					0.08					0.07
LSD 0.05 for C×A					0.1					0.08
LSD 0.05 for V×C×A						0.17				
	0.13									

(3.4 g in both seasons) were registered from Baney-Suief 2 variety. This is to be expected since Baney-Suief 2 registered the maximum values with regard to spike length and 1000-kernel weight and consequently gained the heavier spikes. These results are in agreement with those obtained by Koc *et al.* (2000) and Shalaby *et al.* (2006). Here too, the obtained data focused on the superiority of foliar application by iron nutrient in this respect when compared with untreated treatment (control). Thus, adding 600 ppm of iron nutrient as foliar application surpassed the lower concentrations in this respect. This is a plausible result that the same concentration produced the maximum values of spike length and may be encourage metabolism process to produced high rates of carbohydrate which translated into kernels and subsequently increased weight of kernels spike^{-1}. These results are in accordance with that obtained by Zeidan *et al.* (2010).

Table 5: Grain yield ha^{-1} (kg) of some wheat varieties as affected by foliar application of iron nutrient added at different growth stages and their interaction involved

	Seasons									
	2009/2010					2008/2009				
	0	200	400	600	Mean	0	200	400	600	Mean
Varieties	(ppm)					(ppm)				
V1										
ZGS21	4780.0	5200.0	5540.2	5830.0	5337.6	4680.0	5150.1	5440.3	5790.3	5265.2
ZGS31	4780.0	5510.0	5900.0	6450.0	5660.0	4680.0	5450.3	5869.1	6320.0	5579.9
ZGS55	4780.0	5350.0	5700.0	6000.0	5457.5	4680.0	5265.2	5630.0	5920.0	5373.8
ZGS73	4780.0	5180.0	5500.0	5820.0	5320.0	4680.0	5200.0	5440.0	5700.0	5255.0
Mean	4780.0	5310.0	5660.1	6025.0	5443.8	4680.0	5266.4	5594.9	5932.6	5368.5
V2										
ZGS21	5130.0	5562.0	5900.0	6300.0	5723.0	5200.0	5610.0	5960.2	6350.0	5780.1
ZGS31	5130.0	5980.2	6300.2	6810.0	6055.1	5200.0	5930.3	6400.5	6850.1	6095.2
ZGS55	5130.0	5750.0	6050.0	6500.0	5857.5	5200.0	5780.2	6130.0	6530.0	5910.1
ZGS73	5130.0	5580.2	5900.0	6250.0	5715.1	5200.0	5600.0	5910.0	6300.0	5752.5
Mean	5130.0	5718.1	6037.6	6465.0	5837.7	5200.0	5730.1	6100.2	6507.5	5884.5
V3										
ZGS21	4300.0	4800.0	5250.0	5610.0	4990.0	4400.2	4820.2	5210.0	5560.0	4997.6
ZGS31	4300.0	5150.0	5530.0	6050.0	5257.5	4400.2	5200.3	5500.2	6000.3	5275.3
ZGS55	4300.0	4900.0	5300.0	5650.0	5037.5	4400.2	4960.0	5320.0	5700.0	5095.1
ZGS73	4300.0	4650.0	5110.0	5400.0	4865.0	4400.2	4800.0	5190.0	5460.0	4962.6
Mean	4300.0	4875.0	5297.5	5677.5	5037.5	4400.2	4945.1	5305.1	5680.1	5082.6
General mean	4736.7	5301.0	5665.0	6055.8	-------	4760.1	5313.9	5666.7	6040.1	-------
A×C										
ZGS21	4736.7	5187.3	5563.4	5913.3	5350.2	4760.1	5193.4	5536.8	5900.1	5347.6
ZGS31	4736.7	5546.7	5910.1	6436.7	5657.5	4760.1	5527.0	5923.3	6390.1	5650.1
ZGS55	4736.7	5333.3	5683.3	6050.0	5450.8	4760.1	5335.1	5693.3	6050.0	5459.6
ZGS73	4736.7	5136.7	5503.3	5823.3	5300.0	4760.1	5200.0	5513.3	5820.0	5323.4
LSD 0.05 for V					160.7					150.9
LSD 0.05 for C					213.9					200.3
LSD 0.05 for A					110.0					100.1
LSD 0.05 for V×C					320.8					300.3
LSD 0.05 for V×A					190.3					173.3
LSD 0.05 for C×A					220.9					200.2
LSD 0.05 for V×C×A					382.3					346.6

Foliar application of iron nutrients at ZGS31 gained the heaver kernels and spikes over the early (ZGS21) or late (ZGS55 and ZGS73) applications. This is to be expected since the same time of application produced the longest spike and the highest seed index, consequently increased kernel weight spike $^{-1}$. These results are confirmed with that obtained by Khan *et al.* (2010). Thus, the highest values of thousand kernel weight and kernel weight per spike(65.5 and 4.0 g for thousand kernel weight and kernel weight spike^{-1} in first season, respectively being 65.3 and 4.1 g in second season in the same order) were obtained from Baney-Suief 2 variety, which supplemented with 600 ppm of iron nutrient as foliar application added at ZGS31.

Grain yield in kg ha^{-1}: Data registered in Table 5 show the significant ($p \leq 0.05$) variation between durum wheat varieties in the grain yield in the two growing seasons. Baney-Suief 2

variety surpassed the others two varieties and produced the highest values in this respect (5884.5 and 5837.7 kg ha^{-1} in the first and second seasons, respectively). But, the lowest values in this respect (5082.6 and 5037.5 kg ha^{-1} in the first and second seasons, respectively) were obtained from Karim variety. This is to be logic since the same two varieties gives the maximum and minimum values of kernels weight $spike^{-1}$. These results are harmony with those obtained by Koc *et al.* (2000) and Shalaby *et al.* (2006). Spray 600 ppm iron nutrient to wheat plants out yielded significantly ($p \leq 0.05$) higher grain yield as compared with lowest concentrations and control (Table 5). This result could be explained by the role of iron in plant metabolism which encourage growth and reflex in yield components and consequently increased grain yield. Theses finding are in a good line with those obtained by Abbas *et al.* (2009), Seadh *et al.* (2009), Khan *et al.* (2010) and Zeidan *et al.* (2010). Furthermore, foliar application of iron nutrient at various growth stages had a significant ($p \leq 0.05$) effect on grain yield in both seasons (Table 5). Application at ZGS31 had more efficiency than application at any another stage. Otherwise, the lowest values of grain yield 5347.6 and 5323.4 kg ha^{-1} in the first season were recorded when application at ZGS21 and ZGS73, respectively, being 5350.0 and 5037.5 kg ha^{-1} in the second season in the same order. Also, the data illustrated in Table 5 show the significant ($p \leq 0.05$) influence of the interaction between varieties, iron concentration and application time on grain yield in the two growing seasons. The highest values of grain yield (6850.0 and 6810.0 kg ha^{-1} in the first and second seasons, respectively) were obtained from Baney-Suief 2 variety supplemented with 600 ppm iron nutrient as foliar application at ZGS31.

Grain protein content (%): All studied factors and their interactions involved had a significant ($p \leq 0.05$) effect on grain protein content in both seasons (Table 6). Karim variety gained the highest significant grain protein as compared with the others two varieties. These differences may be due to the genetic behavior combination with environment factors which was suitable for Karim variety than the others genotypes. These finding are in a good line with those obtained by Koc *et al.* (2000) and Shalaby *et al.* (2006). Furthermore, foliar application of iron nutrient enhanced grain protein content over the control (untreated plants).Thus application of 600 ppm iron as foliar to whet plants surpassed the lower doses in this respect. This may be due to the importance of iron for chlorophyll formation, photosynthesis and enzyme systems and respiration of plants (Havlin *et al.*, 1999). Also, Iron plays role in biological redox system, enzyme activation and oxygen carrier in nitrogen fixation (Romheld and Marschner, 1991). Here too, application of iron nutrient as foliar at ZGS55 enrichment grain protein content as compared with the others application times. Thus, the maximum grain protein contents (15.2 and 15.5% in the first and second seasons, respectively) were obtained from Karim variety supplanted with 600 ppm iron nutrients as foliar application at ZGS55.

Protein yield in kg ha^{-1}: Whet varieties varied significantly ($p \leq 0.05$) in this respect in the two growing seasons (Table 6). Although, Karim variety gained the highest values of protein content in grains but Baney-Suief 2 variety gives the maximum values of protein yield (765.1 and 793.9 kg ha^{-1} in the first and second seasons, respectively).This is to be logic since Baney-Suief 2 variety surpassed in grain yield ha^{-1} which compensate the reduction in protein percentage and led to the previous result. Foliar application of iron nutrient by the rate of 600 ppm produced the highest mean values of protein yield. This is to be expected since the same concentration gained the highest mean values of grain yield and grain protein content and consequently protein yield. Also,

Table 6: Grain protein content (%): Plant height (cm) of some wheat varieties as affected by foliar application of iron nutrient added at different growth stages and their interaction involved

	Seasons									
	2009/2010					2008/2009				
	0	200	400	600	Mean	0	200	400	600	Mean
Varieties	(ppm)					(ppm)				
V1										
ZGS21	12.8	13.3	13.6	13.8	13.4	12.5	12.9	13.3	13.4	13.0
ZGS31	12.8	13.7	14.2	14.3	13.8	12.5	13.3	13.9	13.9	13.4
ZGS55	12.8	14.1	14.4	14.6	14.0	12.5	13.7	14.1	14.2	13.6
ZGS73	12.8	13.4	13.5	13.7	13.4	12.5	13.0	13.2	13.3	13.0
Mean	12.4	13.6	13.9	14.1	13.5	12.5	13.2	13.6	13.7	13.3
V2										
ZGS21	12.4	12.9	13.2	13.3	13.0	12.1	12.5	12.9	12.9	12.6
ZGS31	12.4	13.2	13.6	13.8	13.3	12.1	12.8	13.3	13.4	12.9
ZGS55	12.4	14.2	13.9	13.9	13.6	12.1	13.8	13.6	13.5	13.3
ZGS73	12.4	13.6	14.2	14.2	13.6	12.1	13.2	13.9	13.8	13.3
Mean	13.2	13.5	13.7	13.8	13.6	12.1	13.1	13.4	13.4	13.0
V3										
ZGS21	13.2	13.8	14.2	14.4	13.9	12.9	13.4	13.9	14.0	13.6
ZGS31	13.2	14.2	14.8	15.1	14.3	12.9	13.8	14.5	14.7	14.0
ZGS55	13.2	14.7	15.5	15.5	14.7	12.9	14.3	15.1	15.2	14.4
ZGS73	13.2	13.7	14.3	14.5	13.9	12.9	13.3	14.0	14.1	13.6
Mean	13.2	14.1	14.7	14.9	14.2	12.9	13.7	14.4	14.5	13.9
General mean										
A×C	13.2	13.7	14.1	14.3	------	12.5	13.3	13.8	13.9	-----
ZGS21	12.8	13.3	13.7	13.8	13.4	12.5	12.9	13.4	13.4	13.1
ZGS31	12.8	13.7	14.2	14.4	13.8	12.5	13.3	13.9	14.0	13.4
ZGS55	12.8	14.3	14.6	14.7	14.1	12.5	13.9	14.3	14.3	13.8
ZGS73	12.8	13.6	14.0	14.1	13.6	12.5	13.2	13.7	13.7	13.3
LSD 0.05 for V					0.3					0.2
LSD 0.05 for C					0.5					0.4
LSD 0.05 for A					0.4					0.3
LSD 0.05 for V×C					0.5					0.4
LSD 0.05 for V×A					0.6					0.5
LSD 0.05 for C×A					0.7					0.6
LSD 0.05 for V×C×A					1.2					1.0

the presented data in Table 6 denoted the significant effect of application time in this respect in both seasons. The maximum mean values of protein yield were recorded from iron foliar application at ZGS31. Moreover, the highest mean values of protein yield (917.9 and 939.8 kg ha^{-1} in the first and second seasons, respectively) were registered for Baney-Suief 2 variety fertilized by 600 ppm iron nutrient as foliar application at ZGS31. Table 7 denoted the protein yield ha^{-1} (kg) of some wheat varieties as affected by foliar application of iron nutrient added at different growth stages and their interaction involved.

Table 7: Protein yield ha^{-1} (kg) of some wheat varieties as affected by foliar application of iron nutrient added at different growth stages and their interaction involved

	Seasons									
	2009/2010					2008/2009				
	0	200	400	600	Mean	0	200	400	600	Mean
Varieties	(ppm)					(ppm)				
V1										
ZGS21	611.8	691.6	753.5	804.5	715.2	585.0	664.4	684.5	723.67	75.9
ZGS31	611.8	754.9	837.8	922.4	781.1	585.0	724.9	815.8	878.5	747.7
ZGS55	611.8	754.4	820.8	876.0	764.1	585.0	721.3	793.8	840.6	730.8
ZGS73	611.8	694.1	742.5	797.3	712.9	585.0	676.0	718.1	758.1	683.2
Mean	592.7	722.2	786.8	849.5	734.9	585.0	695.2	760.9	812.8	714.0
V2										
ZGS21	636.1	717.5	778.8	837.9	744.0	629.2	701.3	768.9	819.2	728.3
ZGS31	636.1	789.4	856.8	939.8	805.3	629.2	759.1	851.3	917.9	786.3
ZGS55	636.1	816.5	841.0	903.5	796.6	629.2	797.7	833.7	881.6	786.0
ZGS73	636.1	758.9	837.8	887.5	777.3	629.2	739.2	821.5	869.4	765.1
Mean	677.2	771.9	827.2	892.2	793.9	629.2	750.6	817.4	872.0	765.0
V3										
ZGS21	567.6	662.4	745.5	807.8	693.6	567.6	645.9	724.2	778.4	679.7
ZGS31	567.6	731.3	818.4	913.6	751.8	567.6	717.6	797.5	882.0	738.5
ZGS55	567.6	720.3	821.5	875.8	740.5	567.6	709.3	808.6	860.7	733.7
ZGS73	567.6	637.1	730.7	783.0	676.2	567.6	638.4	726.6	769.9	674.9
Mean	567.6	687.4	778.7	845.9	715.3	567.6	677.5	763.9	823.6	706.5
General mean										
A×C	625.2	726.2	798.8	866.0	-------	595.0	706.7	782.0	839.6	------
ZGS21	606.3	689.9	762.2	816.0	716.9	595.0	669.9	741.9	790.6	700.5
ZGS31	606.3	759.9	839.2	926.9	780.7	595.0	735.1	823.3	894.6	757.1
ZGS55	606.3	762.7	829.8	889.4	768.6	595.0	741.6	814.1	865.2	753.4
ZGS73	681.4	698.6	770.5	821.1	720.8	595.0	686.4	755.3	797.3	708.0
LSD 0.05 for V					13.2					12.3
LSD 0.05 for C					21.0					20.6
LSD 0.05 for A					11.2					10.5
LSD 0.05 for V×C					26.4					24.6
LSD 0.05 for V×A					19.73					18.1
LSD 0.05 for C×A					22.4					21.0
LSD 0.05 for V×C×A					38.6					36.33

CONCLUSION

From the results obtained, it has been shown that foliar application of iron has a positive effect on growth, yield components, grin and protein yields of durum wheat. So, the investigator recommended sowing Baney-Suief 2 variety supplemented by 600 ppm iron nutrient as foliar application at ZGS31 under similar conditions.

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