

## Effect of Irrigation Levels and Nitrogen Fertilizer Splitting on the Productivity and Nitrogen Use Efficiency of Two Bread Wheat Cultivars

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Received on: 25/9/2016

Accepted for publication on: 27/9/2016

### Abstract

This work was carried out during 2012/ 2013 and 2013/ 2014 seasons in the Agronomy Department Experimental Farm, Agriculture Faculty, Assiut University to study the effect of irrigation levels and nitrogen fertilizer splitting on the productivity and nitrogen use efficiency of two bread wheat cultivars. Three experiments each season were done. Each experiment was subjected to three irrigation levels (100, 75 and 50 % of irrigation requirement). The experiment was laid out in Randomized Complete Block Design (RCBD) in split - plot arrangement with three replicates. Two treatments of nitrogen fertilizer splitting (2 and 4 times) were assigned in main - plots and the wheat cultivars (Giza-168 and Sids-1) were arranged in sub-plots. The obtained results showed that studied irrigation levels, nitrogen fertilizer splitting and cultivars had a significant effect on all studied traits in the two growing seasons. Here too, the first and second order interactions had a significant influence on most studied traits in both seasons. Moreover, the highest mean values of grain yield (28.13 and 28.02 ardab fed<sup>-1</sup>) and NUE (56.26 and 56.03 kg grain/kg N applied) in the first and second seasons, respectively were obtained from Sids-1 cultivar subjected to I<sub>1</sub> irrigation level and received nitrogen fertilizer at four splits.

**Keywords:** *Irrigation levels, nitrogen fertilizer splitting, wheat cultivars, grain yield and NUE*

### Introduction

Wheat crop consider the most important cereal crops in the world with regard to cultivated area and total production. The cultivated area of wheat in Egypt during 2013 season was about 1418708 ha i.e.3377876 feddan with the total yield production of 9460200 ton (FAO, 2013). While the total consumption reached about 19600000 ton. So, increasing wheat production in order to reduce the gap between production and consumption are the strategic aim. High grain yield and good bread-making quality of wheat are opposite criteria and are influenced by the environmental conditions as well as by the irrigation, va-

riety, N-fertilization, and the interactions between these factors (Rao *et al.*, 1993, Johansson *et al.*, 2004 and Erekul *et al.*, 2012). Water stress is the most important limitation to wheat productivity in semiarid regions of the world. Therefore, the development of the wheat cultivars that use available water more efficiently and that are able to tolerate drought is a major goal for increasing productivity in drought prone environments. Water deficit or drought has profound effects on wheat production in Egypt and worldwide. Water stress was found to significantly reduced grain yield and some agronomic traits of all studied cultivars. Cultivars were

found to respond differently to water stress treatments. In general, drought sensitivity increases with increasing the intensity of water stress. Significant genotypic variations were observed among these durum wheat cultivars in water use efficiency (Al-Tabbal, 2011). Water deficit occurs when water potentials in the rhizosphere are sufficiently negative to reduce water availability to sub-optimal levels for plant growth and development. Grain yield was affected by both the magnitude of water deficit and stage of growth subjected to deficit. Increasing irrigation amounts up to 100% of soil water significantly increased grain yield (Awad *et al.*, 2000). Moisture stress is known to reduce biomass, tillering ability, grains per spike and grain size at any stage when it occurs. So, the overall effect of moisture stress depends on intensity and length of stress (Bukhat, 2005). Concerning nitrogen fertilizer splitting, In order to obtain high wheat yield and reduce potential NO<sub>3</sub>-N for leaching or other adverse environmental impacts, it is important to develop N management strategies to increase the N recovery fraction (NRF: kg N uptake kg N applied<sup>-1</sup>) of applied N. Earlier N fertilizer application increases the risk of N loss from the root zone by leaching and denitrification. Therefore, the NRF of wheat is maximized when fertilizer is applied shortly before the period of most rapid crop N uptake (Howard *et al.* 2002), which occurs between early stem elongation and anthesis, the stage at which the crop can accumulate up to 75% of total N in

above-ground biomass (NAB) at maturity. However, in environments with low water availability, N applications after stem elongation have been reported to reduce NRF and increased N use efficiency (Zebarth *et al.* 2007). Also, El-Agrodi *et al.* (2011) found that application of N in four splits recorded higher N percentage in whole wheat plants, straw and grains over application of N with two splits in 120 kg N per ha doses. Here too, Velasco *et al.* (2012) stated that in four out of six experiments, average N in above ground biomass (NAB), N recovery fraction (NRF), and grain protein content (GPC) for split N application were greater than for full N at Z24 (NAB, 176 and 157 kg N ha<sup>-1</sup>; NRF, 66 and 51%; GPC, 100 and 92 g kg<sup>-1</sup>, for split and full N application, respectively). As shown by Debaeke *et al.* (1996) and Feil (1997) that yield and quality are negatively correlated. The objectives of this study were to determine the effect of irrigation water rationalization and nitrogen fertilizer splitting on the productivity and quality of some wheat cultivars.

### Materials and Methods

This work was carried out during 2012/ 2013 and 2013/ 2014 seasons in the Agronomy Department Experimental Farm, Agriculture Faculty, Assiut University to study the effect of irrigation water rationalization and nitrogen fertilizer splitting on the productivity of two wheat cultivars. The mechanical and chemical analyses of the experimental sites of the soil are presented in Table 1.

**Table1. Some physical and chemical properties of experimental sites:**

Properties	2012/2013	2013/2014
<b>Mechanical analysis:</b>		
Sand	26.00	26.80
Slit	24.20	23.00
Clay	49.80	50.20
Soil type	Clay	Clay
<b>Chemical analysis:</b>		
pH	7.73	7.80
Organic matter %	1.74	1.62
Total N%	0.08	0.07

Three experiments each season were done. Each experiment was subjected to three irrigation levels (100, 75 and 50 % of irrigation requirement i.e. I<sub>1</sub>=4000, I<sub>2</sub>=3000 and I<sub>3</sub>=2000 m<sup>3</sup>/fed-1, respectively). These amounts of irrigation water were recorded from the counter. The experiment was laid out in Randomized Complete Block Design (RCBD) in split - plot arrangement with three replicates. Two treatment of nitrogen fertilizer splitting (2 and 4 times) were assigned in main - plots and the wheat cultivars (Sids 1 and Giza 168) were arranged in sub-plots. Each sub-plot area was 10.5 m<sup>2</sup>. Wheat grains (*Triticum aestivum* L. c.v 'Sids- 1 and Giza-168) were sown by hand on 1 and 2 December in the first and second seasons, respectively. There commended dose of nitrogen fertilizer (75 kg fed -1 as a form of Urea, 46.5%N) divided into two equal doses and add before second and third irrigation in the first splitting treatment (2 times), while, splitting into four equal doses (4 times) was added before the second, third, fourth and fifth irrigation. All other cultural practices that recommended for wheat crop were done in both seasons.

At harvest five guarded main stem for each sub-plot were taken and plant height (cm), spike length (cm), number of spikelet's spike-1, number of kernels spike-1 and kernels weight spike-1 were determined. 1000-kernel weight, number of spikes m-2 and grain and straw yields were determined in plot basis then transferred to ardab and ton fad-1, respectively.

Nitrogen use efficiency (NUE) was calculated as  $NUE = \frac{\text{Grain yield}}{\text{Nitrogen applied}}$  (Ali, 2010).

All data collected from each experiment under irrigation level were analyzed with analysis of variance (ANOVA) Procedures using the SAS Statistical Software Package (v.9.2, 2008). Then, combined analysis was carried out for irrigation levels to reveal the effect of this variable and the interaction involved. Means were compared by LSD at 5% level of significant (Gomez and Gomez, 1984).

## Results and Discussion

### 1-Vegetative traits:

**Plant height (cm):** Data presented in Table 2 show that irrigation levels, nitrogen fertilizer splitting, cultivars and their interaction had a significant influence ( $p \leq 0.05$ ) on wheat plant height in the two growing seasons. Thus, plant height was de-

creased linearly by reducing amount of water applied to wheat plants and the tallest plants were registered from I1 treatment (89.47 and 87.42 cm), while the shortest plants were obtained from I3 treatment (75.21 and 73.39 cm) in the first and second seasons, respectively. This can be explained by the role of water in the cell division and elongation as well as the other physiological process such as photosynthesis, respiration and translocation. Depressed water potential suppresses cell division, organ growth, net photosynthesis, protein synthesis, and alters hormonal balances of major plant tissues (Mohararam and Habib, 2011). Moreover, the splitting nitrogen fertilizer to four times increase plant height as compared to the other splitting treatment (two times) and the amount of increments were reached about 5.8 and 5.3 % in the first and second seasons, respectively. The increase in plant height by increasing N application

number might be attributed to saving N in proper time and maximizing the N utilization through minimizing losses of the applied N. Similar results were reported by El-Agrodi *et al.* (2011). Furthermore, Sids-1 cultivar surpassed Giza-168 one and produced the highest mean values in this respect (86.47 and 83.97 cm) in the first and second seasons, respectively. The differences between cultivars are mainly due to the interaction between their genetic makeup during growth periods and to the environmental factors prevailing during their development. These results are in agreement with that obtained by Al-Tabbal (2011). With regard to second order interaction, data exhibited in this respect reveal that cultivated Sidis-1 cultivar subjected to I1 irrigation level and received nitrogen fertilizer at four equal doses gained the highest mean values of plant height (97.20 and 91.17 cm) in the first and second seasons, respectively.

**Table 2. Effect of irrigation levels, Nitrogen splitting, cultivars and their interactions on plant height (cm)**

Seasons		2012/2013			2013/2014		
Irrigation Levels (I)	Cultivars(C) Splitting(S)	Giza-168	Sids-1	Mean	Giza-168	Sids-1	Mean
		I <sub>1</sub>	S <sub>1</sub>	85.30	86.73	86.02	85.00
	S <sub>2</sub>	88.63	97.20	92.92	87.57	91.17	89.37
Mean		86.97	91.97	89.47	86.28	88.55	87.42
I <sub>2</sub>	S <sub>1</sub>	80.00	81.33	80.67	79.27	80.17	79.72
	S <sub>2</sub>	82.13	84.13	83.13	81.80	83.10	82.45
Mean		81.07	82.73	81.90	80.53	81.63	81.08
I <sub>3</sub>	S <sub>1</sub>	71.57	74.40	72.99	67.73	73.10	70.42
	S <sub>2</sub>	76.80	78.07	77.44	75.07	77.63	76.35
Mean		74.18	76.23	75.21	71.40	75.37	73.39
General mean		80.74	83.64	-----	79.41	81.85	-----
C×S	S <sub>1</sub>	78.96	80.82	79.89	77.33	79.73	78.53
	S <sub>2</sub>	82.52	86.47	84.49	81.48	83.97	82.72
F test and LSD		F test		LSD	F test		LSD
I		*		1.888	*		0.561
S		*		-----	*		-----
C		*		----	*		-----
I×S		*		2.838	*		1.282
I×C		*		1.335	*		0.549
S×C		*		1.090	*		0.448
I×S×C		*		1.888	*		0.777

Where: I<sub>1</sub>, I<sub>2</sub> and I<sub>3</sub> means 100, 75 and 50% of irrigation requirement, respectively

S<sub>1</sub> and S<sub>2</sub> means two and four nitrogen fertilizer splitting, respectively

\* means significantly at 5% level of significant

**Spike length (cm):** Exhibited data in Table 3 reveal that irrigation levels, nitrogen fertilizer splitting, cultivars and their interaction involved had a significant influence ( $p \leq 0.05$ ) on wheat spike length in the two growing seasons. Therefore, decreasing amount of irrigation water applied to wheat plants from I<sub>1</sub> to I<sub>2</sub> or I<sub>3</sub> decreased spike length from 12.58 to 11.21 or 8.55 cm in the first season, being 12.30 to 11.11 or 8.09 cm in the second season in the same order. This is to be expected since the same trend was found with regard to plant height and consequently spike length. Moreover, the splitting nitro-

gen fertilizer to four times increase spike length as compared to the splitting nitrogen to two equal doses and gained 11.33 and 10.97 spike length in the first and second seasons, respectively. The increase in spike length by increasing N application number might be attributed to saving N in proper time and maximizing the N utilization through minimizing losses of the applied N. The similar results were reported by El-Agrodi *et al.* (2011). Furthermore, Sids-1 cultivar surpassed Giza-168 one and produced the highest mean values of spike length (11.04 and 10.79 cm) in the first and second seasons, respec-

tively. The differences between cultivars are mainly due to the interaction between their genetic makeup during growth periods and to the environmental factors prevailing during their development. These results are in agreement with that obtained by Al-Tabbal (2011). Concerning second

order interaction data presented here state that cultivated Sidis-1 cultivar subjected to I1 irrigation level and received nitrogen fertilizer at four equal doses gained the highest mean values of spike length (13.50 and 13.10 cm) in the first and second seasons, respectively.

**Table 3. Effect of irrigation levels, Nitrogen splitting, cultivars and their interactions on spike length (cm)**

Seasons		2012/2013			2013/2014		
Irrigation levels(I)	Cultivars(C) Splitting(S)	Giza-168	Sids-1	Mean	Giza-168	Sids-1	Mean
	I <sub>1</sub>	S <sub>1</sub>	11.87	12.23	12.05	11.60	12.10
S <sub>2</sub>		12.70	13.50	13.10	12.40	13.10	12.75
Mean		12.28	12.87	12.58	12.00	12.60	12.30
I <sub>2</sub>	S <sub>1</sub>	10.93	11.10	11.02	10.70	11.07	10.89
	S <sub>2</sub>	11.30	11.50	11.40	11.17	11.50	11.34
Mean		11.12	11.30	11.21	10.93	11.28	11.11
I <sub>3</sub>	S <sub>1</sub>	7.37	7.83	7.60	7.03	7.63	7.33
	S <sub>2</sub>	8.90	10.09	9.50	8.30	9.37	8.84
Mean		8.13	8.96	8.55	7.67	8.50	8.09
General mean		10.51	11.04	-----	10.20	10.79	-----
C×S	S <sub>1</sub>	10.06	10.39	10.22	9.78	10.27	10.02
	S <sub>2</sub>	10.97	11.70	11.33	10.62	11.32	10.97
F test and LSD		F test		LSD	F test		LSD
I		*		0.279	*		0.174
S		*		-----	*		-----
C		*		-----	*		-----
I×S		*		0.305	*		0.200
I×C		*		0.121	*		0.068
S×C		*		0.099	*		0.056
I×S×C		*		0.171	*		0.096

## 2- Yield components traits:

Number of spikes m<sup>-2</sup>: Data illustrated in Table 4 focus that the studied irrigation levels had a significant effect ( $p \leq 0.05$ ) on the number of spikes m<sup>-2</sup> in both seasons. Thus, number of spikes m<sup>-2</sup> was decreased significantly with decreasing amount of water applied to wheat plants. Decreasing irrigation water amount from I<sub>1</sub> to I<sub>2</sub> or I<sub>3</sub> resulting in the decrease in number of spikes m<sup>-2</sup> reached about 11.36 and 23.99 %, respec-

tively in the first season, being, 10.52 and 24.21 % in the second season in the same order. This may be due to the effect of water stress on the tillering numbers which were decreased in order to irrigation water decreased. Moisture stress is known to reduce tillering ability when it occurs at any stage. So, the overall effect of moisture stress depends on intensity and length of stress (Bukhat, 2005). Furthermore, the data also reveal that the splitting nitrogen fertilizer had a sig-

nificant influence ( $p \leq 0.05$ ) in this respect in both seasons. Splitting nitrogen fertilizer into four equal doses produced the highest mean values of spikes number  $m^{-2}$  (426.7 and 420.3) in the first and second seasons, respectively. The beneficial effect of N splitting may be related to reduction of N losses and enhancement tillering in wheat. Moreover, the presented data state that wheat cultivars varied significantly in this respect in the two growing seasons. Thus, Giza -168 cultivar surpassed Sids-1 cultivar and produced the highest mean values of spikes number  $m^{-2}$  (417.9 and 409.0) in the first and second seasons, respectively. The differences between

cultivars are mainly due to the interaction between their genetic makeup during growth periods and to the environmental factors prevailing during their development. These results are in agreement with that obtained by Al-Tabbal (2011). Furthermore, the first order interaction between irrigation and splitting or cultivars had a significant effect on spikes number  $m^{-2}$  in both seasons. On the other hand, the first order interaction between splitting and cultivar as well as the second order interaction among irrigation, splitting and cultivars don't affect significantly number of spikes  $m^{-2}$  in the two growing seasons.

**Table 4. Effect of irrigation levels, Nitrogen splitting, cultivars and their interactions on number of spikes  $m^{-2}$**

2013/2014			2012/2013			Seasons	
Mean	Sids-1	Giza-168	Mean	Sids-1	Giza-168	Cultivars(C) Splitting(S)	Irrigation levels(I)
436.5	433.0	440.0	447.9	440.0	455.7	S <sub>1</sub>	I <sub>1</sub>
475.5	470.3	480.7	485.5	479.7	491.3	S <sub>2</sub>	
456.0	451.7	460.3	466.7	459.8	473.5	Mean	
396.2	392.3	400.0	402.4	400.0	404.7	S <sub>1</sub>	I <sub>2</sub>
419.9	418.0	421.7	424.5	420.0	429.0	S <sub>2</sub>	
408.0	405.2	410.8	413.4	410.0	416.8	Mean	
325.7	313.0	338.3	339.4	332.0	346.7	S <sub>1</sub>	I <sub>3</sub>
365.5	357.7	373.3	370.0	360.0	380.0	S <sub>2</sub>	
345.6	335.3	355.8	354.7	346.0	363.3	Mean	
-----	397.4	409.0	-----	405.3	417.9	General mean	
386.1	379.4	392.8	396.5	390.7	402.4	S <sub>1</sub>	C×S
420.3	415.3	425.2	426.7	419.9	433.4	S <sub>2</sub>	
LSD		F test		LSD		F test and LSD	
4.160		*		1.536		I	
-----		*		----		S	
-----		*		----		C	
4.307		*		6.161		I×S	
3.216		*		2.274		I×C	
----		NS		---		S×C	
----		NS		----		I×S×C	

**1000- Kernel weight (g):** Exhibited data in Table 5 focus that irrigation levels, nitrogen fertilizer splitting, cultivars and their interactions involved here had a significant effect ( $p \leq 0.05$ ) on 1000 kernel weight in the two growing seasons except the effect of first order interaction between nitrogen fertilizer splitting and cultivars in the first season only. Significant differences in 1000-grain weight were noted among various water stress treatments.  $I_1$  had significantly higher 1000-grain weight than all other water stress treatments in both seasons. Similar effects of water stress on 1000-grain weight were also reported by Qadir *et al.* (1999), Dencic *et al.* (2000) and Akram (2011). Furthermore, the highest mean values of 1000- kernel weight (51.72 and 50.95 g) in the first and second seasons, respectively, were obtained when nitrogen fertilizer was divided into four equal doses. The increase in 1000 kernel weight by increasing N application number might be attributed to saving N in proper time and

maximizing the N utilization through minimizing losses of the applied N which led to high photosynthesis rates, increased the amount of carbohydrate accumulation in the kernels and consequently increased kernel weight. The obtained results are in a good line with those obtained by Hirzel *et al.* (2010), El-Agrodi *et al.* (2011) and Rahman *et al.* (2011). Concerning the studied cultivars effect, data show that Sids-1 cultivar surpassed Giza-168 one in this respect in both seasons. The differences between cultivars are mainly due to the interaction between their genetic makeup during growth periods and to the environmental factors prevailing during their development. These results are in agreement with that obtained by Al-Tabbal (2011) and Moharram and Habib (2011). Also, the data show that the highest mean values of 1000 kernel weight (59.17 and 58.18 g) in the first and second seasons, respectively, were obtained from high irrigation level ( $I_1$ ) with Sids-1 cultivar subjected to four splits of nitrogen fertilizer.

**Table 5. Effect of irrigation levels, Nitrogen splitting, cultivars and their interactions on 1000 kernel weight**

2013/2014			2012/2013			Seasons	
Mean	Sids-1	Giza-168	Mean	Sids-1	Giza-168	Cultivars(C) Splitting(S)	Irrigation levels(I)
53.02	53.78	52.25	53.89	54.50	53.27	S <sub>1</sub>	I <sub>1</sub>
56.66	58.18	55.13	57.84	59.17	56.50	S <sub>2</sub>	
54.84	55.98	53.69	55.86	56.83	54.88	Mean	
47.90	48.37	47.43	48.41	49.07	47.75	S <sub>1</sub>	I <sub>2</sub>
50.61	51.38	49.83	51.13	51.77	50.48	S <sub>2</sub>	
49.26	49.88	48.63	49.77	50.42	49.12	Mean	
42.23	43.57	40.88	43.07	43.92	42.22	S <sub>1</sub>	I <sub>3</sub>
45.60	46.03	45.17	46.19	46.75	45.63	S <sub>2</sub>	
43.92	44.80	43.03	44.63	45.33	43.93	Mean	
-----	50.22	48.45	-----	50.86	49.31	General mean	
47.71	48.57	46.85	48.46	49.16	47.75	S <sub>1</sub>	C×S
50.95	51.86	50.04	51.72	52.56	50.87	S <sub>2</sub>	
LSD		F test		LSD		F test and LSD	
0.129		*		0.299		*	
-----		*		-----		*	
-----		*		-----		*	
0.207		*		0.582		*	
0.153		*		0.252		*	
0.125		*		-----		NS	
0.217		*		0.356		*	
						I	
						S	
						C	
						I×S	
						I×C	
						S×C	
						I×S×C	

**Kernels weight spike<sup>-1</sup>:** Data presented in Table 6 reveal that involved irrigation levels, nitrogen fertilizer splitting, cultivars and their interaction had a significant effect ( $p \leq 0.05$ ) on kernels weight spike<sup>-1</sup> trait in the two growing seasons. Thus, weight of kernels spike<sup>-1</sup> was decreased linearly by shortage in amount of water applied to wheat plants and the heaviest kernels spike<sup>-1</sup> were registered from I<sub>1</sub> treatment (3.73 and 3.60g) while, the thin nest kernels spike<sup>-1</sup> were obtained from I<sub>3</sub> treatment (2.68 and 2.60g) in the first and second seasons, respectively. This is to be logic since the same trend was obtained with regard 1000 kernels weight and consequently weight of kernels spike<sup>-1</sup>. Similar effects of water stress on 1000-grainweight were also reported by

Qadir *et al.* (1999), Dencic *et al.* (2000) and Akram (2011). Moreover, the splitting nitrogen fertilizer to four splits increased weight of kernels spike<sup>-1</sup> as compared to the other splitting treatment (two splits) and the amount of increments were reached about 11.49 and 14.13 % in the first and second seasons, respectively. This is to be expected since the same split treatment produced the highest mean values with regard to 1000 kernels weight trait as mentioned before and consequently produced the highest mean values of kernel weight spike<sup>-1</sup>. The similar results were reported by El-Agrodi *etal.* (2011). Furthermore, Sids-1 cultivar surpassed Giza-168 one and produced the highest mean values in this respect (3.14 and 3.05 g) in the first and second seasons, respectively. This is logic

since the same cultivar recorded the highest mean values with regard to 1000 kernels weight trait as mentioned before and consequently produced the highest mean values of kernels weight spike<sup>-1</sup> trait. These results are in agreement with that obtained by Al-Tabbal (2011). Concerning the second order interaction, data illustrated in this respect focus that

cultivated Sidis-1 cultivar subjected to I<sub>1</sub> irrigation level and received nitrogen fertilizer at four equal doses gained the highest mean values of kernels weight spike<sup>-1</sup> (3.96 and 3.91g) in the first and second seasons, respectively. This is to be expected since the same interaction was significant with regard to 1000 kernel weight.

**Table 6. Effect of irrigation levels, Nitrogen splitting, cultivars and their interactions on kernels weight spike<sup>-1</sup>(g)**

2013/2014			2012/2013			Seasons	
Mean	Sids-1	Giza-168	Mean	Sids-1	Giza-168	Cultivars(C) Splitting(S)	Irrigation levels(I)
3.20	3.29	3.11	3.34	3.49	3.19	S <sub>1</sub>	I <sub>1</sub>
3.76	3.91	3.61	3.84	3.96	3.73	S <sub>2</sub>	
3.48	3.60	3.36	3.60	3.73	3.46	Mean	
2.84	2.88	2.80	2.88	2.92	2.83	S <sub>1</sub>	I <sub>2</sub>
2.98	3.01	2.94	3.03	3.08	2.97	S <sub>2</sub>	
2.91	2.95	2.87	2.95	3.00	2.90	Mean	
2.23	2.47	1.98	2.39	2.62	2.16	S <sub>1</sub>	I <sub>3</sub>
2.70	2.72	2.68	2.73	2.74	2.72	S <sub>2</sub>	
2.47	2.60	2.33	2.56	2.68	2.44	Mean	
-----	3.05	2.86	-----	3.14	2.93	General mean	
2.76	2.88	2.63	2.87	3.01	2.73	S <sub>1</sub>	C×S
3.15	3.21	3.08	3.20	3.26	3.14	S <sub>2</sub>	
LSD		F test		LSD		F test and LSD	
0.044		*		0.057		I	
-----		*		-----		S	
-----		*		-----		C	
0.055		*		0.119		I×S	
0.025		*		0.049		I×C	
0.020		*		0.040		S×C	
0.035		*		0.069		I×S×C	

**Biological yield (ton fed.<sup>-1</sup>):** Data illustrated in Table 7 focus that the studied irrigation levels had a significant effect ( $p \leq 0.05$ ) on the biological yield in both seasons. Thus, biological yield was decreased significantly with decreasing amount of water applied to wheat plants. Decreasing irrigation water amount from

I<sub>1</sub> to I<sub>2</sub> or I<sub>3</sub> resulting in the decrease in biological yield reached about 13.44 and 42.56 %, respectively in the first season, being, 13.41 and 45.67 % in the second season in the same order. This is to be expected since the same trend was obtained with regard to plant height, number of spikes m<sup>-2</sup> and weight of kernels

spike<sup>-1</sup> as mentioned previously. These findings were in a good line with those obtained by Qadir *et al.* (1999), Dencic *et al.* (2000) and Akram (2011). Furthermore, the data also reveal that splitting nitrogen fertilizer had a significant influence ( $p \leq 0.05$ ) on the biological yield in both seasons. Splitting nitrogen fertilizer into four equal doses produced the highest mean values of biological yield (9.14 and 8.77 t fed<sup>-1</sup>) in the first and second seasons, respectively. This is logic since the same trend was obtained with regard to plant height, number of spikes m<sup>-2</sup> and weight of kernels spike<sup>-1</sup> as mentioned previously. Moreover, the presented data state that wheat cultivars varied significantly in this respect in the two growing seasons. Thus, Sids-1 cultivar surpassed Giza -168 one and produced the highest mean values of biological yield (8.90 and 8.54 t fed<sup>-1</sup>) in the first and second seasons, respectively. The differences between culti-

vars are mainly due to the interaction between their genetic makeup during growth periods and to the environmental factors prevailing during their development. These results are in agreement with that obtained by Al-Tabbal (2011). Furthermore, the first order interaction between irrigation and splitting or cultivars had a significant effect on biological yield in both seasons. On the other hand, the first order interaction between splitting and cultivar as well as the second order interaction among irrigation, splitting and cultivars don't affect significantly biological yield in the first season only, while the effects of previous interactions are significant in the second season. Thus, the highest mean value of biological yield (10.80 t fed<sup>-1</sup>) in the second season was obtained from Sids-1 cultivar subjected to I<sub>1</sub> irrigation level and received nitrogen fertilizer at four splits.

**Table 7. Effect of irrigation levels, Nitrogen splitting, cultivars and their interactions on biological yield (ton fed<sup>-1</sup>)**

2013/2014			2012/2013			Seasons	
Mean	Sids-1	Giza-168	Mean	Sids-1	Giza-168	Cultivars(C) Splitting(S)	Irrigation levels(I)
9.98	10.00	9.96	10.13	10.27	10.00	S <sub>1</sub>	I <sub>1</sub>
10.60	10.80	10.40	10.98	11.24	10.72	S <sub>2</sub>	
10.29	10.40	10.18	10.56	10.75	10.36	Mean	
8.42	8.80	8.03	8.77	8.96	8.57	S <sub>1</sub>	I <sub>2</sub>
9.40	9.60	9.20	9.51	9.68	9.33	S <sub>2</sub>	
8.91	9.20	8.62	9.14	9.32	8.95	Mean	
4.88	5.40	4.35	5.43	5.84	5.02	S <sub>1</sub>	I <sub>3</sub>
6.30	6.64	5.95	6.94	7.42	6.45	S <sub>2</sub>	
5.59	6.02	5.15	6.19	6.63	5.74	Mean	
----	8.54	7.98	----	8.90	8.35	General mean	
7.76	8.07	7.45	8.11	8.36	7.86	S <sub>1</sub>	C×S
8.77	9.01	8.52	9.14	9.45	8.84	S <sub>2</sub>	
LSD		F test	LSD		F test	F test and LSD	
0.150		*	0.150		*	I	
----		*	----		*	S	
----		*	----		*	C	
0.275		*	0.085		*	I×S	
0.068		*	0.093		*	I×C	
0.056		*	----		NS	S×C	
0.097		*	----		NS	I×S×C	

**Grain yield (ardab fed.<sup>-1</sup>):**

Data exhibited in Table 8 focus that the studied irrigation levels had a significant effect ( $p \leq 0.05$ ) on the grain yield in both seasons. Thus, grain yield was decreased significantly with decreasing amount of water applied to wheat plants. Decreasing irrigation water amount from I<sub>1</sub> to I<sub>2</sub> or I<sub>3</sub> resulting in the decrease in grain yield reached about 33.15 and 47.85 %, respectively in the first season, being, 32.17 and 48.43 % in the second season in the same order. This is to be expected since the same trend was obtained with regard to 1000 kernels weight, weight of kernels spike<sup>-1</sup> and biological yield as mentioned previous. These findings were in a good line with those obtained by Qadir *et al.* (1999), Dencic *et al.* (2000) and Ak-

ram (2011). Furthermore, the data also, reveal that splitting nitrogen fertilizer had a significant influence ( $p \leq 0.05$ ) on the grain yield in both seasons. Splitting nitrogen fertilizer into four equal doses produced the highest mean values of grain yield (18.95 and 18.45 ardab fed<sup>-1</sup>) in the first and second seasons, respectively. This is logic since the same trend was obtained with regard to 1000 kernels weight, weight of kernels spike<sup>-1</sup> and biological yield as mentioned previous. Moreover, the presented data state that wheat cultivars varied significantly in this respect in the two growing seasons. Thus, Sids-1 cultivar surpassed Giza-168 one and produced the highest mean values of grain yield (18.19 and 17.64 ardab fed<sup>-1</sup>) in the first and second seasons, respectively. This is

logic since the same trend was observed with regard to weight of kernels spike<sup>-1</sup>. The differences between cultivars are mainly due to the interaction between their genetic makeup during growth periods and to the environmental factors prevailing during their development. These results are in agreement with that obtained by Al-Tabbal (2011). Furthermore, the all first order interactions in this respect had a significant effect on grain yield in both seasons. Also, the

second order interaction among irrigation, splitting and cultivars had a significant effect on grain yield in the two growing season. Thus, the highest mean value of grain yield (28.13 and 28.02 ardab fed<sup>-1</sup>) in the first and second seasons, respectively, were obtained from Sids-1 cultivar subjected to I<sub>1</sub> irrigation level and received nitrogen fertilizer at four splits.

**Table 8. Effect of irrigation levels, Nitrogen splitting, cultivars and their interactions on grain yield (ardab fed<sup>-1</sup>)**

2013/2014			2012/2013			Seasons	
Mean	Sids-1	Giza-168	Mean	Sids-1	Giza-168	Cultivars(C) Splitting(S)	Irrigation levels(I)
19.58	21.03	18.12	20.98	22.32	19.63	S <sub>1</sub>	I <sub>1</sub>
25.91	28.02	23.80	26.61	28.13	25.09	S <sub>2</sub>	
22.75	24.53	20.96	23.80	25.23	22.36	Mean	
14.52	15.07	13.96	14.92	15.33	14.51	S <sub>1</sub>	I <sub>2</sub>
16.36	16.80	15.91	16.89	17.30	16.47	S <sub>2</sub>	
15.43	15.93	14.93	15.91	16.32	15.49	Mean	
10.38	11.52	9.24	11.48	12.26	10.69	S <sub>1</sub>	I <sub>3</sub>
13.08	13.39	12.76	13.35	13.82	12.87	S <sub>2</sub>	
11.73	12.45	11.00	12.41	13.04	11.78	Mean	
-----	17.64	15.63	-----	18.19	16.54	General mean	
14.82	15.87	13.77	15.79	16.64	14.94	S <sub>1</sub>	C×S
18.45	19.40	17.49	18.95	19.75	18.14	S <sub>2</sub>	
LSD		F test		LSD		F test and LSD	
0.610		*		0.232		I	
-----		*		-----		S	
-----		*		-----		C	
0.727		*		0.350		I×S	
0.261		*		0.152		I×C	
0.213		*		0.124		S×C	
0.370		*		0.215		I×S×C	

**Straw yield (t fed.<sup>-1</sup>):** Data exhibited in Table 9 focus that the studied irrigation levels had a significant effect ( $p \leq 0.05$ ) on the straw yield in both seasons. Thus, straw yield was decreased significantly with decreas-

ing amount of water applied to wheat plants. Decreasing irrigation water amount from I<sub>1</sub> to I<sub>2</sub> or I<sub>3</sub> resulting in the decrease in straw yield reached about 3.43 and 38.05 %, respectively in the first season, being, 4.07 and

44.33 % in the second season in the same order. This is to be expected since the same trend was obtained with regard to biological yield as mentioned previous. These findings were in a good line with those obtained by Qadir *et al.* (1999), Dencic *et al.* (2000) and Akram (2011). Furthermore, the data also, reveal that splitting nitrogen fertilizer had a significant influence ( $p \leq 0.05$ ) on the straw yield in both seasons. Splitting nitrogen fertilizer into four equal doses produced the highest mean values of straw yield (6.30 and 6.00 t fed<sup>-1</sup>) in the first and second seasons, respectively. This is logic since the same trend was obtained with regard to biological yield as mentioned previous. Moreover, the presented data state that wheat cultivars varied significantly in this respect in the two growing seasons. Thus, Sids-1 cultivar surpassed Giza -168 one and produced the highest mean values of straw yield (6.17 and 5.89t fed<sup>-1</sup>) in

the first and second seasons, respectively. This is logic since the same trend was observed with regard to biological yield as mentioned before. The differences between cultivars are mainly due to the interaction between their genetic makeup during growth periods and to the environmental factors prevailing during their development. These results are in agreement with that obtained by Al-Tabbal (2011). Furthermore, the all first order interactions in this respect had a significant effect on straw yield in both seasons. Also, the second order interaction among irrigation, splitting and cultivars had a significant effect on straw yield in the two growing season. Thus, the highest mean value of straw yield (7.06 and 7.24 t fed<sup>-1</sup>) in the first and second seasons, respectively was obtained from Giza-168 cultivar subjected to I<sub>1</sub> irrigation level and received nitrogen fertilizer at two splits.

**Table 9. Effect of irrigation levels, Nitrogen splitting, cultivars and their interactions on straw yield (ton fed<sup>-1</sup>)**

2013/2014			2012/2013			Seasons	
Mean	Sids-1	Giza-168	Mean	Sids-1	Giza-168	Cultivars(C) Splitting(S)	Irrigation levels(I)
7.04	6.85	7.24	6.98	6.92	7.06	S <sub>1</sub>	I <sub>1</sub>
6.71	6.60	6.83	6.99	7.02	6.96	S <sub>2</sub>	
6.88	6.72	7.04	6.99	6.97	7.01	Mean	
6.24	6.54	5.94	6.53	6.66	6.39	S <sub>1</sub>	I <sub>2</sub>
6.95	7.08	6.81	6.98	7.09	6.86	S <sub>2</sub>	
6.60	6.81	6.38	6.75	6.87	6.63	Mean	
3.32	3.67	2.96	3.71	4.00	3.42	S <sub>1</sub>	I <sub>3</sub>
4.34	4.63	4.04	4.94	5.35	4.52	S <sub>2</sub>	
3.83	4.15	3.50	4.33	4.67	3.97	Mean	
---	5.89	5.64	----	6.17	5.87	General mean	
5.54	5.69	5.38	5.74	5.86	5.62	S <sub>1</sub>	C×S
6.00	6.10	5.90	6.30	6.49	6.12	S <sub>2</sub>	
LSD		F test	LSD		F test	F test and LSD	
0.303		*	0.078		*	I	
----		*	----		*	S	
----		*	----		*	C	
0.330		*	0.069		*	I×S	
0.190		*	0.061		*	I×C	
0.155		*	0.050		*	S×C	
0.268		*	0.086		*	I×S×C	

**Nitrogen use efficiency (NUE):** Data exhibited in Table 10 focus that the irrigation levels studied had a significant effect ( $p \leq 0.05$ ) on the NUE in both seasons. Thus, NUE was decreased significantly with decreasing amount of water applied to wheat plants. Decreasing irrigation water amount from I<sub>1</sub> to I<sub>2</sub> or I<sub>3</sub> resulting in the decrease in NUE reached about 33.16 and 47.85 %, respectively in the first season, being, 32.12 and 48.42 % in the second season in the same order. This is to be expected since the same trend was obtained with regard to grain yield as mentioned previous. Furthermore, the data also, reveal that splitting nitrogen fertilizer had a significant influence ( $p \leq 0.05$ ) on the NUE yield in the two growing seasons. Splitting

nitrogen fertilizer into four equal doses produced the highest mean values of NUE (37.90 and 36.89kg grain/kg N applied) in the first and second seasons, respectively. This is logic since the same trend was obtained with regard to grain yield as mentioned previous. Similar obtained were found by Rahman *et al.*, (2002) and Rahman *et al.* (2011). Moreover, the presented data state that wheat cultivars varied significantly in this respect in the two growing seasons. Thus, Sids-1 cultivar surpassed Giza -168 one and produced the highest mean values of NUE (36.39 and 35.27kg grain/kg N applied) in the first and second seasons, respectively. This is logic since the same trend was observed with regard to grain yield. The differences

between cultivars are mainly due to the interaction between their genetic makeup during growth periods and to the environmental factors prevailing during their development. These results are in agreement with that obtained by Rahman *et al.* (2002). Furthermore, the all first order interactions in this respect had a significant effect on NUE in both seasons. Also, the second order interaction

among irrigation, splitting and cultivars had a significant effect on NUE in the two growing season. Thus, the highest mean value of NUE (56.26 and 56.03kg grain/kg N applied) in the first and second seasons, respectively, was obtained from Sids-1 cultivar subjected to I<sub>1</sub> irrigation level and received nitrogen fertilizer at four splits.

**Table 10. Effect of irrigation levels, Nitrogen splitting, cultivars and their interactions on nitrogen use efficiency (NUE) kg/kg N.**

2013/2014			2012/2013			Seasons	
Mean	Sids-1	Giza-168	Mean	Sids-1	Giza-168	Cultivars(C) Splitting(S)	Irrigation levels(I)
39.16	42.06	36.25	41.95	44.65	39.25	S <sub>1</sub>	I <sub>1</sub>
51.81	56.03	47.59	53.23	56.26	50.19	S <sub>2</sub>	
45.48	49.05	41.92	47.59	50.46	44.72	Mean	
29.02	30.13	27.91	29.84	30.67	29.01	S <sub>1</sub>	I <sub>2</sub>
32.71	33.60	31.82	33.77	34.60	32.94	S <sub>2</sub>	
30.87	31.87	29.87	31.81	32.64	30.98	Mean	
20.77	23.04	18.49	22.96	24.54	21.37	S <sub>1</sub>	I <sub>3</sub>
26.15	26.77	25.53	26.69	27.64	25.74	S <sub>2</sub>	
23.46	24.91	22.01	24.82	26.09	23.56	Mean	
-----	35.27	31.27	-----	36.39	33.08	General mean	
29.65	31.74	27.55	31.58	33.29	29.88	S <sub>1</sub>	C×S
36.89	38.80	34.98	37.90	39.50	36.29	S <sub>2</sub>	
LSD		F test	LSD		F test	F test and LSD	
0.247		*	0.119		*	I	
----		*	---		*	S	
----		*	----		*	C	
0.252		*	0.118		*	I×S	
0.282		*	0.154		*	I×C	
0.194		*	0.132		*	S×C	
0.279		*	0.219		*	I×S×C	

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## تأثير مستويات الري وتجزئة السماد الأزوتي علي الانتاجية وكفاءة استخدام الأزوت لصنفين من قمح الخبز

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### الملخص:

اجريت تجربة حقلية بمزرعة قسم المحاصيل- كلية الزراعة - جامعة أسيوط خلال موسمي ٢٠١٢/٢٠١٣ و ٢٠١٣/٢٠١٤ لدراسة تأثير مستويات الري وتجزئة السماد الأزوتي علي الانتاجية وكفاءة استخدام الأزوت لصنفين من قمح الخبز. تم عمل ثلاث تجارب منفصلة في كل موسم تعرضت كل واحدة منها لمستوي من مستويات الري (١٠٠ ، ٧٥ ، و ٥٠% من الاحتياج المائي) وصممت كل تجربة باستخدام القطاعات كاملة العشوائية بترتيب القطع المنشقة مرة واحدة بثلاث مكررات. حيث تم وضع تجزئة السماد الأزوتي (٢ و ٤ مرات) في القطع الرئيسية بينما تم وضع الاصناف (جيزة ١٦٨ و سدس ١) في القطع المنشقة. وكانت اهم النتائج ما يلي:

اثر كلا من مستويات الري وتجزئة السماد الأزوتي والاصناف محل الدراسة معنويا علي كل الصفات المدروسة لكلا الموسمين. كما كان تأثير تفاعلات الدرجة الاولي وتفاعل الدرجة الثانية معنويا علي معظم الصفات محل الدراسة في موسمي الدراسة. وتم الحصول علي اعلي متوسط لقيم محصول الحبوب (٢٨,١٣ و ٢٨,٠٢ اردب للفدان للموسم الاول والثاني علي التوالي) وكفاءة استخدام الأزوت (٥٦,٠٣ و ٥٦,٢٦ كجم حبوب/كجم أزوت للموسم الاول والثاني علي التوالي) من زراعة الصنف سدس ١ تحت مستوي الري ١٠٠% من احتياج الري وتجزئة السماد الأزوتي علي اربع دفعات.