

## Effect of Nitrogen Fertilization Rates on Wheat Grown under Drip Irrigation System

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### Abstract

Application of nitrogen (N) fertilizer is one of the most important actions that increases grain yield and improves grain quality in winter wheat (*Triticum aestivum* L.) production. Presently, there are a large number of investigations in the field on different nitrogen fertilizer application regimes. However, there is little information available about the optimum level of N for drip irrigated wheat. Filed experiments in Randomized Complete Block Design (RCBD) conducted to study the response of drip irrigated wheat to three levels of N (120, 180, and 240 kg N ha<sup>-1</sup>). The field experiments were carried out at the Agricultural Experimental Station farm of the Faculty of Agriculture, Assiut University, Egypt during the two successive growth seasons of 2013/14 and 2014/2015. The application of N significantly ( $P<0.05$ ) enhanced the growth of drip irrigated wheat. The highest rate of nitrogen increased the uptake of N, P, and K by 61, 75, and 57% compared to the lowest treatment. Increasing rate of nitrogen to 240 kg N per hectare increased the Water Use Efficiency (WUE) by 34 and 22% in the first and second season, respectively, compared to N<sub>120</sub> treatment. The number of spike per m<sup>2</sup>, number of grains per spike, and grain weight per spike of wheat were affected significantly ( $P<0.05$ ) by N treatments. The application of N<sub>240</sub> increased the wheat grain yield by 34 and 22% in the first and second season, respectively, compared to N<sub>120</sub>. Based on the obtained results, it is recommended to fertilize drip irrigated wheat by 240 kg N per hectare.

**Keywords:** Drip irrigation, wheat, urea, nutrients uptake, water use efficiency, yield

### Introduction

In arid and semi-arid regions, water scarcity is the main yield limiting factor, where it is difficult to apply full crop water requirements to sustain maximal growth and yield. Therefore it is very important to determine how to maintain optimum crop yields under water deficit conditions. Recently, this has stimulated the researchers to find new irrigation technology, systems, and irrigation strategies to improve water and nutrients use efficiency. In modern irrigation systems, water and nutrients are supplied simultaneously (fertiga-

tion), mainly by drip irrigation devices (Bar-Yosef, 1999) which considered to be the most effective method to supply water and nutrients to plants (Zhang *et al.*, 2013). Drip irrigation has several advantages over traditional methods, such as better water and nutrients management (Eissa *et al.*, 2013), increasing crops yields and quality (Aujla *et al.*, 2007; Eissa *et al.*, 2013), and greater increases in water and nutrients use efficiency (Al-Omran *et al.* 2005; Mathieu *et al.*, 2007; Eissa *et al.*, 2013; Liang *et al.*, 2014). Fertigation is an effective tool to control placement,

timing, and the type of fertilizer needed according to the soil fertility status and the growth stage of crop. When combined with an efficient irrigation system, both nutrients and water can be manipulated and managed to obtain the maximum possible yield of marketable production from a given quantity of these inputs, moreover, minimize environmental pollution (Schumann *et al.*, 2009; Melgar *et al.*, 2010; Eissa *et al.*, 2013; Liang *et al.*, 2014).

Agriculture soil resources in Egypt are limited, only 3.5% of the total area is agricultural, whereas desert occupies 96% of total area. Water scarcity is one of the major problems for crop production in Egypt, this is needs to reduce the consumption of water in irrigation by developing new technologies and methods that can be help full to utilize this precious input in an effective way. Agriculture in Egypt is almost entirely dependent on irrigation and the single main source of water is the Nile.

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops of the world on account of its wide adaptability to different agro-climatic conditions and different soils. Among major cereals, wheat ranks first in area and production at the global level and it contributes more calories and proteins to the world's human diet than any other cereals. It is the main staple food of nearly 35 per cent of the world population. The total cultivated area of wheat in the world is 240.00 million hectares with an annual production of 713 million tonnes, with an average productivity of 2717 kg $ha^{-1}$  (FAOS-

TAT, 2014). In Egypt, wheat is the first most important food crop; with a cultivated area of 1.3 million hectares in 2013 which produced 8.53 million tones (FAOSTAT, 2014). Wheat production in Egypt represents 54% of the total consumption and imports the reset amount yearly (FAOSTAT, 2014).

Recently a great attention of several investigations has been directed to increase the productivity of wheat to minimize the gap between the Egyptian production and consumption by increasing the cultivated area and wheat yield per unit area (Zaki *et al.*, 2012). Wheat production in Egypt using drip irrigation was study by several researchers (Shalby *et al.*, 1997; Selim, 2004; Abd El-Rahman, 2009; Eissa *et al.*, 2010; Eissa *et al.*, 2013). In order to get best economic returns from wheat under arid regions, there is an urgent need to identify and adopt effective irrigation and fertilization management strategies. Using drip irrigation improves quality and yield of wheat as well as it increases the water and nutrient use efficiency (Eissa *et al.*, 2010; Abdelraouf *et al.*, 2013; Wang *et al.*, 2013).

Nitrogen (N) is the one of the most limiting factor in wheat production. Hence, the application of nitrogen fertilizers results in higher biomass yields and protein content (Gomaa *et al.*, 2015). Managing N inputs on wheat production systems is an important issue in order to achieve maximum profitable production and minimum negative environmental impact. Meanwhile, the farmers still believe that increasing nitrogen fertilizer is the only way of obtaining high

yields of wheat. Indeed, the grain yield of wheat was increased with increasing rates of fertilizer application, which were reported from a series of field experiments (Garabet *et al.*, 1998; Li *et al.*, 2004). However, it is also found that the excessive application of nitrogen cannot increase crop yields further, but considerably increases N leaching (Ju *et al.*, 2009; Hou *et al.*, 2012). Overuse of fertilizer not only increased the high cost of production, but also led to degradation of water and soil quality, especially the groundwater (Zhu *et al.*, 2005; Garnier *et al.*, 2010).

Application of nitrogen (N) fertilizer is very important in winter wheat (*Triticum aestivum* L.) production. However, unsuitable nitrogen fertilizer often leads to a low nitrogen use efficiency and serious nitrogen loss, bringing a potential risk of pollution to the environment (Zhu *et al.*, 2005; Garnier *et al.*, 2010). There is little information available about the

effect of nitrogen fertilization rates on the nutrients uptake, quality, and yield of drip irrigated wheat. The present research aims to study the response of drip irrigated wheat to nitrogen fertilization rates and to assess the optimum fertilization rate.

## Materials and Methods

### Field experiment

The present investigation was carried out at the Agricultural Experimental Station farm of the Faculty of Agriculture, Assiut University, Egypt, which is located around the point of 27°12' N latitude and 31°09' E longitude and at 51 m altitude. The soil was classified as Typic Torri fluvents according to Soil Taxonomy (Soil Survey Staff, 2014). Selected physical and chemical properties are summarized in Table 1. The experiment included three rates of nitrogen (120, 180, and 240 kg ha<sup>-1</sup>). The experimental design was randomized complete block design (RCBD) with three replicates.

**Table 1. Some physical and chemical soil properties (0-30 and 30-60 cm)**

Properties	0-30 cm	30-60 cm
Sand (%)	24.1	24.3
Silt (%)	62.4	62.5
Clay (%)	13.5	13.2
Texture	Si. L	Si. L
Field capacity (v%)	42.7	42.5
Wilting point (v%)	21.1	20.1
CaCO <sub>3</sub> (%)	5.42	5.08
pH (1:2.5 suspension)	7.54	7.78
EC <sub>e</sub> dS m <sup>-1</sup>	0.99	0.95
Organic matter (g kg <sup>-1</sup> )	2.41	2.25
Total nitrogen (mg kg <sup>-1</sup> )	560	520
Available nitrogen (mg kg <sup>-1</sup> )	67.2	62.4
Available Olsen P (mg kg <sup>-1</sup> )	11.78	11.32
Available-K (mg kg <sup>-1</sup> )	258.1	477.4

Each value represents a mean of three replicates

The experimental site was irrigated using a drip irrigation system. The in-line GR dripper laterals were installed 0.7 m apart. The emitters were spaced 0.30 m apart with a flow

rate of 2.1 L h<sup>-1</sup>. Wheat grains (*Triticum aestivum vulgare*, cv *vinicty 6*) at rates of 190 kg ha<sup>-1</sup> were sown directly beneath the dripper's line and on the two side of it. The sowing was

done on December 5<sup>th</sup>, 2013 and December 1<sup>st</sup>, 2014 in the first and second season respectively. All the agriculture practices were applied at the recommendations set by the Ministry of Agriculture and Land Reclamation (Egypt). 238 kg of super phosphate (15.5% P<sub>2</sub>O<sub>5</sub>) per hectare was added directly to the soil in one dose before planting. Potassium fertilizer at a rate of 119 kg potassium sulphate (48% K<sub>2</sub>O) per hectare was added with the irrigation water in two equal portions. Nitrogen fertilizer levels were applied with the irrigation water in the form of urea (48%N) at five equal doses. Composite plant samples each represent to 1/2 m<sup>2</sup> were taken from each experimental unit after 70 days of planting (18 samples) and were used to study the uptake of nitrogen, phosphorus, and potassium. These plant samples were cleaned, washed with tap and distilled water, air dried, then dried in oven at 70 °C until constant weight, ground and stored for chemical analysis. Wheat plants were harvested on May 7<sup>th</sup>, 2014 and May 6<sup>th</sup>, 2015 in first and second seasons respectively and the grain and total yield were recorded.

### Irrigation water requirements

The daily reference evapotranspiration (ET<sub>o</sub>) was estimated using Penman–Monteith’s modified equation (Allen *et al.*, 1998). The actual evapotranspiration (ET<sub>c</sub>) was calculated according to the equation (ET<sub>c</sub> = ET<sub>o</sub> × K<sub>c</sub>). K<sub>c</sub> values used for wheat were 0.65, 0.70, 0.75, 0.70 for growth stages initial, development, mid, and end, respectively (Allen *et al.*, 1998). Based on the climate data in Table 2, the ET<sub>c</sub> values for wheat were calculated. The estimated ET<sub>o</sub> was 602 and 557 mm and the ET<sub>c</sub> was 431 and 399 mm in 2014 and 2015 respectively. The total irrigation water requirement during the whole growth season was 558.1 and 516.3 mm in the first and second season, respectively, (the application efficiency for drip irrigation (%) (E<sub>a</sub> = 85) and the leaching fraction was considered as 10% of water requirement). Water use efficiency (WUE) was calculated using the equation (WUE = GY / ET<sub>c</sub>), where GY equals grain yield, ET<sub>c</sub> equals seasonal actual evapotranspiration (mm). Irrigation water use efficiency (IWUE) was estimated using the formula (IWUE = GY / IW), where IW equals seasonal crop water applied (mm).

**Table 2. Average monthly maximum (T<sub>max</sub>) and minimum (T<sub>min</sub>) temperature, relative humidity (RH), wind speed (WS) and reference evapotranspiration (ET<sub>o</sub>) during 2014 and 2015 growing seasons.**

Month	T <sub>max</sub>	T <sub>min</sub>	RH (%)	ET <sub>o</sub> (mm)	WS (km h <sup>-1</sup> )
December, 2013	20.6	7.6	40.5	2.80	2.80
January, 2014	22.4	6.3	55.2	2.42	3.95
February, 2014	23.8	7.4	49.2	3.58	6.00
March, 2014	27.9	12.1	42.4	4.68	5.75
April, 2014	32.8	15.8	34.9	5.84	5.45
December, 2014	23.2	8.5	48.4	3.15	7.20
January, 2015	20.5	5.5	44.0	3.25	8.00
February, 2015	22.7	7.6	38.8	4.11	8.20
March, 2015	27.2	12.2	34.0	5.77	9.69
April, 2015	29.3	14.6	25.6	6.93	9.93

Rainfall was 0 for the two growth season. Data were obtained from Assuit weather station at Central Laboratory for Agricultural Climate

### Soil and plant analysis

Composite soil sample was collected before cultivation from the top 30 cm. Air-dried, crushed, and sieved to pass through a 2-mm. Selected physical and chemical properties of the soil were determined according to Burt (2004). The soil pH was measured in 1:2.5 soil to water suspension using a digital pH meter. The electrical conductivity (EC) was estimated using the salt bridge method (Rhoades, 1982). Available soil nitrogen was extracted by 2 M potassium chloride, and then nitrogen in the extract was determined using micro-kjeldahl method Burt (2004). Available soil phosphorus was extracted by 0.5 M sodium bicarbonate solution at pH 8.5 according to Olsen *et al.* (1954) and phosphorus was determined by spectrophotometer. Available potassium was extracted by ammonium acetate method and was measured by flame photometry (Jackson, 1973).

Plant samples were digested in  $H_2SO_4$  and  $H_2O_2$  as described by Parkinson and Allen (1975) then were analyzed for N, P, and K as described by Page *et al.* (1982).

### Statistical analysis:

Data obtained in each season were statistically analyzed. Statistical computer program MSTAT-C, Crop & Soil Sciences Dept. Michigan State University was used. Mean values were compared for each other using Duncan's test at  $P < 0.05$ . MSTAT (1987) micro computer program.

### Results and Discussion

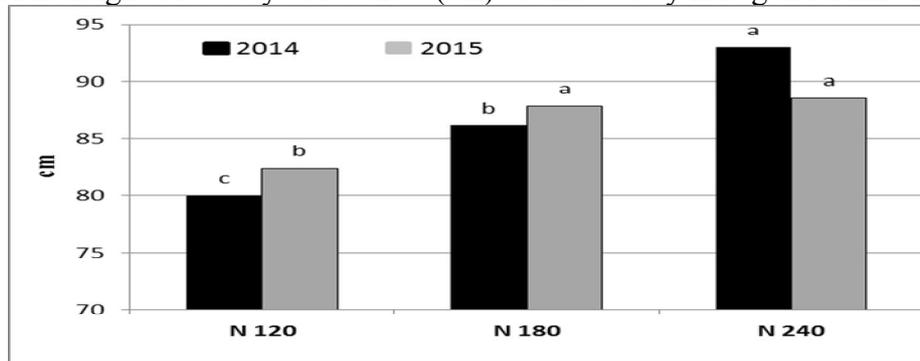
#### Effect of nitrogen rates on the growth of drip irrigated wheat

The data in Fig. 1 show the wheat plant highest as affected by the different nitrogen fertilization rates. The application of nitrogen to drip irrigated wheat significantly ( $P < 0.05$ ) affected the height of drip irrigated wheat. The height increase due to the rate of nitrogen ( $240 \text{ kg ha}^{-1}$ ) was 16 and 7% increase in the plant height in the first and second season, respectively, compared to the low treatment ( $120 \text{ kg ha}^{-1}$ ). Fig 2 and 3 illustrated the effect of nitrogen fertilization on the fresh and dry wheat. The highest significant values of fresh and dry weights were obtained when wheat amended with  $240 \text{ kg ha}^{-1}$ . The application of nitrogen at a rate of  $240 \text{ kg N per hectare}$  increased the fresh weights by 40 and 39% in the first and second season, respectively, compared to the low treatment ( $120 \text{ kg N ha}^{-1}$ ). The application of nitrogen at a rate of  $240 \text{ kg N per hectare}$  increased the dry weights by 40 and 34% in the first and second seasons, respectively, compared to the low treatment ( $120 \text{ kg N ha}^{-1}$ ). The current study indicates that increasing nitrogen rates increased the growth of drip irrigated wheat. Nitrogen plays a vital role in all living tissues of the plants and is a constituent of many fundamental cell components such as nucleic acids, amino acids, enzymes, and photosynthetic pigments (Bungard *et al.*, 1999). Hussain *et al.* (2006) studied the response of wheat to five rates of nitrogen i.e., 0, 50, 100, 150, and  $200 \text{ kg ha}^{-1}$  and they reported that increasing N rates increased the dry matter production of wheat. Ryan *et al.* (1991), Davidson and Campbell (1983), and Pala *et al.*

(1996) proposed that this increase may be due to the increase leaf of area index, green plant area, and an increase in the period for which the

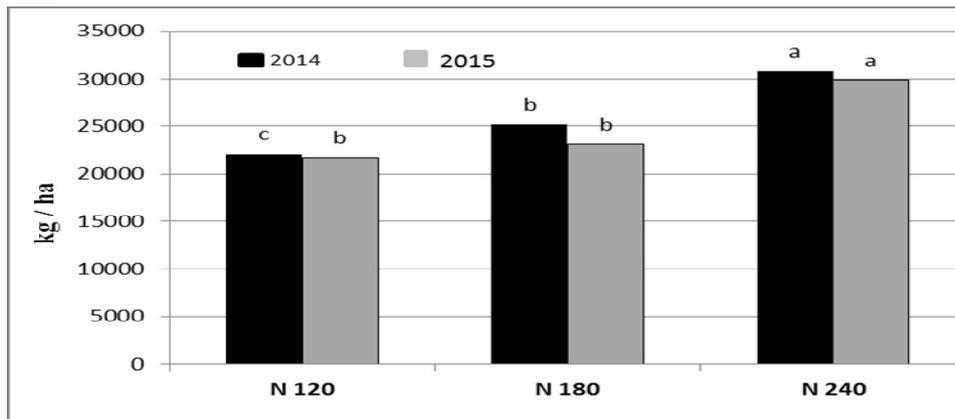
crop remained green which resulted in increased capture efficiency of radiation energy and consequently more dry matter production.

**Fig. 1:** Plant height of 70 days-old wheat (cm) as affected by nitrogen fertilization rates



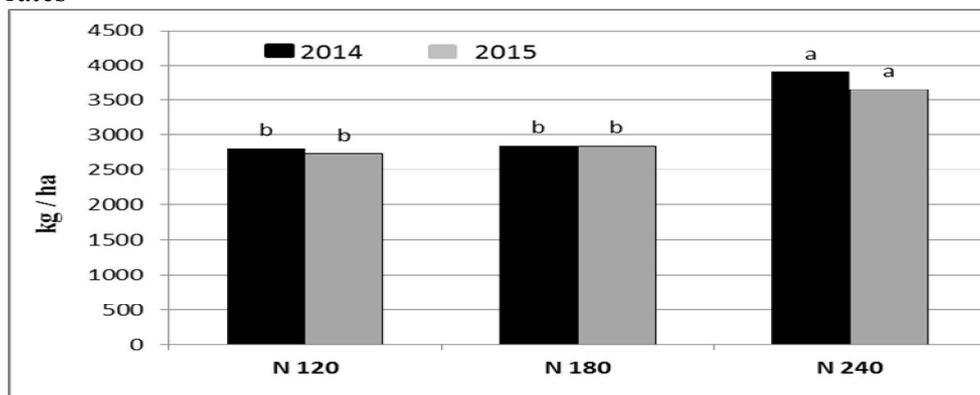
Means denoted by the same letter indicate no significant difference according to Duncan's test at  $P < 0.05$ .

**Fig. 2:** Fresh weight of 70 days-old wheat ( $\text{kg ha}^{-1}$ ) as affected by nitrogen fertilization rates



Means denoted by the same letter indicate no significant difference according to Duncan's test at  $P < 0.05$ .

**Fig. 3:** Dry weight of 70 days-old wheat ( $\text{kg ha}^{-1}$ ) as affected by nitrogen fertilization rates



Means denoted by the same letter indicate no significant difference according to Duncan's test at  $P < 0.05$ .

**Effect of nitrogen rates on N, P, and K concentrations and uptake by drip irrigated wheat**

The data illustrated in Table 3 show the nitrogen (N), phosphorus (P), and potassium (K) concentrations in the shoots of 70 days-old wheat as affected by nitrogen fertilization rates. The application of nitrogen to drip irrigated wheat significantly ( $P < 0.05$ ) affected the concentrations of N, P, and K. The highest significant values of N, P, and K concentrations were obtained when wheat amended with 240 kg ha<sup>-1</sup>. The application of nitrogen at a rate of 240 kg N per hectare increased the concentrations of N by 16.4 and 6.4 % in the first and second seasons, respectively, compared to the low treatment (120 kg N ha<sup>-1</sup>). The application of nitrogen at a rate of 240 kg N per hectare increased the concentrations of P by 25.4 and 31.4% in the first and second seasons, respectively, compared to the low treatment (120 kg N ha<sup>-1</sup>). The application of nitrogen at a rate of 240 kg N per hectare increased the concentrations of K by 21.1 and 5.7% in the first and second seasons, respectively, compared to the low treatment (120 kg N ha<sup>-1</sup>). In

general, the concentrations of N, P, and K in the shoots of drip irrigated wheat responded to all the studied nitrogen rates and the highest significant values were recorded when N was applied at a rate of 240 kg N per hectare.

The data illustrated in Table 3 show the nitrogen N, P, and K uptake by the 70 days-old wheat as affected by the nitrogen fertilization rates. The application of nitrogen to drip irrigated wheat significantly ( $P < 0.05$ ) affected the uptake of N, P, and K. The highest significant uptake of N, P, and K were obtained when wheat amended with 240 kg ha<sup>-1</sup>. The application of nitrogen at a rate of 240 kg N per hectare increased the uptake of N by 61% in the first season compared to the low treatment (120 kg N ha<sup>-1</sup>). The application of nitrogen at a rate of 240 kg N per hectare increased the uptake of P by 75 and 76 % in the first and second season, respectively, compared to the low treatment (120 kg N ha<sup>-1</sup>). The application of nitrogen at a rate of 240 kg N per hectare increased the uptake of K by 57 and 42 % in the first and second season, respectively, compared to the low N treatment (120 kg N ha<sup>-1</sup>).

**Table 3. N, P, and K concentrations (g kg<sup>-1</sup>) and uptake (kg ha<sup>-1</sup>) by 70 days-old wheat as affected by nitrogen fertilization rates**

	2014						2015					
	N		P		K		N		P		K	
	conc.	Up-take	conc.	uptake	conc.	uptake	conc.	up-take	conc.	uptake	conc.	uptake
N <sub>120</sub>	36.220 <sub>b</sub>	101c	5.978c	16.74c	30.268c	103.0c	37.80 <sub>b</sub>	117a	7.21c	17.09c	34.70c	94.54c
N <sub>180</sub>	40.620a	115b	6.850 <sub>b</sub>	19.41 <sub>b</sub>	35.667 <sub>b</sub>	108.5 <sub>b</sub>	38.30 <sub>b</sub>	113a	7.78 <sub>b</sub>	22.05 <sub>b</sub>	38.59a	109.33 <sub>b</sub>
N <sub>240</sub>	42.173a	165a	7.500a	29.30a	36.667a	162.8a	40.22a	122a	8.24a	30.12a	36.68 <sub>b</sub>	134.02a

Means denoted by the same letter indicate no significant difference according to Duncan's test at  $P < 0.05$

Based on the data in Table 3, the concentrations and uptake of N, P, and K by drip irrigated wheat responded to all the studied nitrogen rates and the highest significant values were recorded when N was applied at a rate of 240 kg N per hectare. Addition of N could stimulate development of plant roots, contributing to increased nutrients uptake (Zhang *et al.*, 2004). Campillo *et al.* (2010) studied the response of wheat to five rates of nitrogen i.e., 0, 150, 200, 250, and 300 kg ha<sup>-1</sup> and they reported that increasing N rates increased the N concentrations in wheat tissues. Similar results were reported by Hussain *et al.* (2006). The application of nitrogen improves the root growth and this will increase the ability of roots to explore more soil and increases the uptake of nutrients. Zhang *et al.* (2004) reported that added N increased the growth of roots and produced a mass of fine roots. Moreover, the application of nitrogen may be increase the availability of nutrients in soil. Ouyang *et al.* (1999) stated that application of nitrogen fertilizer not only increased soluble P concentrations in the band area, but increased P diffusion from the fertilizer zone to the surrounding soil as well. In the current study, drip irrigated wheat was fertilized by different rates of nitrogen in the form of urea. Once incorporated in the soil, urea reacts through hydrolysis to form NH<sup>+4</sup> ions (Mitchell *et al.*, 2000). NH<sup>+4</sup> ions enhancing rhizosphere acidification and may increase P availability and plant uptake (Zhang *et al.*, 2004). Interactions between N and K in crop fertilization have been described by several stu-

dies. Increasing rates of nitrogen increased the availability and uptake of K where NH<sup>+4</sup> compete with the exchangeable K (Rowe *et al.*, 2008; Zhang *et al.* 2010; Bar-Tal, 2011).

#### **Effect of nitrogen rates on spike number, grain number, and grain weight of drip irrigated wheat**

The data in Table 4 show the number of spike (NS) per m<sup>2</sup>, number of grains (NG) per spike, and grain weight (GW) per spike of wheat as affected by the different rates of nitrogen. The number of spike per m<sup>2</sup> and number of grain per spike significantly ( $P<0.05$ ) affected by the application of nitrogen in both the two season. The highest significant NP and NG values were obtained when wheat amended with 240 kg ha<sup>-1</sup>. The application of nitrogen at a rate of 240 kg N per hectare increased the NP by 17 and 5% in the first and second season, respectively, compared to the low treatment (120 kg N ha<sup>-1</sup>). The application of nitrogen at a rate of 240 kg N per hectare increased the NG by 15.7 and 14% in the first and second season, respectively, compared to the low treatment (120 kg N ha<sup>-1</sup>). The application of nitrogen at a rate of 240 kg N per hectare increased the GW by 17 and 3.0% in the first and second season, respectively, compared to the low treatment (120 kg N ha<sup>-1</sup>). In general, the number of spike per m<sup>2</sup>, number of grains per spike, and grain weight per spike of wheat were affected significantly by the different rates of nitrogen and the highest significant values were recorded when N was applied at a rate of 240 kg N per hectare. Mandic *et al.* (2015) studied the effect of three rates of N (0, 75, and 150 kg N

ha<sup>-1</sup>) on wheat growth and they found that increasing N rates increased number of spike per m<sup>2</sup>, number of grains per spike, and grain weight

(GW) per spike. Similar results were reported by Hussain *et al.* (2006) and Asif *et al.* (2012).

**Table 4. Number of spike (NS) per m<sup>2</sup>, number of grains (NG) per spike, and grain weight (GW) per spike in gram**

	2014			2015		
	NS	NG	GW	NS	NG	GW
N <sub>120</sub>	496.0c	89.3c	4.7a	469.3b	92c	4.91a
N <sub>180</sub>	626.0a	97.5b	4.6a	452.0b	100a	4.67a
N <sub>240</sub>	580.3b	103.0a	5.5a	494.3a	105a	5.06a

Means denoted by the same letter indicate no significant difference according to Duncan's test at  $P < 0.05$ .

### Effect of nitrogen rates on yield and yield components of drip irrigated wheat

The data in Table 5 show the grain (GY), straw (SY), and biological yield (BY) of wheat as affected by the different rates of nitrogen. The grain yield ranged from 5083 to 8884 kg ha<sup>-1</sup> while the straw yield ranged from 20315 to 25536 kg ha<sup>-1</sup>. Wheat biological yield ranged from 26933 to 31750 kg ha<sup>-1</sup>. The application of nitrogen to drip irrigated wheat significantly ( $P < 0.05$ ) affected on yield and yield components of wheat in both the two seasons. The highest significant grain, straw, and biological yield was obtained when wheat was amended with 240 kg ha<sup>-1</sup>. The application of nitrogen at a rate of 240 kg N per hectare increased the wheat grain yield by 34 and 22% in the first

and second seasons, respectively, compared to the low treatment (120 kg N ha<sup>-1</sup>). The application of nitrogen at a rate of 240 kg N per hectare increased the wheat straw yield by 10.5 and 16.4% in the first and second season, respectively, compared to the low treatment (120 kg N ha<sup>-1</sup>). The application of nitrogen at a rate of 240 kg N per hectare increased the wheat biological yield by 16.4 and 17.5% in the first and second seasons, respectively, compared to the low treatment (120 kg N ha<sup>-1</sup>). In general, yield and yield components of drip irrigated wheat responded to all the studied nitrogen rates and the highest significant grain, straw, and biological yield were recorded when N was applied at a rate of 240 kg N.

**Table 5. Grain (GY), straw (SY), and biological yield (BY) of wheat (Kg ha<sup>-1</sup>) as affected by nitrogen fertilization rates**

	2014			2015		
	GY	SY	BY	GY	SY	BY
N <sub>120</sub>	6618 <sup>c</sup>	20315 <sup>b</sup>	26933 <sup>b</sup>	5083 <sup>c</sup>	21935 <sup>c</sup>	27019 <sup>c</sup>
N <sub>180</sub>	7027 <sup>b</sup>	20810 <sup>b</sup>	27837 <sup>b</sup>	5546 <sup>b</sup>	23931 <sup>b</sup>	29477 <sup>b</sup>
N <sub>240</sub>	8884 <sup>a</sup>	22462 <sup>a</sup>	31346 <sup>a</sup>	6214 <sup>a</sup>	25536 <sup>a</sup>	31750 <sup>a</sup>

Means denoted by the same letter indicate no significant difference according to Duncan's test at  $P < 0.05$ .

High yields are the result of environmental, technological, manage-

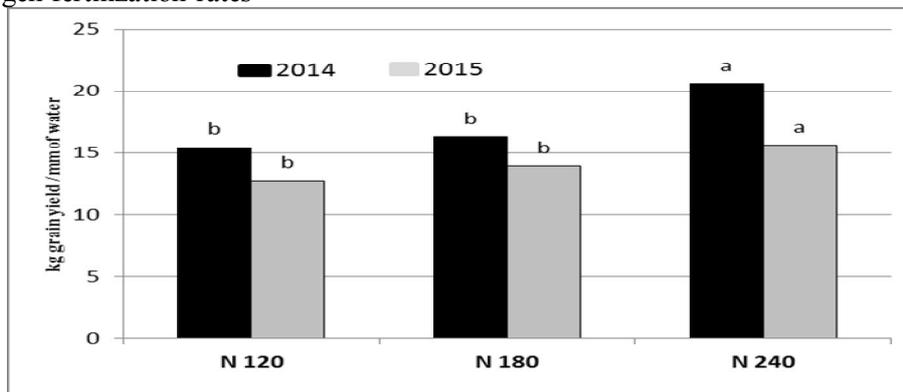
ment, capital, and input conditions. High wheat yields require increases

in N application (Semenov *et al.*, 2007; Campillo *et al.*, 2010). Many studies have shown that increasing the fertilizer N rate properly can increase the grain, straw, and biological yield of wheat (Subedi *et al.*, 2007, Asif *et al.*, 2012; Mandic *et al.* 2015). Yu and Zhenwen (2008) studied the response of wheat irrigated by traditional surface irrigation to three levels of N i.e., 0, 168, and 240 kg N ha<sup>-1</sup> and they found that the application of N fertilizer increased the grain yield and protein content of the grain. Similar results were reported by Han *et al.*(1998) and Yue *et al.* (1998).

**Effect of nitrogen rates on water use efficiency of drip irrigated wheat**

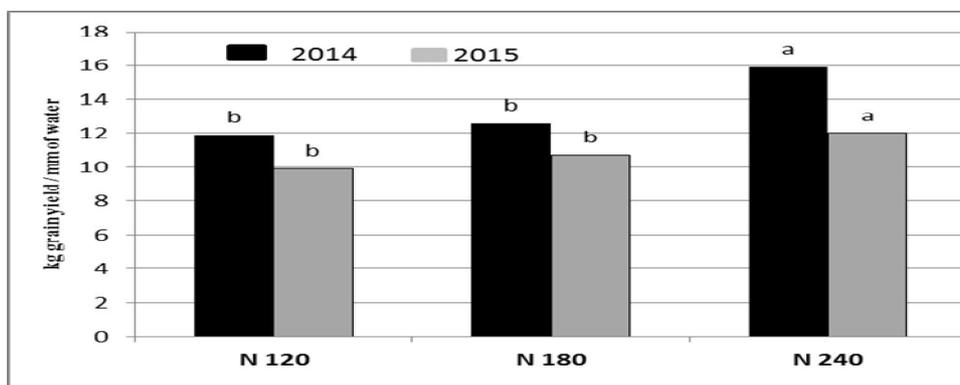
The data in Fig. 4 and 5 show the water use efficiency and irrigation water use efficiency of wheat as affected by the different rates of nitrogen. The application of nitrogen to drip irrigated wheat significantly ( $P<0.05$ ) affected on water use efficiency and irrigation water use efficiency in both the two seasons. Increasing rate of nitrogen to 240 kg N per hectare increased the WUE by 34 and 22% in the first and second seasons, respectively, compared to the lowest rate (120 kg N ha<sup>-1</sup>). The application of 240 kg N ha<sup>-1</sup> increased the IWUE by 34 and 21% compared to the lowest rate.

**Fig. 4:** Water use efficiency (WUE) of wheat (kg grain yield mm<sup>-1</sup> of water) as affected by nitrogen fertilization rates



Means denoted by the same letter indicate no significant difference according to Duncan's test at  $P<0.05$ .

**Fig. 5:** Irrigation water use efficiency (IWUE) of wheat (kg grain yield mm<sup>-1</sup> of water) as affected by nitrogen fertilization rates



Means denoted by the same letter indicate no significant difference according to Duncan's test at  $P < 0.05$ .

In the current study, drip irrigated wheat used water more efficiently under the high rate of nitrogen. Investigations have shown that WUE of wheat increased with increasing nitrogen rates (Hussain, Al-Jaloud, 1995; Wang *et al.*, 2012; Shirazi *et al.*, 2014). Increasing water use efficiency requires increasing photosynthetic capacity; therefore, more nitrogen will be required (Martin *et al.*, 2010). Nitrogen is a major limiting factor of plant growth and development. Nitrogen is an integral part of DNA, RNA, chlorophyll and proteins, plays an important role in cell metabolism, affects photosynthetic capacity of leaves by increasing stromal and thylakoid proteins in leaves (Marschner, 1995; Bungard *et al.*, 1997).

It may be concluded that, nitrogen fertilization enhanced the growth and yield of drip irrigated wheat. Moreover, N application improved the uptake of nutrients and enhanced water use efficiency. Based on the obtained results, 240 kg per hectare is the optimum nitrogen level for drip irrigated wheat.

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تأثير معدلات التسميد النيتروجيني علي القمح النامي تحت نظام الري بالتنقيط  
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### الملخص

تعد إضافة الأسمدة النيتروجينية واحدة من أهم العمليات التي تزيد من محصول الحبوب وتحسن من جودته في إنتاج القمح. في الوقت الحاضر، هناك عدد كبير من الأبحاث في هذا المجال على نظم مختلفة لاستخدام الأسمدة النيتروجينية. ومع ذلك، هناك القليل من المعلومات المتاحة عن المعدل الأمثل من النيتروجين للقمح المروي بالتنقيط. التجارب الحقلية في تصميم القطاعات كاملة العشوائية التي أجريت لدراسة استجابة القمح المروي بالتنقيط الي ثلاث معدلات من النيتروجين ١٢٠ و ١٨٠ و ٢٤٠ كجم نيتروجين للهكتار. وقد أجريت التجارب الحقلية في مزرعة محطة الأبحاث الزراعية بكلية الزراعة، جامعة أسيوط، مصر خلال موسمين متعاقبين ٢٠١٤/١٣ و ٢٠١٥/١٤. إضافات النيتروجين أدت الي زيادة معنوية ( $P < 0.05$ ) لنمو القمح المروي بالتنقيط. المعدل الأعلى للنيتروجين أدى الي زيادة في امتصاص النيتروجين والفوسفور، والبوتاسيوم بنسبة ٦١، ٧٥، ٥٧٪ مقارنة مع أدنى معدل. زيادة معدل النيتروجين إلى ٢٤٠ كجم نيتروجين للهكتار الواحد أدى إلى زيادة كفاءة استخدام المياه (WUE) بنسبة ٣٤ و ٢٢٪ في الموسم الأول والثاني، على التوالي، مقارنة مع معدل النيتروجين ١٢٠. تأثر عدد السنبال في المتر المربع وعدد الحبوب في السنبلة ووزن الحبوب في السنبلة من القمح معنوياً ( $P < 0.05$ ) من خلال معاملات النيتروجين. إضافة النيتروجين ٢٤٠ وحدة زادت محصول الحبوب للقمح بنسبة ٣٤ و ٢٢٪ في الموسم الأول والثاني، على التوالي، مقارنة إضافة النيتروجين بعدل ١٢٠ وحدة. واستنادا إلى النتائج التي تم الحصول عليها، فمن الأفضل تسميد القمح المروي بالتنقيط بمعدل ٢٤٠ كجم نيتروجين للهكتار الواحد.

**الكلمات المفتاحية:** الري بالتنقيط، القمح، اليوريا، إمتصاص العناصر، كفاءة استخدام المياه، المحصول.