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# Response of some wheat varieties to irrigation and nitrogen fertilization using ammonia gas in North Nile Delta region

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**Abstract** Strategies of regulated irrigation and fertilization are one of the most practical ways in saving irrigation water and N-fertilizer of farmland in arid and semi-arid regions. A field experiments were conducted in the two winter seasons of 2012/2013 and 2013/2014 on clay soil to investigate the effect of 3, 4 and 5 irrigation events and their interaction with two N-fertilization levels using ammonia gas; 75 and 90 kg N $fed^{-1}$ which represent 100% and 120% of nitrogen recommended dose, respectively on wheat water consumptive use, grain yield, yield components and water productivity (WP) of three Egyptian wheat varieties; Misr-1, Misr-2 and Sakha-94 and compare the estimated wheat crop evapotranspiration ($ET_c$) values computed using Hargreaves, Penman–Monteith and Class A pan methods with the measured actual wheat evapotranspiration ($ET_a$) to evaluate the suitable method for estimating the reference evapotranspiration in North Nile Delta conditions.

The obtained results showed that the irrigation treatments (3 events) gave the lowest values for water consumptive use, grain, straw, biological yield and 1000-grain weight. Nitrogen fertilizer in ammonia up to 90 kg N $fed^{-1}$ decreased all characters studied except grain yield which has no any significant differences between both N levels. Significant differences were detected among the three wheat varieties in all characters studied during both seasons and their interaction with the other treatments combined. Misr-1 cultivar was superior and gave the highest value of all studied characters and yield response to water factor ($K_y$) followed by Misr-2 while Sakha-94 showed the lowest values in all studied characters. Thus, Misr-1 cultivar proved to be more tolerant cultivar to drought followed by Misr-2 and Sakha-94. WP decreased with increasing irrigation events and nitrogen levels, and reached the maximum values at three irrigation treatments (3 events) and at 90 kg N $fed^{-1}$. So, irrigating the wheat 4 events during growing seasons and application of 75 kg N $fed^{-1}$ in the form of ammonia gave the highest values of yield and yield components of Misr-1 wheat cultivar under North Nile Delta condition.

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Also, results showed that FAO Penman–Monteith is a suitable method for North Delta, Egypt, because of the least amount of error and least percentage deviation between $ET_a$ and $ET_c$ comparing with the other evaluated methods.



## Introduction

Within the arid and semi-arid regions, water available is a major limitation for crop production. Wheat crop needs sufficient available water and N to achieve optimum yields, quality and adequate grain-protein content. In recent years, the water shortage has gradually increased in our country mainly due to the annual increasing irrigation and dry climate. Therefore, a better understanding of the water balance is essential for exploring water saving measures. One of the most important aspects of water balance is number of irrigation to the crop, which is a key factor to determine proper to improve water use efficiency in irrigated agriculture. In Egypt, its production does not meet the current demand. The Egyptian government is doing more efforts to reduce the imported percentage to less than 50% from the total consumption (Abdrabbo et al., 2010).

The key to raise crop yield, lies to a large extent, in the increase of usable water and raising the efficiency of water use (Li et al., 2001). Over the last decades, a number of studies have been conducted on the regulation of water and fertilizers in arid and semi-arid regions in an attempt to increase crop yield (De Juan et al., 1999 and Li et al., 2001). Ouda et al. (2010) reported that irrigation was rescheduled (1804.6 $m^3$ -fed$^{-1}$) and number of irrigations for wheat was reduced to 5 irrigations instead of 6 irrigations. Sarwar et al. (2010) found that wheat crop supplied with five irrigations at crown root + tillering + booting + earing + milking recorded the highest grain yield (5696.8 kg ha$^{-1}$). Wajid et al. (2002) reported that wheat crop produced highest grain yield by applying irrigation at all definable growth stages. Because irrigation is an expensive input, farmer, agronomist, economist and engineer need to know the response of yield to irrigation.

There were many intelligent irrigation systems computing applied water and evapotranspiration (ET) that based on climatic conditions (McCready et al., 2009; Mendez-Barroso et al., 2008; Lozano and Mateos, 2008). Aggarwal et al. (1986) showed that water use efficiency (WUE) for wheat decreased with increasing ET. The use of frequent, but low water application volumes is superior to the more traditional scheduling of few applications of large irrigation volumes in terms of irrigation water use efficiency (IWUE) (Dukes et al., 2010; Locascio, 2005; Zotarelli et al., 2009). Jin et al. (1999) reported that excessive irrigation led to a decrease in crop WUE and that effective deficit irrigation may result in higher production and WUE. On the contrary, Olesen et al. (2000) showed that the effect of irrigation on wheat yield was almost solely due to increase transpiration, while WUE and harvest index remained unaffected.

Moussa and Abdel-Maksoud (2004) found that evapotranspiration (ET) value was increased as supplemental irrigation increased in wheat crop, since evapotranspiration ranged from 338 to 382 mm at one third of full supplemental irrigation and from 434 to 453 mm at full supplemental one. El-Far and Teama (1999) found that the highest number of spikes m$^{-2}$, 1000-grain weight and grain yield was obtained from irrigation every 31 days but the highest straw yield was obtained at irrigation every 21 days. Sharaan et al. (2000) reported that skipping irrigation either at heading or at drought-ripe stage decreased all studied traits except biological and straw yields fed$^{-1}$. Moreover, Normal irrigation produced the highest averages of different traits followed by those resulted from skipping one irrigation at drought ripe stage, meanwhile, the lowest values were obtained from skipping one irrigation at heading stage.

Both organic and inorganic sources of supplemental nitrogen are available to the farmers. Costs and form of the supplemental nitrogen dictate which of these sources should be used in a given situation. In addition, nitrogen fertilizer sources have considerable effect on both soil pH and solubility of cations. Shams El-Din et al. (1990) found that anhydrous ammonia, urea, ammonium sulfate and ammonium nitrate were equal as a source of nitrogen fertilization, and the effect of the interactions between N rates and sources on the yield and yield components was not significant. So, on the basis of previous and from an economical point of view, the use of anhydrous ammonia in fertilizing wheat crop was recommended under Egyptian conditions. Many researchers found that grain and straw yields of wheat plants were increased due to increasing nitrogen level while, Abd El-Hmeed and Omar (2006) concluded that, increasing N levels up to 105 kg N fed$^{-1}$ significantly increased each of spike length, 1000-grain weight and grain yield. Mahmoud et al. (2006) recorded that grain and straw yields for wheat plants were increased due to increasing nitrogen level from 20 to 40, 60, 80 and 100 kg N fed$^{-1}$.

The determination of crop water requirements is the first step used in planning and design. The operation commonly involves of the reference crop evapotranspiration ($ET_o$) or evaluation of crop evapotranspiration ($ET_c$). Better estimates of crop evapotranspiration play important role to accurately determine the crop water requirements. Different methods can be used to determine crop evapotranspiration ($ET_c$), which is an essential element in crop water use (Attarod et al., 2005). The FAO Penman–Monteith method (Allen et al., 1998) is generally considered to be the best approach for estimating crop evapotranspiration. Crop coefficients are used to estimate evapotranspiration of crops multiplied by calculated potential or reference evapotranspiration ($ET_o$). An estimate of evapotranspiration forms the foundation for the planning and designing of all irrigation projects and efficient water usage, providing a basic tool for computing water balance and predicting water availability and requirement (Humphrey et al., 1994; Pereira et al., 1999). Crop water requirements are directly related to crop evapotranspiration ($ET_c$) and vary depends on crop grown and its different growth stages. Evapotranspiration involves a highly complex set of processes, which