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COTTON RESPONSE TO IRRIGATION INTERVALS UNDER DIFFERENT LEVELS OF POTASSIUM AND NITROGEN.

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Abstract: Two field experiments were carried out at Mallawi region, Naway village, Minia governorate, during the two successive seasons of 2006 and 2007 to study the effect of application amount of potassium, 0, 24 and 48 kg k_2O/fed, and nitrogen, 60 and 90 kg N/fed, on the response of cotton cultivar Giza 80 to water stress imposed by extending irrigation intervals from every two weeks to be every three week. Results of this study could be summarized as follows:

Irrigation intervals every three weeks resulted in significant reduction in plant height, number of fruiting branches/plant, number of open bolls/plant and seed cotton yield (kentar/fed) in the two studied seasons, and leaves content of K and seed index in 2007 season only.

Increasing K amount up to 48 kg K_2O/fed significantly increased leaves content of N and K, yield and yield components but significantly decreased lint%, however, the differences were not always significant between the lower K level (24 kg K_2O/fed) and the control or between the two amounts of K.

Increasing N amount from 60 to 90 kg N/fed significantly increased leaves content of N and K, plant height and number of fruiting branches/plant in both seasons but, it failed to exert any significant effects on yield or yield components except for number of open bolls/plant in 2006 season only.

The interaction of irrigation intervals × K amount significantly affected only seed cotton yield and seed index in both seasons when K application increased both traits under longer irrigation intervals greater than under closer ones.

The interaction between irrigation intervals and N fertilization exhibited significant effects only on plant height in both seasons and number of fruiting branches/plant in 2007 season only when growth of well-watered plants responded to increasing N amount more favorably than that of water-stressed plants.

The interaction of irrigation intervals × K × N or the interaction of K × N exerted no significant effects on all studied characteristics in both seasons.

It could be concluded from this study that increasing K amount significantly increased seed cotton yield particularly under water inadequacy conditions otherwise, increasing N amount to 90 kg N/fed failed to significantly increase seed cotton yield at either longer or closer irrigations intervals.

Key words: cotton, irrigation intervals, potassium, nitrogen.

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Intrtoduction

Water stress is considered the most agronomic variable affecting crop production worldwide. In Egypt, the forthcoming water shortage, though it is currently not well recognized by the agro-public, is a true challenge facing agricult-ural development and crop production in particular. Under such pressing threat of water limitations, irrigation water should be efficiently utilized so that water savings could be used in other agricultural activities. Additionally, the high input/ high output from of agriculture dominated in develop-ing countries including Egypt can not be sustainable and thus, crops should be managed to perform well and produce high yield under low input conditions. Therefore, enhan-cing water use efficiency has recently become a valuable goal attracting intensive research at both global and local scales.

Cotton plant, however, reacts strongly to moisture conditions in soil and the proper water supply during different stages of plant development is the most potent single factor making for a high cotton yield. Water deficiency especially during fruiting stage markedly restricts overall plant growth fruit retention and seed cotton yield (El-Shahawy and Abd EL-Malik, 1999; El-Sayed, 2005 and Hamed, 2007). Regardless of water availability, even irrigated cotton plants usually experience some degree of water stress, particularly at midday time, due to poor timing of irrigation or due to high evapotranspirative conditions (Reddy *et al*, 1998) like those prevailing in Upper Egypt. Even short-duration mild water stress could damage cotton yield (Reddy *et al*, 1998), which confirms the need for enhancing cotton tolerant to water stress.

Efficient and balanced nutrition has proved to be a means for improving plant tolerance to vari-ous environmental stresses include-ing drought. Plants receives proper nutrients supply exhibit better performance and productivity under stressful conditions (Szezepaniak and Grzebisz, 2007). Balanced fertilization improves water use efficiency (Marchand, 2007). Thus, the development of more efficient nutrients management strategies is needed to maximize use of all available recourses in cotton production (Reiter and Krieg, 2000).

Potassium (K) plays a particular role in stress physiology. It is the nutrient that contributed most to the tolerance of plants to various environmental stresses (Cakmak, 2005). Sufficient K supply repress-ents a relatively sheap insurance policy against biotic and abiotic stresses (Krauss, 2003), also K increases water uptake and transport in plants and its role on the control of osmotic pressure is vital under conditions of water stress (Marchand, 2007). It has been shown that adequate K supply enhances cotton growth and productivity (Sabik *et al*, 2002; El-Sayed, 2005 and Hamed, 2007), improves lint quality and cotton resistance to various stresses (Oostrhius, 1995). Insufficient K causes poor cuticle development in cotton plants, which may result in increased water loss by non-stomatal transpiration (Xi *et al*, 1989). Abd EL-Hadi *et al* (1997) under Egyptian conditions, obtained remarkable increases for a wide range of annual crops by K application when the water supply was restricted.

Following water irrigation, nitrogen fertilization is the variable that exerts profound effects on cotton growth and productivity. N supply can affect cotton response to drought via promoting root vigor, antioxidant activities in roots and N concentrations in roots (liu *et al*, 2008). Also, Cadena and Cothren (1995) reported that N supply improved water use efficiency which was positively correlated with the N status of cotton plant. An additive effect of N and water in cotton yield was also reported by Grimes *et al*, (1969) indicating that the addition of N may substitute for a lack of water, in an agronomic sense, and the converse is also true. However, some research results indicated that cotton response to N supply is usually diminished by water stress (Reiter and Krieg, 2000 and Silvertooth *et al*, 2007) and excessive N supply had a deleterious effects on cotton plant resistance to drought (Liu *et al*, 2008).

The main objective of this investigation was to study the effect of increasing K and/or N levels on the response of cotton growth and yield to irrigation inadequacy.

Materials and Methods

Two fields experiments were conducted at Mallawi region, Naway village, Minia governorate, during the two growing seasons of 2006 and 2007 to investigate the response of Giza 80 cotton to irrigation intervals (irrigation every two weeks and every three weeks throughout the growing season starting after the first irrigation) under different levels of potassium (0, 24, 48 kg K_2O/fad) and nitrogen (60 and 90 kg N/fad)

A split split plot design with three replicates used in which main plots were assigned to irrigations intervals, sub plots were occupied by potassium levels , and sub sub plots were devoted to nitrogen levels . The experimental unit included 5 ridges (3 .5 m long and 60 cm apart) occupying an area of 10.5 m² = 1/400 fad. Cotton seeds were planted on 26th and 29th of March in 2006 and 2007 seasons, respectively.

Phosphorus fertilizer as calcium super phosphate (15.5% P2O5) was incorporated into the seedbed during soil preparation for planting. Nitrogen fertilizer in the form of ammonium nitrate (33.5 % N) was applied in two equal doses, immediately before the first and the second irrigations. Potassium fertilizer was side-dressed in a single dose before the second irrigation.

Some physical and chemical properties of the surface layer (0.0 – 30cm) of the soil before planting are shown in Table (1). Soil properties were estimated according to the procedures outlined by Jackson (1967) and Gee and Bauder (1986).

In both seasons for determining leaves of N and K, samples of the fourth upper most leaves were collected after 30 days of flowering imitation, dried at 70 C°, ground and digested with a mixture of the H_2SO_4 and H_2O_2 as recommended by Piper (1950). Total N was analyzed using the Microkjeldahl procedure according to A. O. A. C. (1995). Total K was determined according to Jackson (1967).

Table(1): Some physical and chemical properties of the experimental soils.

Soil properties	2006 season	2007 season
-Particle size distribution		
Sand (%)	7.95	8.15
Silt (%)	54.25	53.85
Clay (%)	37.80	38.00
Texture grade	Silty clay loam	Silty clay loam
- pH†	8.10	8.15
- E C (dS m^{-1})‡	1.75	1.78
- Organic matter (%)	1.18	1.15
- Available N (ppm)	18.75	17.55
- Available K(ppm)	172.0	168.0
- Soluble cations (meq/L)		
Calcium (Ca^{2+})	8.75	8.85
Magnesium (Mg^{2+})	2.45	2,35
Sodium (Na^{+})	4.35	4.15
Potassium (K^{+})	0.21	0.19
- Soluble anions (meq/L)		
Chloride (Cl^{-})	5.15	5.10
Sulphate (SO_4^{2-})	7.70	7.65
Carbonate (CO_3^{2-})	-	-
Bicarbonate (HCO_3^{-})	3.65	3.45

† PH was measured in a soil-water suspension (ratio 1: 2.5).

‡ EC = Electrical Conductivity was measured in a soil-water extracted (ratio 1:5).

At harvest, 6 guarded plants were chosen from the central row of each sub sub plot to determine plant height (cm), number of fruiting branches, number of open bolls/plant, boll weight (gm), lint % and seed index (gm). Seed cotton yield was estimated on the basis of plot yield in terms of kilogram/plot and converted to Kentar/faddan (Kentar= 157.5 Kg).

All collected data were subjected to statistical analyses as proposed by Gomez and Gomez (1984) and means were compared by LSD at 5% level of probability.

Results and Discussion

1- Effect of irrigation intervals:

Results shown in Tables (2 and 3) reveal that, in comparison with biweekly intervals, irrigation every three weeks tended to reduce leaves content of N and K but the significant reduction was reached only in leaves content of K in 2007 season only. Such lower leaves content of N and K associated with longer irrigation intervals could be due to lower nutrient uptake under lower soil moisture since water is required as a medium for minerals and fertilizers solubility and nutrients availability and their uptake by roots. Similar results were reported by EL-Naggar *et al*, (2001).

With regard to effect of irrigation intervals on plant growth (Tables 2 and 3), it is clear that longer intervals significantly decreased plant height and number of fruiting branches per plant as compared with closer irrigation intervals in both seasons. The reduction in plant growth in case of longer irrigation cycles could be in part due to limiting the plant ability to absorb nutrients needed for optimal growth and development of the plant. Also, it is will recognized that water is not only required for different biochemical activities of all leaving cells, but also water-generated turgger pressure is a driving force of cell expansion (Xiong and Zhu, 2002). Thus water deficit disrupts normal cellular activities and restricts plant growth. Many research results indicated that vegetative growth of cotton plant is in close parallism with the quantity of irrigation applied (El-Nagger, 2001; EL-Sayed, 2005 and Hamed, 2007).

It is clear from Tables (4 and 5) that extending irrigation intervals significantly decreased number of open bolls per plant, boll weight and seed cotton yield in both seasons and seed index in only 2007 season in comparison with biweekly irrigations. Lint % was not significantly affected by irrigation intervals in the two seasons. The obtained reduction yield and its component owing to extending irrigation intervals may be due to the reduction nutrient uptake which chemical composition, vegetative growth and the yielding capacity of plant are good criteria. Similar results were obtained by EL-Shahawy and Abdel-Malik (1999) and EL-Sayed, 2005.

2- Effect of Potassium level:

It is obvious from Tables (2 and 3) that leaves content of N and K was significantly increased by the two application rates of K compared with the control (no K) in both seasons. The higher K level (48 kg K_2O/fed) significantly increased K concentration and numerically increased N concentr-ation in leaves compared with the lower K level (24 kg K_2O/fed) in both seasons. In this connection, it has been shown that K supply alters plant composition via affecting nutrient uptake, movement and metabolism. Adequate K supply ensures efficient N uptake, quick N transfer and rapid N metabolism (Krauss, 2003). Further, increasing leaves content of K could be a direct result of increasing K availability in soil with increasing K application rate. These results are in agreement with those of Oostrhuis (1995) who reported that K balances charges of anions and influences their uptake and transport.

As for K effect on plant growth (Tables 2 and 3), it is clear that K application at both rates signific-antly increased plant height and number of fruiting branches compared with the control in both seasons. The higher (48 kg K_2O/ fed) significantly increased both traits compared with the lower K level (24 kg K_2O/fed) in both seasons. The positive effect of K application on plant growth could be a result of improving mineral status in leaves and promoting the long distance translocation of water and solutes which might boost plant metabolic activities and physiolo-gical processes and thereby, stimulate plant growth. Increases in cotton growth due to K application were also obtained by EL-Sayed (2005) and Ghaly *et al* (2007).

Results shown in Tables (4 and 5) indicate that, in both seasons there were gradual increases in number of open bolls per plant, boll weight, seed cotton yield and seed index with increasing K level but the differences were not always significant between the lower K level (24 kg K_2O/fed) and the control or between the two application rates of K. In comparison with the control, both K application levels significantly decreased lint %with no significant deference between them on both seasons. Such yield enhancement obtained by K application seems to be a result of the overall positive effects of K on plant physiology which enhance the plant ability to form and store carbohydrates. In this concern, Krauss (2003) stated that it is difficult to see any step in yield creating processes that are not influenced, directly or indirectly, by K. These results are in agreement with those of EL-Sayed (2005) and Hamed (2007) who found a positive liner relationship between K level and cotton yield.

3- Effect of nitrogen level:

It is clear from Tables (2 and 3) that increasing N level from 60 to 90 kg N /fed exhibited a significant increase in leaves content of N and K in both seasons. This could be a result of enhancing root growth and its capacity in nutrient uptake by increasing N level. Similar results were reported by El-Nagger (2001). With regard to N effects on plant growth (Table 2 and 3), result reveal that cotton plants received 90 kg N /fed were taller with more fruiting branches than those received 60 kg N /fed in both seasons. These results may be due to the well known roles of N in building up the plant tissues and stimulating its growth. It is well established that cotton plant, owing to its indeterminate growth habit, responds favorably to increasing N rate and its growth is linearly correlated with N supply (Silvertooth *et al*, 2007).

Results presented in Tables (4 and 5) indicate that increasing N level from 60 to 90 kg N/fed failed to exert significant increase in yield and its components except for number of open bolls per plant in 2006 season only. It is well established that increasing N rate and its subsequent increase in vegetative growth don't necessarily led to higher cotton yield but, however, it insteadly could reduce it. With increasing N rate, cotton yield always reaches a plateau then it declines. These results are in harmony with those of EL-Shahawy and Abd El-Malik (1999).

4-Effect of interactions:

Results show that the both interaction of K × N and the the second–order interaction of irrigation × K × N exerted no significant effect on all studied characters in both seasons (Tables 2, 3, 4 and 5). The interaction between irrigation and K significantly affected only seed cotton yield and seed index in the two studied seasons, while the interaction between irrigation and N significantly influenced plant height in both seasons and number of fruiting branches in 2007season only.

The significant effects of irrigation × K interaction on seed cotton yield and seed index indecate that K application increased both traits under longer irrigation intervales greater than under closer ones. The application of K increased seed cotton yield under both irrigation cycles but its positive effect on cotton yield was more pronounced under inadequacy of watering conditions. In other words, water-stressed cotton plants benefited from K supply more than well-watered ones. This could be owing to the uniquely positive influence of K on water management of crop plants. Crops response to K fertilization is greater in dry than in wet conditions (Szezpaniak and Grzebisz, 2007). Plenty of research documents that K ameliorates drought impact on plant growth and yield through modifying the morphology, anatomy and physiology of water-stressed plants.Several mechanisms were suggested by which K improve drought tolerance and water use efficiency; Szezpaniak and Grzebisz (2007) reported that K functions as a water-stress ameliorative nutrient mainly by enhancing roots size, depth and uptake capacity of water and nutrients. Cakmak (2005) reported that the reason for enhanced need for K by plants suffering from drought is related to the fact that K is required for stomatal opening, and thus for the maintainace of photosynthesis, which protect cells from oxidative damage associated with limited photosynthesis caused by drought especially under high light intensity. It has been shown that K increase leaf water potential and bound water content, promotes the development of translocation tissues and maintains normal cell activities by safeguarding activities of antioxidants enzymes which mitigate the injury of free radicals of active oxygen, derived from drought stress, to cell structure and functions (Fusheng, 2006).

The interaction irrigation × N significantly affected plant growth parameters, but it failed to exert any significant effects on yield or yield component. The effect of such interaction on plant growth reveal that growth of well- watered plants responded more favorably to N supply than of that water-stressed plants. Similar results were obtained by Cadena and Cothren (1995) who reported that N supply increased growth of well-watered cotton plants greater than that of water-stressed plants because of poor N uptake under water inadequacy since N fertilizers require water availability in soil enough for fertilizer dissolution in soil and nutrient uptake by roots. Also, Silvertooth *et al* (2007) reported that N uptake by cotton plant is usually diminished under water stress conditions and they attributed this to drought–induced stomatal closure which not only limits the transpirational stream and thus the upward flow of N solutes to the leaves, but also, it limits photosynthesis which result in reducing the availability of energy necessary for active N uptake. Similar trend was found by EL-Naggar *et al* (2001).

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استجابة القطن لفترات الرى تحت مستويات مختلفة من كل من البوتاسيوم والنتروجين

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اجريت هذه الدراسة بقرية نواى التابعة لمركز ملوى بمحافظة المنيا خلال موسمى الزراعة 2006 ، 2007م بهدف دراسة استجابة نمو ومحصول صنف القطن المصرى جيزة 80 لفترات الرى (الرى كل اسبوعين ، الرى كل ثلاثة اسابيع ، بداية من بعد الرية الاولى) تحت مستويات مختلفة من كلا من البوتاسيوم (صفر ، 24، 48 كجم بو$_2$ا/ف) والنيتروجين (60، 90 كجم ن/ف) ، ويمكن تلخيص اهم نتائج هذه الدراسة فيما يلى:

- ادت اطالة الفترة بين الريات الى ثلاثة اسابيع الى نقص معنوى فى طول النبات وعدد الافرع الثمرية/نبات و عدد اللوز المتفتح/نبات و وزن اللوزة ومحصول القطن الزهر (قنطار/ف) فى كلا الموسمين ومحتوى الاوراق من البوتاسيوم ومعامل البذرة فى موسم 2007 فقط مقارنة بالرى كل اسبوعين.
- اظهرت زيادة مستوى البوتاسيوم الى 48 كجم بو$_2$ا/ف زيادة معنوية فى محتوى الاوراق من النيتروجين والبوتاسيوم وكل صفات النمو والمحصول ومكوناته فيما عدا نسبة الشعر التى نقصت معنويا بزيادة مستوى البوتاسيوم ، بينما لم تكن الفروق معنوية دائما بين مستوى البوتاسيوم 24 كجم بو$_2$ا/ف ومعاملة المقارنة او بين مستويى البوتاسيوم وذلك لكلا الموسمين.
- ادت زيادة مستوى النتروجين من 60 الى 90 كجم ن/ف الى زيادة معنوية فى محتوى الاوراق من النيتروجين والبوتاسيوم وطول النبات وعدد الافرع الثمرية/نبات فى كلا الموسمين ولكن ذلك لم ينعكس فى صورة زيادة معنوية فى المحصول ومكوناته باستثناء زيادة عدد اللوز المتفتح/نبات فى موسم 2006 فقط.
- اظهر التفاعل بين فترات الرى والبوتاسيوم تاثيرا معنويا فقط على محصول القطن الزهر/ف ومعامل البذرة فى كلا الموسمين حيث ادت زيادة مستوى البوتاسيوم الى زيادة كلا الصفتين تحت الرى كل ثلاثة اسابيع بمقدار اكبر من زيادتهما تحت الرى كل اسبوعين.
- اظهر التفاعل بين فترات الرى والنتروجين تاثيرا معنويا فقط على طول النبات فى كلا الموسمين وعلى عدد الافرع الثمرية/نبات فى موسم 2007 فقط حيث كانت استجابة نمو النباتات لزيادة مستوى النتروجين تحت الرى كل اسبوعين اكبر منها تحت الرى كل ثلاثة اسابيع.
- لم يكن للتفاعل فترات الرى × البوتاسيوم × النتروجين او للتفاعل البوتاسيوم × النتروجين اى تاثير معنوى على كل الصفات تحت الدراسة فى كلا الموسمين.
- يمكن ان نستخلص من نتائج هذه الدراسة ان زيادة مستوى البوتاسيوم اظهرت زيادة معنوية فى محصول القطن وخاصة تحت ظروف نقص مياه الرى ، بينما لم تظهر زيادة مستوى النتروجين الى 90 كجم ن/ف الى زيادة معنوية فى محصول القطن سواء تحت الرى كل اسبوعين او كل ثلاثة اسابيع.