

Water stress effect on yield and water use efficiency of two wheat varieties

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Abstract

Wheat is one of the first food crops to be domesticated and is a basic stable food in Europe, Asia and Africa. Wheat production is limited by insufficient water especially in the hot dry environments. In the arid and semi-arid regions, wheat is grown under irrigation, but its production is threatened by water shortages caused by pronounced droughts or water mismanagement. There is therefore need for growing varieties with improved water use efficiency and good water management practices to reduce evaporative and other losses. This study was carried out in Sudan to evaluate the effect of water stress on yield and water use efficiency of two wheat varieties (Tagana and Khalifa) under Gezira conditions. The trials was arranged as a split plot with four replications comprising seven treatments. Treatments included full irrigation (water applied every ten days) and other six treatments were imposed by skipping one irrigation at different crop growth stages. The highest grain yield of 1400 kg/ha, averaged over wheat varieties, was obtained by watering every ten days throughout crop growth. Water use efficiency (WUE) was 87% and 66% for Tagana and Khalifa, respectively.

Key words: Khalifa, Tagana, water stress, water use efficiency, wheat varieties, yield

Résumé

Le blé est l'une des premières cultures vivrières à être domestiquée et est un aliment de base stable en Europe, en Asie et en Afrique. La production de blé est limitée par l'insuffisance de l'eau en particulier dans les environnements chauds et secs. Dans les régions arides et semi-arides, le blé est cultivé sous irrigation, mais sa production est menacée par les pénuries en eau causées par les sécheresses prononcées ou une mauvaise gestion de l'eau. Il est donc nécessaire pour les variétés de culture, d'améliorer l'efficacité d'utilisation de l'eau et de promouvoir les bonnes pratiques de gestion de l'eau afin de réduire les pertes par évaporation ainsi que d'autres pertes. Cette étude a été réalisée au Soudan pour évaluer l'effet du stress hydrique sur le rendement et l'efficacité d'utilisation

de l'eau de deux variétés de blé (Tagana et Khalifa) dans des conditions de Gezira. Les essais ont été organisés sous forme de parcelle de scission avec quatre répétitions comprenant sept traitements. Les traitements comprenaient l'irrigation complète (eau appliquée tous les dix jours) et les six autres traitements ont été imposés en sautant une irrigation à de différents stades de croissance des cultures. Le rendement le plus élevé de 1400 kg / ha, en moyenne au-dessus des variétés de blé, a été obtenu par arrosage tous les dix jours tout au long de la croissance des cultures. L'efficacité d'utilisation de l'eau (EUE) était de 87% et 66% pour Tagana et Khalifa, respectivement.

Mots clés: Khalifa, Tagana, stress hydrique, efficacité d'utilisation de l'eau, variétés de blé, rendement

Background

Wheat (*Triticum aestivum* L.) is one of the major food crops in the world. In the Sudan, its cultivation along the Nile banks in the Northern region, between latitudes 16°N and 22°N. The main commercial production areas are the irrigated schemes of Gezira, Rahad, New Halfa and White Nile. The hot dry short season and inadequate irrigation water are the major factors responsible for the low yields of the crop. Average annual flow of the Nile is about 84 bcm, measured at Aswan. According to the 1959 Nile Water Agreement between Sudan and Egypt, respective shares of the two countries are 18.5 and 55.5 bcm. Currently, annual amount of water available to the Sudan from national and international sources is about 35.5 to 37 bcm. The Agricultural sector consumes more than 90 percent of this amount. The Ministry of Irrigation and Water Recourses, under the Long Term Agricultural Strategy, projected that the irrigation water needs, human and animal consumption, domestic and other uses and evaporative losses by the year 2027 will be about 59.2 bcm. This implies the need for very efficient use of water resources (Ahmed *et al.*, 2007). The objective of this study is to estimate the water use efficiency of two wheat varieties (Tagana and Khalifa) and to evaluate their response to water stress at different growth stages.

Literature Summary

Detection of crop water stress is critical for efficient irrigation water management. Water stress corresponded to reduction in evaporation due to the limited availability at root zone soil moisture (Bolute *et al.*, 2006). Deficit irrigation imposed during flowering and grain filling stages of wheat may provide an option for minimal yield reduction with limited supplies of irrigation water (Ishag *et al.*, 1992). Wheat can tolerate irrigation intervals

Study Description

of up to 21 days during the vegetative growth stage and omissions of the second or the final irrigation at grain filling stage. However, to attain maximum yield, moisture stress should be avoided at the time of booting and anthesis (Farah, 1987).

The experiment was carried out during 2008/09 and 2010/011 winter seasons at the Gezira Research Station Farm (14° 24' N· 33° 29' E and 405 m altitude). The soil is classified as Typic haplusterts fine, semictitiz, isohyperthermic, characterised by swelling when wet and shrinking when dry. Treatments were two wheat varieties, namely Tagana and Halifax and seven watering treatments. These were a control (watering the crop every ten days throughout the season) and other six were water stressed treatments imposed by skipping one irrigation at different irrigation times starting from the forth irrigation (Table 1). The crop was sown in the last week of November for both seasons. Sowing was on flat plots at a seed rate of 120 kg / ha in rows 20 cm apart. Experimental design was a split plot with water treatments as main plots and varieties as subplots with four replications. Plot size was 4×6 m² and 4×4 m² during the first and second seasons, respectively. The recommended fertiliser rate were applied (86 Kg N ha⁻¹ supplied by urea and 43 Kg P₂O₃ ha⁻¹ supplied by Triple Superphosphate). All the recommended cultural practices were carried out as usual. Grain yield (kg/ha) was calculated at the harvest. . Water use efficiency was calculated as the grain yield per unit area per unit of ET_c according to Al-Jamal *et al.* (2001).

Table 1. Treatments detail.

Treatments	Time of water application									
	1 st	4 th	5 th	6 th	7 th	8 th	9 th	10 th	11 th	
1	*	*	*	*	*	*	*	*	*	*
2	*	x	*	*	*	*	*	*	*	*
3	*	*	x	*	*	*	*	*	*	*
4	*	*	*	x	*	*	*	*	*	*
5	*	*	*	*	x	*	*	*	*	*
6	*	*	*	*	*	x	*	*	*	*
7	*	*	*	*	*	*	x	x	x	x

* and x: indicate not stress and stress by skipping one, respectively.

Research Application

First season results (Fig.1) showed that watering treatments had a highly significant effect ($P < 0.001$) on grain yield. Skipping one irrigation reduced seed yield at all growing stages for both varieties. The highest seed yield (1048.4kg /ha,

averaged over the two wheat varieties) was obtained by treatment seven. This was followed by the control i.e., watering every ten days through all the season (1035.5 kg/ha). The two yields were not significantly different. From the results, variety Tagana yielded more than variety Khalifa, although the difference was non-significant. . Ishag *et al.* (1992) reported similar results that the highest grain yield was obtained from irrigating every 10 days.

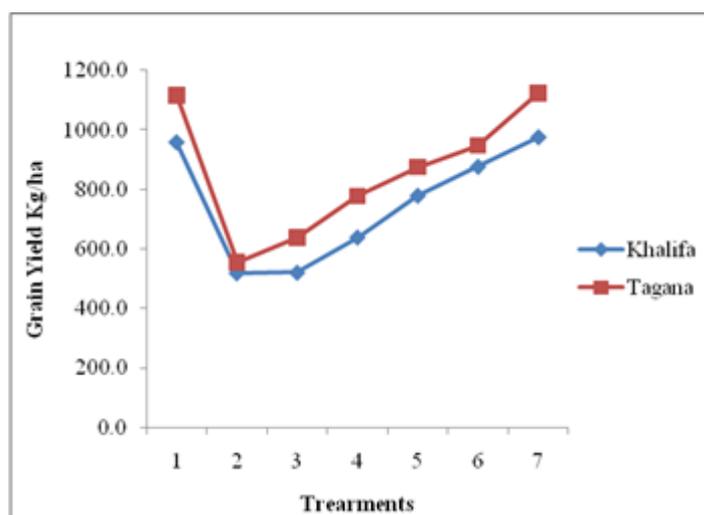


Figure 1. Effect of imposing water stress at different growth stages on wheat grain yield (season one).

The lowest yield (518 kg/ha) was recorded from variety Khalifa on treatment 2 where water stress coincided with the booting stage (40 days after sowing) (Fig.1). Farah (1987) reported that longer intervals of irrigation (21 days) during the insensitive growth stages of wheat should help in reducing the pressure imposed by crops on water demand and labour.

These results are in agreement with those of Ahmed (1992) who reported that skipping irrigation for 21 days during vegetative growth stage was permissible to avoid water shortage during the critical reproductive stages. These results suggested that deficit irrigation imposed during flowering and grain filling stages of wheat may result into minimal yield reduction when the supply of irrigation water is limiting.

Grain yield in season two was significantly higher than yield in season one ($P \leq 0.001$). Skipping irrigation at different developmental stages significantly affected grain yield ($P \leq 0.001$) (Fig. 2). Grain yield was 1375.4 and 1320.8 kg/ha for treatment

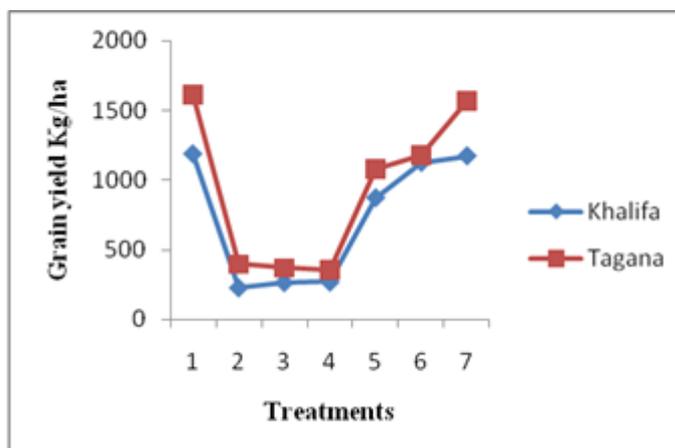


Figure 2. Effect of water stress on grain yield season two.

one and seven. Again these were not significantly different. Treatments 2, 3 and 4 had negative and significant effects on seed yield for the two wheat varieties.

The lowest yield (i.e., 230 and 268kg/ha) was obtained with treatment two and three where water stress was imposed 40 and 50 days after sowing. These coincided with the productive stages (Fig. 2). Ahmed (1992) also reported that grain yield was considerable reduced when irrigation was skipped during heading and early grain yield stages.

The highest ratios of water use efficiency (WUE%) were 90 and 87% and were both recorded from season one for the varieties Tagana and Khalifa, respectively. The respective values for season 2 were 96 and 90%, respectively and were

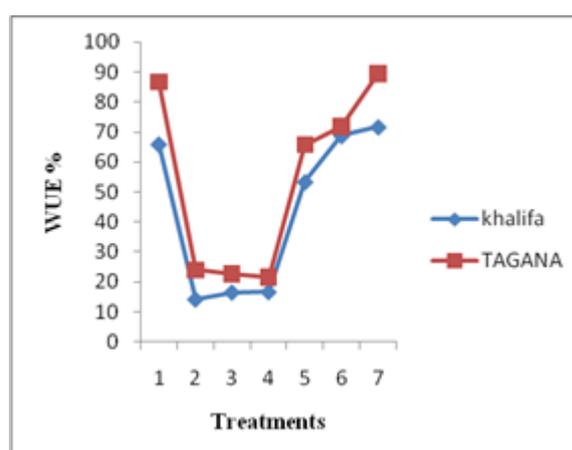


Figure 3. Effect of water stress on water use efficiency for two wheat varieties (season one).

recorded from . treatment seven. Water use efficiency was highest when water stress coincided with productive stages 90 DAS (Fig. 3, Fig. 4). At this stage, irrigation can be stopped to save water with no significant reduction in yield (Howel, 2001). The crop water requirement CWR for two newly wheat varieties was 1802.5m³/ha and skipping one irrigation would save 163.8 m³/ha/day.

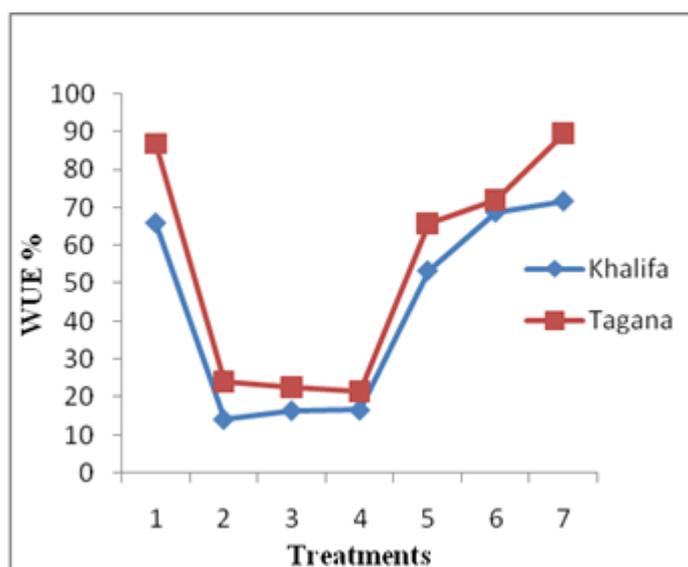


Figure 4. Effect of water stress on water use efficiency for two wheat varieties (season two).

Acknowledgement

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