WATER STRESS EFFECTS AND WATER USE EFFICIENCY FOR COTTON

EFFETS DE STRESS HYDRIQUE ET EFFICIENCE DE L'UTILISATION DE L'EAU – CAS DE COTON

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ABSTRACT

Moisture stress is one of the most important factors affecting cotton yield quality and quantity. Cotton requires lots of water to complete its growth and development. However, excess irrigation as well as moisture stress lead to lower quality and quantity of yield. The present study was conducted to investigate effects of moisture stress on cotton (var.varamin) yield at the farm of Kashmar Agriculture Research Station. The experiment was laid out in a radomized complete block design. Treatments were four different irrigation scheduling viz . irrigation after 60,70,100 and 120mm cumulative evaporating from class A Evaporation pan. Treatments were replicated thrice. The experiment was carried out on a silt loam soil with pH=7.5and EC=3 dSm^{-1}. Results revealed that different irrigation scheduling significantly affected the cotton yield. Maximum yield 3754.6 kgha^{-1} and minimum yield 2357 kgha^{-1} were recorded in plot under 70mm and 120mm evaporation treatments, respectively . Both frequent irrigation as well as continuous water deficit adversely affected cotton and reduced its yield. Since rainfall was negligible, almost all crop water requirements was met by irrigation. Keeping in view water use efficiency (After 100mm evaporation from class A pan), it is recomended to irrigate at 10 days interval in early as well as late season while 7 days interval in the middle of the growing season.This scheduling needs 8890 m^3 irrigation water. However to achive maximum yield (70mm evaporation) about 1060m^3 of water should be provided. The net water requirment of cotton was estimated as about 10000m^3 according to Iran Soil&Water Institute (Major crops water requirment -vol.1…).

Key words: *cotton, water stress, yield, irrigation*

RESUME

Le stress hydrique est l'un des facteurs importants qui affectent la qualité et la quantité du rendement de coton. Le coton exige une grande quantité de l'eau pour sa croissance et son développement. Cependant, l'irrigation excédentaire ainsi que le stress hydrique réduit

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la qualité et la quantité du rendement. Cette étude a été menée à la Station de recherche agricole de Kashmar pour examiner les effets de stress hydrique sur le rendement du coton (var.varamin). L'expérimentation a été conduite selon la conception du bloc randomisée. 4 périmètres irrigués étaient à l'étude. Les traitements ont été répétés trois fois. L'expérimentation a été effectuée sur un sol riche en limon terreau de pH=7,5 et EC=3 dSm^{-1}. Les résultats ont montré que le pilotage d'irrigation différent affecte de manière significative le rendement du coton. Un rendement maximal de l'ordre de 3754,6 kg/ha^{-1} et un rendement minimum de 2357 kg/ha^{-1} sont constatés dans les lots faisant l'objet de traitement par évaporation entre 70mm et 120mm. L'irrigation fréquente ainsi que le déficit continu d'eau a affecté de manière défavorable le coton et a réduit son rendement.

La précipitation étant négligeable, l'irrigtion a satisfait toutes les demandes d'eau agricole. Compte tenu de l'efficience de l'eau, il est recommandé d'irriguer à l'intervalle de 10 jours au début et à la fin de la saison, et à l'intervalle de 7 jours au milieu de la période de croissance. Le pilotage exige de 8890 m^3 d'eau d'irrigation. Cependant, pour réaliser un rendement maximal (évaporation de 70mm), on exige 1060 m^3 d'eau. Selon l'institut iranien du sol et de l'eau, la demande nette de l'eau pour le coton est de l'ordre de 10000 m^3.

Mots clés: *Coton, stess hydrique, rendement, irrigation*

1. INTRODUCTION

Cotton(Gossypium hirsutum.L) is one of the most important commercial crops playing a key role in economic and social affairs in Iran. Its area coverage in Khorassan province ranked secound after Golestan province that shows its importance in the region. Yield of cotton is sensetive to irrigation, and moisture stress is one of the most important factors affecting cotton yield quality and quantity. cotton requires lots of water to complete its growth and development. Howere, its yield decreases with either too much or too little water (Grimes et al,1969). cotton yield is highly correlated with the number of flowers and bolls produced (Grimes etal 1969). Harris and Hawkins (1942) reported that the excessive growth during fruiting that tended to decrease yield could be prevented or limited by delaying irrigation. Singh(1975) conducted pot and field trials with four cotton cultivars and reported that withholding irrigation until the plants wilted in the early morning during the pre-flowering stage increased the number of flowers and bolls per plant and increased seed cotton yield. Although severe water deficit increases boll shedding, the effects of plant water status on boll retention are not simple. Kittock (1979) discussed the requirement of water stress for maximum cotton production, whereas Stockton et al, (1961), Bruce and Romkens (1965) and Lashin et al, (1970) reported increased flowering with increased irrigation. Excess irrigation as well as moisture stress leads to lower quality and quantity of yield. Leaf expansion in several species has been shown to be sensitive to water stress (Gunning,1982). Several studies have shown that drought inhibits cotton canopy development. An understanding of the response of cultivars to water deficits is also important in attempts to model cotton growth and estimate irrigation needs (Pace et al.1999). Irrigation scheduling aids have been available to farmers and growers for years (Thomson and fisher, 2006). An understanding of the response of plants to water deficits is important in efforts to model cotton (Gossypium hirsutum L.) growth, estimate irrigation needs, and breed drought-resistant cultivars.The World Meteorological Organization (WMO) has recommended that the Class A evaporation pan be adopted as the standard instrument for crop water use determination. Smajstrla et al. (2000) presented detailed procedures on using the Class A evaporation pan along with a water accounting method for irrigation scheduling. Stanhill (2002), concluded that pan may still be the most practical and accurate meteorological method for determining irrigation requirements. Proper scheduling of irrigation using the Class A evaporation pan could be a challenge in arid and semi arid regions because of low rainfall. The potential payoff could be great since removal of even one irrigation could save water and energy.The objective of this study was to provide guide lines for setup and use of Class A pan for irrigation of cotton in a silt loam soil in Kashmar (cotton growing area).

2. MATERIALS AND METHODS

The present study was conducted to investigate the effects of moisture stress on cotton yield var.varamin, at the farm of Kashmar Agriculture Research Station on an aluvial soil with Silty Loam texture and pH=7.1 and EC=3dSm^{-1}. The experiment was laid out in a Randomized Complete Block Design. Treatments were four different irrigation scheduling viz . irrigation after 60,70,100 and 120mm cumulative evaporation from Class A evaporation pan. Treatments were replicated thrice. Cotton "veramin" was planted and stands were hand thinned at the seedling stage to a population of about 72000 plants/ ha in rows 0.7 m apart. Water for irrigation was delivered by pipe at one end of the field while the other end was sealed and runoff was zero. After planting, 3 irrigarion with 7days interval were applied to all plots for uniform emergence of seedlings. Irrigation treatments were applied after emergence of seedlings. The amount of water requierd for each irrigation was calculated according to equation below

$$d = \frac{Fc - Aw}{100} * Bd * D$$

$$v = \frac{d}{100} * A$$

In which, d is irrigation water depth (cm); Fc is soil moisture per cent (by weight) at field capacity; Aw is soil moisture per cent (by weight) just before irrigation; Bd is soil Bulk density (g/cm^3); D is rooting depth of cotton; V is the volume of irrigation water (cubic meter) and A is area of each plot . cotton was harvested at two times. Each plot had 4 lines and all mesurments were done on the two middle lines, two other lines were as guard.

3. RESULTS AND CONCLUSIONS

Results indicated that both high frequency irrigation (wet regim) and severe water stress(dry regim) had similar effects on cotton yield and reduced it significantly. As Table 1 indicats maximum tempreature occurred in August in both the years and mnimum relative humidity was also in this month while percipitation in this month was zero and highest Evaporation was mesured in the same month. These climatological factors help us to understand why sever stress has rduced cotton yield. Wet regime of irrigation may had two effects for yield reduction; firstly, excess water might have promoted vegetative growth, that has restricted the yield, and secondly excess water might have leached nutrients such as nitrogen below the root zone. Kerby and Buxton (1981) suggested that boll load and resulting competition for nutrients strongly affect boll retention. Boll retention rate decreased as active boll load increased early in the season (Table2). Gunnin (1982) reported that with moisture deficit, anutritional stress increased ethylene production in the young bolls and increased their abscission rate

Table 1. Min, Max monthly temperature (T), Relative humidity(RH%), Percipitation (P mm), Evaporation from class A pan (mm), in both the years.

Month	Tmin		Tmax		RH%		P(mm)		Evaporation (mm)	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
APR	8.4	8.5	18.5	19.9	47	47	26.1	45.1	-	-
MAY	15	14.1	26.4	25.7	29	40	9.4	3.9	243.5	131
JUNE	20.4	22.1	33.4	34.7	25	27	5.3	3.1	410.6	368.6
JULY	21.9	23.6	34.6	37.2	23	18	0	0	468.9	467.2
AUG	22.1	22.7	35.4	38.2	24	18	0	0	475.7	428.1
SEP	19.8	18	29.6	32.4	23	19	0	0	222.3	139.2
OCT	13.7	16.3	26	28.8	38	34	2.4	0.8	-	-

Water deficit had significant effect on cotton yield and the highest negative effect was pronounced in delaying irrigation untill 120mm evaporation. We think that water deficit in this treatment (I4) decreased flowering and decreased boll retention.

A plot of plant hight as an index for vegetative growth vs. water deficit showed that water deficit could prevent to some extent vegetative growth and increase yield, while in non stress lots active competition between sink and source would deacrese yield.

Table 2. Cotton yield under different irrigation regimes(cumulative Eva from class A pan)

Treatment	Yield(kg/ha)	
	First year	Secound year
Irrigation after 60 mm	2776 B*	2618 B*
Irrigation after 70 mm	3279 A	3751 A
Irrigation after100 mm	3026 A	3142 A
Irrigation after120 mm	2178 C	2386 B
Duncan test at 5% level		

Table 3. Mean plant hight(cm) in different irrigation regimes (Mesurments started from 1st July with 10 days interval).

Irrigation treatment	60 mm Eva.	70 mm Eva.	100 mm Eva.	120 mm Eva.
1st july	24	20	18	17
11th july	28	23	25	19
21st july	37	31	29	30
31st july	57	44	46	38
10th aug	77	57	63	63
20th aug	102	95	84	75

Water Use Efficiency (WUE) is an other important parameter that must receive much attention, paticularly in arid and semiarid regions where water is a restricting factor. Our results showed that mild water stress increased WUE but severe stress decreased it (TABLE 4).

Table 4. Water Use Efficiency under different irrigation regimes.

Treatment Year	evapotation from Class A evapotation pan(mm)			
	60	70	100	120
First year	0.23	0.34	0.35	0.28
Secound year	0.26	0.32	0.34	0.26

These results should not be interpreted to mean that water deficit always increases yield. Soil physical properties can play a key roll in this conection when irrigation is delayed for a long time, subsquent flowering rate will be affected and the phenomenon is complex.

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