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Effects of Different Trickle Irrigation Regimes on Cotton (*Gossypium hirsutum* L.) Yield in Western Turkey

Necdet Dağdelen, Ersel Yilmaz, Fuat Sezgin, Talih Gürbüz and Selin Akçay
Department of Farm Structure and Irrigation, Faculty of Agriculture,
Adnan Menderes University, 09100 Aydin, Turkey

Abstract: This study was conducted to investigate the effect of different trickle irrigation regimes on seed cotton yield and water use factors under the semiarid region of western Turkey. The experiment was set up in Randomized Block Design with two factors and three replications during the years of 2002 and 2003. Trials, comprised of two irrigation intervals (once in IR4 and IR8 days) and three irrigation levels (100, 67, 33% of cumulative Class-A pan evaporation) were investigated. The highest irrigation water was applied to the full irrigation (IR4-100 and IR8-100) treatments for both irrigation intervals. Data obtained from the two year study showed that seed cotton yield was significantly ($p<0.01$) affected by irrigation intervals and irrigation levels treatments. The highest seed cotton yield was obtained from the 8-day irrigation interval (IR8-100) as averaging 5592 kg ha^{-1}. WUE and IWUE values increased with decrease in irrigation water applied in both years. The highest WUE averaging 1.25 kg m^{-3} was obtained in IR4-33 treatment and minimum WUE averaging 0.82 kg m^{-3} was observed in IR4-100 treatment. In this study, averaging the yield response factor (k_y) were determined as 0.56 during the entire growing season based on two irrigation intervals.

Key words: Cotton, trickle irrigation, water stress, water use

INTRODUCTION

Western Turkey is one of the most important agricultural and industrial region in Turkey. Cotton (*Gossypium hirsutum* L.) grown mostly under irrigated conditons, is a major commercial field crops in the Aegean region of Turkey. Present cotton production in Turkey is about 882.000 tons of lint cotton from 760.000 ha. The Aegean region of western Turkey produce 38% of national cotton production of the country[1]. Long-term average annual precipitation in the region is about 657 mm, with more than 89% of it falling from October to March. Water loss by evapotanspiration is very high during the growing season. Therefore, irrigation is needed at this growing season to maintain and enhance crop growth and yield.

Irrigation water is the most important limiting factor for agriculture during the hot and dry summer period of Aegean region. Limited availability of irrigation water requires fundamental changes in irrigation management or urges the application of water saving methods. Common irrigation methods practiced for cotton production in this region are wild flooding, furrow and basin. In general, the farmers over irrigate, resulting in high water losses and low irrigation efficiencies and thus creating drainage and salinity problems[2]. However, the use of micro-irrigation techniques is inevitable in the near future because of the salinity problem caused by traditional irrigation methods[3].

In scheduling irrigation programs, methods based on pan evaporation are widely used due to their easy applications[4]. Pan evaporation (Class A Pan) can be utilized in irrigation programming incase with available pan coefficient in hand. Howell *et al.*[5] tested drip and furrow methods for cotton irrigation. The authors found that there were no yield differences between both methods. Hodgson *et al.*[6] compared furrow and drip irrigation methods for cotton and found that Water Use Efficiencies (WUE) were 0.223 and 0.189 kg m^{-3} for drip and furrow irrigation methods, respectively. Çetin *et al.*[7] compared different irrigation methods for effective water use on cotton in the GAP area. The highest seed cotton yield was obtained from drip irrigated plots with 4650 kg ha^{-1} followed by furrow method with 3120 kg ha^{-1}. Yazar *et al.*[2] carried out a research project in order to compare LEPA and trickle

Corresponding Author: Dr. Necdet Dağdelen, Department of Farm Structure and Irrigation, Faculty of Agriculture, Adnan Menderes University, 09100 Aydın, Turkey
Tel: +90 256 7727023 Fax: +90 256 7727233

irrigation of cotton under southeast Anatolia conditions. The authors reported that irrigation levels both in LEPA and trickle-irrigated plots significantly increased cotton yield. According to the results, both the trickle and LEPA technique could be used successfully for irrigating cotton crop under the arid climatic conditions of the GAP area.

The objective of this study was to analyze the effects of different irrigation intervals and irrigation levels on yield and water use efficiencies of cotton in the western Turkey.

MATERIALS AND METHODS

The experiments were conducted during the growing seasons of 2002-2003 at the Agricultural Research Station of Adnan Menderes University, Aydin-Turkey. The altitude, latitude and longitude of the experimental site are 56 m, 37°51' N and 27°51' E, respectively. Climate in this region is semi-arid with total annual precipitation of 657 mm. The climatic variables for experimental years and long-term means for May-September are given in Table 1[8].

The soil type of the experimental area was loam and sandy loam in texture. For the cotton experiment area water content at field capacity varied from 20.3 to 27.6% and wilting point varied from 7.2 to 9.7% on dry weight basis. The dry soil bulk densities ranged from 1.42 to 1.50 g cm^{-3} throughout the 1.2 m deep profile. The total available soil water content within the top 1.2 m of the soil profile is 281 mm.

Nazilli-84 cotton variety was planted first week of May in 2002 and 2003, respectively. Cotton plants were thinned to a spacing of 0.70 m (row width) x 0.25 m when the plants were about 0.15 m in height. A compound fertilizer of (15 , 15, 15% composite) was applied at a rate of 60 kg ha^{-1} pure N, P and K at planting. The required remaining portion of nitrogen was followed by 82 kg ha^{-1} as Ammonium nitrate 33% before first irrigation.

Field trials were arranged in a randomised complete block design with three replications. Irrigation treatments consist of two different irrigation intervals (IR-4 and IR-8 day interval). Irrigation water was applied based on cumulative Class-A Pan evaporation within the irrigation intervals. IR4-100 and IR8-100 designated to receive 100% of cumulative Class A-Pan evaporation on a 4 and 8-day basis, respectively. Two deficit irrigation treatments received 67 and 33% of the full-irrigation treatments of IR4-100 and IR8-100. Irrigation treatments were started using trickle irrigation system when the water content of soil decreased to 50% of available soil water. Each experimental plot was designed as 15 x 2.8 m (4 rows per plot) and had a total area of 42 m^2 at sowing. There were 3.0 m space between each plot in order to minimize water movement among treatments. A trickle irrigation system

Table 1: Long term monthly and growing season climatic data of the experimental area[a]

Years	Months	$T_{average}$ (°C)	RH (%)	W ($m\ s^{-1}$)	Average sunshine duration (h)
1929-2003	May	22.6	49.5	1.7	9.0
	June	27.0	47.1	1.7	11.0
	July	28.9	54.6	1.7	11.4
	August	28.6	50.1	1.7	10.9
	September	24.1	57.1	1.6	9.8
2002	May	21.5	63.0	1.7	10.8
	June	27.2	52.7	1.7	11.2
	July	28.5	58.2	1.7	10.9
	August	27.7	58.3	1.7	10.7
	September	22.8	68.2	1.5	7.8
2003	May	22.7	62.4	1.4	9.4
	June	27.6	51.5	1.6	11.0
	July	29.1	53.2	1.5	11.3
	August	28.7	62.5	1.5	10.9
	September	23.4	66.1	1.6	9.2

[a]$T_{average}$ =Average temperature; RH = Relative Humidity; W = Average Wind speed at 2 m

was designated for the experiment. Laterals diameter were 16 mm PE and each lateral irrigated one plant row. In the system, inline emitters with discharge rate of 4 L h^{-1} were spaced at 33 cm intervals on the lateral line. The irrigation system was managed 10 m operating pressure.

The water balance equation was used in order to determine seasonal evapotranspiration for all the treatments[9]. Water use efficiencies were calculated based on total depth of irrigation water (IWUE) and seasonal evapotranspiration (WUE))[10]. In order to evaluate sensitivity of treatments to water stress, yield response factor k_y defined as the ratio of relative yield decrease to relative evapotranspiration deficit, was calculated from the actual yield, the maximum yield, the actual evapotranspiration and the maximum evapotranspiration[11].

Cotton yield was determined by hand harvesting the 14.5 m sections of the two center rows in each plot on 20 September 2002 and on 17 September 2003. Data were analyzed seasonally by analysis of variance and relationship between water use and cotton yield were evaluated using regression analysis.

RESULTS AND DISCUSSION

As shown in Table 2, the amount of irrigation water applied varied from 508 to 168 mm in 2002 and from 513 to 169 mm in 2003. The results were similar in both years. Seasonal water use ranged from 252 to 611 mm (IR4-IR8 irrigation intervals) in 2002 and varied between 313 and 650 mm (IR4-IR8 irrigation intervals) in 2003. Irrigation intervals resulted in similar crop water use in each year. On the other hand, during the 2nd year, irrigation water and water use values were higher than that of first year. This may be attributed to the different climatic conditions

Table 2: Yield and water use factors of cotton for the experiment period in 2002-2003

Years	Treatments	Seed cotton yield (kg ha^{-1})	Irrigation water applied (mm)	Water use (mm)	WUE (kg m^{-3})	IWUE (kg m^{-3})
2002	IR4-100	5288	508	611	0.86	1.04
	IR4-67	4884	336	426	1.14	1.45
	IR4-33	3785	168	252	1.50	2.25
	IR8-100	5751	508	599	0.95	1.12
	IR8-67	5241	336	426	1.22	1.56
	IR8-33	3606	168	255	1.41	2.15
Irr. intervals						
IR4		465.2a**				
IR8		486.6a				
Irr. levels (%)						
100		551.9a**				
67		506.2b				
33		369.5c				
2003	IR4-100	5085	513	642	0.79	0.99
	IR4-67	4557	339	484	0.94	1.34
	IR4-33	3414	169	340	1.00	2.01
	IR8-100	5433	513	650	0.83	1.05
	IR8-67	5061	339	476	1.06	1.49
	IR8-33	3348	169	313	1.07	1.97
Irr. intervals						
IR4		435.2b*				
IR8		461.4a				
Irr. levels (%)						
100		525.9a**				
67		480.9b				
33		338.1c				

*, **: Mean followed by different letter(s) indicate statistically significant differences at the level of 5 and 1% for Duncan's Multiple Range Test, respectively

of the years. Water use increased with increased amount of irrigation water applied to the treatments. These result were in agreement with Yazar *et al.*[2] and Sezgin *et al.*[12].

WUE ranged from 0.86-1.50 kg m^{-3} (4 day irrigation interval) to 0.95-1.41 kg m^{-3} (8-day irrigation interval) in 2002 and varied between 0.79-1.00 kg m^{-3} (4-day irrigation interval) and 0.83-1.07 kg m^{-3} (8-day irrigation interval) in 2003. The highest WUE averaging 1.25 kg m^{-3} was obtained in IR4-33 treatment and minimum WUE averaging 0.82 kg m^{-3} was observed in IR4-100 treatment based on averages of 2 years. The Irrigation Water Use Efficiency (IWUE) of the treatments were higher than water use efficiencies (WUE) for both years because water consumption was higher than the amount of irrigation water applied. WUE values of 0.38-0.46 kg m^{-3} was obtained by Anaç *et al.*[13] in Bornova conditions. Sezgin *et al.*[12] determined WUE values as 0.57-0.80 kg m^{-3} under drip method in Aydin plain conditions. The WUE values of cotton irrigated by LEPA and drip method were 0.55-0.67 kg m^{-3} and 0.50-0.74 kg m^{-3} in Harran plain conditions[2]. WUE values of cotton was obtained by Fangmeir *et al.*[14] as 0.44-0.49 kg m^{-3}; by Hodgson *et al.*[6] as 0.223-0.189 kg m^{-3}, respectively, under drip irrigation conditions.

Data obtained from the two year study showed that seed cotton yield was significantly ($p<0.01$) affected by irrigation intervals and irrigation level treatments (Table 2). The highest seed cotton yield was obtained from the 8-day irrigation interval as averaging (IR8-100) 5592 kg ha^{-1}. The lowest seed cotton yield was observed from the 8-day irrigation interval (IR8-33) treatment as averaging 3477 kg ha^{-1}. Cotton yield was reduced with deficit irrigation in both years. Treatments IR4-100 and IR8-100 provided the highest yield group (Table 2). The lowest yield group was comprised of treatments IR4-33 and IR8-33, respectively. Howell *et al.*[5] concluded that there were no yield differences between drip and furrow methods for cotton irrigation. Çetin *et al.*[7] compared different irrigation methods for effective water use on cotton in the GAP area. The highest seed cotton yield was obtained from drip irrigated plots with 4650 kg ha^{-1} followed by furrow method with 3120 kg ha^{-1}. Moreover, in Aydin plain conditions, the highest average seed cotton yield was 4979 kg ha^{-1} under well irrigated drip treatment, followed by well irrigated furrow treatment with 4691 kg ha^{-1}[12].

The relationships between seasonal water use and seed cotton yield have been evaluated for each experimental year (Fig. 1 and Table 2). Linear and curvilinear relationships were obtained between seed cotton yield and water use based on 4 and 8 day irrigation interval treatments, respectively. Results of the regression statistical analysis showed that close relationship exist between seasonal water use and seed cotton yield ($p<0.01$).

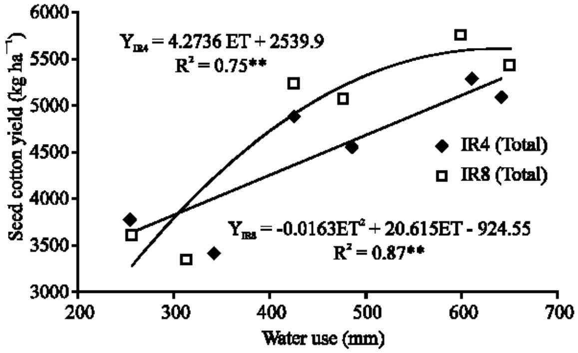

Fig. 1: Relationship between seed cotton yield and water use in 2002 and 2003

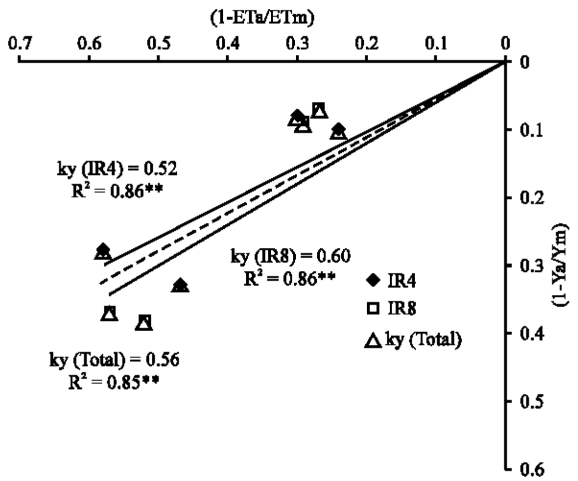

Fig. 2: Relationship between relative evapotranspiration deficit and relative yield decrease in 2002 and 2003

The response of seed cotton yield to water supply can be quantified through the yield response factor (k_y) which relates relative yield decrease to relative evapotranspiration deficit. The slope of the fitted regressions (Fig. 2 and Table 2) represents the yield response factor (k_y). Values of k_y were found as 0.52 and 0.60 for the IR4 and IR8 treatments respectively, based on averages of 2 years. The average yield response factor was k_y = 0.56 determined from our study based on 4 and 8 day irrigation intervals.

Results showed that cotton is sensitive to the deficiency of the moisture level in the root zone. The highest seed cotton yield was obtained from the 8-day irrigation interval (IR8-100) as averaging 5592 kg ha^{-1}. The lowest seed cotton yield was observed from the 8-day irrigation interval (IR8-33) treatment as averaging 3477 kg ha^{-1}. WUE and IWUE values increased with decrease in irrigation water applied in both years. In this study, averaging the yield response factor (k_y) were determined as 0.56 during the entire growing season. The WUE and k_y values obtained for two year of different irrigation regimes could be used for the purposes of irrigation management and water allocation scheduling over irrigation schemes and limited irrigation water supply.

Overall, IR8-100 treatment (irrigation applied at the rate of 100%) could be used for cotton grown in semiarid regions under no water shortage. On the other hand, results obtained from the IR8-67 treatment (irrigation applied at the rate of 67%) could be used as a good basis for reduced irrigation strategy development in semiarid regions under water shortage. Under this conditions, 33% of water saving for cotton was obtained even though there were a 8.0% yield losses for cotton based on averages of 2 years.

REFERENCES

1. Anonymous, 2003. Agricultural productions summary. Turkish Republic, Natl. Inst. Stat., Ankara, Turkey.
2. Yazar, A., S.M. Sezen and S. Sesveren, 2002. LEPA and trickle irrigation of cotton in the Southeast Anatolia Project (SAP) area in Turkey. Agric. Water Manag., 54: 189-203.
3. Şimşek, M., M. Kacıra and T. Tonkaz, 2004. The effects of different drip irrigation regimes on watermeleon (*Citrullus lanatus*) yield and yield components under semi-arid climatic conditions. Aust. J. Agric. Res., 55: 1149-1157.
4. Elliades, G., 1988. Irrigation of greenhouse-grown cucumbers. J. Hortic. Sci., 63: 235-239.
5. Howell, T.A., M. Meron, K.R. Davis, C.J. Phene and H. Yamada, 1989. Water management of trickle and furrow irrigated narrow row cotton in the San Joaquin Valley. Soils and Fertilizers, 52: 1-4.
6. Hodgson, A.S., G.A. Constable, G.R. Duddy and I.G. Danieles, 1990. A comparison of drip and furrow irrigated cotton on a cracking clay soil. II. Water-use efficiency waterlogging, root distribution and soil structure. Irr. Sci., 11:143-148
7. Çetin, Ö., E. Özyurt and S. Şener, 1994. The effects of different irrigation methods on the yield and water use efficiency of cotton in Harran Plain. Proc. 17th Eur. Regional Conf. Efficient and Ecol. Sound Use of Irrigation Water with Special Reference to Eur. Countries, Varna, Bulgaria, May 16-22. ICID.
8. Anonymous, 2003. Meteorological Station, 1929-2003. Aydın,Turkey.
9. James, L.G., 1988. Principles of Farm Irrigation System Design. John Wiley and Sons. Inc. New York.

10. Howell, T.A. and E.A. Hiler, 1975. Optimization of water use efficincy under high frequency irrigation I. Evapotranspiration and yield relationship. Trans. ASAE., 18: 873-878.
11. Doorenbos, J. and A.H. Kassam, 1979. Yield response to water. FAO Irrigation and Drainage Paper No. 33, FAO Rome, Italy.
12. Sezgin, F., E. Yılmaz, N. Dağdelen and S. Baş, 2001. Effect of different irrigation methods and water supply level application on water-yield relations in cotton growing. 3rd Natl. Hyrol. Cong., Univ. September 9, Izmir, Turkey, June 27-29.
13. Anaç, S., M.A. Ul, I.H. Tüzel, D. Anaç, B. Okur and H. Hakerler, 1999. Optimum Irrigation Scheduling for Cotton under Deficit Irrigation Conditions. In: Kırda, C., P. Moutonnet, C. Hera and D.R. Nielsen, (Eds.). Crop Yield Response to Deficit Irrigations , Kluwer Academic Publishers, Dordrecht, The Netherlands.
14. Fangmeier, D.D., D.J. Garrot, Jr., S.H. Humsan and J. Perez, 1989. Cotton water stress under trickle irrigation. Trans. ASAE., 32: 1955-1959.