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Araştırma Makalesi

Farklı Azot Seviyeleri ve Sulama Aralıklarının Doğu Akdeniz Bölgesinde Yetiştirilen Pamuk Bitkisinde Verim ve Su Kullanma Randımanı Üzerine Etkileri[&]

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Öz

Bu çalışma, farklı azot seviyelerinin ve sulama aralıklarının pamuk verimi ve su kullanma randımanı üzerine etkilerini belirlemek amacıyla 2012 ve 2013 yıllarında Kahramanmaraş Doğu Akdeniz Geçit Kuşağı Tarımsal Araştırma Enstitüsü Müdürlüğü deneme alanında yürütülmüştür. Denemede Erşan-92 pamuk çeşidi bitkisinde, 3 farklı azot seviyesi (N_0:0, N_{15}:150, N_{30}: 300 kg ha^{-1}) ve 2 farklı sulama aralığı (I_5:5 ve I_{10}:10 gün) test edilmiştir. Uygulanan sulama suyu miktarının 5 ve 10 gün sulama aralıklarında 60 cm'lik kök derinliğindeki eksik nem tarla kapasitesine getirilmesiyle belirlenmiştir. Araştırma bölünmüş parseller deneme deseninde göre 3 yinelemeli olarak yürütülmüştür. Araştırma yıllarında sulama konularına uygulanan sulama suyu miktarı sırasıyla 511.9-633.8 ve 498-611 mm arasında değişmiştir. Farklı sulama ve azot konularında pamuk verim değerleri sırasıyla 2520-3360.0 ile 2360-3540 kg ha^{-1} arasında değişmiştir. Sonuç olarak, her 5 günde bir sulama konularında 10 günde bir sulama konularına göre daha az su uygulanmasına rağmen daha yüksek verim elde edilmiştir. Farklı sulama konuları ve azot uygulamaları interaksiyonu verim, Su kullanma randımanı (WP) ve sulama suyu kullanma randımanı (IWP) üzerine etkisi istatistiksel olarak %1 düzeyinde önemli bulunmuştur. Ekonomik analiz değerlendirmesinde en yüksek net gelir 5 günlük sulama aralığı 150 kg ha^{-1} azot uygulaması konusunda, en düşük ise 10 günlük sulama aralığı 0 kg ha^{-1} azot uygulamasında elde edilmiştir. Deneme sonucunda, 5 gün sulama aralığında 150 kg ha^{-1} azot uygulanması tavsiye edilmiştir.

Anahtar kelimeler: *Pamuk, bitki su tüketimi, su kullanma randımanı, sulama suyu kullanma randımanı, net gelir*

The Effects of Different Nitrogen Levels and Irrigation Intervals on Yield and Water Productivity of Cotton Grown in the Eastern Mediterranean Region

Abstract

The experiment was conducted to determine the effect of nirogen levels and irrigation intervals applied with drip system on cotton yield, evapotranspiration and water use efficiency in the East Mediterranean Transitional Zone Agricultural Research of Institute Located in Kahramanmaras, Turkey during 2012 and 2013. In the experiment, 3 different nitrogen levels (N_0:0, N_{15}:150, N_{30}: 300 kg ha^{-1}) and 2 different irrigation intervals (I_5: 5 and I_{10}:10 days) were investigated on Erşan-92 cotton variety. The amount of irrigation water was estimated by replenishment of soil water deficit in 60 cm root-zone depth to the field capacity in the irrigation intervals of 5 and 10 days. The experimental design was split-plots with three replications. The amount of irrigation water applied to treatments in the research years varied between 511.9-633.8 and 498-611 mm respectively. Cotton yield values in the research years for irrigation and nitrogen applications ranged between 2520-3360 and 2360-3540 kg ha^{-1} respectively. Higher yields were obtained with 5-day irrigation frequency compared with irrigation every 10 days. The effects of different irrigation intervals and nitrogen application of interaction on yield, Water use efficiency (WP) and Irrigation water use efficiency (IWP) were found to be statistically significant at 1% level. I_5 N_{15} generated the highest net income and the lowest income was found in I_{10} N_0. As a result of the experiment, 150 kg ha^{-1} nitrogen dose in 5 days irrigation interval was recommended for cotton production in the region.

Key words: *Cotton, evapotranspiration, water productivity, irrigation water productivity, net income*

Introduction

in the world population of 9 billion by 2050, while Turkey's population is estimated to approach 98 million (FAO, 2015). This situation increases the demand for cotton plant (*Gossypium Hirsutum* L.), which is the most cultivated in the world and among the plants used as raw material in many industrial areas, especially in the textile industry. Cotton crop consume approximately 10% of world irrigation water, after wheat (*Triticum aestivum* L.) and rice (*Oryza sativa* L.) (Ram et al., 2011). Cotton is a significant crop with regard to economy agricultural and industry in Turkey (Çetin and Kara, 2019). Cotton planting area of 542 thousand hectares, production is 955 thousand tons, and the yield of 1760 kg ha^{-1} in Turkey (Özdoğru, 2013). Approximately 20% of cotton production in Turkey is grown in the Mediterranean region. (TUIK, 2016). On the other hand, the water requirement for cotton is very high, and irrigation is generally completed by surface irrigation (Tanriverdi et al., 2015).

However, the use of drip irrigation and fertigation for cotton has increased immensely as a result of government supports in recent years (Çetin and Üzen, 2018). Surface drip irrigation and fertigation are more and composite compared with surface irrigation and fertilizing (Cetin et al., 2015). The drip irrigation method not only increases the cotton yield but also saves on irrigation water. However, the maximum irrigation water productivity was recorded in drip-irrigated parcels (Kumar, 2016).

The use of nitrogen fertilizers for field crop production is also increasing on a global scale. (FAO, 2015). The most critical limits for cotton (*Gossypium hirsutum* L.) production in arid and semi-arid areas are water and nitrogen (N) fertilizers (Morrow and Krieg, 1990).

This study was expected to determine the effects of different irrigation intervals and nitrogen levels on yield, water use and water productivity of cotton cultivation in the Kahramanmaraş Region.

Material and Method

The research was carried out in 2012 and 2013 in the experiment area of Kahramanmaraş Agricultural Research Institute. The experimental area has an average altitude of 700 m from the sea and lies between 27 ° 11 '- 38 ° 36' north parallels and 36 ° 15'-37 ° 41 'east meridians.

Compared to the long-term averages of 2012 and 2013, it was hotter, less humid and rainy.

In the growing period of cotton (May-October), average temperature values were found higher than average long annual values (Anonymous, 2013).

The soil of the experimental area is classified as class SC (sandy-clay). Some of the physical and chemical properties of the soil are given in Table 1. In the infiltration rate test performed with a double cylinder infiltrometer, and the soil stable infiltration rate was found to be 25 mm h^{-1}. Soil water content at field capacity varied between between 26.37% and 26.83%; wilting point varied between 14.4%-14.6% and bulk densities varied between 1.46-1.49 g cm^{-3}.

Irrigation water used in the experiment was taken from the well drilled in Kahramanmaraş Agricultural Research Institute. As a result of the analysis, irrigation water class was determined as C_2S_1. Electrical conductivity of irrigation water 0.327 dS m^{-1}; pH. 7.0; Na rate was found to be 19%. Each treatment was planned as 8 m long 4.2 m wide and had a total area of 33.60 m^2 at sowing. In order to minimize the water movement between the parcels, 3.0 m space is left between each parcel.

Irrigation applications consist of 5 and 10 days (I_5 and I_{10}) irrigation interval in 60 cm soil profile where replenished to the FC, and nitrogen level applications 0, 150 and 300 kg ha^{-1} (N_0, N_{150} and N_{300}). The experiment was planned as split plots with three replicates.

In the drip irrigation system, drip lateral pipes were placed in every cotton crop row. Drip tapes had inline emitters with discharge rate of 1.6 l h^{-1} spaced at 0.20 m. The amount of irrigation water in each parcel was measured with a flow meter.

A Time Domain Reflectometer was used to measure the soil water content (SWC) in the 0.3 m depth range (TDR Trase System) before irrigation applications at 5 and 10 days intervals during the cotton growing seasons. TDR probes were located in the mid parcel between two plants in the experimental subplots.

Evapotranspiration was calculated based on a 90 cm soil profile and the moisture content of the soil by water balance equation Eq. 1 (Doorenbos and Kassam 1979).

$$ET = I + P + \Delta W - Dp \quad \text{(Eq. 1)}$$

Where, ET, evapotranspiration (mm), P, precipitation (mm), I, irrigation water (mm), ΔW, change in soil water storage (mm), Dp, deep percolation (mm).

In the study, the following equation was used to determine water-use efficiency and irrigation water use efficiency (Howell et al., 1990).

$$WP = Y / ET \quad \text{(Eq. 2)}$$

$$IWP = Y / I \quad \text{(Eq. 3)}$$

Where, WP is water-use efficiency (kg m^{-3}), Y is yield (kg ha^{-1}) and IWP is irrigation water-use efficiency (kg m^{-3}).

Statistical analysis of experiment data was done in JMP Statistics software program. (SAS Institute, Inc., Cary, NC, USA). Two-way variance analyses (ANOVA) were conducted to determine the differences among treatment means. Least Significant Difference (LSD) at a 5% probability level was made (Steel and Torrie, 1980).

Cotton economic analysis was applied to calculate the net return in all irrigation and nitrogen applications. The net return was calculated as the difference between total manufacture costs and gross incomes per hectare (Dağdelen et al., 2009; Sezen et al., 2015). Information about cotton production costs and sale prices were achieved from the "Chamber of Farmers Association" and the "Agricultural Provincial Directorate" in Kahramanmaras. Cotton production costs included land rental, fertilizer, seed, soil cultivation, plant protection, and labor cost for irrigation, harvesting and transportation costs. For the calculation of the total cost of cotton production for an average of two years, the sum of crop production costs, the yearly cost of the irrigation system, irrigation labor, and water cost were taken into account.

Table 1. Physical and chemical properties of different soil layers of the experimental field

Depth	Soil Type	FC Pw (%)	PW PPw (%)	BD (g cm^{-3})	pH	Cation (me L^{-1})				Anion (me L^{-1})		
						Na^+	K^+	Ca^{++}	Mg^{++}	HCO_3^-	CL^-	SO_4^-
0-30	SC	26.4	14.6	1.47	7.45	0.43	0.09	1.53	1.31	1.52	1.28	0.56
30-60	SC	26.6	14.4	1.46	7.53	0.49	0.07	1.62	1.53	1.49	1.08	1.14
60-90	SC	26.8	14.5	1.49	7.69	0.52	0.11	1.59	1.55	1.52	1.06	1.19

FC: Field capacity; PWP: permanent wilting point; BD: bulk density.

Results and Discussion

Cotton yield, ET, I, WP and IWP values obtained from the treatments were given in Table 2. The amount of irrigation water applied in the study varied according to different irrigation intervals and nitrogen levels. Statistical analysis results on yield, WP and IWP of cotton under different treatments are given in Table 3. Applied irrigation amounts in treatment of I_{10} were more than the treatment of I_5. The highest amount of irrigation was 634 and 611 mm in I_{10}-N_{150} and the lowest irrigation amount was 512 and 498 mm in I_5N_0 for two years, respectively.

The total precipitation for the period from planting to harvesting is in the first year of the study (2012) was 154.3 mm and in the second year (2013) was 101 mm. Cotton evapotranspiration (ET) varied from 741 mm (I_5-N_0) to 837 mm (I_{10}-N_{150}) in 2012 and from 688 mm (I_5-N_0) to 813 mm (I_{10}-N_{150}) in 2013 (Table 2). The seasonal evapotranspiration (ET) increased with the increasing irrigation water amount and intervals.

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Table 2. Cotton yield, I, ET, WP and IWP values under the different treatments

Years	Treatments	I (mm)	Yield (kg ha^{-1})	ET (mm)	IWP (kg m^{-3})	WP (kg m^{-3})
2012	I_5N_0	498	2360 e	741	0.47	0.32 e
	I_5N_{150}	567	3540 a	784	0.63	0.45 a
	I_5N_{300}	520	3230 b	746	0.62	0.41 b
	$I_{10}N_0$	533	2140 f	783	0.37	0.26 f
	$I_{10}N_{150}$	611	3080 c	837	0.52	0.37 c
	$I_{10}N_{300}$	551	2850 d	793	0.52	0.36 d
2013	I_5N_0	512	2870 c	688	0.56	0.42 b
	I_5N_{150}	599	3360 a	756	0.57	0.44 a
	I_5N_{300}	555	3060 b	724	0.55	0.42 b
	$I_{10}N_0$	560	2530 f	742	0.45	0.34 c
	$I_{10}N_{150}$	634	2740 d	813	0.43	0.34 c
	$I_{10}N_{300}$	588	2610 e	771	0.44	0.34 c

I: Irrigation; ET: Evapotranspiration; WP: water use efficiency; IWP: Irrigation water use efficiency; P< 0.01(** %1 significant level); P< 0.05 (* %5 significant level)

Table 3. Statistical analysis results on yield, WP and IWP of cotton under different treatments

Years	Treatments	Yield (kg ha^{-1})	WP (kg m^{-3})	IWP (kg m^{-3})
2012	Irrigation intervals	LSD=112.4; P=0.0054**	LSD=0.006; P=0.0005**	LSD=0.01; P=0.0004**
	Nitrogen Level	LSD=38.1; P=0.0001**	LSD=0.01; P=0.0001**	LSD=0.268; P=0.0001**
	Interaction of irrigation interval and nitrogen level	LSD=53.8; P=0.00024**	LSD=0.0502*; P=0.014**	ns
2013	Irrigation intervals	LSD=70.4; P=0.0012**	LSD=0.0005; P=0.002**	LSD=0.02; P=0.0018**
	Nitrogen Level	LSD=57; P=0.0001**	LSD=0.008; P=0.242*	ns
	Interaction of irrigation interval and nitrogen level	LSD=80; P=0.0014**	LSD=0.012; P=0.0059**	ns

WP: Water productivity; IWP: Irrigation water productivity ; LSD: Least significant difference; P< 0.01(** %1 significant level); P< 0.05 (* %5 significant level); P > 0.05 ns (not significant)

In 2012, the maximum yield of 3230 kg ha^{-1} was obtained the under the I_5-N_{150} treatment, followed by the I_5-N_{300}, I_{10}-N_{150}, $I_{10}N_{300}$, I_5N_0 treatments, with 3230 kg ha^{-1}, 3080 kg ha^{-1} , 2850 kg ha^{-1}, 2360 kg ha^{-1} respectively, while the minimum yield of 2140 kg ha^{-1} was obtained under the $I_{10}N_0$ treatment. In 2013, the maximum yield of 3360 kg ha^{-1} was obtained the under the I_5-N_{150} treatment, followed by the I_5-N_{300}, I_{10}-N_{150}, $I_{10}N_{300}$, I_5N_0 treatments, with 3060 kg ha^{-1}, 2740 kg ha^{-1} , 2610 kg ha^{-1}, 2870 kg ha^{-1} respectively, while the minimum yield of 2530 kg ha^{-1} was obtained under the $I_{10}N_0$ treatment (Table 2). In both of years, cotton yield decreased significantly as the irrigation interval increased and nitrogen levels decreased (Table 3). Cotton yields are affected by irrigation intervals (Dagdelen et al., 2009; Ertek and Kanber, 2000, 2002) and nitrogen applications (Ogunlela et al. 1982; Ebelher et al., 2000; Taş and Gençer, 2002).

The values of WP and IWP gave in Table 3. Generally, WP and IWP values decreased with increasing irrigation intervals. WP; the lowest values 0.26 kg m^{-3}, 0.34 kg m^{-3} in I_{10}-N_0 and the highest values 0.45 kg m^{-3}, 0.44 kg m^{-3} in the I_5-N_{150} in 2012 and 2013 respectively. The effects of different irrigation intervals and nitrogen levels on WP were statistically significant ($P \leq 0.01$), the interaction of irrigation intervals and nitrogen levels were also significant ($P \leq 0.05$) in 2012. The effects of different irrigation intervals and interaction of irrigation intervals and nitrogen levels were statistically significant ($P \leq 0.01$), nitrogen levels were also significant ($P \leq 0.05$) in 2013. IWP values ranged from 0.37 kg m^{-3} in I_{10}-N_0 to 0.63 kg m^{-3} in the I_5-N_{150} in 2012 and from 0.43 kg m^{-3} in I_{10}-N_{150} to 0.57 kg m^{-3} in the I_5-N_{150} in 2013. I_5-N_{150} treatment resulted in greater IWP values than others treatments in the experimental years. Although the effects of different irrigation intervals and nitrogen level on IWP were statistically significant ($P \leq 0.01$), interaction of irrigation intervals and nitrogen levels was found to be not significant in 2012. In 2013, the effects of different irrigation intervals on WP were statistically significant ($P \leq 0.01$) but interaction of irrigation intervals and nitrogen level were insignificant. In general, several factors affect the WP and IWP, such as irrigation interval, nutritive elements, crop management, climatic conditions (Abdelaziz et al., 2019; Atia et al., 2019; El-Mogy et al., 2019; Abuarab el at., 2020). WP are similar to the Yazar and Gençoğlan (1999) who found between 0.22-1.25 kg m^{-3} in cotton different water applications in Çukurova region; Coşkun (2015), found it between 0.48-0.61 kg m^{-3} in the Harran region, and Candemir and Ödemiş (2018) found it between 0.43-0.83 kg m^{-3} in Hatay conditions.

Combined economic analysis results based on investment, operating and production costs were given in Table 4. Economic evaluation revealed that the maximum net income was generated as 7925 \$ ha^{-1} with I_5N_{150} and the lowest value was 5770 \$ ha^{-1} with I_5N_0 treatment.

Table 4. The summary of the combined economic analysis of the different irrigation treatments

Treatments	Irrigation Water (m^3/ha) (1)	Labor cost for irrigation (\$ m^{-3}) (2)	Total cost for irrigation labor (\$) (3) (1×2)	Water price (\$ m^{-3}) (4)	Water price (\$ ha^{-1}) (5) (1×4)	Crop production costs (\$ ha^{-1}) (6)
I_5N_0	500.0	0.08	40.0	0.6	24.0	1150
I_5N_{150}	582.5	0.08	46.6	0.6	27.9	1350
I_5N_{300}	537.5	0.08	43.0	0.6	25.8	1450
$I_{10}N_0$	546.5	0.08	43.7	0.6	26.2	1150
$I_{10}N_{150}$	622.5	0.08	49.8	0.6	29.8	1350
$I_{10}N_{300}$	569.0	0.08	45.5	0.6	27.3	1450
Treatments	Irrigation system cost per ha (\$ h^{-1}) (7)	Annual cost for the irrigation system (\$ ha^{-1}) (8) (9/5)	Total cost for 1 year (\$ ha^{-1}) (9) (3+5+6+8)	Yield (kg ha^{-1}) (10)	Cotton sales price (\$ kg^{-1}) (11)	Gross income per ha (\$ ha^{-1} $year^{-1}$) (12) (10×11)
I_5N_0	1620	324	1538	2610	2.8	7308
I_5N_{150}	1620	324	1748	3455	2.8	9674
I_5N_{300}	1620	324	1843	3145	2.8	8806
$I_{10}N_0$	1620	324	1544	2330	2.8	6524
$I_{10}N_{150}$	1620	324	1754	2905	2.8	8134
$I_{10}N_{300}$	1620	324	1847	2730	2.8	7644

Conclusion

In the research years, the maximum amount of irrigation water given to the plant was determined as 611 and 634 mm for $I_{10}N_{150}$ and the minimum amount of irrigation water was determined as 498 and 512 mm for I_5N_0, respectively. Considering all irrigation interval treatments, it was determined that the I_5 resulted in higher yield values for each nitrogen level different from the I_{10}, despite their less irrigation water amounts. In addition, all I_5 treatments were determined to have higher IWP and WP values than all I_{10} treatments. I_5-N_{150} treatment resulted in greater WP and IWP values than other treatments in the experimental years.

As a result of the analysis, both nitrogen levels and irrigation interval were important in increasing the yield of cotton. The highest yield cotton yield and net income were obtained in the application of 150 kg ha^{-1} nitrogen and 5-day irrigation interval.

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