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The Effects of Different Drip Irrigation Levels and Seed-Coated Techniques on Yield and Water Use Efficiency of Cotton

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Abstract This study was conducted to observe the effects of different drip irrigation levels and seed-coated techniques on seed cotton yield and water use efficiency values (WUE; IWUE) produced from Eksperia cotton variety in the Aegean Region of Turkey during 2019. The trial was designated in randomized complete block design with two factors and three replications. In the study, three different irrigation levels (100, 67 and 33%) and three different seed-coated techniques (Boron coated, Zinc coated with 9.2% and delinted seed) were investigated. The highest irrigation water level was applied to the full irrigation treatment (IL-100) for three seed applications. Seasonal water use values in the treatments varied from 305 mm to 723 mm in growing season. Irrigation levels (IL) had significantly effects on seed cotton yield. The highest seed cotton yield was obtained from IL-100 treatment as averaging 6068 kg ha^{-1}, followed by IL-67 treatment as averaging 4531 kg ha^{-1}. The lowest yield was obtained from IL-33 treatment as averaging 3609 kg ha^{-1}. It was determined delinted seed applications performed higher yields than boron and zinc seed-coated applications. Average water use efficiency (WUE) values varied between 0.834 and 1.193 kg m^{-3}. The yield response factor (k_y) was determined to be 0.73 in the boron seed applications, 0.74 in the zinc coated applications and 0.82 in the delinted seed applications, respectively. In conclusion, the results of this research indicated that delinted seed applications; with IL-100 treatment (D_3) could be used for cotton grown in semi-arid Aegean regions under no water shortage. Moreover, results obtained from the delinted seed applications; with IL-67 treatment could be used as a good basis for reduced drip irrigation strategy development under water shortage.

Keywords Cotton, drip irrigation, water use efficiency, yield response factor

1. Introduction

Aegean Region is one of the most important agricultural and industrial region in west part of Turkey. All cotton production areas of this region receive inadequate amounts or inadequate distribution of rainfall. Decreasing ground water supplies and the high cost of energy also affect production of irrigated cotton. Turkey must take urgent action to solve the water-shortage problem for important agricultural crops including cotton, wheat, and other crops in coming years. Nowadays limited availability of irrigation water requires fundamental changes in irrigation management and urges the application of water saving methods. Under such conditions, different irrigation systems such as drip irrigation, sprinkler irrigation, subsurface drip irrigation (SDI), and low energy precision applicators (LEPA) should be considered to provide growers with high irrigation efficiency. Especially, the use of drip irrigation techniques is inevitable in the near future because of the salinity problem caused by traditional irrigation methods [1]. Thus, this creates the need for continuous improvement in irrigation practices, especially in the cotton production of the Aegean region. Turkey's seed cotton production meets approximately 44% of the needs of its domestic market. Turkey is among the top 11 cotton production countries in the world. In 2018/2019, seed cotton acreage and crop production of Turkey is 508 000 ha and 988 000 t, respectively. Average cotton lint yield is about 1944 kg ha^{-1} [2]. A reduction in underground water sources as a result of climate change and an increase in industrial and domestic water consumption have led to a reduction in the amount of water available for agricultural production. In addition to this, the effects of global warming are more and more being felt, and one of the most important of these is drought. This has a negative effect on crop production. Cotton is irrigated by the surface irrigation method in Turkey although sprinkler and drip irrigation have been suggested as a means of supplying most types of crops with frequent and uniform applications of water, since it is adaptable over a wide range of topographic and soil conditions [3, 4]. They also reported that cotton yield and water use efficiency was higher in drip irrigation than furrow and sprinkler irrigation. [5] reported that water use efficiency was 30% higher with drip irrigation treatments, indicating a definitive advantage of this method under conditions of limited water supply. Water availability is a major concern in cotton production. Cotton is an excellent candidate for irrigation. Besides different drip irrigation levels, with proper management such as seed-coated techniques should be studied by the researchers. [6] studied the effect of irrigation methods, irrigation frequency and pan coefficients under Southeast Anatolia conditions of Turkey. Highest seed cotton yield of 5850 kg ha^{-1} was obtained from the full irrigation treatment (100 %) in trickle-irrigated plots with 6-day intervals. In another study, the highest yield was found to be 4220 kg ha^{-1} with 5-day irrigation interval and seasonal water consumption was 511 mm under drip irrigated cotton in Çukurova plain-Turkey [7]. Efficient use of irrigation water is becoming increasingly important and alternative water application methods such as drip and sprinkler, may contribute substantially toward making the best use of water for agriculture and improving irrigation efficiency [8]. A number of previous studies reported the advantage of drip irrigation methods in terms of high WUE and cotton yield [5, 7, 3, 6, 9, 10]. [11], in a study to determine the effect of five different doses of water in a drip irrigation system on water use efficiency, yield, yield components and fibre quality characteristics, found that when the dose of water was reduced from 100% to 75%, water use efficiency rose from 0.62 to 0.71 kg m^{-3}. It was also found that raw cotton yield, the number of bolls and the weight of cotton per boll fell in parallel with the reduction in irrigation level. [12] conducted field trials in the Aegean region in 2004-2005 to determine the effect of various levels of water using the drip irrigation method on water use efficiency and fibre quality parameters. They reported variations of 256-753 mm in average seasonal plant water consumption, 2550-5760 kg ha^{-1} in average cotton yield, and 0.76-0.98 kg m^{-3} in water use efficiency. [13], in a study conducted on cotton under Syrian conditions to determine the effect of different irrigation doses on water use efficiency, cotton yield and fibre quality, found variations of 408-773 mm in crop water consumption and 2909-5090 kg ha^{-1} in average cotton yield. Also, in each of the years in which the study was conducted, the highest water use efficiency value, 0.71 kg m^{-3}, was obtained from a water level of D180. [14], conducted a study to determine the effects of 0%, 25%, 50% 75% and 100% irrigation levels on the yield of cotton using drip irrigation under Aydın-Turkey conditions. The researchers found average WUE and IWUE values varied between 0.747-1.120 and 0.972-2.503 kg m^{-3} respectively.

Water availability is a major concern in cotton production. Cotton is an excellent candidate for irrigation. Besides different drip irrigation levels, with proper management such as seed-coated techniques should be studied by the researchers. Therefore, limited availability of irrigation water requires fundamental changes in irrigation management or urges the application of water saving methods. The objectives of this study was to determine the effects of different seed-coated techniques and irrigation levels on the seed cotton yield and water use efficiency under drip irrigation system and to choose the most suitable irrigation schedule for cotton cultivar under semi-arid climatic conditions.

Materials and Methods

Field experiments was carried out at the Agricultural Research Station of Aydın Adnan Menderes University, Aydin-Turkey at 37° 51’ N latitude, 27°51’ E longitude and 56 m altitude during the 2019 growing season. Climate in this region is semi-arid with total annual precipitation of 657 mm. Average seasonal rainfall is 657 mm, with 90% of the rain occurring between November and March. Typical Mediterranean climate prevails in the experimental area. Table 1 summarizes the monthly mean climatic data compared with the long-term mean climatic data for Aydın [15]. The growing season temperatures were typical of long term-means (1970-2018) for Aydın located in the western Aegean region of Turkey.

Table 1: Weather conditions prevailed during the experiments compared to the long- run at the experimental site

1970-2018				
Month	**Temperature (°C)**	**Relative Humidity (%)**	**Rainfall (mm)**	**Evaporation (mm)**
May	21	56.9	35.6	161.3
June	26	49.2	16.6	222.1
July	28.6	48.6	7.5	257.5
August	27.6	52.9	5.3	231.6
September	23.3	55.9	15.1	161.9
2019				
Month	**Temperature (°C)**	**Relative Humidity (%)**	**Rainfall (mm)**	**Evaporation (mm)**
May	21.6	56.2	11.9	149.9
June	26.9	54.3	26.9	185.6
July	28.4	46.6	1.2	248.5
August	29.3	46.4	0.0	228.7
September	24.4	58.7	16.6	154.6

The soil series in the research area was Büyük Menderes Basin developed on aluvial materials [16]. The soil of the experimental site is classified as Entisols and Fluvisols-Regosols silty-clay-loam with relatively high water holding capacity. For the experiment area, water content at field capacity varied from 18.3 to 20.1% and wilting point varied from 7.1 to 10.2% on dry weight basis. Research area soils contain high percentages of sand (49.7-68.2%), followed by silt (19.2-32.0%) and clay (13.6-17.5%) and could be classified as Sandy-loam. The dry soil bulk densities ranged from 1.35 to 1.47 g cm^{-3} throughout the 1.2 m deep profile.

The Eksperia cotton variety was planted on 29 April 2019, with 0.70 × 0.20 m spacing. A compound fertilizer of (15%, 15%, and 15% composite) was applied at a rate of 60 kg ha^{-1} pure N, P and K before planting. The required remaining portion of nitrogen was followed by 82 kg ha^{-1} as Ammonium nitrate 33% before first irrigation.

The trial was designated in randomized complete block design with two factors and three replications. In the study, three different irrigation levels (100, 67 and 33%) and three different seed-coated techniques (boron coated, zinc coated with 9.2% and delinted seed) were investigated. There were 3 m between each plot. Each experimental plot had six cotton rows at 0.7 m spacing and 5 m in length. Irrigation water was applied when ~40% of available soil moisture was consumed in the 1.20-m root zone at B_1,$C_{1,}$ and D_1 control treatments (100%) during the irrigation periods. Other treatments (B_2,$C_{2,}$ D_2 and B_3,$C_{3,}$ D_3) irrigations were applied at the rates of 67 and 33% of B_1,$C_{1,}$ and D_1 control treatments on the same day, respectively. A drip irrigation system was designated for the experiment. Irrigation water was used from a deep well located near the experimental site. The control unit consisted of screen filter with 10 l s^{-1} capacity, control valves, manometers mounted on the inlet and outlet of each unit. Distribution lines consisted of PVC pipe manifolds for each plot. The diameters of the laterals were 16 mm PE and each lateral irrigated one plant row. The inline emitters were used with a discharge rate of 4 L h^{-1} above 10 m operating pressure. In the system, emitter and the lateral spacing were chosen as 0.20 and 0.70 m, respectively.

Crop water consumption under varying irrigation regimes was calculated using the soil water balance equation [14] as; [17]

$$ET = R + I - D \pm \Delta W \quad (1)$$

Where, ET is the water use (mm), R is the rainfall (mm), I is the depth of irrigation (mm), D is the depth of drainage (mm), and ΔW is the change of soil water storage in the measured soil depth.

WUE was calculated as yield (kg ha^{-1}) divided by seasonal water use (mm). IWUE was determined as yield (kg ha^{-1}) per unit irrigation water applied (mm) [18]. Regression analysis was used to evaluate the water use-yield relationships derived from seasonal crop water use and yield data obtained from the experiment. Seasonal values of the yield response factor (k_y), which represent the relationship between relative yield reduction [1-(Ya/Ym)] and relative evapotranspiration deficit [1-(ETa/ETm)], were determined using equation 2 given byDoorenbos and Kassam [19]:

$$1-(Ya/Ym)=k_y(1-ETa/ETm) \quad (2)$$

Where, *ETa* and *ETm* are the actual and maximum seasonal crop water use values (mm), respectively, and *Ya* and *Ym* are the corresponding actual and maximum yields (kg ha^{-1}).

Seed cotton yield was determined by hand harvesting in each plot on 23 October 2019. In order to determine the differences between irrigation treatments, the data relating to seed cotton yield was subjected to variance analysis. The Least Significant Differences (LSD) test was used for comparing and ranking the treatments. Differences were declared significant at $P< 0.05$. Variance analysis and LSD tests were carried out with the use of the TARİST program, which was developed for this purpose [20].

Results & Discussion

The total irrigation water amounts applied, seasonal water use and water use efficiency values (WUE, IWUE) were presented in Table 2. The first irrigation was applied on July 10, and irrigations were lasted on September 2, in 2019, respectively. Seasonal amount of irrigation water applied for different drip treatment ranged from 190 to 576 mm in growing season. Irrigation water was applied eight times to the treatments over the growing season (Table 2).

Table 2: Seed cotton yield and water use efficiency values as influenced by seed applications and irrigation levels

Seed coated-applications	Irrigation Levels	Seed yield (kg ha^{-1})	Irrigation water applied (mm)	Water use (mm)	Water use efficiency (WUE) (kg m^{-3})	Irrigation water use efficiency (IWUE) (kg m^{-3})
Boron coated	B_1-100%	5959	576	714.4	0.834	1.034
	B_2-67%	4513	386	528.2	0.854	1.169
	B_3-33%	3667	190	317.2	1.156	1.930
Zinc coated	C_1-100%	6024	576	711.1	0.847	1.045
	C_2-67%	4410	386	513.2	0.859	1.142
	C_3-33%	3640	190	305.0	1.193	1.915
Delinted seed	D_1-100%	6223	576	723.0	0.860	1.080
	D_2-67%	4672	386	533.0	0.876	1.210
	D_3-33%	3522	190	327.0	1.077	1.853

Seasonal plant water use values varied in connection with the irrigation water applied to the treatments and the amount of moisture at planting and harvest. At the same time, although it has a great effect on plant water consumption, there was no rain on the experimental area during the growing season. Water use values increased with increasing irrigation levels in each seed-coated techniques. Seasonal water use varied from 723 mm D_1 treatment (delinted seed) to 327 mm in D_3 treatment plots in growing season; and 714.4 mm in B_1 (Boron coated) treatment to 317 mm in B_3 treatment plots. This was followed by C_1 (Zinc coated with 9.2%) treatment with 711.1 mm and C_3 treatment with 305 mm in growing season (Table 2). This small difference in water use between the techniques can be attributed to the variations of seed-coated applications and environmental conditions. The highest seasonal water use values were obtained from treatments B_1,C_1, and D_1 control treatments (100%) as 714.4 mm, 711.1 mm and 723 mm, respectively. Seasonal water use in the full irrigation treatment S_1, was in agreement with results obtained by [14] in the Aydın plain with the drip system and who determined water use values as 800 mm. Seasonal water use of cotton under the same region has been reported as 899 mm by [21]; as 855-882 mm by [4] under furrow irrigation system; as 265-753 mm by [12] and as 268-754 mm by [11] under drip irrigation system. Once the results of this study are compared with those of furrow irrigation studies at the same region, it is clear that drip irrigation systems are able to save substantial amount of water. Under drip irrigation applications, seasonal water use of cotton was obtained by [22] as 287-584 mm in Adana conditions; as 410-725 mm by [23] in the High Texas Plains. On the other hand, [10] found that seasonal water use in cotton varied between 432 and 739 mm depending on irrigation regimes in Uzbekistan conditions by using drip and furrow irrigation methods. In another study, [9] applied a total of 738 mm irrigation water amount to drip irrigated cotton in the Bekaa Valley of Lebanon. The results observed in this research were in agreement with the others given above.

The response of seed cotton yield to different irrigation treatments are given in Table 3. Data obtained from study showed that seed cotton yield was significantly affected by irrigation levels. No interactions between seed-coated techniques (T) and irrigation levels (IL) were observed for any investigated parameters in year. Seed-coated techniques (T) had no significant effect on seed yield. The delinted seed application resulted in higher yield than boron and zinc coated applications. Seed cotton yield was found to increase with irrigation water levels. Examining these results from the point of view of irrigation levels (IL), three groups formed in year. The first group consisted of the 100% treatments where no water restriction had been applied in the whole growing season, treatments in which water had been applied at the 67 % level were second, and treatments which had received water at the 33 % level formed the last group. Especially, as the irrigation level increased, seed cotton yield were increased in all seed coated applications. The highest average yield was obtained from IL-100 treatment as 6068 kg ha^{-1}, followed by IL-67 treatment as 4531 kg ha^{-1}. The lowest yield was obtained from IL-33 treatment as 3609 kg ha^{-1}. The reduction rate was 40.5% between the highest and lowest seed cotton yield. When the amount of applied water through drip irrigation was reduced 33% (LL-67) the decrease in yield was about 25.3% in growing year. A significant decline in seed yield under deficit irrigation treatment is reported in many previous researches.

Table 3: Seed cotton yield (kg ha^{-1}) as influenced by seed-coated applications and irrigation levels

Seed-coated techniques (T)	Boron coated	4713
	Zinc coated with 9.2%	4691
	Delinted seed	4805
F value (T)		ns
LSD $_{\%5}$		17.523
Irrigation levels (IL)	IL-100%	6068a
	IL-67%	4531b
	IL-33%	3609c
F value (IL)		**
LSD $_{\%5}$		17.523
T x IL		ns

*P< 0.05; **P< 0.01; ns: not significant

In a column values with a common letter are not significantly differ from one another using $LSD_{\%5}$

According to the results of a study conducted on drip irrigated cotton in Aydın area, the highest cotton yield was achieved from a treatment in which 100 % of the amount of evaporation from a class A-pan was applied at 8-day irrigation interval [24]. On the other hand, the highest seed cotton yield (5870 kg ha^{-1}) was reported in the Harran plain from the full irrigation treatment (100%) with 6-day irrigation interval using drip irrigation method [6]. The average seed cotton yield was obtained as 5760 kg ha^{-1} under drip irrigated treatment in western Turkey [12]. Another Aydın plain conditions the highest average raw cotton yield was obtained from S_1 treatment (Carisma-V1) as averaging 6300 kg ha^{-1}. It was determined Carisma (V1) cultivar performed higher yields than Candia (V2) and Gloria (V3) [25]. Similar results were obtained by [14] as 5985 kg ha^{-1} at the same conditions. The results observed in this research were in agreement with the others given above. In evaluations conducted previously, it has been found that irrigation level have significant effect on seed cotton yield. It has been concluded that the most proper irrigation programme suggested for achieving highest cotton yield would be using the delinted seed applications under water abundant conditions in which the crop water requirements were fully met by IL-100 treatment (treatment D_1).

In order to evaluate the effects of water use on seed cotton yield regression analysis was conducted. There was a significant second order polynomial relationships were found between seasonal water use and seed cotton yield in irrigation treatments (Fig 1). Polynomial relationships of water use and seed cotton yield for drip irrigated cotton were given by [6, 12, 14, 22].

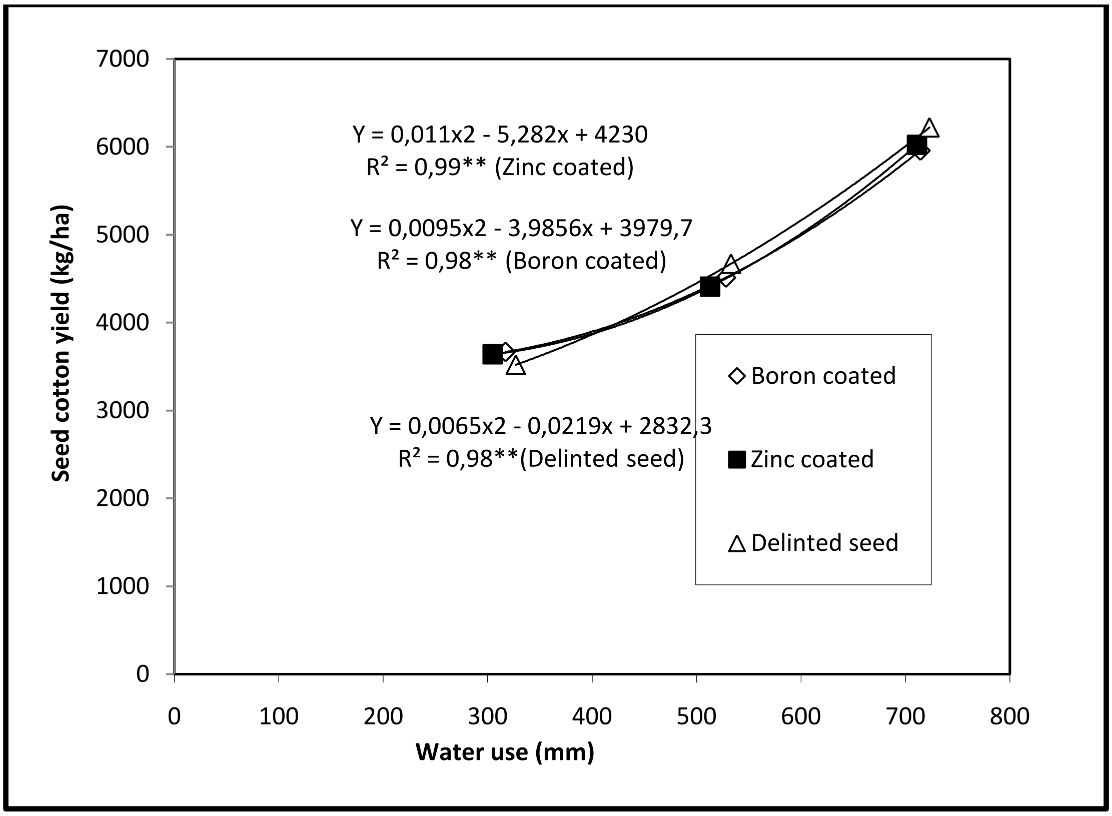

Figure 1: The relationship between water use and seed cotton yield

The k_y factor which represents the slope of the relationship between relative ET and relative yield, was determined the methods of [26]. The yield response factor (k_y) was determined to be 0.73 in the boron seed applications, 0.74 in the zinc coated applications and 0.82 in the delinted seed applications, respectively. The average k_y for the whole growing season were found to be 0.84 by [19], 0.89 by [6] and 0.78 by [12] in Aydın conditions.

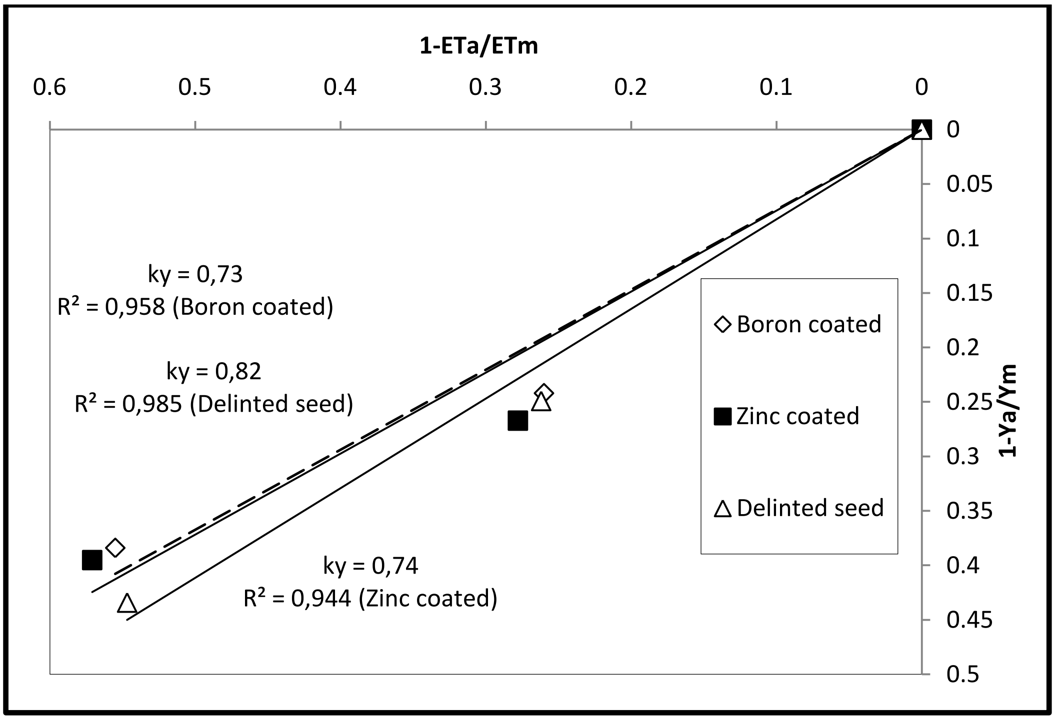

Figure 2:Yield response factor, k_y, cotton seed applications

Water use and irrigation water use efficiencies (WUE, IWUE) values are listed in Table 2 for growing season. As the amount of water applied increased, WUE and IWUE decreased. In general, the IWUE values were higher than those of WUE in all treatments. This could be attributed to water used from soil storage. Water use efficiency (WUE) varied from 0.834 kg m^{-3} to 1.193 kg m^{-3} among treatments. The highest WUE was obtained as 1.193 from C_3 (zinc coated for IL-33) treatments and the lowest WUE was observed 0.834 kg m^{-3} from B_1 (boron coated for IL-100) treatments. It can be said that from the point of view of water saving, treatment IL-33from all applications (C_3, B_3 and D_3)used water more efficiently. Thus, when water was restricted under these conditions, a reduction of 39.5%, 38.4% and 43.4% were seen in yield. Table 4 shows a comparison of water use efficiency values (WUE; IWUE) obtained from the results of the study and water efficiency values reported by other researchers. The table shows that both IWUE and WUE values were similar to the findings of other researchers.

Table 4: The comparison of WUE and IWUE values for different research

Sources	Irrigation system	WUE (kg m^{-3})	IWUE (kg m^{-3})
Our research	Drip	0.83-1.19	1.03-1.93
[7]	Drip	0.58-0.62	0.75-0.94
[6]	Drip	0.50-0.74	0.60-0.81
[6]	Lepa	0.55-0.67	0.58-0.77
[9]	Drip	0.80-1.30	-
[10]	Drip	0.63-0.88	0.82-1.12
[12]	Drip	0.77-0.96	0.82-1.44
[11]	Drip	0.62-0.85	0.66-1.57
[27]	Drip	0.83-1.26	1.05-1.96
[25]	Drip	0.73-1.13	0.91-2.23
[14]	Drip	0.74-1.12	0.97-2.50

Conclusion

Our results significantly demonstrated that the effects of the amount of the irrigation water and seed-coated applications as well as water use are the prime factors in obtaining higher seed cotton yields of cotton under Aegean semi-arid climatic conditions. Irrigation levels (IL) had significant effects on the yield of cotton at a P<0.01 level. The highest seed cotton yield was obtained from IL-100 treatment as averaging 6068 kg ha^{-1}, followed by IL-67 treatment as averaging 4531 kg ha^{-1}. Seed-coated techniques had no significant effect on seed yield. Moreover, delinted seed applications with IL-100 treatment (D_3) performed higher yields than boron and zinc seed-coated applications. The results indicated that the WUE and IWUE values decreased with the increasing irrigation interval. The higher WUE and IWUE were obtained at the lowest irrigation level of each seed applications. However, the lowest irrigation levels resulted in lower seed cotton yields in all seed coated applications. Thus, the use of low irrigation levels for drip irrigated cotton production in the region is not recommended. Significant relationships between seed yield and the seasonal water use were found for each applications in this study. Overall, the results of this research indicated that delinted seed applications, with IL-100 treatment could be used for cotton grown in Aegean region similar to the area in Turkey under no water shortage. On the other hand, results obtained from the delinted seed applications, with IL-67 treatment could be used as a good basis for reduced drip irrigation strategy development in semi-arid regions under water shortage. Under this conditions, when the amount of applied water through drip irrigation was reduced 33% (IL-67) the decrease in yield was about 25.3% in growing season.

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References

[1]. Simsek, M., Kacıra, M., & Tonkaz, T. (2004). The Effects of Different Drip Irrigation Regimes on Watermelon (Citrullus lanatus) Yield and Yield Components Under Semi-Arid Climatic Conditions. J. Agric. Res, 55: 1149-1157.

[2]. Anonymous, (2019a). Cotton report. T.C. Ministry of Customs and Trade, Ankara, TURKEY, pp.2-3.

[3]. Çetin, Ö., & Bilgel, L. (2002). Effects of Different Irrigation Methods on Shedding and Yield of Cotton. Agricultural Water Management, 54: 1-15.

[4]. Dağdelen, N., Yılmaz, E., Sezgin, F. & Gürbüz, T. (2006). Water-Yield Relation and Water Use Efficiency of Cotton (Gossypium hirsutum L.) and Second Crop Corn (Zea mays L.) in Western Turkey. Agricultural Water Management,82: 63-85.

[5]. Mateos, l., Berengena, J., Orgaz, F. & Fereres, E. (1991). A Comparison Between Drip and Furrow Irrigation in Cotton at Two Levels of Water Supply. Agric. Water Manag., 19: 313-324.

[6]. Yazar, A., Sezen, S.M., & Sesveren, S. (2002). LEPA and Trickle Irrigation of Cotton in the Southeast Anatolia Project (GAP) Area in Turkey. Agricultural Water Management, 54(3):189-203.

[7]. Ertek, A., & Kanber, R. (2001). Effects of Different Irrigation Programs on the Growth of Cotton Under Drip Irrigation. Turkish Journal of Agriculture and Forestry, 25: 415-425(in Turkish with English abstract).

[8]. Sezen, S.M., Yazar, A., Canbolat, M., Eker, S., & Çelikel, G. (2004). Effect of Drip Irrigation Management on Yield and Quality of Field Grown Green Beans. Agric. Water Manag., 54: 189-203.

[9]. Karam, F., Lahoud, R., Masaad, R., Daccache, A., Mounzer, O. & Rouphael, Y. (2006). Water Use and Lint Yield Response of Drip Irrigated Cotton to Length of Irrigation Season. Agricultural Water Management, 85: 287-295.

[10]. Ibragimov, N., Evett, S.R., Esanbekov, Y., Kamilov, B.S., Mirzaev, L., & Lamers, J.P.A. (2007). Water use efficiency of irrigated cotton in Uzbekistan under drip and Furrow Irrigation. Agric. Water Manag., 90: 112-120.

[11]. Basal, H., Dağdelen, N., Ünay, A., & Yılmaz, E. (2009). Effects of Deficit Drip Irrigation Ratios on Cotton (Gossypium hirsutum L.) Yield and Fiber Quality. Journal of Agronomy & Crop Science, 195(1): 19-29.

[12]. Dağdelen, N., Basal, H., Yılmaz, E., Gürbüz, T., & Akçay, S. (2009). Different Drip Irrigation Regimes Affect Cotton Yield, Water Use Efficiency and Fiber Quality in Western Turkey. Agricultural Water Management, 96(1): 111-120.

[13]. Hussein, F., Janat, M., & Yakoub, A. (2011). Assessment of Yield and Water Use Efficiency of Drip-Irrigated Cotton (Gossypium hirsutum L.) as Affected by Deficit Irrigation. Turkish Journal of Agriculture and Forestry, 35: 611-621.

[14]. Erten, E., & Dağdelen, N. (2020). Yield and Water Relations of Drip Irrigated Cotton Under Various Irrigation Levels. Journal of Scientific and Engineering Research, 7(2): 204-211.

[15]. Anonymous, (2019b). Climatic Report of Aydın Province, State Meteorological Organization Publications, Aydın, Turkey.

[16]. Aksoy, E., Aydın, G., & Seferoğlu, S., (1998). The important characteristics and classification of soils of the land of Agricultural Faculty, Adnan Menderes University. In: First Agricultural Conference in Aegean Region, 7–11 September, Aydın, Turkey (in Turkish with English abstract).

[17]. Heerman, D.F. (1985). ET in irrigation management. In: Proceedings of the National Conference on Advances in Evapotranspiration. 16-17 December 1985, Transactions of the ASAE, 323-334.

[18]. Howell, T.A., Cuence, R.H., & Solomon, K.H. (1990). Crop yield response. In: Management of Farm Irrigation Systems. (G.J. Hoffman, et al), ASAE, St. Joseph, MI, 93-122.

[19]. Doorenbos, J., & Kassam, A.H., (1986). Yield response to water, Irrigation and Drainage, FAO, ROME, Paper: 33, pp. 257.

[20]. Açıkgöz, N., Aktas, M.E., Mokhaddam, A.F., & Özcan, K. (1994). Tarist an agrostatistical package programme for personel computer. Ege Üniv. Fac. of Agriculture, Field Crops Symposium, İzmir, Turkey (in Turkish with English abstract).

[21]. Sezgin, F., Yılmaz, E., Dağdelen, N., & Bas, S. (2001). Effect of different irrigation methods and water supply level application on water-yield relations in cotton growing. In: Proceedings of the Third National Hydrology Congress. 27-29 June 2001, 9 Eylül Univ., Izmir, Turkey (in Turkish with English abstract).

[22]. Ünlü, M., Kanber, R., Koç, D.L., Tekin, S., & Kapur, B. (2011). Effects of Deficit Irrigation on the Yield and Yield Components of Drip Irrigated Cotton in Mediterranean Environment. Agricultural Water Management, 98: 597-605.

[23]. Colaizzi, P.D., Evett, S.R., & Howell, T.A. (2005). Cotton production with SDI, LEPA and spray irrigation in a thermally limited climate. In: Proceedings of the Conference on Emerging Irrigation Technology. 6-8 November 2005, The Irrigation Association, Phoenix, Arizona, (CD ROM), 15-30.

[24]. Dağdelen, N., Yılmaz, E., Sezgin, F., Gürbüz, T., & Akçay, S. (2005). Effects of Different Trickle Irrigation Regimes on Cotton (Gossypium hirsutum L.) Yield in Western Turkey. Pakistan of Biological Sciences, 8(10): 1387–1391.

[25]. Dağdelen, N., Gürbüz, T., & Tunalı, S.P. (2019). Response of Different Cotton Cultivars to Water Stress on Water-Yield Relations Under Drip Irrigation Conditions in Aydın Plain. Derim, 36(1): 64-72 (in Turkish with English abstract).

[26]. Stewart, J.L., Danielson, R.E., Hanks, R.J., Jackson, E.B., Hagan, R.M., Pruitt, W.O., Franklin, W.T., & Riley, J.P. (1977). Optimizing crop production through control of water and salinity levels in the soil, Utah Water Lab, PRWG151-1, Logan, USA, p 191.

[27]. Akçay, S., & Dağdelen, N. (2017). Water productivity and fiber quality parameters of Deficit Irrigated Cotton in a Semi-Arid Environment. Fresenius Environmental Bulletin, 26(11): 6500-6507.