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Effects of Different Levels of Irrigation and Nitrogen on Yield and Water Productivity in Watermelon Irrigated by Drip Method[A]

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Abstract: Water and nitrogen (N) are the main determinants affecting watermelon plants' vegetative and generative growth. This study aimed to determine the yield response and water-yield relationships of watermelon plants grown in Bursa ecological conditions and clay soils under different irrigation and N levels. Four irrigation levels (IR-100, IR-75, IR-50, and IR-25) and five N ratios (kg ha^{-1}) (N0, N75, N150, N225 and N300) were considered as experimental treatments. In the study, a split-plot experimental design was used. While irrigation water was applied to thetreatments between 201 and 550 mm, actual crop evapotranspiration varied between 275 and 634 mm. Among the irrigation treatments, the IR-100 yielded the highest fruit yield. With the decrease in irrigation levels, the yield also decreased. Fruit yield, weight, and size increased to a N level of 225 kg ha^{-1} and decreased at higher levels. Irrigation and N interaction showed a statistically significant effect ($p<0.01$) on fruit yield and some yield components. While the highest yield and yield components were obtained at N225 and N150 N rates under IR-100 treatment, the second highest yield was obtained from the IR75×N225 interaction. Relatively higher water productivity was found at low irrigation levels (IR-25 and IR-50) and increasing N rates up to 225 kg ha^{-1}. Yield response factor varied between 0.67 and 1.08 for different N doses. As a result, to obtain high watermelon yield and increase water productivity, IR-75 irrigation treatment and a N rate of 225 kg ha^{-1}. As a result of these conditions, the amount of applied irrigation water, actual evapotranspiration, fruit yield, and water productivity values were determined as 434 mm, 537 mm, 100.23 t ha^{-1}, and 18.47 kg m^{-3}, respectively.

Keywords: Drip irrigation, irrigation programming, nitrogen, yield components.

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Damla Yöntemiyle Sulanan Karpuzda Farklı Sulama ve Azot Seviyelerinin Verim ve Su Verimliliği Üzerine Etkileri

Öz: Su ve azot (N), karpuz bitkisinin vejetatif ve generatif gelişimini etkileyen temel belirleyicilerdir. Bu çalışmada, farklı sulama ve azot seviyeleri altında Bursa ekolojik koşullarında ve kil bünyeli topraklarlarda yetiştirilen karpuz bitkisinin verim tepkisi ve su-verim ilişkilerinin belirlenmesi amaçlanmıştır. Dört sulama seviyesi (IR-100, IR-75, IR-50 ve IR-25) ve beş nitrogen oranı (N, kg ha^{-1}) (N0, N75, N150, N225 ve N300) deneme konusu olarak ele alınmıştır. Araştırmada, bölünmüş parseller deneme deseni kullanılmıştır. Deneme konularına 201 ile 550 mm arasında sulama suyu uygulanırken bitki su tüketimi 275 ile 634 mm arasında değişiklik göstermiştir. En yüksek meyve verimi, IR-100 konusundan elde edilmiştir. Sulama seviyelerindeki azalmayla birlikte verim de azalmıştır. Meyve verimi, tek meyve ağırlığı ve meyve büyüklüğü 225 kg ha^{-1} azot seviyesine kadar artış göstermiş daha yüksek seviyelerde azalmıştır. Meyve verimi ve verim bileşenleri, sulama ve azot interaksiyonundan önemli ($p<0.01$) düzeyde etkilenmiştir. En yüksek verim ve verim bileşenleri IR-100×N225 ve IR-100×N150 interaksiyonlarında, ikinci en yüksek verim IR75×N225 interaksiyonundan elde edilmiştir. Sulama suyu kısıdı yüksek olan konularda ve 225 kg ha^{-1}'a kadar artan azot oranlarında daha yüksek su üretkenliği saptanmıştır. Verim tepki etmeni, farklı azot dozları için 0.67 ile 1.08 arasında değişiklik göstermiştir. Sonuçta, makul seviyede yüksek karpuz verimi almak ve su verimliliğini iyileştirmek için IR-75 sulama konusu ve 225 kg ha^{-1} N oranı tavsiye edilebilir. Bu durumda, sulama miktarı, karpuz su tüketimi, birim alan başına verim ve su verimliliği sırasıyla 434 mm, 537 mm, 100.23 t ha^{-1} ve 18.47 kg m^{-3} olarak saptanmıştır.

Anahtar Kelimeler: Damla sulama, sulama programlama, azot, verim bileşenleri.

Introduction

Watermelon (*Citrullus lanatus*) is an important plant grown in every region of the world. Almost 20% of the world's agricultural land for vegetable farming is used for watermelon cultivation (Kuşçu et al., 2015). According to 2022-year statistics, the primary watermelon-growing countries are China, India, Russia, Senegal, Brazil, and Turkey. China has a share of 48% in terms of production area. On the other hand, Turkey ranks second in terms of watermelon production, with 3,394,783 tons. The average watermelon yield in Turkey is 49 t ha^{-1}, well above the world average (34 t ha^{-1}) (FAO, 2024). Bursa ranks fourth in production in our country, with 189,460 tons after Adana, Antalya, and Mersin (TUIK, 2024).

The yield and quality of watermelon plants are affected by many environmental factors, such as climate, soil, water, plant nutrients, and genetic factors. In watermelon cultivation, irrigation to the plant root zone is vital when rainfall is insufficientin summer. When watermelon cultivation occurs in Bursa province, rainfall decreases while temperatures increase, and irrigation becomes necessary. Moreover, rainfall in Bursa is expected to decrease in parallel with climate change (Yetik and Candoğan, 2024). On the other hand, Bursa is a city where the agricultural sector is high due to its suitable soil characteristics, and it is a city where the population growth rate is high due to the effect of the developed industrial sector. For this reason, there is competition between agriculture, industry, and domestic use sectors in terms of the demand for water throughout the province, which has limited water resources. Approximately 70% of freshwater resources are used for agricultural irrigation purposes. Therefore, it is inevitable to take precautions to confirm effective use of irrigation water. It is crucial to popularize the drip irrigation method, to make farmers adopt irrigation time planning techniques, and to irrigation at the right time, thus increasing water efficiency. Deficit irrigation is an important strategy to protect water resources and increase water efficiency (Sarwar and Perry, 2002; Lorite et al., 2007; Pereira et al., 2009; Mushtaq and Moghaddasi, 2011; Yang et al., 2018).

Watermelon is one of the most thoughtful horticulture crops to water stress due to its high water consumption. The response of watermelon plants to water stress may vary depending on the differences in application. Daşgan et al. (2021) determined that different varieties and irrigation levels may cause differences in physiological characteristics, yield components, and watermelon fruit yield. Grafted watermelon plants have a higher rooting capacity, so they tend to be more vigorous than non-grafted plants and have higher water productivity (Devi et al., 2020). Duraktekin et al. (2018) investigated the effects of different irrigation amounts on watermelon grown in Mersin conditions. They determined that the highest yield was obtained under full irrigation, the lowest yield was achieved under deficit irrigation with half-wetting, and water efficiency increased at the 25% deficit irrigation level. Researchers also found that irrigation interval significantly affects water productivity (Duraktekin et al., 2019). Çamoğlu et al. (2009) studied the effects of different irrigation levels on water productivity and yield components in watermelon. Researchers have stated that while the highest productivity was achieved under well irrigation settings, the productivity decreased with irrigation water deficit; in contrast, water efficiency improved with a 20% irrigation water deficit. Kuşçu et al. (2015) informed that water productivity was affected by different irrigation amounts in Bursa ecological conditions, and yield, ascorbic acid, total acidity, and total sugar contents differed according to the treatments. Erdem and Yüksel (2003) determined that flowering is the most sensitive period of watermelon to water stress. Pan evaporation and soil moisture content measurements or soil-water balance simulations are widely used in planning irrigation timing (Nuruddin et al., 2003). Many studies have been conducted on watermelon irrigation using these methods, and the highest yields from watermelon have generally been determined under adequate irrigation conditions (Orta et al., 2003; Wang et al., 2004; Erdem et al., 2005; Ghawi and Battikhi, 2008; Rouphael et al., 2008; Wang et al., 2022; Zokirov, 2023).

Nitrogen is one of the most crucial macronutrients affecting watermelon plants' vegetative and generative development. It must provide sufficient N levels to root of the plant to obtain economic yields. Numerous trainings have been conducted to determine the effects of N on the yield, yield components, and fruit quality characteristics of watermelon plants. Oktay and Doran (2005), increasing doses of ammonium nitrate (0, 75, 150, 225, and 300 kg ha^{-1}) in the form of ammonium nitrate in the tillering watermelon variety also increased yield, and the highest yield was obtained from 300 kg ha^{-1} N application. Goreta et al. (2005) investigated the effects of

115, 195, and 275 kg ha^{-1} N doses on the Crimson Sweet watermelon variety, and the yield did not increase at doses above 115 kg ha^{-1}. Pereira et al. (2019) investigated the effects of five irrigation depths and five N doses on watermelon development and the best development was obtained at 200 kg ha^{-1} N dose and 317.09 mm irrigation amount.

The effects of irrigation or N on yield and quality of watermelon have been commonly studied nationally and internationally. On the other hand, information on the effects of different levels of irrigation and N interactions on yield, yield components, and water productivity in drip-irrigated watermelon is limited. Therefore, the goals of this study were (1) to define the yield response of drip-irrigated watermelon to different irrigation amounts and N ratios in Bursa ecological conditions; (2) to determine evapotranspiration, water productivity, and water-yield relationships; and (3) to conclude optimum irrigation and N rates to increase water productivity.

Material and Method

Field experiments

Field experiments were conducted at the Faculty of Agriculture of Bursa Uludağ University (40º 13' N, 28º 51' E; 119 m a.s.l.) in 2022. In the Bursa city, the average annual temperature is 14.7 °C, relative humidity is 68%, and annual rainfall is around 700 mm. According to long-term average data, the total rainfall between May and August was 126.1 mm, when the experiment was conducted (2022), while the rainfall in the same period was 142.0 mm (Table 1). In the specified periods, the temperature averages in 2022 were higher than the long-term average temperatures, and the relative humidity values were also well above the long-term averages. Some soil properties of the experiment area were shown in Table 2. The chemical properties of the soil were determined according to the instructions given by Page et al. (1982). The structure of the soils in the 0-90 cm soil profile is clayey.

Table 1. Climatic properties for long years (LY, 1928-2022) and 2022 year for Bursa province

Months	Rainfall (mm)		Temperature (°C)		Relative humidity (%)	
	LY	2022	LY	2022	LY	2022
May	50.5	26.4	17.7	18.7	68.5	61.2
June	35.5	90.8	22.0	23.3	62.4	67.5
July	21.9	1.2	24.5	24.8	58.8	56.0
August	18.2	23.6	24.4	26.2	60.4	65.7
Sum./Avr.	126.1	142.0	22.1	23.3	62.5	62.6

Table 2. Soil characteristics of the experimental area

0-30 cm						
Total N (%)	Available P (P_2O_5 kg ha^{-1})	Exchangeable K (K_2O kg ha^{-1})	Organic matter (%)	pH (saturation)	EC (1:2.5 dS m^{-1})	Infiltration rate (mm h^{-1})
0.18	89	460	0.72	6.1	0.45	4.2
0-90 cm						
Bulk density (g cm^{-3})		Field capacity (%)		Permanent wilting point (%)		
1.35		40.4		27.0		

Agricultural applications and experimental treatments

The experiments were arranged in the field using a split-plot design with irrigation applications as main plot, and N levels as subplots. The experimental treatments consisted of four irrigation levels [1.00 × Epan (IR-100), 0.75 × Epan (IR-75), 0.50 × Epan (IR-50), and 0.25 × Epan (IR-25] and five N application levels [0 (N0), 75 (N75), 150 (N150), 225 (N225), and 300 (N300) kg ha^{-1}]. The amount of irrigation water applied was determined using a class A pan. The following equation determined the amount of applied irrigation water (Çetin et al., 2002).

$$IR = A \, . \, Epan \, . \, Kpc \, . \, P \tag{1}$$

In the equation, *IR*: irrigation water applied to the experimental plot (L), *A*: Plot area (m^2), *Ep*: Cumulative pan evaporation amount in the irrigation interval (mm), *Kpc*: Pan-crop coefficient, *P*: Wetting area percentage (%) were taken into account. Irrigation applications were made at 3-4 day intervals. Irrigation intervals increased in rainy weather.

The research used Bonus F1 watermelon variety grafted onto Patron pumpkin variety rootstock. Bonus watermelon fruits have shiny and tawny. The flesh is dark red, fiberless, sweet and crunchy. It is resistant to transportation. It is resistant to Fusarium races 0 and 1 and tolerant to Anthracnose (Anonymous, 2023). Watermelon seedlings (Nev Seed Compamy, Inc.Bursa, Turkey) with 3-4 leaves were planted in the experimental plots in the second week of May. The subplot area was 6 × 10 m (60 m^2), with five rows. 2 m space was left between subplots. The distance between two plant rows is 2 m and the distance between two plants on the row is 1.5 m. Seedlings were planted at a density of 3333 plants/ha. Subplots were fertilized with triple super phosphate (43-44% P_2O_5) fertilizer at 100 kg ha^{-1} P_2O_5 level during the soil preparation phase before planting. According to the soil test results, no additional K fertilizer was applied to the plots since it indicated a sufficient potassium level in the soil. Urea (46% N) fertilizer was used in N applications. 1/3 of the N dose calculated according to the treatments was applied directly to the plant root zone during the planting period and 2/3 in the first week of June. One lateral was installed in each plant row. The discharge rate of the pressure-regulated drippers inserted into the thick-walled laterals was 3.0 L h^{-1} at 100 kPa with 0.30 m dripper spacing. The first irrigation was done at an amount that brought the soil moisture of all plots to field capacity for a 90 cm soil profile. Hoeing was done twice to control weeds. No pesticides were used since no diseases or pests were observed.

Measurements

The following equation calculates seasonal watermelon evapotranspiration for the treatments (James, 1988; Kuscu et al., 2014).

$$ETa = IR + P \pm \Delta S - D, \quad (2)$$

Where, *IR* is the seasonal irrigation amount (mm), *P* is the effective rainfall amount during the growing season (mm), Δ*S* is the change in soil water content at the beginning and end of the experiment (mm), and *D* is the drainage (mm). *IR* was measured using a water-meter. *P* was obtained from the data measured at the Bursa-Nilüfer Meteorological Station of the General Directorate of State Meteorology, located 500 m from the experimental area. Δ*S* was determined by gravimetric method. The gravimetric method determined soil moisture changes below 90 cm, and drainage status was checked. In this study, drainage was not observed since irrigation was controlled by the drip method.

All fruits that reached harvest maturity were harvested on August 4, 2022, weighed with a precision scale, and recorded, and the yields per unit area (kg ha^{-1}) of each experimental plot were calculated. For each experimental plot, single fruit weight, length, and diameter measurements were made of 5 random watermelon plants.

Water-yield relationships

Irrigation water productivity (IWP) and water productivity (WP) values were calculated by dividing the yield by the amount of irrigation water applied and the actual evapotranspiration, respectively.

The relationship between the irrigation amount and watermelon yield was determined using Microsoft Excel spreadsheets and graphical charting features.

The yield response factor was calculated using Stewart model (Doorenbos and Kassam, 1979).

Statistical analysis

Data were analysed following variance analysis (ANOVA) technique with computer package SPSS-23. In case of significant differences among the experimental treatments, mean comparisions were performed using Duncan's Multiple Range Test at a 0.05 significance level.

Results and Discussion

Irrigation amount and watermelon evapotranspiration

The total irrigation amount for each experimental treatment is shown in Figure 1. During the growing season, 201 mm, 317 mm, 434 mm, and 550 mm of total irrigation water was applied to the plant root zone for the IR-25, IR-50, IR-75, and IR-100 experimental tratments, respectively. Rainfall during the growing season was 104 mm. 60 mm of this rainfall occurred between 8 and 17 June. Therefore, no irrigation was applied during these dates. On the first day of transplanting, 37 mm of life water was applied to the experimental area of watermelon seedlings. On the second day, 46 mm of irrigation water was applied to bring the soil moisture at the effective root depth to the field capacity. Irrigation applications consistent with the experimental treatments, started on 26.05.2022 and were done at 3-5 day intervals. Irrigation was suspended on rainy days. A total of 550 mm of irrigation water was applied to the watermelon plants under the IR-100 treatment from seedling planting to harvest. In contrast, 434, 317, and 201 mm of irrigation water were applied to the IR-75, IR-50, and IR-25 irrigation treatments, respectively. Leskovar et al. (2002) applied 395, 298, and 173 mm of irrigation water to 1.0×ET, 0.75×ET, and 0.50×ET irrigation treatments in the experiment conducted in Texas, respectively. Özmen et al. (2014) applied 136-414 mm of irrigation water in Düzce province, and Kuşçu et al. (2015) applied 106-467 mm of irrigation water in Bursa. The irrigation amount may vary depending on the climatic characteristics, especially the rainfall of the cultivation region.

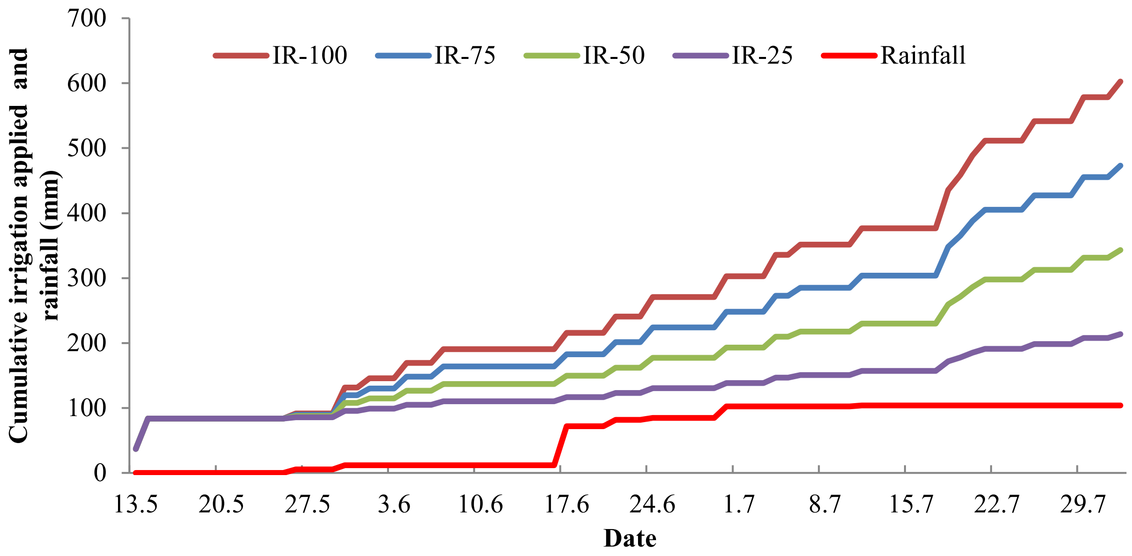

Figure 1. *Irrigation water applied and rainfall*

Seasonal actual evapotranspiration (ETa) values are given in Table 3. Seasonal average ETa values varied between 275 and 634 mm. The highest ETa was obtained under IR-100 irrigation and N-150 N level, while the lowest was determined in the IR-25×N0. Çamoğlu et al. (2010) reported that daily evapotranspiration in watermelon plants was higher in flowering and fruit formation periods compared to vegetative, ripening, and harvest periods, and seasonal evapotranspiration varied between 130 and 516 mm. Seasonal watermelon evapotranspiration was reported as 343.3-504.6 mm by Sezgin et al. (2000), 417-677 mm by Şimşek et al. (2004), and 70-677 mm by Kırnak and Doğan (2009). It is thought that this difference between irrigation water and ET values obtained in this study and other studies is due to different levels of N applications as well as climatic conditions.

Table 3. Seasonal crop evapotranspiration (mm) under different irrigation and nitrogen levels

Treatments	N0	N75	N150	N225	N300	Average
IR-25	275	297	303	297	284	291
IR-50	401	409	419	414	407	410
IR-75	516	540	546	543	541	537
IR-100	614	632	634	624	626	626

Fruit yield and yield components

Watermelon fruit yield values are shown in Table 4. The yield was significantly affected due to different irrigation levels ($p < 0.01$). In general, yield increased with increasing irrigation levels. The highest yield was obtained from the IR-100 treatment, which received 100% ETc irrigation water, followed by the IR-75, and the lowest fruit yield was obtained from the IR-25, which received minor irrigation water. Different N levels significantly affected watermelon yield ($P < 0.01$). According to the evaluation made in terms of N ratios, the N225 yielded the highest fruit yield. Yield increased with the increase in N rates at different levels up to the N225 level, but there was a decrease in yield at the N300 level compared to the N225 treatment. As expected, the lowest yield was measured at N0 where no N was applied. The relationship between fruit yield and N rates is given in Figure 2.

Table 4. Yield, weight, height, and diameter of fruit in watermelon about irrigation and nitrogen levels.

Treatment	Yield (t ha^{-1})	Fruit weight (kg)	Fruit height (cm)	Fruit diameter (cm)
Irrigation level (IR)				
IR-100	82.01 a	8.04 a	29.96 a	22.54 a
IR-75	76.00 b	7.03 b	27.55 b	20.51 b
IR-50	59.18 c	6.18 c	27.30 b	20.51 b
IR-25	43.03 d	5.68 c	24.98 c	18.91 c
Nitrogen ratio (N)				
N300	78.07 b	8.16 b	28.66 b	21.08 b
N225	87.16 a	8.96 a	33.77 a	22.72 a
N150	75.40 c	7.18 c	27.52 c	20.66 b
N75	61.95 d	6.14 d	26.79 c	20.62 b
N0	22.68 e	4.00 e	23.50 d	18.29 c
Interactions				
IR-100×N300	97.80 b	8.50 bc	31.09 ab	23.21 a
IR-100×N225	103.56 a	9.57 a	32.53 a	23.37 a
IR-100×N150	104.10 a	9.60 a	31.32 ab	23.48 a
IR-100×N75	76.40 e	8.39 bc	29.67 bcd	23.21 a
IR-100×N0	27.66 k	4.15 gh	25.22 fg	19.45 def
IR-75×N300	94.50 c	8.25 bc	27.80 de	19.84 cde
IR-75×N225	100.23 b	9.45 a	31.80 ab	23.63 a
IR-75×N150	91.53 d	7.15 de	27.20 ef	20.20 cde
IR-75×N75	65.53 gh	6.10 f	27.10 ef	20.87 cd
IR-75×N0	28.20 k	4.23 gh	23.58 gh	19.20 efg
IR-50×N300	69.86 f	8.39 bc	28.63 cde	21.16 bc
IR-50×N225	77.40 e	8.41 bc	30.58 abc	22.66 ab
IR-50×N150	63.30 h	6.98 de	27.98 de	20.92 cd
IR-50×N75	63.10 h	6.50 ef	26.93 ef	20.56 cde
IR-50×N0	22.23 l	3.79 h	22.42 h	17.25 h
IR-25×N300	50.13 i	7.51 cd	27.15 ef	20.12 cde
IR-25×N225	65.53 fg	8.44 bc	28.19 de	21.23 bc
IR-25×N150	42.70 j	4.99 g	23.58 gh	18.07 fgh
IR-25×N75	42.23 j	3.60 h	23.48 gh	17.87 gh
IR-25×N0	12.63 m	3.85 h	22.50 h	17.27 h
Significance				
IR	**	**	**	**
N	**	**	**	**
IR×N	**	*	**	**

Not: Small letters indicate statistically significant differences among experimental treatments. **, * Significant at the 1% and 5% level, respectively.

Irrigation and N interaction had a significant ($p<0.01$) effect on fruit yield. The highest fruit yield was measured from IR-100×N225 and IR-100×N150 interactions, while the second highest yield was measured from IR-100×N300 and IR-75×N225 combinations. According to these results, a farmer can obtain maximum yield by applying 100% ETc irrigation level and 150 to 225 kg ha^{-1} N in areas without water deficit. On the other hand, in conditions of irrigation water deficit, a farmer can obtain a reasonably high yield by saving 25% irrigation water by applying 75% ETc level and 225 kg ha^{-1} N. Depending on the amount of irrigation water, the lowest and highest watermelon yield were obtained from Sezgin et al. (2000) as 18.08-54.87 t ha^{-1}, Orta et al. (2003) as 42-

90 t ha^{-1} in the first year and 43-75 t ha^{-1} in the second year, Erdem and Yüksel (2003) as 46.8-103.7 in the first year and 41.6-89.8 t ha^{-1} in the second year, McCann et al. (2007) as 55-95 t ha^{-1}, Kırnak and Doğan (2009) as 6.9-34.5 t ha^{-1} in the first year and 7.3-38.2 t ha^{-1} in the second year, Çamoğlu et al. (2010) obtained 7.04-64.82 t ha^{-1}, 37.2-80.3 82 t ha^{-1}. Oktay and Duran (2005) reported that the highest yield was obtained at 225 kg N ha^{-1} in their studies, in which they obtained yields between 30.5 and 93.25 t ha^{-1} under different N levels. These differences between the studies are due to plant variety, agricultural practices, climate, and soil factors.

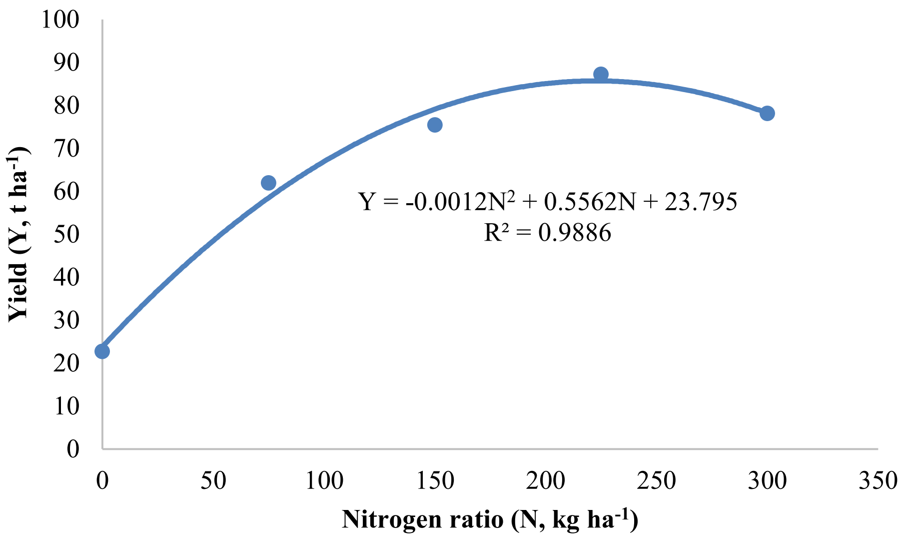

Figure 2. *Yield response to N ratio under four irrigation levels*

The effects of irrigation and N levels on fruit weight, fruit height, and fruit diameter were statistically significant ($p<0.01$) (Table 4). The weight, height, and diameter of watermelon fruits were highest in the IR-100 treatment. In general, there was a decrease in the yield components with a decrease in irrigation levels. At the same time, no statistically significant difference was measured between IR-75 and IR-50 treatments, and the lowest values were detected in the IR-25 treatment. The effect of N rates on the measured watermelon fruit yield components was significant ($p<0.01$). The highest yield components were obtained from the N225 treatment, while the lowest values were measured from the N0. There was a decrease in all measured yield components in the N300 compared to the N225. This result showed that the watermelon plant was sensitive to N fertilization, and the optimum level was around 225 kg ha^{-1}. However, the research results showed that different N applications under different irrigation levels significantly affected all measured yield components because irrigation × nitrogen interactions were statistically significant. The highest fruit weight values were obtained from IR-100×N225, IR-100×N150, and IR-75×N225 interactions. Similarly, the highest fruit height values were obtained from IR-100 irrigation treatment with N150, N225, and N300 N rates and IR75×N225 interactions. The highest fruit diameter values were measured from IR-100 irrigation treatment with 75-300 kg N ha^{-1} treatments and IR-75×N225 interactions.

Water productivity

IWP, which is an indicator of the yield obtained in response to the amount of irrigation water applied, and WP, which is an indicator of the yield obtained in response to evapotranspiration considering the rainfall together with the applied irrigation water, are shown in Figure 3 for different irrigation and N level treatments.IWP and WP values were generally calculated higher at low irrigation levels. However, since satisfactory yields per unit area cannot be obtained economically at low irrigation levels, focusing on IR75 and IR100 irrigation treatments is beneficial. IWP and WP values obtained from the IR-75 irrigation treatment were higher than the IR-100. Under the IR-75 irrigation, the IWP value is 23.12 kg m^{-3}, and the WP value is 18.47 kg m^{-3} in the N225 N ratio. The N225 N ratio has the highest value in all irrigation treatments. In similar studies on the water productivity of watermelon, Sezgin et al. (2000) reported that WP values were 5.27-10.87 kg m^{-3}. Şimşek et al. (2004) found WP values as 9.6-11.7 kg m^{-3} in the first year and 10.8-13.1 kg m^{-3} in the second year of their experiments, IWP was 9.6-11.7 kg m^{-3} in the first year and 10.8-13.1 kg m^{-3} in the second year. Kırnak and Doğan (2009) found WP values as 5.23-9.85 kg m^{-3}, IWP values as 5.43-13.53 kg m^{-3}. Çamoğlu et al. (2010) reported WP values as 6.58 to 12.94 kg m^{-3} and IWP values as 7.92 to 12.51 kg m^{-3} based on two-year average results.

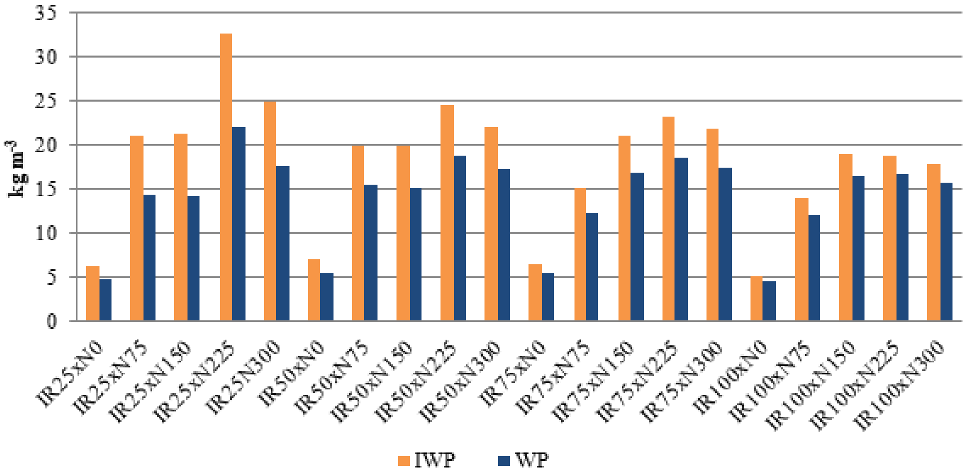

Figure 3. *Irrigation water productivity and water productivity values*

Irrigation water-yield relationship

The relationship between the irrigation and the yield in watermelon plants is shown in Figure 4. A second-degree polynomial equation was obtained between the irrigation amount and yield as $Y = -0.0002(IWA)^2 + 0.2258(IWA) -1.3215$ (Figure 4). The coefficient of determination was 0.99. The high coefficient shows that the obtained equation has a high degree of accuracy in estimating yield for different irrigation levels.

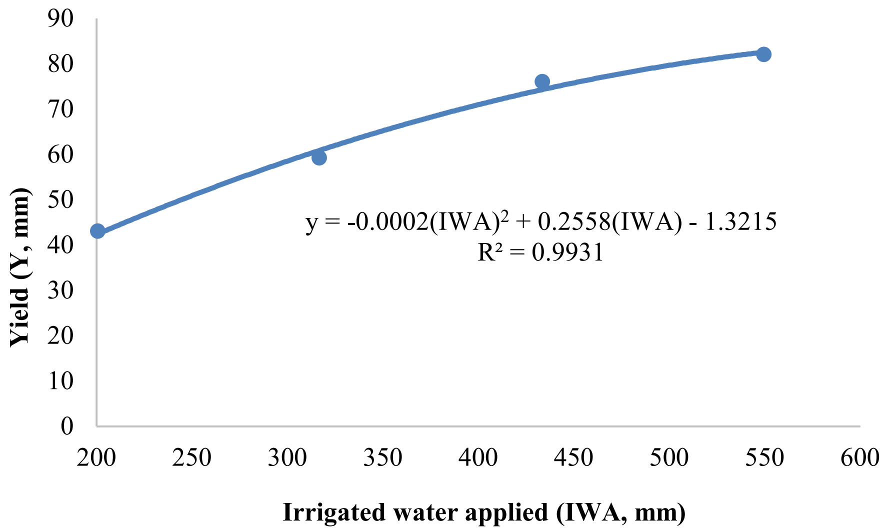

Figure 4. *Relationship between amount of irrigation amount and fruit yield*

Yield response factor

Seasonal yield response factor (ky) values, which show the relationship between the rate of decrease in yield and the decrease in the evapotranspiration, were determined for each N level (Figure 5). While the ky values were determined as 1.08 for N150, they varied between 0.67 and 0.82 below 1 for other N rates. It is thought that the reason why it is higher in N150 nitrogen application compared to other nitrogen treatments is due to the lower rate of decrease in yield. This results also show that different cultural practices other than irrigation cause differences in the ky value. Erdem and Yüksel (2003) determined the ky value as 1.27, Şimşek et al. (2004) as 1.15, Kırnak and Doğan (2009) as 1.13-1.16.

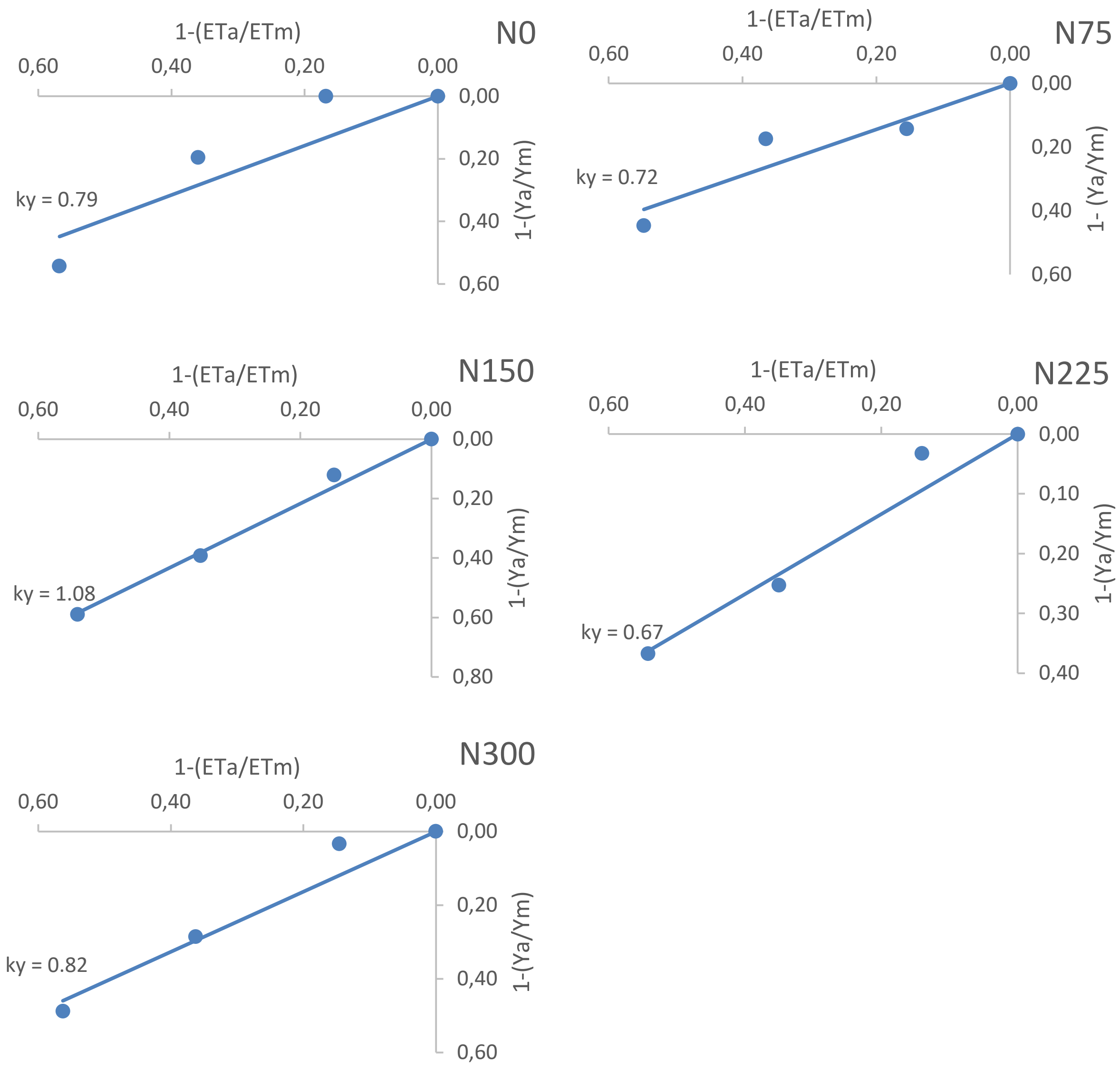

Figure 5. *Yield response factor (ky) for the five N ratios*

Conclusion

In Bursa, where rainfall values are low and temperatures are high in the summer months, a field experiment was conducted in which different irrigation and N levels were considered to plan the irrigation time and determine the optimum N level in watermelon (Bonus F1 variety) irrigated using drip irrigation method. According to the study results, to obtain maximum efficiency from the unit amount of applied irrigation water and to protect water resources and considering water productivity values, it can be recommended to prepare an irrigation program by applying kpc=0.75 coefficient to the water evaporated from Class A pan in watermelon cultivation in subhumid conditions. Under this condition, 25% water saving can be achieved, and relatively higher water productivity can be achieved compared to irrigation, where the kpc=1.00 coefficient is applied. In addition, 225 kg ha^{-1} N application is recommended to obtain higher yield and yield components.

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