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Irrigation Frequencies and Corn (*Zea mays* L.) Yield Relation in Northern Turkey

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Abstract: A field experiment was conducted during summer season of 2005 at the Research Station (altitude 180 m above sea level, 41°21' N and 36°15'E) Faculty of Agriculture, Ondokuz Mayis University, Samsun, Turkey. Experiment consisted of three irrigation levels and a non-irrigation level. Drip irrigation treatments consisted of three soil water deficits in the 90 cm soil profile depth was replenished to field capacity. Irrigation treatments were A: no irrigation, B: irrigation at 50% of available soil water capacity, C: irrigation at 30% of available soil water capacity, D: irrigation at 15% of available soil water capacity. The average seasonal water use values ranged from 257.14 to 285.71 mm in corn treatments. Irrigation frequencies (intervals) significantly affected corn crop yields. The average corn grain yields varied from 7.98 to 29.16 t ha^{-1}. The treatment D was recorded significantly higher corn grain yield 29.16 t ha^{-1} compared to B (21.59 t ha^{-1}); C (19.15 t ha^{-1}) and A (7.98 t ha^{-1}), respectively. According to research results, the maximum corn grain yield was obtained when the corn plants were irrigated at 15% of available soil water capacity to field capacity.

Key words: Corn, drip irrigation, irrigation frequencies

INTRODUCTION

Corn is one of the cultivated grain-cum-fodder crop with tremendous yield potential grown round the year under irrigated conditions. In many parts of the world, maize is the most important food stuff and particular, provides the daily bread for the indigenous population of rural areas. Maize is one of the most efficient field crop in producing higher dry matter per unit quantity of water (Viswanatha *et al*., 2002). During recent years, irrigated corn production has expanded rapidly in Turkey. Corn has become a widely grown feed grown particularly as a second crop after wheat or barley. The corn production in Turkey is about 2,200,000 tons of grain corn from 575,000 ha (NIS, 2004).

Irrigation water is the most important limiting factor for agriculture during the hot and dry summer period. Limited availability of irrigation water requires fundamental changes in irrigation management or urges the application of water saving methods. A generally applicable procedure is to asses the benefits of changing irrigation water management based on deficit irrigation, which is the practice deliberately under-irrigation field crops. Under these conditions, there is one way for farmers to maximize their profit from corn production. The way is to determine the water-yield relationships of corn crops and to choose the most appropriate irrigation scheduling for saving irrigation water and timing (Pandey *et al*., 2000; Dagdelen *et al*., 2006; Doorenbos and Kassam, 1979; Howell *et al*., 1997).

Water is the prime natural resource which very often becomes costly and limiting input particular in semi-arid tropics and needs to be judiciously used to reap the maximum benefit of the other inputs. Drip irrigation provides the efficient use of limited water with increased water use efficiency (Viswanatha *et al*., 2002). The higher green cob yield with increased moisture level was reported by Braunworth and Mack (1989).

Common irrigation methods used for corn production in the region are wild flooding, furrow and sprinkler irrigation. In general, the farmers over irrigate, resulting in high water losses and low irrigation efficient, thus creating drainage and salinity problems (Yazar *et al*., 2002).

The amount and timing of irrigation are important for efficient use of applied water and for maximizing crop yields. Predicting yield response to water use corn is important in developing strategies and decision-making for use of by farmers and their advisors and the researchers for irrigation management under limited water conditions (Dagdelen *et al*., 2006).

Doorenbos and Kassam (1979) indicated that the maximum corn yield was usually obtained when the corn plants were irrigated 50% of available water capacity.

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The objectives of this study were to determine effects of different irrigation frequencies and intervals on yield and yield components of corn under the Middle Black Sea climatic conditions of Turkey.

MATERIALS AND METHODS

The experiment was conducted at the Agricultural Faculty Research Station of Ondokuz Mayis University, Samsun, Turkey during 2005 corn growing season. The station has the latitude of 41°21' N, the longitude 36°15'E and altitude 180 m above sea level. The soil of the experimental site is clay-loam textured throughout the profile. The water holding capacity of the soil is 182 mm in the 90 cm profile. Some physical properties are shown in Table 1.

The Electrical Conductivity (EC) of irrigation water was 0.41 dS m^{-1} and the sodium adsorption rate was 0.42 which are not risk for growing corn plants (Ayers and Westcot, 1985).

Long-term annual precipitation in the region is about 683.2 mm, with more than 80% of it falling from October to April. Water loss by evapotranspiration is very high during the growing season. Therefore, irrigation is needed in during the growing season to maintain and enchance crop growth and yield.

Based on the daily evaporation from a standard class A pan evaporimeter which installed at the field. The meteorological sub-station located at about 300 m from the site of experimentation, the calculated quantity of water was given under drip irrigation levels.

In this study, RX-788 hybrid sweet corn (*Zea mays* saccharata) variety was used as the crop material. Fertilizer applications were based on soil analysis results and all the plots received the same amount of total fertilizer. The recommended dose of 75 kg ha^{-1} pure N, P and K (15, 15, 15 composite) before sowing and additional nitrogen dose of 115 kg ha^{-1} was applied as Ammonium nitrate 50% when the plant reach to 0.4-0.5 m in height.

The experiment was laid out in randomized block with three replications. Each plot consisted of five rows of 5 m in length. The plants were grown 0.7 m apart between the rows with 0.25 m spacing each row. The crop was sown on June 3, 2005 according to spacing mentioned. There was a 2.0 m space between each plot. For three treatments, irrigation was applied when approximately 50% of the available soil water was consumed in the root zone (B), irrigation was applied when approximately 30% of the available soil water was consumed in the root zone (C), irrigation was applied when approximately 15% of the available soil water was consumed in the root zone (D) and for one treatments was non-irrigated.

The drip irrigation system consisted of four manifolds and distribution lines. Drip laterals of 16 mm in diameter had in-line emitters spaced 25 cm apart, each delivering 41 h^{-1} at the pressure 100 kPa.

First irrigation water was applied to all treatments, during the experiments in 2005 to bring water content in 0-90 cm soil depth up to level of field capacity. Irrigation treatments were started using drip irrigation system when the water content of the soil decreased to treatment level of available soil water.

Crop water consumption in the treatments was calculated using Eq. 1 (Heerman, 1985).

$$ET = R + 1 - D \pm \Delta W \tag{1}$$

Where:

ET = The evapotranspirations (mm).
R = The rainfall (mm).
I = The depth of irrigation (mm).
D = The depth of drainage (mm).
ΔW = The change of the soil water storage in the measured soil depth.

Since the amount of irrigation water was only sufficient to bring the water deficit to the field capacity, drainage was neglected.

The water use-yield relationship was determined using the Stewart's model (Stewart *et al*., 1977) as follows:

$$\left(1-\frac{Y_a}{Y_m}\right) = k_y\left(1-\frac{ET_a}{ET_m}\right) \tag{2}$$

Where:

Y_a = Actual yield (t ha^{-1}).
Y_m = The maximum harvested yield (t ha^{-1}).
k_y = The yield response factor.
ET_a = The actual evapotranspiration (mm).
ET_m = The maximum evapotranspiration (mm). Corresponding to Y_m, $1-(Y_a/Y_m)$ is the relative yield decrease.

Table 1: Some physical properties of soil layers of the experimental field

Soil depth (cm)	Particle size distribution (%) Clay	Silt	Sand	Texture class	Field capacity (%)	Permanent wilting point (%)	Bulk density (g cm^{-3})
0-30	37.44	24.86	37.70	CL	45.00	29.97	1.25
30-60	40.58	28.87	30.54	CL	48.65	33.00	1.25
60-90	29.53	28.97	41.50	CL	48.65	30.68	1.25

$1 - (Et_a/ET_m)$ = The relative evapotranspiration deficit.

Doorenbos and Kassam (1979), stated that, when $K_y<1$, yield loss is less important than evapotranspiration deficit; when $K_y>1$, yield loss is more important than evapotranspiration deficit and when $K_y=1$, yield is equal to evapotranspiration deficit.

The crop was harvested on September 11, 2005 and the plant status, available soil moisture (%) water requirement, water use efficiency were recorded and subjected to statistical analysis.

RESULTS AND DISCUSSION

There is no irrigation applied to treatment A; four irrigations applied to treatment B; six irrigations applied to treatment C and thirteen irrigations applied to treatment D for corn during the growing season. The amount of irrigation water applied varied from 285.71 to 257.14 mm in irrigated treatments. As expected, the highest grain corn yield occurred in the short irrigation interval. Treatment D occurred with highest grain corn yield because of corn did not take any stress with more often irrigation (Table 2).

Data obtained from the study showed that the corn grain yield was significantly ($p<0.01$) affected by irrigation treatments. Decreasing irrigation intervals resulted in relatively higher yield. The maximum yield was obtained at treatment D (29.16 t ha^{-1}; B (21.59 t ha^{-1}); C (19.15 t ha^{-1}) and A (7.98 t ha^{-1}), respectively (Table 2).

At the no irrigation, 4, 6 and 13 day irrigation frequencies, the rates of relative yield were 27.4, 74.0, 65.7 and 100%, respectively. The lowest grain yield was observed in the non irrigation treatment since low humidity and high air temperatures cause plant stomas to close, resulting in less assimilation due to a decreased CO_2 uptake for photosynthesis (Oktem *et al*., 2003).

Since water stress cause a decrease in leaf area (Jamiesson *et al*., 1995; Stone *et al*., 2001), a reduction in yield is observed because of low photosynthesis. Pandey *et al*. (2000) reported that the highest leaf area index for corn was obtained in well irrigated conditions.

The relationships between seasonal irrigation frequencies and corn grain yield have been evaluated for experimental year (Fig. 1).

The relationships between seasonal irrigation frequencies and corn grain yield was linear ($p<0.01$). The linear relation Y = 1.4933(I) + 10.884 (R^2 = 0.86) were found of corn grain yield. The linear relation of corn grain yield to water use is in agreement with other studies for corn (Howell *et al*., 1995; Dagdelen *et al*., 2006).

Table 2: Total No. of irrigation, amount of irrigation applied and yield of corn for the experiment period in 2005

Treatments	No. of irrigation	Irrigation water applied (mm)	Grain corn yield (t ha^{-1})	Relative yield (%)
A	-	-	7.98b	27.4
B	4	285.71	21.59ab	74.0
C	6	257.14	19.15ab	65.7
D	13	276.30	29.16a	100.0

There are no statistical differences among same letter(s) at 0.01 level according LDS test

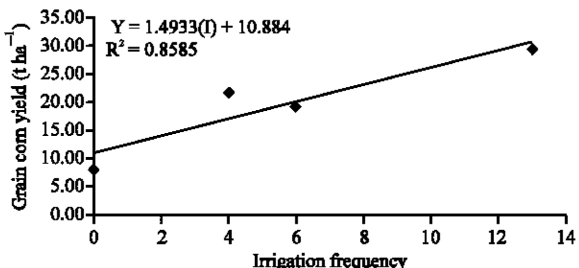

Fig. 1: The relationship between corn grain yield and seasonal irrigation frequencies and irrigation intervals

CONCLUSION

In this study, the highest corn grain yield was obtained from the treatment D. maximum grain corn yield was found that 29.16 t ha^{-1} with 13 irrigation application with 214 mm ha^{-1} water amount for each irrigation. Grain corn yield was reduced as the irrigation application decreased. The reductions in relative yield were 74.0% (B), 65.7% (C) and 27.4% (A). The results of the research indicate that 13 irrigation applications in corn growing season by a drip system would be optimal for corn grown in semi-arid regions similar to the area in where this study was conducted.

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