Water Use Efficiency of Silage Maize Under Deficit Irrigation and Nitrogen Fertigation

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Introduction

• In order to increase water use efficiency (WUE) and crop production, efficient irrigation management in conjunction with an improved fertigation practice is required.

• In many areas of Iran and regions with similar climatic conditions, scarcity of water is a limiting factor for crop growth. It is, therefore, necessary to improve the water use efficiency, particularly in the semi-arid regions.

• The objective of this study was to determine the effects of various levels of irrigation and nitrogen fertilizer applied via sprinkler irrigation on water use efficiency and yield of maize grown for silage.

Materials & Methods

• The study was conducted in 2003 and 2004 at Varamin, located in the central region of Iran (Lat: 35°20' N, Long: 51°38' E and 973 m above the sea level).

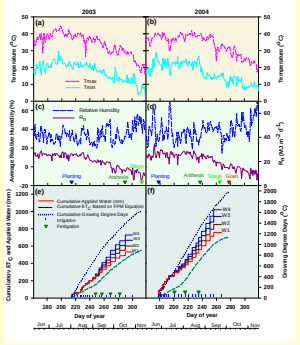
• Time and amount of irrigation were determined based on soil moisture deficit (SMD) with management allowed depletion (MAD) equal to 50% (Cuenca, 1989) for the full irrigation treatments (W3).

• The experimental layout was a strip-plot design, with randomized complete blocks.

• Hybrid single-cross 704 with a population density of 66666 Plant ha^{-1} in 2003, and 88888 Plant ha^{-1} in 2004.

• Nitrogen levels: No nitrogen (N0)
150 kg N ha^{-1} (N150)
200 kg N ha^{-1} (N200)

Fig. 1. Climatic parameters, plant development information, and irrigation and fertigation schedule for 2003 and 2004



• Irrigation levels:
0.70 SMD (W1)
0.85 SMD (W2)
1.00 SMD (W3)
1.13 SMD (W4)

Measurement Indexes

$$WUE = \frac{Y}{ET_a} \qquad IWUE = \frac{Y}{I_g} \qquad (1 - \frac{Y_a}{Y_m}) = ky \times (1 - \frac{ET_a}{ET_m})$$

Where WUE is the water use efficiency (kg m^{-3}), Y is the total crop biomass at silage stage (kg ha^{-1}), ET_a is the actual evapotranspiration that measured by soil water balance method (mm-ha), IWUE is the irrigation water use efficiency (kg m^{-3}), I_g is the gross water depth (irrigation plus rain) during the growing season (mm-ha), Y_a is the actual harvested yield (kg ha^{-1}), Y_m is the maximum harvested yield (kg ha^{-1}), ky is the yield response factor, and ET_m is the maximum evapotranspiration.

Results

Soil Moisture Profile

• Deep percolation did not occur from a soil depth of 60 cm for the deficit irrigation levels (W1 and W2) and full irrigation level (W3).

• The change in soil moisture indicated that maize extracted most of the water from a depth of 0 to 60 cm.

• Dividing the root zone into four layers, the smallest amount of soil moisture was extracted from the fourth layer of the root zone and the highest amount of soil moisture was extracted from the second layer of the root zone.

Fig. 2. Soil moisture profile during the growing season for all irrigation levels, (DAI: Day after irrigation)

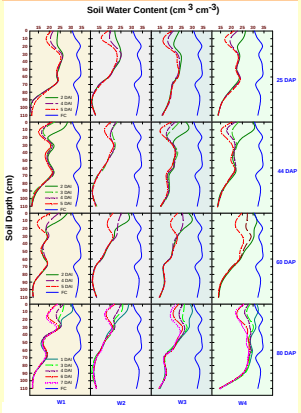
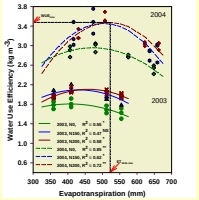


Fig. 3. Water use efficiency for different levels of N fertilizer in 2003 and 2004



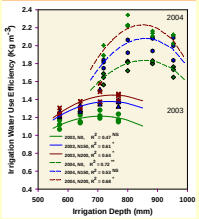
Water Use Efficiency

• Analysis of variance showed that WUE was effected by irrigation and nitrogen fertilizer in 2003 and 2004. However, interaction of water and nitrogen on WUE was not significant in both years.

• Deficit irrigation increased WUE for all N fertilizer treatments and the maximum WUE occurred for the deficit irrigation levels (Fig. 3).

• The maximum of the WUE (WUE-max) and $ET_{WUE\text{-}max}$ for the N0 level was lower as compared to the N150 and N200 levels in 2003 and 2004.

Fig. 4. IWUE for different levels of N fertilizer in 2003 and 2004



Irrigation Water Use Efficiency

• IWUE was effected by irrigation and nitrogen fertilizer in 2003 and 2004. However, interaction of water and nitrogen on IWUE was not significant in both years.

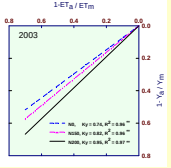
• The maximum IWUE occurred for the full irrigation level (W3) for all three N fertilizer levels in 2003 and for the N0 level in 2004 (Fig. 4).

• The IWEU-max decreased by 12.3% in 2003 and by 11.5% in 2004 at the N0 level as compared to the N150 level. The IWEU-max decreased by 5% in 2003 and by 7% in 2004 at the N150 level as compared to the N200 level.

Yield Response Factor

• The minimum Ky was obtained for the N0 level and the maximum Ky was obtained for the N200 level in 2003 and 2004. This indicates that the sensitivity of silage maize yield to water stress increased with an increase in N fertilizer application (Fig. 5).

Fig. 5. Yield response factor for N0, N150, and N200 in 2003



Conclusion

• The average WUE over two years indicated that the highest WUE was obtained for the second deficit irrigation level (0.85ET) for all N levels.

• IWUE increased as the amount of nitrogen fertilizer increased and the highest of IWUE was obtained for the full irrigation level.

• N fertilizer application has an effect on the sensitivity of silage maize growth to water stress.

Reference: Cuenca, R.H. 1989. Irrigation system design: An engineering approach. Prentice-Hall, NJ.