Grain Yield in Corn Hybrids Exposed to Water Stress at Different Growth Stages and the Use of Thermal Imaging

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INTRODUCTION

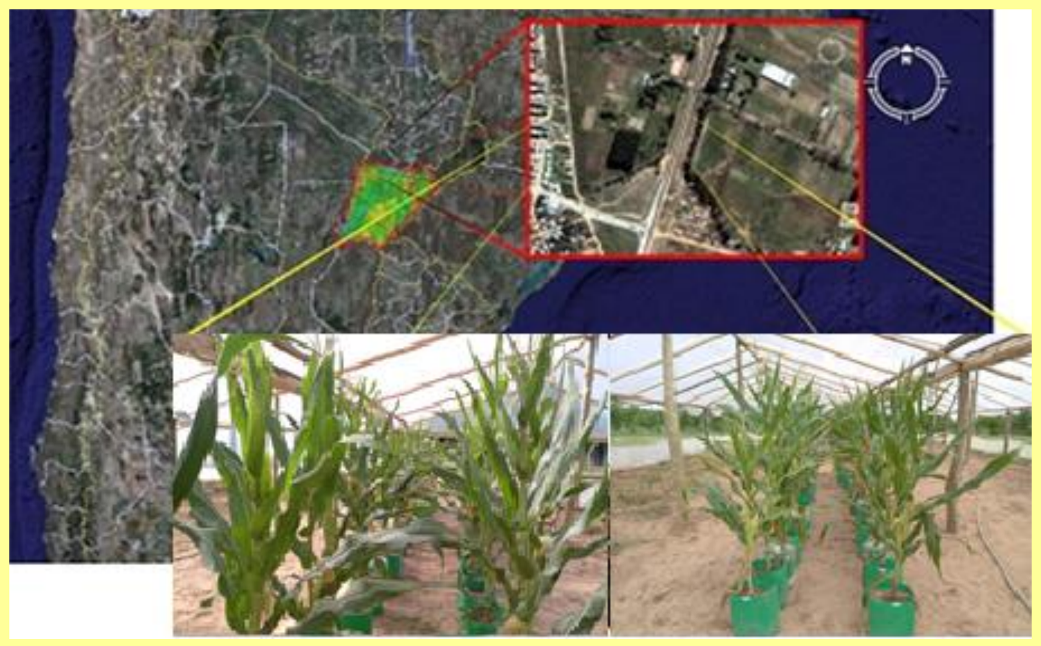
The Argentinean agricultural frontier has been expanded towards the north of the country with high probabilities of incorporating irrigation. Tropical corn, temperate, or their crosses, are planted with a different response to the environment. At leaf level, stomatal opening and closure are influenced by several factors such as CO_2 levels, light, temperature and water stress (Curtis *et al*., 2008). Zia *et al*. (2013) found a high relationship between stomatal conductance and canopy temperature. Thermography serves the phenotype of different genetic materials (Prashar and Jones, 2014) and is an incipient method, although work has been reported using infrared thermometers (Fuchs, 1990). Water stress is the main cause of yield gaps between potential and actual corn yield in the northeast region of Argentina. The present work was carried out with the objective of evaluate decreases in yield and its components in two maize hybrids subjected to drought at different growth stages and to establish leaf temperature differences between plants, through thermography.

MATERIALS and METHODS

An irrigated pot experiment was conducted at FCA-UNNE (Corrientes, Argentina) during 2016, under a polyethylene film roof of 100 microns, and without nutrient restrictions.

A randomized design with one plant per pot and three replications was used in pots of 20 L. (i) Two commercial hybrids (Te= temperate, and Tx= tropical x temperate) were grown with (ii) five water treatments (T0= full-irrigated control; and withholding irrigation during T1= 20-10 days presilking, T2= 10 days presilking, T3= 10 days postsilking, and T4= 10-20 days postsilking).

Thermal imaging (FLIRC2) and soil moisture measurements (Decagon 5TM) were taken daily. Images were processed whit flir tools.



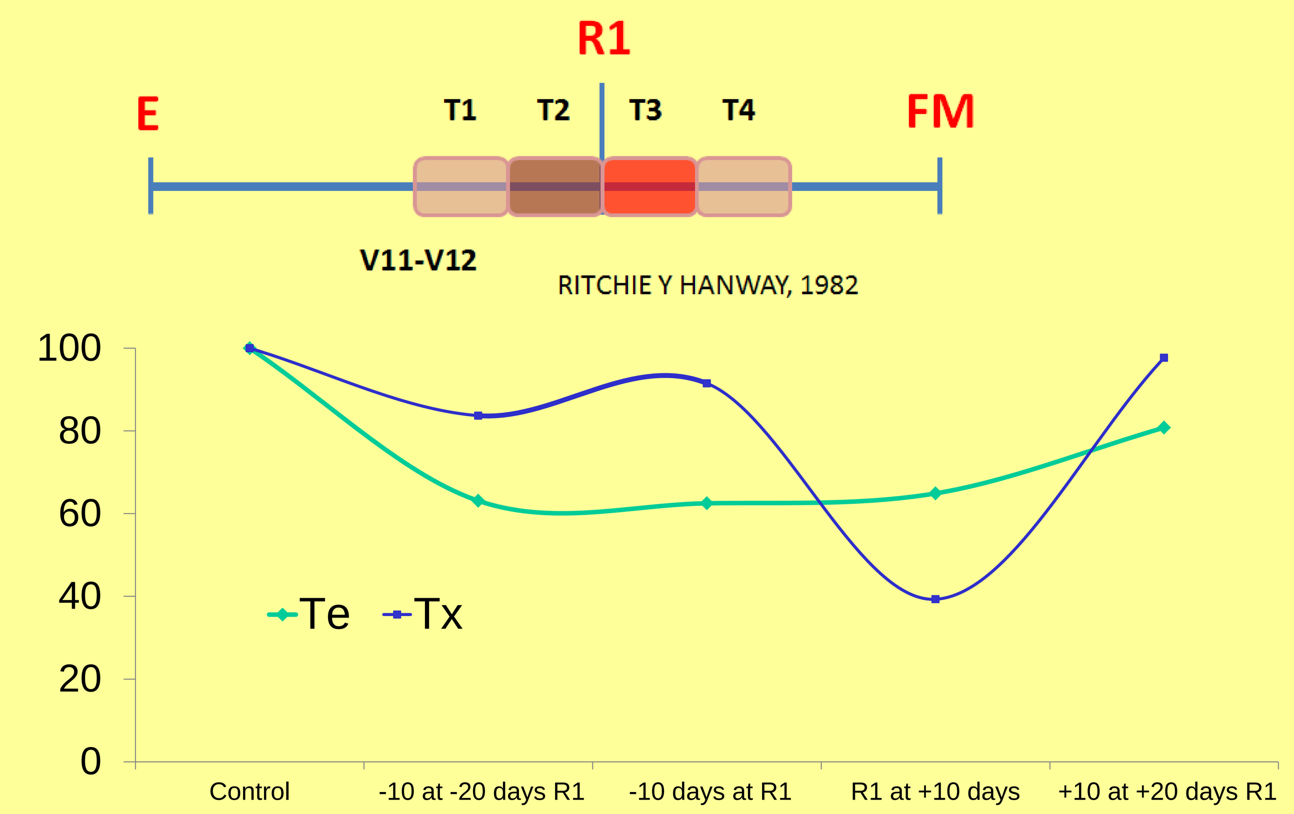


Fig 1: Decreased yield compared to the control at four times of drought stress (periods of 10 days) in two hybrids, temperate: Te and tropical x temperate: Tx

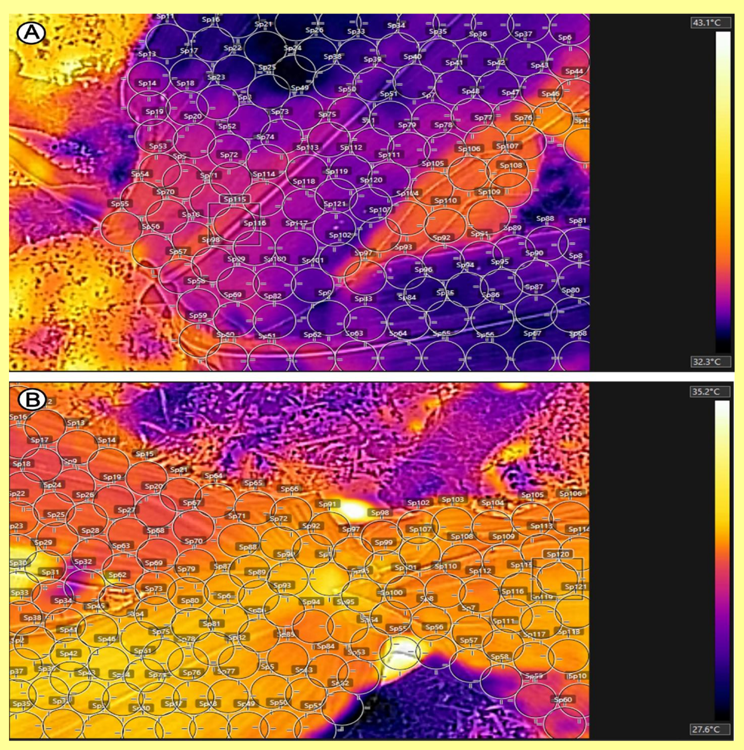


Fig. 2. A. Control plants (Average leaf temperatures <29ºC). B. Stressed plants (T1) with average leaf temperatures > 33 ˚ C

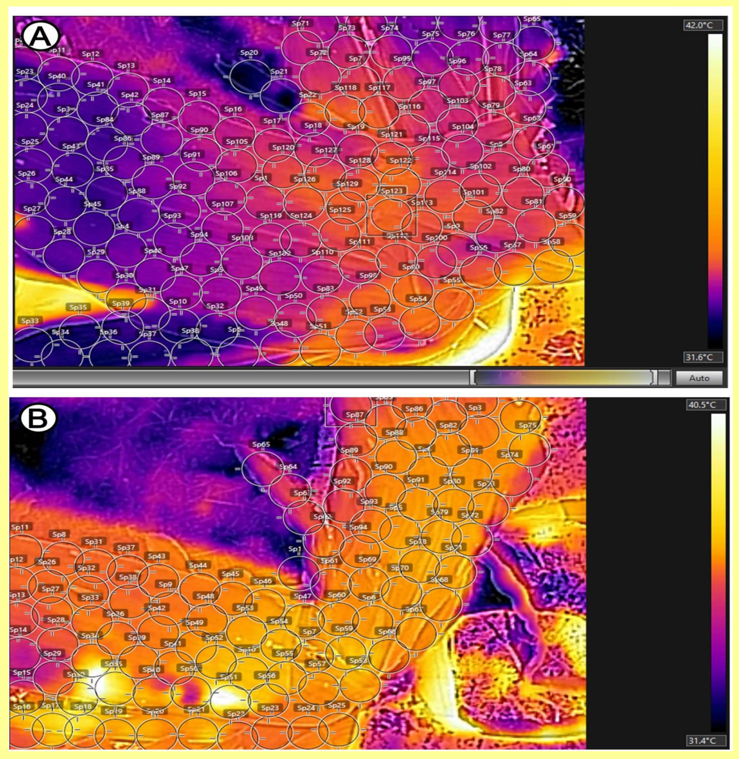


Fig. 3. A. Control plants (Average leaf temperature <32ºC). **B.** Stressed plants (T2) with average leaf temperatures >35ºC.

RESULTS and DISCUSSION

The grain yield was 1949,40 at 8303,76 Kg ha^{-1} (p= 0,2504), (p= 0,0025), (p= 0,0834) for hybrid, drought treatment factors and their interaction, respectively (Table1). Results showed that grain yield (relative % to the control treatment) was lower in Te (63.1, 62.5, 64.9 and 80.8% for T1, T2, T3 and T4 respectively) than in Tx (83.7, 91.5, 39, 3 and 97.7%, respectively), mainly in presilking.
Thermal imaging detected soil water content variations, especially in T3 and in Tx. A negative association was found between soil moisture and leaf temperature in the most affected treatment, which increased with the passing days (R^2=0.2817 on day 6, and 0.7611 on day 12 of drought) for both hybrids. The grain number (GN) was the 234,67 at 751 grain m^2 (p=0,1525), (p=0,0656), (p=0,0008) for hybrid, drought treatment factors and their interaction, respectively . The weight grain (WG) was the 120,5 at 279,09 gr (p=0,7289), (p=0,4628), (p=0,2314) for hybrid, drought treatment factors and their interaction, respectively. The greatest decreses grain yield was in T1 y T2 for both hybrids, being DK 7210 (temperate) the more affected.

Table 1: Numeric Yield Components: Analysis of variance for grain yield (kg ha^{-1}), weight 1000 grains (g) and number of grains for two maize hybrids growing at four droughts treatment in Corrientes.

HYBRID	T	YIELD (Kg ha^{-1})	KW (mg)	KN (number)
DK 7910	Control	8303,76 D	279,09 B	584,5 BC
Tr x Te	T1	5700,00 BCD	203,75 AB	453,33 AB
	T 2	1949,40 A	206,48 AB	157,5 A
	T 3	7182,00 CD	160,1 AB	759,67 C
	T 4	6338,40 CD	143,15 A	751 C
DK 7210	Control	7332,48 CD	207,26 AB	621,8 BC
Te	T1	4628,40 ABC	250,96 AB	310,67 A
	T 2	3214,80 AB	246,73 AB	234,67 A
	T 3	4765,20 ABC	120,58 A	641,33 B
	T 4	5700,00 BCD	221,69 AB	448 AB
VARIATION			**p-values**	
HYBRID (H)		0,2504	0,7289	0,1525
DROUGHT TREAT (DT)		0,0025	0,4628	0,0656
H x DT		0.0834	0.2314	0.0008
LSD (0.05) **		281,11843	144,17763	3007,08401

It was possible to show the increase in leaf temperature of the stressed plants (Fig 2 and 3) and their negative correlation with the soil moisture content (Fig 4).

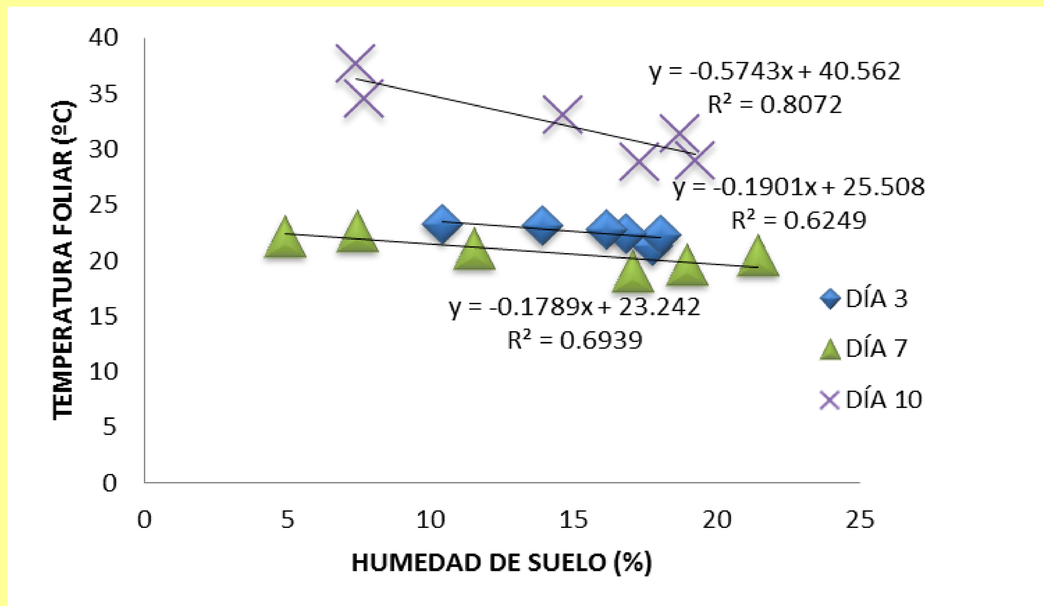


Fig 4. Relationship between soil moisture expressed as a percentage and leaf temperature expressed in degrees centigrade in the treatment of drought 20 days post R1 (T4) on days 3, 7 and 10 of drought.

CONCLUSIONS

- The temperate hybrid was the most affected in the moments when the stress was induced, presenting lower yields in the treatments of drought in relation to the cross hybrid.
- Through the use and process of images, it was possible to show the increase in leaf temperature of the stressed plants and their negative correlation with the soil moisture content.
- The use of thermal imaging proved to be a reliable method for determining soil moisture content that agronomists can apply to evaluate water stress in corn.