Effects of Water Deficiency on the Physiology and Yield of Three Maize Genotypes

Salifu Mahama[1], Lajos Fulop Doka[2]

University of Debrecen, institute of crop science. 4032 Debrecen, Boszormenyi ut 138

***Abstract*— *Three maize genotypes research experiment was carried out in the experimental farm of University of Debrecen, Hungary. The genotypes were subjected to two different treatments, (irrigated and non-irrigated) where the irrigated was the control experiment. Physiological parameters (SPAD, LAI, HEIGHT) and grain yield (kg ha^{-1}) were measured and statistically computed. From our results, SPAD, LAI and HEIGHT values were significantly affected by water stress in the three studied genotypes. Grain yield was reduced in two of the studied genotypes (S.Y Zephir and S.Y Chorintos). But no significant difference was notice in the KWS 4484 cultivar. LAI was not affected in the second measurement in the S.Y Chorintos genotype and, plant height did not record any difference in the first measurement in the KWS 4484 cultivar. Our results suggest second experiment to specifically look at the critical stage in the genotypes growth where water stress has the severe effect on the studied genotypes.*

***Keywords*— Maize genotype, water deficiency, Physiology and Yield.**

I. INTRODUCTION

Maize (Zea mays L) is an important cereal crop consumed by both human beings and animals all over the world. It is also an important industrial crop which serves as a raw material to produce corn sugar, corn starch, corn syrup and industrial corn oil. (Onwueme IC and Sinha TD, 1991; Ekpeyong TE, 1985; Anochili BC, 1984). Maize crop has more genetic diversity than other cereals and is one of the most cultivated cereal crops worldwide. It is ranked as the third world cereal produced following wheat and rice as reported Food and Agriculture Organization (FOA, 2002).

Water deficit has been recognised as one most single yield reducing factor for crops. Water deficit may occur frequently even in regions characterized by high annual rainfall. Water deficit affect growth and decrease the conversion of radiation into biomass in the maize. (Bohnert and Bressan, 2001; Otegui et al., 1995). Maize is very sensitive to drought two weeks before and two to three weeks after silking (Otegui et al., 1995; Hall et al., 1992). Drought stress is an important environmental factor in the reduction of plants growth and development. Hayat and Ali (2004), stated that, moisture stress is a limiting factor for crop growth in arid and semi-arid regions due to low and uncertainty precipitation. Water deficiency is a critical problem limiting maize growth through its impact on the physiological, morphological and biochemical processes. Water stress in maize crop production affects cell enlargement and thus reduces stem length by inhibiting inter-nodal elongation and also checks the tillering capacity of the maize plant (Ashraf M and Oleary JW, 1996; Chaves MM and Oliveira MM, 2004). According to (Dutt, 2005), Maize cultivars differ in their growth characteristics, yield and yield components and there recommend that growers and breeders must select the most promising combiners in their breeding programmes.

II. MATERIALS AND METHODS

Three maize (Zea mays L) genotypes (KWS4484, S.Y Chorintos and S.Y Zephir) were planted in the experimental station site of University of Debrecen (Latokep) which lies along the number 33 main road, about 15 kilometres from the main township of Debrecen (N. Latitude 47°33’, E. Longitude 21°27’) in the 2018 cropping year. The sowing and harvesting dates for this experiment were 14th April 2018 and 13th September, 2018 respectively. The soil of the experiment site is that of lowland chernozem with deposits of lime formed on loess. It has a medium nitrogen and phosphorus supply with a high content of humus (70-90 cm layer thickness). The average annual precipitation is 565.3mm and the precipitation for the cropping season was 120.7mm as shown in (Figure 1) below.

To study and evaluate the effects of water deficiency on the maize genotypes, two treatments of water was applied with three replications in a complete non-randomise block with each plot having 5 roles. The two treatments were irrigated and non-irrigated where the irrigated treatment was the control experiment, whiles the non-irrigated depended on the natural rainfall. In the control treatment, irrigation was applied three times within the cropping season and the dates and quantity of water supplied is as follows;

June 5th, 2018: 50mm
June 24th, 2018:50mm
July 20th, 2018:25mm.

The chlorophyll content was measured using SPAD-502 plus (Konica Minolta, Japan) at three different stages in the maize growing period (V12, VT and R1). Leaf Area Index (LAI) values were measured using SS1-Sunscan Canopy Analysis System (Delta-T Devices, UK). Plant height was manually measured using a long ruler just before harvest. All measurements were randomly done on 10 plants from each plot from the experimental field.

Statistical analysis of data was done using SPSS version 22 software and an independent sample T-Test was used to compare the means.

The aim for this current experiment was to study the effects of water stress on the chlorophyll parameters, plant height and yield on different maize genotypes under irrigation and non-irrigation conditions.

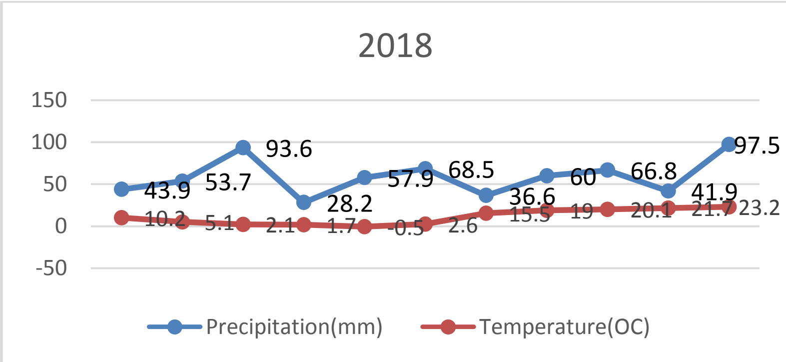

FIGURE 1: Precipitation (mm) and Temperature (^{O}C) data from the experimental site (Debrecen - Latokep)

III. RESULTS AND DISCUSSION

Results from the analysis date from this experiment showed that, chlorophyll (SPAD) content was lower in the non-irrigated treatments in all the three genotypes under study compared to the control experiment (irrigated). The mean difference was significantly noticed at the third measurement (Silking stage (R1)) for the genotype KWS 4484 and S.Y Zephir and at the second measurement (Tassel stage (TV)) for the S.Y Chorintos genotype as recorded in table 1 below. Water deficiency in maize crop production is one of the main factors limiting photosynthetic activities of the plant (Malakouti et al., 2005). Findings of Zobayed et al. (2005) has it that, chlorophyll concentration is an index for evaluation and there, a decrease of its concentration could be considered as non-stomata limiting factor under drought stress conditions. Kuroda et al., 1990 also reported a decrease in chlorophyll content mean value under drought stress condition. The reduction in chlorophyll in the drought stressed treatments could be as a result the proline in the plant tissues which has missed water, since water is needed for by plants for their physiologically and biochemical activities. Plants need a maximum amount of water to maintain their chlorophyll activities (Bohrani and Habili, 1992).

Leaf Area Index (LAI) was lower for the drought stressed maize plants in two genotypes (KWS 4484 and S.Y Zephir) in the first and third measurements respectively compared to the control experiment which had supplementary water applied through irrigation. The genotype S.Y Chorintos was however not affected in all the three measurement dates as shown in the (table1) below. Water stress significantly reduced leaf area index in this research due to reduction in cell division and this may reduce plant turgor pressure and cell expansion, thus resulting in dry mass being contain within a smaller leaf area and increasing the density of leaves (Hsiao, 1973; Rascio et al., 1990).

Means comparison as seen in (table1) below shows an increase in the drought stress resulted in a significant decrease in the leaf area index and this findings coincided with other research finding such as that of (Nouri and Ehsanzadeh, 2007; Saberali et al.,2007; Pandey et al.,2000) all reported significant reduction in maize under drought stress condition. Ritchie, 1987 also reported that, there was difference between irrigated and drought stress at the end of the growing season whereby plants under stress conditions lost the leaf area. The genotype LAI means comparison showed that the KWS 4484 had the highest rate of LAI (3.89) and the S.Y Zephir genotype had the lowest LAI rate (2.51) under the irrigated regime whereas under the drought stress treatment, S.Y Zephir genotype had the highest LAI value rate of (3.40) and KWS 4484 had the lowest mean value rate of (1.86).

TABLE 1
WATER DEFICIENCY EFFECT ON THE PHYSIOLOGICAL PARAMETERS AND YIELD ON THREE MAIZE GENOTYPES

KWS 4484		MEAN	Independent Sample Test		S.Y ZEPHIR		MEAN	Independent Sample Test		S.Y CHORINTOS		MEAN	Independent Sample Test	
			t	Sig.(2-tailed)				t	Sig.(2-tailed)				t	Sig.(2-tailed)
SPAD 1	IRRIGATED	56.90	.242	.821	**SPAD 1**	IRRIGATED	61.20	-1.851	.138	**SPAD 1**	IRRIGATED	64.80	-.341	.750
	NON-IRRIGATED	57.57				NON-IRRIGATED	59.00				NON-IRRIGATED	64.37		
SPAD 2	IRRIGATED	63.00	1.839	.140	**SPAD 2**	IRRIGATED	65.20	-1.724	.160	**SPAD 2**	IRRIGATED	72.33	-6.682	**.003**
	NON-IRRIGATED	66.77				NON-IRRIGATED	63.40				NON-IRRIGATED	55.67		
SPAD 3	IRRIGATED	76.80	-3.337	**.029**	**SPAD 3**	IRRIGATED	70.93	-6.813	**.002**	**SPAD 3**	IRRIGATED	65.03	-1.279	.270
	NON-IRRIGATED	62.63				NON-IRRIGATED	58.37				NON-IRRIGATED	60.33		
LAI 1	IRRIGATED	2.46	-2.997	**.040**	**LAI 1**	IRRIGATED	2.51	-1.176	.305	**LAI 1**	IRRIGATED	2.71	-1.938	.125
	NON-IRRIGATED	1.87				NON-IRRIGATED	2.21				NON-IRRIGATED	2.07		
LAI 2	IRRIGATED	3.18	-.683	.532	**LAI 2**	IRRIGATED	2.99	1.046	.355	**LAI 2**	IRRIGATED	3.05	-1.880	.133
	NON-IRRIGATED	2.67				NON-IRRIGATED	3.40				NON-IRRIGATED	2.29		
LAI 3	IRRIGATED	3.89	-2.009	.115	**LAI 3**	IRRIGATED	3.86	-3.210	**.033**	**LAI 3**	IRRIGATED	2.92	-.430	.689
	NON-IRRIGATED	2.72				NON-IRRIGATED	2.81				NON-IRRIGATED	2.86		
HEIGHT	IRRIGATED	291.33	-.791	.474	**HEIGHT**	IRRIGATED	352.67	-.3.902	**.018**	**HEIGHT**	IRRIGATED	295.00	-6.547	**.003**
	NON-IRRIGATED	287.33				NON-IRRIGATED	276.00				NON-IRRIGATED	285.00		
YIELD	IRRIGATED	16106.3	1.023	.364	**YIELD**	IRRIGATED	16995.7	2.921	**.043**	**YIELD**	IRRIGATED	26401.0	3.681	**.021**
	NON-IRRIGATED	13232.7				NON-IRRIGATED	10552.0				NON-IRRIGATED	13928.7		

BOLD: is significant at P<0.05

In this experiment, plant height of two maize genotypes (S.Y Zephir and S.Y Chorintos) were significantly affected by water stress as they showed greater mean value compared to the well irrigated genotypes whereas the KWA 4484 genotype was not significantly affected even though the irrigate treatment had a higher mean value (291.33) against the water stress treatment crop (287.33). The difference in plant height in this study is in consistent with the results of Sarvar and Ali, 1999 who studied the impact of drought stress on two maize genotypes and reported plant height reduction in both genotypes. El Neomani et al., 1990 also recorded a drastic decrease in maize plant height under water stress situation and reported that, at the beginning of rapid growth, stress drastically reduces maize height although dry matter production depends on levels of photo-assimilate product. This reduces the amount of photo-assimilate during grain filling in the maize ear. This current study also relates to that of Sionit and Kramer (1977) who recorded no significant difference in in plant height under water stress (Genotype KWS 4484) as observed in (table1). Other researchers whose results are in consistent with this current study included (Pandey et al., 2000; Yazar et al., 2002 and Denmead and Show, 1960).

Maize plant yield was higher for the control experiment (irrigated) compared to the water deficient regime in all the three genotypes studied. Significant difference was recorded for the genotypes S.Y Zephir and S.Y Chrorintos. There was no significant difference in 4484 genotypes although the irrigated treatment had a high value; this value was statistically not significant (Table 1). This study agreed with previous studies which reported maize grain yield reduction under drought stress situation. Chimenti et al. (2002) and Erdem et al. (2006) have both reported grain yield and weight of 1000 grain decreased in with an increase in drought stress. Karam et al. (2007) indicated that, with increasing in drought stress, leaf area index, grain yield and its components were significantly reduced. Environmental stresses in the form of heat intensity and nutrient unavailability to plants because of water deficiency could be a major driver causing plants yield reduction in this study.

IV. CONCLUSION

The effects of water deficiency on the physiological parameter and grain yield on maize cannot be over emphasized as the results in this study showed different reaction by the different maize genotypes used for this experiment. This study confirms that irrigation significantly affect chlorophyll measurement in all the three genotypes. Leaf area index was affected by water stress in KWS 4484 and S.Y Zephir genotypes but S.Y Chrorintos was not affected. Water deficit also significantly affected maize height except KWS 4484 genotype. The effects of this physiological parameters translated to the maize grain yield which resulted in the reduction in yield in all the studied genotypes under the drought stress treatments and was significantly noticed in the S.Y Zephir and S.Y Chrorintos genotypes in this study. This experiment could be repeated to further investigate the critically sensitive stages of this genotype’s growth to water stress for one year of study is not enough to conclude of definite results, although it gives an initial understanding of drought effect on maize genotypes.

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