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Effects of Water Deficiency on Phosiological Traits, Grain Nutrition Quality and Yield of three Maize (Zea mays L) Genotypes

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***Abstract*— Water deficit or drought has an adverse effect on crop production, and it is one of the limiting factors of world food security. A field experiment was conducted on different maize genotypes in University of Debrecen to assess the impact of water deficit on the physiology, grain nutrition and yield of three maize genotypes. The studied treatments were full irrigation and non-irrigation. The irrigated treatment did not significantly affect grain yield and starch content. Grain protein, moisture content SPAD and leaf area index(LAI) were significantly affected by irrigation. There was significant yield difference between the hybrids and grain nutrition quality was also affected by hybrids difference at LSD 1%. For good nutritional quality grain from the studied genotypes, the researchers propose (P 9911) Genotype under similar environmental condition.*

***Keywords*— Maize, Genotype, water deficiency, Physiology, Nutrient, and Yield.**

I. INTRODUCTION

Soil water deficit is one of the biggest challenges in maize plant growth Wu et al., (2011a). The effect of the global changes resulting in varying rainfall patterns makes drought more severe and frequent Easterling et al., (200)), andmodels predict a 25% decrease in soil moisture content between 2000 and 2040 Sabate et al., (2002), which will bring big challenge to crop production because about 66% of total cereal crop production is by rain-fed agriculture Lobell et al., (2014).

The sensitivity of drought stress to plants depends on varied degree of the drought stress, plant variety, and plant developmental stages Demirevska et al., (2009). Several studies have shown a reduction in plant growth because of reduction in chemical signals being the cause of water deficit in the soil. (Ismail and Davies, 1998; Hurley and Rowarth, 1999; Ismail et al.,1994). Fresh and dry biomass reduction are the common adverse effect of drought on maize plants as reported by Zhao et al., (2006). The effect of water deficit on the height, stem diameter photosynthesis reduction caused because of decreases in maize leaf expansion which impaired photosynthetic activities has been reported (Zhao et al.,Demirevska et al.,2009; Wahid et al.,2005). Photosynthetic pigments and reduction in relative water content has been noted in a wide variety of plants Anjum et al., (2003) and Nayyar and Gupta, (2006).

Drought is a protracted period of water deficient precipitation resulting in extensive crops damage and yield loss. Drought stress or water deficit is an inevitable and recurring feature of global agriculture. Kramer (1980) reported that about one-third of the world's potentially arable land suffers due to water shortage, and most of the crops production is often reduced by drought. Water being integral part of plants plays a pivotal role in the initiation of growth, and subsequent maintenance of developmental process throughout the plant's life. The maize crops may experience reductions of grain yields when subjected to water deficit during the critical period of crop cycle from tasseling stage to initiation of grain filling.

Plants productivity growth is fundamental to meeting the increasing demands of the ever-increasing population, but projection indicates that the future growth in cereal yields will decline across nearly all regions. Water deficits are responsible for a significant amount of this decline in developing countries, where food security is will continue to be a problem.

Irrigation plays a particularly large role in agricultural production in developing countries, where it is projected to account for 57% of the growth in cereal production between 1995 and 2025, and 80% of the growth in global irrigated cereal production between 1995 and 2025 (Rosegrant*et al.* 2002). Nevertheless, added constraints will continue to be placed on irrigation water supplies as non-agricultural demand for water rises at much faster rates than water demand for irrigation — though total water consumption for non-irrigation uses will still be much lower than consumption for irrigation. Several other factors will also affect the availability of water for agricultural production, including unsustainable groundwater use, environmental demands for water and water quality problems.

Maize (*Zea mays* L.) is a major cereal crop world over, serving as a major staple for both human consumption and animal feed. It has also become a major resource for industrial applications and bioenergy production. Maize grain is widely used for the preparation of corn starch, corn syrup, corn oil dextrose, corn flakes, gluten, grain cake, lactic acid and acetone which are used by various industries such as textile, foundry, fermentation and food industries. The consumption of maize as feed has also increased tremendously with the development of poultry and livestock industry. Maize is one of the grain crops in the world which is the most versatile. It is used in the human diet in both fresh and processed forms. The value added has been an important economic driver in the corn markets (Hallauer and Miranda, 1988).

II. MATERIALS AND METHODS

This is a long-term experimental set up at Latokep the experimental field of university of Debrecen, Hungary in the 2018 cropping year. Latokep experimental field is about 15km away from the city centre with(Latitude $47^0 33'$N and Longitude $21^0 27'$E).The area of Latokep Crop Production Experiment Site lies along road 33 and has an independent water extraction facility which provides water necessary for irrigation from the water reservoir. The soil for the experimental site calcareous chernozem formed on the sag loess ridge. The climate and weather condition are continental and often extreme. The 30-year – average value of precipitation 565.3mm, whiles the precipitation for the planting to harvesting time was 290.4mm.

In this experiment set up, three maize genotypes(DKC5943, P9903, and P9911) were planted on a plot of land which has been used for the past 30 years. The plot was divided into fully-irrigated and non-irrigated plots. Fertilization of NPK(500kg ha^{-1}) and a plant density of 72,500/ha^{-1}were used for all genotypes

In the irrigation treatment, crops were irrigated three times at different dates as follows in the 2018 cropping season;

24th June – 50mm water

5th July – 25mm water

30th August-25mm water.

The leaf area index (LAI) was measured using SS1-SunScan Canopy Analysis System (Delta-T Devices, UK) at four growing stages. The chlorophyll content of the leaves was recorded using SPAD-502 plus (Konica Minolta, japan). The Normalized Difference Vegetative Index (NDVI) was measured using GreenSeeker Hand-held NDVI Sensor, whiles plant height was measured by a long ruler just before harvest. The grain quality (protein, and starch) was recorded using a grain analyzer granolyzer after harvest.

The aim of this experiment was to determine the effect of water deficits on physiological traits, grain quality and yield of three maize genotypes. Statistical analysis of data was done using SPSS version 19 software to compare the means.

III. RESULTS AND DISCUSSION

In this study, we examined the effect of irrigation on different genotypes with regards to photosynthetic parameters, grain nutrient quality and crop yield on the selected hybrids. The evaluation of the data collected was done using SPSS 19 for Windows statistical program.

From table1 (A) below, there is no significant difference between the three Hybrids of maize from the analyzed data of SPAD and LAI. NDVI had a significant difference at LDS 5% between the hybrids.

Grain nutrients quality and grain yield in this experiment were significantly affected at LDS 1% between the different maize hybrids.

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Table 1: Effects of water deficit on physiological trait, grain quality and yield on different hybrids.

HYBRID (A)	SPAD	LAI	NDVI	PROTEIN	MOISTURE	STARCH	YIELD(t/ha)
DKC 4943	61.23	2.44	0.75	8.68	14.85	74.38	15648.33
P 9903	61.15	2.56	0.74	9.23	15.25	73.60	15624.12
P 9911	59.58	2.55	0.77	9.61	16.09	74.48	16584.54
SZD 5%	3.38	0.77	0.02	0.22	0.25	0.52	749.04
SIG	ns	ns	*	**	**	**	**
IRRIGATION(B)							
NONIRRIGATED	62.90	2.45	0.74	9.43	15.08	74.05	15025.16
IRRIGATED	59.61	2.34	0.76	9.74	15.35	73.86	15200.01
SZD 5%	1.95	0.44	0.01	0.13	0.14	0.30	432.46
SIG	**	ns	**	**	**	ns	ns

**=1%, *= 5% and ns= not significant

This study find out that, SPAD, NDVI, Protein and Moisture content were all significantly affected irrigation at LSD 5% while Leaf area index, starch and yield were not affected by irrigation as shown in table 1(B) above.

The non-significant difference of maize grain yield noted from this study could be attributed to the good precipitation in the cropping season resulting to unsevered or harsh deficit conditions for the non-irrigated crops. This study did not coincide with (Hall et al.,1980) who revealed that, water deficit reduces leaf area and delays silking and thereby reducing grain yield components, particularly grain number.Stegman (1982) reported that yield of maize was not significantly affected when it was exposed to water deficit that induces a 30-40% depletion of available water between irrigation. The review made by Kirda (2000) indicated that similar works on many other crops like sugar beet, sunflower, wheat, and potato have demonstrated the possibility of achieving optimum crop yields under deficit irrigation practices by allowing a certain level of yield loss from a given crop with higher returns gained from diverting the saved water for irrigating other crops. McPherson and Boyer (1977) on their work indicated that water deficit during grain filling stage on sorghum caused only a small drop in yield. The average grain yield of the genotype P9911 (15200.01 t/ha) under irrigation condition.

Protein content was significantly affected by the level of irrigation and varied considerably between the genotypes ss shown in Table 1A.The protein content of maize grain was significantly lower in treatments under non-irrigated condition. The highest protein content (9.61% on average) was noted in the genotype P9911 under irrigation treatment. This showed that the protein content decreased if the quantity of irrigation was above or below a certain level and that shows that, proper water supply to maize was beneficial to protein formation of maize grain. The high protein content under irrigation treatment could be attributed to the increase in the activities of glutamate synthase and glutamine synthetase, which are involved in nitrogen metabolism by promoting nitrogen accumulation and increasing the protein content of maize grains.This study agrees with , (Aydinsakir et al. 2013)who determined that in the ecological conditions in Antalya, Turkey, the protein content of maize grain was the highest with full irrigation and significantly lower with deficit irrigation and under rainfed conditions. Contrary to this present findings, Ertek and Kara 2013 studied the effects of different irrigation levels on the yield and quality of sweet corn in Turkey and reported the results that, increasing irrigation decreased the protein content of maize grain. Since protein is an important aspect of maize grain production, the irrigation level for maize in the agro-ecological environment of Hungary should be maintain.

From Table 1(A) above, the irrigation treatments had a significant effect on the starch content in all three studied genotypes meaning that the rate of grain filling differed between genotypes. In the present research, the average values of starch content percentage gradually increased with increasing irrigation water, indicating that the grain filling rate was different between the rainfed non-irrigated treatment and irrigated treatments. The increase was not large but statistically significant at LDS 5%. The reason for these changes could be alterations in starch biosynthetic enzyme activity and the accumulation of starch in grain as water availability enhance enzyme activities. The conclusion to this phenomenon is that irrigation might result in qualitative and quantitative differences in the rate of grain carbohydrate metabolism, as well as endosperm changes that enhances the rate of starch synthesis. (Zhao et al.,2009)however reported that, mild drought increased and that a large water deficit decreased the starch content. Research conducted by Lu et al.,2015 in China showed that water deficit had no effect on the starch content of fresh waxy maize. Liu et al.,2013 also reported that the starch content of the grain samples of maize grown with less irrigation was 3.0% smaller than with high irrigation levels.

IV. CONCLUSION

In summary, maize growth and yield responses were related to adequate supply of water and careful selection of cultivars in any given ecological zone. In this study, there was a significant difference between different Maize hybrids in their grains nutrition quality thus; protein, moisture and starch content as well as maize grain yield were all significantly affected at LSD 1% ($P < 0.01$). Photosynthetic parameters were not affected expect NDVI which was significantly affected at LSD 5%. Irrigation treatment significantly affected photosynthetic parameters of SPAD and NDVI, and Maize grain protein and moisture content at LSD 1%. Maize grain yield was not affected although the irrigated treatment recorded a higher average value of 15200.01t/ha, it was not statistically significant.

Water deficit regulated the activities of antioxidative defence system in all the maize hybrids thus, reducing the severity of the drought. Again, all maize hybrids in this study showed a variable response to water deficit stress resulting in the production and accumulation of different osmolytes in all hybrids. This study needs to carry out again for one year of this experiment is enough to give a definite general conclusion.

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