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Faculty of Agrobiotechnical Sciences Osijek

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5. do 10. rujna 2021., Vodice, Hrvatska

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and
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03

Genetika, oplemenjivanje bilja i sjemenarstvo
Genetics, Plant Breeding and Seed Production

Original scientific paper

Time-resolved chlorophyll fluorescence measurements in maize reveal different patterns of responses to increasing temperatures among maturity groups

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Abstract

Early maturing maize hybrids are expected to enter the senescence and reach maturity more quickly, while in later maturity hybrids this process is stretched over a longer period of time. The aim of this study was to analyze the photosynthetic efficiency of maize hybrids belonging to different maturity groups in time-resolved manner. Chlorophyll fluorescence (ChlF) was continuously measured from 07:00 to 14:00 on 48 maize hybrids in two experiments. Our results indicate that early-maturing hybrids from groups FAO 300 and 400 display more sensitive reactions to high temperatures and lower yields compared to late maturing ones.

Keywords: maize, chlorophyll fluorescence, heat, maturity, adeptness

Introduction

On-farm trend in Southeastern Europe show inclination towards earlier maturing maize hybrids. Reasons for such practice are manifold with efficient utilization of resources in terms of an earlier harvest and a decrease of drying costs. Early maturing hybrids flower earlier and are thus able to avoid the periods with high incidence of drought, at theoretical cost of entering senescence more quickly thus compressing the time-frame of productive photosynthetic activity. Earlier maturing hybrids also show genetic distinctness as hybrid formulas often include flint – dent combinations as compared to dent - dent in later maturity ones (Mikel, 2011). The ChlF is based on property of photosynthetic tissues to emmit weak light called fluorescence upon illumination with strong light source after being adapted to dark. High-density measurement of ChlF reveals increase in fluorescence signal during the first one second, the phenomenon called Kautsky-effect. Kinetics of this fluorescence rise reveal unique pattern called OJIP allowing biophysical interpretation of electrochemical reactions in real time in so-called JIP-test framework (Strasser et al., 2004). JIP-test is sensitive to environmental deviations, especially abiotic stresses such as heat (Galic et al., 2019) and water deficit (Begović et al., 2020). The most used, highly sensitive parameter of JIP-test, PI_{ABS} (i.e. performance index of photosystem II on absorption basis) quantifies primary photochemistry.

The aim of this study was to analyze the differences in ChlF reactions between hybrids from different maturity groups in time-resolved manner.

Material and Methods

Experimental and commercial maize hybrids (48 in total) from different maturity groups were planted in three experiments, two in fields of Agricultural Institute Osijek (45°32'22.1''N 18°44'01.8''E and 45°32'17.3''N 18°44'27.6''E) with 2-week difference planting dates and single experiment in field of Faculty of Agrobiotechnical Sciences Osijek (45°30'48.3"N 18°47'15.8"E). Six hybrids belong to group FAO 300, 13 to FAO 400, 15 to FAO 500, nine to FAO 600 and five to FAO 700. ChlF was measured with handheld fluorometer (Handy-PEA, Hansatech, UK) on ear-leaves continuously during one month (25th of June to 25th of July), on every day with clear weather from 07:00 to 14:00 when the highest temperatures are expected. Five plants of every hybrid were measured at three growth stages: VT (last vegetative stage with visible tassel), anthesis (first reproductive stage with more than 50% of plants showing anthers) and early grain filling. Totally, more than 16000 measurements were carried out. Plots were manually harvested and weighted and the moisture was determined on a five-ear sample. Agrometeorological parameters were measured by Pinova weather station. Data was handled in Microsoft Excel.

Results and Discussion

All measured agrometeorological parameters showed daytime-related trends. Relative humidity decreased from 07:00 to 14:00, while air and leaf temperatures increased (Figure 1).

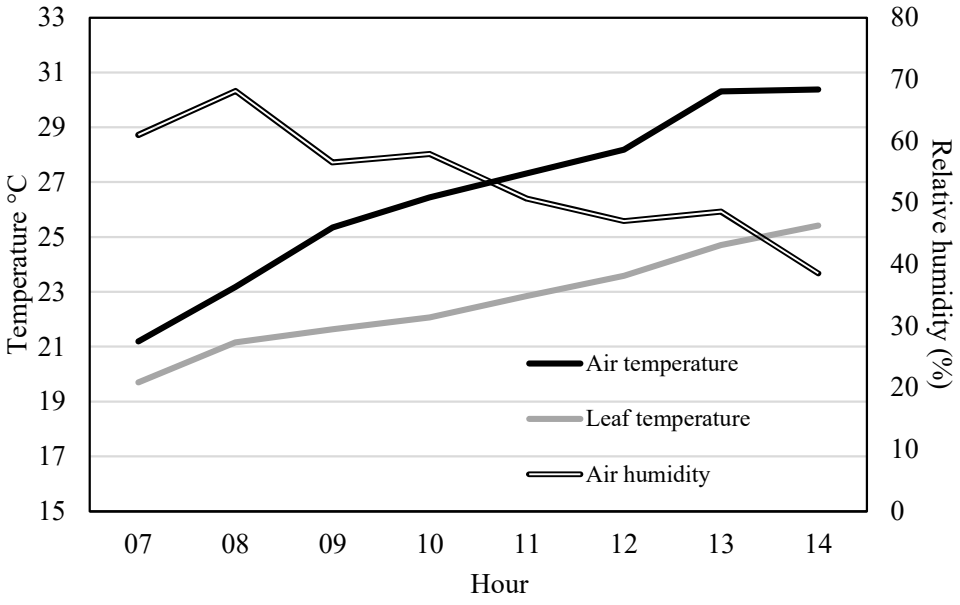

Figure 1. Aggregated means of agrometeorological parameters by hour during the days when ChlF measurements were carried out

Maturity related positive trend of increase in grain yield was followed by increase in grain moisture. Very strong coefficients of determination were calculated for relationship between grain yield (93.51%) and FAO maturity group, as well between grain moisture and FAO maturity group (91.63%, Figure 2). Such trend is expected in full-season maize hybrids grown in full-season environments (Bennetzen and Hake, 2009).

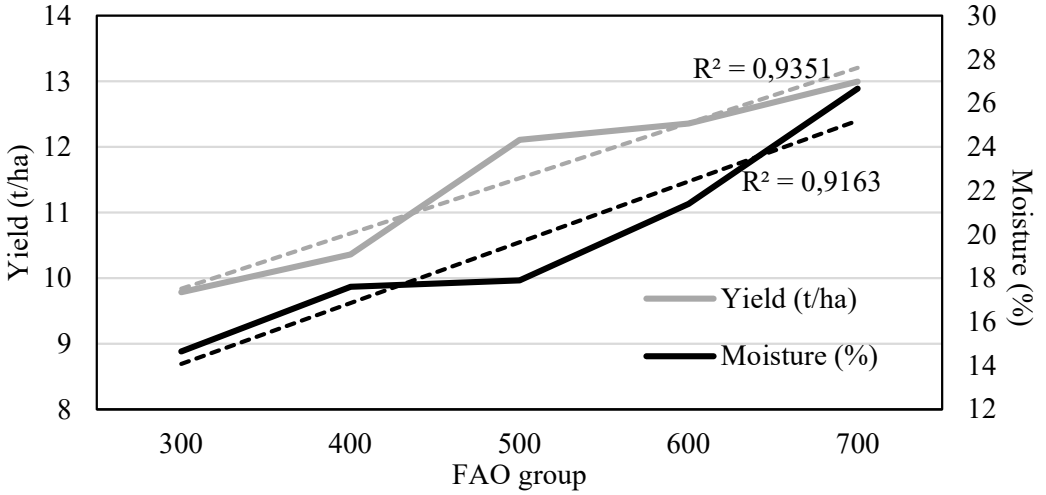

Figure 2. Grain yield and harvest moisture of maize hybrids from different FAO maturity groups

Different time-related trends were observed in PI_{ABS} between different maturity groups. Hybrids from FAO groups 300 and 400 showed similar patterns of reactions with lowest morning values and slight negative slope towards the afternoon (R^2 = 83.63% and 89.5%). Hybrids from FAO groups 500, 600 and 700 showed higher morning values and steeper slope towards the afternoon, except in highest yielding group FAO700, where slight increase was observed in hours with the highest temperatures (Figure 3). Heat sensitivity of ChlF is expected to be affected by maturity and to vary between different genotypes (Oukarroum, et al., 2016, Franić et al., 2019).

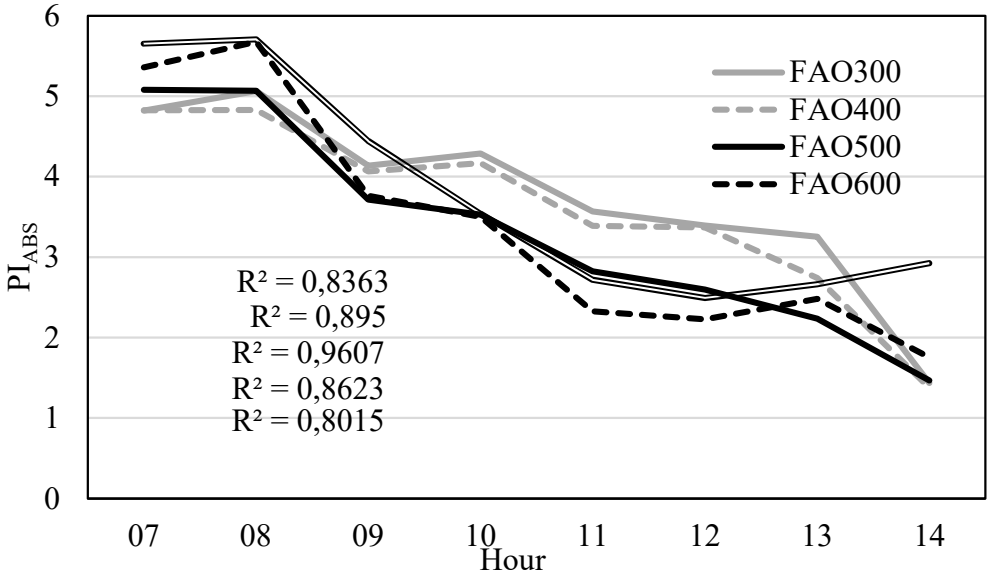

Figure 3. Means of performance index on absorption basis (PI_{ABS}) by hour along with R^2 values of simple linear models

Conclusions

Hybrids from different maturity groups show distinct responses to daytime changes in environmental conditions. This is possibly influenced by different mechanisms of coping with increasing temperatures. Application of ChlF as a tool for constant monitoring of maize physiological status needs to be further investigated, but the results are promising especially

in context of newly developed remote sensing and inter-communicating devices. Constant monitoring of maize plant status could provide the farmers the means to perform ameliorative measures when needed, where needed and the underlaying models need to be calibrated to best represent the field conditions and scenarios.

Acknowledgments

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Mjerenje fluorescencije klorofila kroz vrijeme pokazuje različite uzorke reakcija na visoke temperature između skupina dozrijevanja

Sažetak

Očekuje se da hibridi kukuruza ranih skupina dozrijevanja efikasnije akumuliraju toplinske jedinice i ulaze u senescenciju prije nego hibridi kasnijih skupina. Cilj ovog istraživanja bio je ispitati promjene fotosintetske učinkovitosti hibrida kukuruza različitih skupina dozrijevanja kroz vrijeme. Fluorescencija klorofila (ChlF) mjerena je kontinuirano od 07:00 do 14 sati na 48 hibrida kukuruza u tri pokusa. Linearni model pokazao je visoku sličnost dviju metoda podjele vremena dozrijevanja. Rezultati istraživanja pokazali su da hibridi grupa FAO 300 i 400 imaju osjetljivije reakcije na visoke temperature, praćene nižim prinosima u odnosu na hibride kasnijih skupina.

Ključne riječi: kukuruz, fluorescencija, adaptacija, visoke temperature, skupine zrenja