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# AGRICULTURE IN NATURE AND ENVIRONMENT PROTECTION

Osijek, Republic of Croatia, 07th- 09th September 2020

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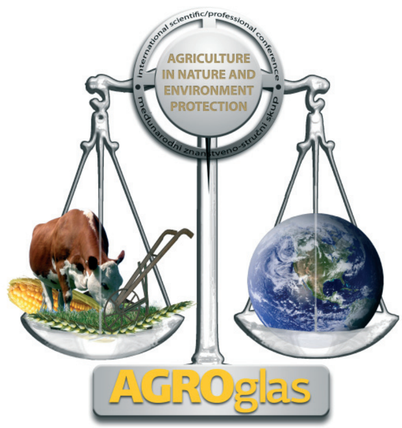


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# Grain filling of maize in the function of crop density and genotype

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## Abstract

Present experimental data indicate that meteorological conditions, with regard to genotype and crop density, are the main factor that contribute to grain yield variations of maize hybrids. H6, as a hybrid with longer vegetative period, responded better, with increased grain yield when it was grown at D1. Nevertheless, H3 could be characterised as more efficient in kernel weight accumulation, having higher values of shelling percentage and grain yield. DM accumulation is mainly dependable on maturity group. Thus, hybrids from later groups (H4-H6) had lesser DM accumulation from phase V to VI (especially at D1) indicating slower assimilates accumulation and/or gradual moisture releasing from the grain. That means that a longer grain filling period, as the background of high yield achievement, is not closely related to kernel weight. Grain filling period is the main factor that contributes to yield potential, what is mainly highlighted in hybrids from early maturity groups (H1-H3), particularly when they were grown at higher densities (D2), giving them advantage over hybrids from later groups.

**Key words:** maize hybrids, grain yield, shelling percentage, dry matter

## Introduction

Forming of grain yield is a complex process, based on kernel filling, and depending on all factors that could affect its realisation. Mandić et al. (2016) noticed that differences between growing seasons are more prominent to variations of maize grain yield and yield parameters than growing density.

Grain filling is one of the most important and sensitive phases in maize cropping. The post-silking period is characterised by gradual remobilization of water and assimilates from green leaves (source) into kernels (sink). In the study that involved comparison of maize hybrids of older and newer generations, based on source-sink ratio (post-silking dry matter accumulation to kernel number per plant), Chen et al. (2016) detected that newer hybrids were improved by increased SSR ratio, particularly when they were grown on high N rates and low plant density. Newer hybrids were also characterised by increased dry matter accumulation, as well as kernel weight, thus improving yield potential. All these improvements are based on higher leaf dry matter and N content at maturity, indicating that holding up the leaf activity by improved leaf biomass and N accumulation has as a consequence increased kernel weight, N and dry matter accumulation (Chen et al., 2015). Nevertheless, Eichenberger et al. (2014) find that a correlation between length period of grain filling and kernel filling rate does not exist when maize populations were grown at higher densities. Thus, higher grain yields, achieved by growing at higher densities are not connected to biomass accumulation and final kernel weight.

Grain filling is susceptible to variations in agro-ecological conditions, particularly various abiotic and biotic stressors, affecting kernel formation and yield potential. What is more, dynamics of kernel filling, dry matter and water accumulation in kernels is highly dependable on genotype, agro-ecological conditions and their interaction (Brooking, 1990, Gambín et al., 2007, 2008). The same authors highlighted furthermore the importance of the relationship between kernel mass accumulation and water loss during maize filling, indicating that maximum kernel volume corresponds to the maximum water content, which dropped down to the physiological maturity.

The aim of this experiment was to examine dynamics of grain filling, based on shelling percentage and dry matter percentage, of six maize hybrids from different maturity groups, grown at densities of 59523 plants ha$^{-1}$ and 89286 plants ha$^{-1}$.

## Material and methods

The experiment was conducted in Zemun Polje, on a slightly calcareous chernozem, within the growing season of 2017 and 2018. The experiment was performed with the aim to study how lower and higher crop density: 59523 plants ha$^{-1}$ (D1) and 89286 plants ha$^{-1}$ (D2) affects the dynamics of grain filling, including fluctuations of shelling percentage and dry matter percentage (DM) in kernels of six maize hybrids from different FAO groups: ZP 4007 (H1), ZP 5008 (H2), ZP 5561 (H3), ZP 5901 (H4), ZP 6561 (H5) and ZP 6901 (H6). Winter wheat was a preceding crop. Sowing was performed during the first half of April. Applied cropping practices involved conventional tillage: shallow ploughing performed immediately after wheat harvesting, primary tillage in the autumn and seedbed preparation in the spring. Fertilization included the application of 50 kg P ha$^{-1}$ and 50 kg K ha$^{-1}$ in the autumn, prior to primary tillage, while N fertilizer was applied in the spring, by supplying up to 240 kg N ha$^{-1}$ (based on soil analysis). The experimental area was treated with a pre-emergence mixture for grass and brad-leaf weeds control (terbuthylazine + metolachlor, in recommended dose: 500 + 960 g a.i. ha$^{-1}$). The sampling of maize cobs was done every 10 days (phase I to phase VI), starting from the 15$^{th}$ day after full pollination. Cobs were weighted and then grains were detached and weighted. The dry matter was determined and calculated after drying at 105 °C. At the end of vegetative cycle, maize grain yield was measured and calculated to 14% of moisture.

Experimental data were statistically processed by analysis of variance (ANOVA) and analysed by the LSD-test (5%), while shelling percentage and dry matter accumulation were presented with standard deviation (SD).

Meteorological data indicated that 2018 was characterised with higher average temperature and greater precipitation amount, with precipitation peak present in June (Table 1). Nevertheless, 2017 was a drier year, with higher average temperature and relative low precipitation amount during July-August, i.e. kernel filling period.

Table 1. Average monthly air temperatures and precipitation sums for the vegetative period (April–October) of 2017 and 2018 at Zemun Polje

| | Month | IV | V | VI | VII | VIII | IX | X | Aver./Σ |
|---|---|---|---|---|---|---|---|---|---|
| T aver. | 2017 | 12.4 | 18.6 | 24.4 | 25.5 | 25.8 | 18.4 | 13.3 | 19.8 |
| | 2018 | 18.0 | 21.7 | 22.7 | 23.6 | 25.7 | 19.8 | 15.9 | 21.1 |
| Σ precip. | 2017 | 47.1 | 49.2 | 39.0 | 26.7 | 23.7 | 36.6 | 62.0 | 284.3 |
| | 2018 | 24.6 | 39.0 | 150.1 | 61.9 | 44.0 | 16.9 | 20.8 | 357.3 |

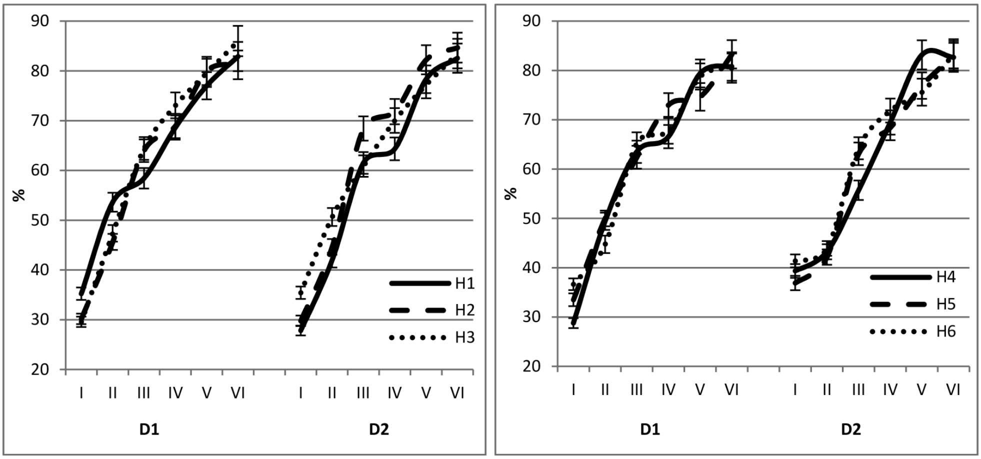
## Results and discussion

A significant difference in grain yield was observed between experimental years, as well as all interactions (Y×D, Y×H, D×H, Y×D×H). Nevertheless, the highest values of average grain yield were achieved by H3 at both densities, as well as H3 in 2017 and H5 in 2018. Moreover, higher average yields were achieved in D2 in 2018 and slightly lower in the same year in D1. In 2017, as the year with lesser precipitation amount, in both densities, grain yield was two times lower. Mandić et al. (2016) also concluded that differences between growing years are more prominent to variations of maize grain yield and yield parameters, than it is sowing density. High plant densities could negatively affect filling rate and grain yield of maize (Jia et al., 2018). Our results indicate slight and non-significant variations in grain yield between examined densities, except for H6, which had on average a 16% lower yield when it was grown at D2, in comparison to D1.

Table 2. Grain yield of six maize hybrids grown during 2017 and 2018, in two sowing densities: 59523 plants ha$^{-1}$ (D1) and 89286 plants ha$^{-1}$ (D2)

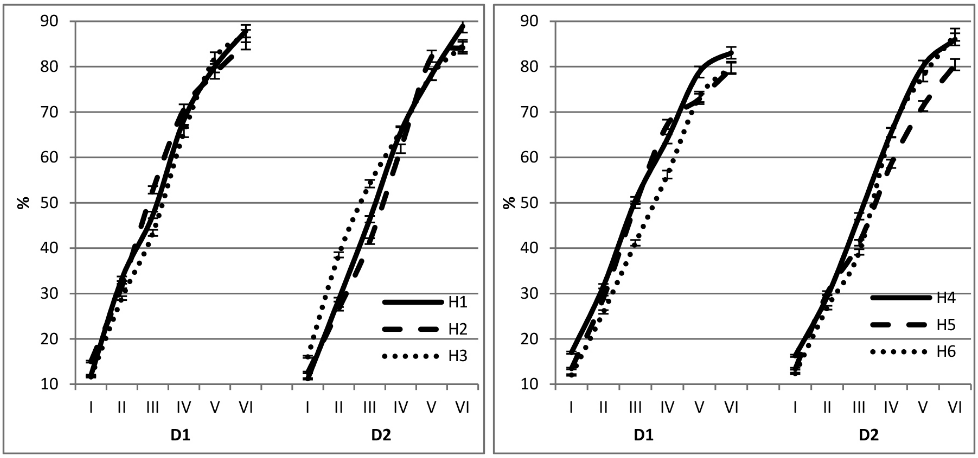
| | D 1 | | | D 2 | | | Year | | |
|---|---|---|---|---|---|---|---|---|---|
| Hybrid | 2017 | 2018 | Aver. | 2017 | 2018 | Aver. | 2017 | 2018 | Aver. |
| H1 | 6.64 | 8.21 | 7.43 | 6.07 | 8.74 | 7.40 | 6.35 | 8.47 | 7.41 |
| H2 | 5.49 | 8.82 | 7.15 | 4.48 | 10.00 | 7.24 | 4.99 | 9.41 | 7.20 |
| H3 | 6.42 | 9.54 | 7.98 | 5.69 | 10.41 | 8.05 | 6.06 | 9.97 | 8.01 |
| H4 | 6.82 | 7.93 | 7.37 | 4.43 | 10.14 | 7.29 | 5.63 | 9.03 | 7.33 |
| H5 | 5.08 | 9.60 | 7.34 | 3.16 | 11.41 | 7.29 | 4.12 | 10.50 | 7.31 |
| H6 | 5.21 | 10.44 | 7.82 | 4.13 | 9.03 | 6.58 | 4.67 | 9.73 | 7.20 |
| Aver. | 5.94 | 9.09 | 7.52 | 4.66 | 9.95 | 7.31 | 5.30 | 9.52 | |
| LSD 0.05 | Year | Dens. | Hyb. | Y×D | Y×H | D×H | Y×D×H | | |
| | 1.312 | 2.507 | 1.089 | 1.206 | 1.177 | 0.841 | 0.974 | | |

Grain filling is characterised by successive accumulation of assimilates from green parts (source) into kernels (sink) and further accumulation of starch, protein, oil and other components, characteristic for particular species and genotype. It is obvious that grain filling is not a continuous process and that it depends on growing conditions, including sowing density, as well as genotype. Based on data presented on Graph 1, it is obvious that some genotypes, like H3 have intensive accumulation of assimilates into grain, having steeper increase of shelling percentage, while the others, such as H1, H4 and H5 have slowing in shelling percentage, which is mainly present between phase III and IV. This trend is particularly underlined in D2, as well as phase V at hybrid H4. Chen et al. (2016) exhibited the presence of a great difference between newer and older maize hybrids in overall source-sink ratio, as well as kernel filling that reflects on kernel weight, indicating that newer ones have longer active filling period, together with higher kernel weight. This could be recognised particularly with H3, as more efficient in kernel weight rise (increased shelling percentage and grain yield).




Graph 1. Dynamics of shelling percentage of six maize hybrids (H1-H6), measured every 10 days (phase I to VI) from the starting point of 15 days after pollination (results present average of 2017 and 2018 ± SD)

Opposite to shelling percentage, DM accumulation in maize kernels is a more intensive process (Graph 2). DM accumulation also depends on the hybrid, where it is almost linear for H1 and H6, particularly when they are grown at higher density (D2). Some hybrids, like H4, H5 and H6, grown at lower density (D1), have lesser DM accumulation from phase V to VI, indicating slower assimilates accumulation and/or gradual moisture releasing from the grain. Gambín et al. (2007) highlighted the importance of the relationship between kernel mass accumulation and water loss during maize filling, indicating that maximum kernel volume was achieved by maximum in water content, which dropped the physiological maturity. They also noticed the presence of high variability among maize hybrids. Then again, Chen et al. (2015) emphasized that maize hybrids of newer generations can accumulate greater leaf biomass, in order to retain higher DM in leaves and afterward to replace it slower to kernels. This means that these hybrids have longer grain filling period (Chen et al., 2016) what gives them ability to achieve greater yield potential. This notice is in line with higher values of average grain yield obtained by the same hybrids at D1 density (Table 2). Slightly lower values of DM content and shelling percentage, obtained by H2 and H3 and in small degree by H1 at higher density (D2), are not closely tied to kernel weight, i.e. yield potential, as it was previously noticed by Eichenberger et al. (2014), but could be more like linked to sink-source relations.




Graph 2. Dynamics of dry matter of six maize hybrids (H1-H6), measured every 10 days (phase I to VI) from the starting point of 15 days after pollination (results present average of 2017 and 2018 ± SD)

## Conclusion

Present experimental data indicate that meteorological conditions, in regard to genotype and crop density, are the main factor that contributes to grain yield of variations of maize hybrids. H6, as a hybrid with a longer vegetative period, responded better, with increased grain yield when it was grown at D1. Nevertheless, H3 could be characterised as more efficient in kernel weight accumulation, having higher values of shelling percentage and grain yield. DM accumulation is mainly dependable on maturity group. Thus, hybrids from later groups (H4-H6) had lesser DM accumulation from phase V to VI (especially at D1) indicating slower assimilates accumulation and/or gradual moisture releasing from the grain. That means that a longer grain filling period, as the background of high yield achievement, is not closely related to kernel weight, as the main factor that contributes to yield potential. This is mainly underlined at hybrids from early maturity groups (H1-H3), particularly when they were grown at higher densities (D2), having faster DM accumulation, and possibly increased kernel weight, giving them advantage over hybrids from later groups.

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# Nalijevanje sjemena kukuruza u funkciji gustoće usjeva i genotipa

## Sažetak

Postojeći pokusni podaci govore kako su meteorološki uvjeti, s obzirom na genotip i gustoću usjeva, glavni faktor koji pridonosi varijabilnosti u prinosu zrna hibrida kukuruza. H6 je, kao hibrid s duljim vegetativnim razdobljem reagirao bolje s povećanim prinosom zrna kad je uzgojen pri D1. Ipak, H3 se može okarakterizirati kao efikasniji u nakupljanju mase zrna, s višim vrijednostima postotka krunjenja i prinosa zrna. Akumulacija suhe tvari uglavnom ovisi o skupini zriobe. Dakle, hibridi iz kasnijih grupa (H4-H6) imali su manju akumulaciju suhe tvari od faze V do VI (posebno pri D1), što ukazuje na sporije nakupljanje asimilata i/ili postupno oslobađanje vlage iz zrna. To znači da dulje razdoblje nalijevanja zrna, kao pozadina postignuća visokog prinosa, nije usko povezano s masom zrna. Razdoblje nalijevanja zrna glavni je faktor koji pridonosi potencijalu prinosa, što se uglavnom ističe kod hibrida iz skupina rane zriobe (H1-H3), osobito kada su uzgajani pri većim gustoćama (D2), što im daje prednost u odnosu na hibride iz kasnijih grupa.

**Ključne riječi:** hibridi kukuruza, prinos zrna, postotak krunjenja, suha tvar