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SUITABILITY OF THE SELECTED LOCAL MAIZE HYBRIDS FOR SILAGE PRODUCTION

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Abstract: The main goal of this study was to observe the properties of fifteen different genotypes of maize hybrids from Serbia in order to determine their suitability for the production of high-quality silage for ruminant feed. The research was conducted in a two-year field experiment at the location of the Maize Research Institute in Zemun Polje, Serbia, and the laboratory analyses included yield structure of the investigated maize hybrids, assessment of the lignocellulosic fiber composition, as well as the *in vitro* dry matter digestibility of the whole plant samples. All maize hybrids have shown good quality traits that are a prerequisite for the production of high-quality silage.

Key words: maize hybrids, lignocellulosic fibres, *in vitro* dry matter digestibility, silage

Introduction

The total 2021 world production of maize (*Zea mays* L.), one of the most important cultivated crops, amounted to 1125.03 million metric tons (Shahbandeh, 2021). The history of maize hybrids started way back in 1918 when D. F. Jones created the first double-cross inbred maize that was later introduced experimentally in 1924 by H. A. Wallace (Sutch, 2011). Furthermore, first attempts of ensiling maize for forage were conducted in late nineteenth century, nevertheless, the extensive use of silage maize in cattle diet began decades later, after flint x dent hybrids tolerant to low temperatures were developed (Barrière, 2018). Silage maize is, at the present time, among the most important annual forage crops used worldwide as a main source of energy in ruminant nutrition. It is not difficult to produce and store, and can be consumed daily throughout the year (Barrière, 2018). The breeding of silage maize has lately been especially focused on designing hybrids with improved whole plant yield, nutritive value, as well as agronomic traits that provide better ensiling quality (Terzić, 2020). Studies have shown that the *in vitro* digestibility of forages decreases as the maturity of the plant increases after the optimal physiological stage (Johnson, 1999).

The main aim of this study was to investigate some of the most important quality parameters of the whole plant of fifteen maize hybrids harvested at the

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physiological maturity stage, in order to determine their suitability for the preparation of silage for ruminant nutrition.

Material and methods

Fifteen dent maize hybrids of different genetic backgrounds and maturity groups created at the Maize Research Institute Zemun Polje were tested in the field experiments in two consecutive years (2019 and 2020).

The field trial was set up in the experimental field of the Maize Research Institute, Zemun Polje, Belgrade, Serbia (44°52´N, 20°19´E, 81m asl) according to the randomized complete block design with two replicates. The elementary plot size amounted to 21 m2 and the sowing density was 60,000 plants per hectare. Plants from each replication were harvested from two inner rows of the experimental plot (area of 7 m2), and five average plants from each replication were singled out for further testing. The plants were harvested in the full waxy phase of maize maturity, i.e. between one-quarter and one-half milk-line kernel stages (whole plant dry matter content approximately 30 - 35%).

Samples of the whole plants, plants without ears, and ears were first chopped and then dried at 60˚C for 48 h in a forced-air drying oven until constant moisture was reached and ground afterward in the mill with 1-mm mesh sieves.

The total dry matter content content was analyzed by drying the samples at 105˚C in a laboratory drying oven for 12 h, until a constant mass was reached. The fiber analysis included determination of lignocellulosic constituents: neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL), hemicellulose and cellulose, according the detergent method by Van Soest (1980), with some modification (Mertens, 1992). The *in vitro* dry matter digestibility of the whole plant samples was determined by the enzymatic method by Aufrere (2007). The results are shown as the percentage per dry matter (d.m.). The data were analyzed in Minitab19 Statistical Software using one-way ANOVA analysis of variance with Fisher's LSD test, and reported as a mean ± standard deviation of at least three repetitions. Differences between the means with probability $P<0.05$ were accepted as statistically significant. The level of confidence was set at 95%.

Results and discussion

The results shown in Table 1 represent the yield structure of the fifteen investigated maize hybrids. Dry matter content of the harvested maize plants ranged from 33.89% (ZP 666) to 41.34% (ZP 747), the highest whole plant dry matter yield (23.25 t ha^{-1}) was achieved by hybrid ZP 749, and the highest ear dry matter yield was determined with hybrid ZP 745 (11.30 t ha^{-1}).

Tabela 1. Struktura prinosa ispitivanih hibrida kukuruza

Table 1. Yield structure of the investigated maize hybrids

Hibrid *Hybrid*	Sadržaj suve materije cele biljke (%) *Whole plant dry matter content (%)*	Prinos suve materije cele biljke (t ha^{-1}) *Whole plant dry matter yield (t ha^{-1})*	Prinos suve materije klipa (t ha^{-1}) *Ear dry matter yield (t ha^{-1})*
ZP 173/8	34.17±2.11^{e}	15.20±0.14^{f}	7.90±0.42^{d}
ZP 377	34.04±2.79^{e}	16.70±1.41^{ef}	8.80±0.85^{cd}
ZP 440	34.72±0.01^{e}	19.35±1.06^{cde}	9.50±0.00^{abcd}
ZP 444	36.29±0.51^{cde}	19.40±0.71^{cde}	9.75±0.64^{abcd}
ZP 560	37.13±0.38^{bcde}	19.90±1.98^{cd}	9.85±1.34^{abc}
ZP 600	38.96±2.49^{abcd}	20.45±0.64^{bcd}	10.60±0.71^{abc}
ZP 606	36.20±1.97^{de}	20.60±0.71^{abcd}	10.65±0.78^{abc}
ZP 623	35.60±2.42^{de}	23.20±2.40^{ab}	10.65±1.20^{abc}
ZP 643	36.36±1.44^{cde}	20.10±0.28^{cd}	9.20±0.28^{bcd}
ZP 666	33.89±0.76^{e}	18.75±1.77^{de}	9.85±1.48^{abc}
ZP 667	37.13±0.57^{bcde}	21.65±0.21^{abc}	10.60±0.28^{abc}
ZP 679	37.26±0.33^{abcde}	20.85±0.64^{abcd}	11.00±0.42^{ab}
ZP 745	40.42±2.69^{abc}	22.10±1.98^{abc}	11.30±1.56^{a}
ZP 747	41.34±4.36^{a}	21.40±1.27^{abcd}	10.95±0.92^{ab}
ZP 749	40.64±0.85^{ab}	23.25±1.34^{a}	11.15±0.07^{a}

Results are given as mean ± standard deviation. Means that do not share a letter are significantly different.

Tabela 2. Sadržaj lignoceluloznih vlakana cele biljke kukuruza

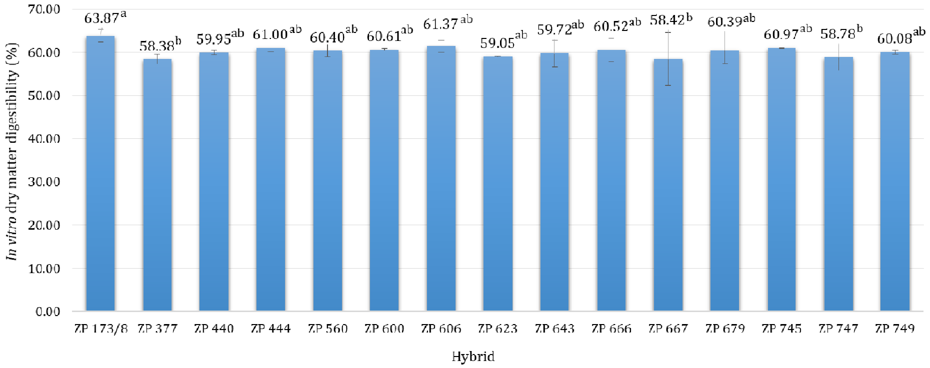
Table 2. Content of the lignocellulosic fibers of the whole maize plant

Hibrid *Hybrid*	NDF (%) *NDF (%)*	ADF (%) *ADF (%)*	ADL (%) *ADL (%)*	Celuloza (%) *Cellulose (%)*	Hemiceluloza (%) *Hemicellulose (%)*
ZP 173/8	46.09±2.54^{a}	23.71±1.24^{bc}	3.32±0.05^{b}	21.35±0.17^{abc}	21.43±2.66^{ab}
ZP 377	48.58±2.18^{a}	25.89±0.65^{abc}	3.41±0.17^{b}	22.96±1.15^{ab}	22.22±0.86^{ab}
ZP 440	46.53±2.90^{a}	24.88±0.05^{abc}	3.77±0.08^{ab}	22.40±1.80^{abc}	20.37±1.03^{ab}
ZP 444	47.90±3.15^{a}	25.25±0.09^{abc}	3.68±0.10^{ab}	23.33±2.11^{a}	21.09±0.86^{ab}
ZP 560	44.15±2.19^{a}	23.73±1.53^{bc}	3.29±0.37^{b}	20.61±0.93^{abc}	20.25±0.89^{ab}
ZP 600	43.49±1.49^{a}	23.85±0.69^{abc}	3.58±0.42^{ab}	19.78±0.98^{c}	20.15±0.10^{b}
ZP 606	46.30±0.67^{a}	24.98±0.71^{abc}	3.59±0.18^{ab}	20.55±0.28^{abc}	22.16±0.19^{ab}
ZP 623	46.64±0.42^{a}	24.37±1.32^{abc}	3.61±0.01^{ab}	20.45±0.83^{abc}	22.59±1.29^{ab}
ZP 643	46.84±0.78^{a}	24.11±0.57^{abc}	3.75±0.23^{ab}	21.59±1.40^{abc}	21.50±1.95^{ab}
ZP 666	47.04±4.41^{a}	25.45±1.56^{abc}	3.60±0.40^{ab}	20.92±2.47^{abc}	22.52±1.53^{ab}
ZP 667	49.06±4.96^{a}	25.97±1.57^{ab}	3.83±0.54^{ab}	21.79±1.53^{abc}	23.45±2.88^{a}
ZP 679	47.31±3.80^{a}	26.29±1.86^{a}	4.19±0.53^{a}	21.35±2.39^{abc}	21.78±0.88^{ab}
ZP 745	44.81±1.17^{a}	23.71±0.79^{bc}	3.35±0.11^{b}	20.83±0.00^{abc}	20.63±1.06^{ab}
ZP 747	44.15±4.04^{a}	23.44±2.06^{c}	3.36±0.74^{b}	20.16±1.20^{bc}	20.66±2.07^{ab}
ZP 749	46.14±0.34^{a}	24.16±0.59^{abc}	3.52±0.03^{ab}	20.77±0.80^{abc}	21.86±1.11^{ab}

Results are given as mean ± standard deviation. Means that do not share a letter are significantly different.

The contents of the individual lignocellulosic fibers of the whole maize plant, considered among the most important indicators of the nutritional value and technological quality of maize biomass intended for ruminant nutrition, are shown in Table 2. The NDF content ranged from 43.49% (ZP 600) 49.06% (ZP 667). The NDF potion of the lignocellulosic complex consists of cell wall material including cellulose, hemicellulose, lignin and silica. Lignin is is completely indigestible and it reduces the availability of cellulose and hemicellulose in the silage. The NDF fiber is required by ruminant animals even though it can be a negative indicator of silage quality. With the progressing of the maize plant maturity, the NDF share increases and animals tend to consume less forage. A study by Bittman (2004) has shown that the content of ADF, mainly consisting of cellulose, lignin and inorganic silica, is negatively correlated with digestibility of feed.

Dry matter digestibility is one of the most important parameters of silage maize. The *in vitro* dry matter digestibility of parts of the maize plant depends on the hybrid, therefore the quality of maize hybrids is determined by the morphology and structure of the plant (Bertoia, 2014). The percentage of the determined *in vitro* dry matter digestibility of the investigated hybrids is shown in Graph 1.



Graf 1. *In vitro* svarljivost suve materije cele biljke hibrida kukuruza (%)
Graph 1. In vitro dry matter digestibility of the maize hybrids whole plant (%)

Hybrid ZP 173/8 had the highest *in vitro* dry matter digestibility (63.87%), followed by ZP 606 (61.37%), and ZP 444 (61.00%). These findings are in accordance with previous studies (Nikolić, 2020). A number of previous studies reported that the digestibility of the stover portion (plant without ear) of maize silage decreases significantly with advanced maturity from 3 weeks before to 5 weeks after physiological maturity (Johnson, 1999). Furthermore, an increasing share of grain as the maize plant matures blurs the correlation between plant maturity and digestibility of whole plant maize silage.

As a strategy in future breeding programs for improved silage maize hybrids, more attention should be directed toward creating genotypes that maintain high *in* *vitro* dry matter digestibility while increasing grain content at advanced stages of maturity.

Conclusion

Maize hybrids investigated in this two-year study have shown traits required for high-quality silage production. Apart from a good dry matter yield structure, optimal lignocellulosic fibers content and sufficient dry matter digestibility are properties that make the investigated maize hybrids suitable for ruminant feed production. Hybrid ZP 173/8 had the highest *in vitro* dry matter digestibility (63.87%), followed by ZP 606 (61.37%), and ZP 444 (61.00%). The results are implying that the agronomic traits, chemical composition, as well as other genetically predisposed properties of maize hybrids, are crucial for their end-use.

These findings can be of great importance for future breeding programs directed toward creating new and improved silage maize hybrids.

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