

Productivity of corn hybrids in the North-eastern upper volga region, Russia

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ABSTRACT

This paper presents data on characteristics of growth, development, and yield formation of 34 corn hybrids obtained in 2019 at the "Skopa" LLC, the Sonkovsky District of the Tver Region (Russia). Four groups of hybrids with different productivity levels were identified. Average values of corncob and herbage yield and moisture-free herbage yield were the following: first group – six hybrids (17.6%), 79.48 t/ha and 18.55 t/ha; second group – six hybrids (17.6%), 58.97 t/ha and 11.1 t/ha; third group – 13 hybrids (38.2%), 41.1 t/ha and 9.4 t/ha; fourth group – nine hybrids (26.1%), 31.2 t/ha and 7.3 t/ha. The hybrids LG 30189 (Lima Grain, France) and Zeta 110 S (LABOULET, France) were the most productive: corncob and herbage yields were 87.5 t/ha and 91.8 t/ha, respectively, and moisture-free herbage yields were 21.39 t/ha and 18.52 t/ha, respectively. Of the Russian hybrids, Kaskad 195 SV (Rossosh gibrad), ZP 190 SV, and Voronezh 158 (Zolotoy pochatok) were the most productive: corncob and herbage yields were 44.8-49.0 t/ha, and moisture-free herbage yields were 9.10-10.7 t/ha.

Key words: Corn, Hybrids, Growth and development, Yield capacity, Yield class.

Introduction

Corn (*Zea máys* L.) is an annual monocotyledonous diclinous monoecious herbaceous plant of the Poaceae family; the type of photosynthesis is C4 (Posypanov *et al.*, 2015; Kuznetsov and Dmitrieva, 2006; Shults, 2016). It is a culture of multilateral use (Shults, 2016; Paulsen *et al.*, 2019; Hussein, 2020). The biological characteristics of this culture and its modern hybrids allow for the formation of high yields even in the northern areas of corn cultivation, which includes the Tver Region of Russia (Usanova and Migulev, 2019).

A large role in obtaining high productivity belongs to the variety (hybrid) Usanova *et al.*, 2018; Torikov *et al.*, 2017; Lardner *et al.*, 2017). The difference in the studied hybrids yield capacity in several

experiments reached 200-300% and more. In recent years, hybrids of non-Russian breeding have become widespread in the agricultural market (Usanova *et al.*, 2018). Agricultural commodity producers have to solve the difficult task of choosing the best hybrids that are more adapted to specific agro-climatic conditions. This requires scientific research.

The study aimed to determine the most productive hybrids which provide 60-80 t/ha of herbage and corncobs with milky-wax grain ripeness in the Upper Volga Region.

Materials and Methods

The studies were conducted in 2019 on well-cultivated sod-podzol soil that formed on covering silt, in the crop rotation of the "Skopa" LLC in the

Sonkovsky District of the Tver Region. Thirty-four corn hybrids were studied (Table 1). In the experiment, the preceding crop before corn was spring wheat (a link in the potato – barley – spring wheat crop rotation). 90 t/ha of liquid manure was introduced before corn sowing. Nitrogen, phosphorus, and potassium as needed for the planned yield (80 t/ha) that were lacking in manure were added using potassium fertilizer (Kalimag, 1 c/ha), ammonium nitrate phosphate fertilizer (50 kg/ha), and liquid complex fertilizer (30 kg/ha) applied in rows and liquid sarbamide-ammonia mixture (CAM) fertilizer (1 c/ha) as a top dressing. The main tillage was conducted in spring by deep disking (16-18 cm) using the DV-1500 disk stubble plough. Cultivation with harrowing and leveling was carried out before sowing. Corn was sown on May 15, 2019 using Rhythm⁻¹ MT seeding machine with an 80 thousand seeds/ha seeding rate. The care included treatment of the crops with Mays Ter Power herbicide (1.35 l/ha) and CAM top-dressing. Inter-row tilling was not performed, the effectiveness of the use of herbicides was high. The harvest was recorded on September 25, 2019.

The degree of density, field germination rate, plant viability, plant height, yield structure and quality, yield capacity, and dry matter yield per hectare were determined according to the methodology of Z.I. Usanova (2015).

The weather conditions in 2019 were characterized by higher temperatures in May and the first

half of June, combined with moisture deficiency and cold weather in July (air temperature was 2.7 °C lower than normal) and the first 10 days of August (air temperature was 5.2 °C lower than normal) with total precipitation lower than normal by 143 and 364%, respectively. In general, during the period from sowing to harvesting, accumulated temperatures was 1,871.6 °C (23.8 °C lower than normal) and total precipitation was 344 mm (120% of the normal). Hydrothermal index (according to Selyaninov) was 1.82 in 2019 (normal value is 1.50). During the grain filling stage, the heat supply and moisture supply of corn crops were satisfactory.

According to literature, cold-resistant hybrids have been created that stop their growth at the temperatures below 6 °C. Therefore, the temperatures above 6 °C is considered as effective for the growth and development of corn (Jager, 2003; Privalov *et al.*, 2018).

Results

The results showed that, out of 34 studied hybrids, 14 reached milk-wax ripeness (41.2%) and six reached milk ripeness (17.6%). Grain did not reach the milky state (41.2%) in other hybrids. Riper corn-cobs with a well-formed top were obtained from the Zeta 115 S, LG 30189, LG 30179, and Clifton hybrids with FAO values from 115 to 180. Hybrids differed from each other in sprouting density and field germination rate. Higher sprouting density and field

Table 1. Characteristics of the studied corn hybrids.

Hybrids	FAO	Origin	Hybrids	FAO	Origin
MAS 18L	200	Mas Seeds (France)	Competence	200	KWS (Germany)
MAS 14G	190		Cromwell	180	
MAS 10A	160		Corifey	190	
MAS 15?	200	LABOULET (France)	Clifton	175	Feed factory "Zolotoy pochatok" LLC (Russia)
Zeta 110 S	110		SILVINIO	220	
Zeta 140 S	140		ZP 165 MV	160	
Elamia	210		ZP 153 MV	150	
Zeta 115 S	115		ZP 200 SV	200	
Silicia	170		ZP 190 SV	190	
Zeta 105 S	95		Kaskad 195 SV	190	
LG 2195	190		Lima	Kaskad 166 ASV	
Nikita	260	Grain (France)	Voronezhskiy 158	160	"Rossosh Gibrid" LLC (Russia)
LG 30179	170		Kaskad 195 SV	190	
LG 30189	180		Voronezhskiy 160	160	
LG 30215	200		Voronezhskiy 158	160	
LG 31233	230		Kaskad 166 SV	170	
LG 31235	240		Voronezhskiy 175 ASV	180	

germination rate were observed for the Zeta 110 S and Silvinio hybrids (75.1 thousand units/ha and 93.9%). Six hybrids (MAS 14G, Sicily, LG 30189, Competence, Clifton, Corifey) had sprouting density of 64.3-67.9 thousand units/ha and field germination rate of 80.4-84.9%. For other hybrids, sprouting density and field germination rate were lower and ranged from 42.9 to 60.8 thousand units/ha and from 53.6 to 76%, respectively. Degree of density had a significant impact on yield capacity.

The development of plants during the first month of the vegetation period occurred differently, which affected the growth of plants in height and leaf formation. On the 28-30th day after sprouting (June 27, 2019), the height of the plants ranged from 55 cm (Competence) to 86.3 cm (Zeta 110 S), and the number of leaves was from 8.0 (MAS 18L) to 11.0 (ZP 165 MV and Elamia).

Biological differences between hybrids and their adaptive features affected the herbage yield. Differences in these characteristics allowed us to distin-

guish four groups of hybrids (Tables 2-4). The first group had the highest corncob and herbage yield (from 91.8 to 71.0 t/ha), mainly with corncobs with milk and milk-wax ripeness of grain. The second group had an average corncob and herbage yield (66.4-50.5 t/ha), grain in corncobs did not reach milk ripeness. The third group had low corncob and herbage yield (48.0-40.1 t/ha), mainly with poorly-formed corncobs. The fourth group had low corncob and herbage yield (39.4-31.2 t/ha), with corncob with milk-wax and wax ripeness and partially with grain in watery state. The first and second groups included six hybrids (17.6% each), the third group included 13 hybrids (38.2%), the fourth group included the remaining nine hybrids (26.6%), which are not shown in Tables 2-4.

The hybrids Zeta 110 S and LG 30189 were more productive with corncob and herbage yields of 91.8 t/ha and 87.5 t/ha, respectively, and moisture-free herbage yields of 18.9 t/ha and 21.39 t/ha, respectively. The dry matter content in the cob differed in

Table 2. The group of hybrids with herbage yield of 70.0 t/ha and higher.

Hybrids	FAO	Origin	Yield, t/ha		Dry solids content, %			Moisture-free herbage yield, t/ha
			herbage	corncoobs	in stalks and leaves	in corncoobs	in herbage	
Zeta 110 S	110	LABOULET (France)	91.8	16.3	20.0	20.7	20.1	18.5
LG 30189	180	LimaGrain (France)	87.5	24.3	24.3	24.8	24.4	21.3
LG 31233	230		79.1	24.5	19.8	17.2	19.0	15.0
LG 2195	190		74.5	15.8	19.2	22.6	19.9	14.9
LG 30179	170		73.0	20.2	22.8	26.1	23.7	17.3
MAS 15T	200		71.0	19.6	18.7	21.5	19.5	13.8
	Group average		79.5	20.2	20.8	22.1	21.1	16.8

Table 3. The group of hybrids with herbage yield of 50.0-70.0 t/ha.

Hybrids	FAO	Origin	Yield, t/ha		Dry solids content, %			Moisture-free herbage yield, t/ha
			herbage	corncoobs	in stalks and leaves	in corncoobs	in herbage	
MAS 14G	190	Mas Seeds (France)	57.7	15.4	17.8	18.2	17.9	10.3
Silicia	170	LABOULET (France)	61.8	18.4	23.6	9.6	19.4	12.0
Elamia	210		50.5	14.2	18.1	24.8	20.0	10.1
SILVINIO	220	KWS (Germany)	66.4	12.2	23.7	15.0	22.1	14.7
Competence	200		62.2	22.3	23.0	9.9	18.3	11.4
ZP 200 SV	200	Feed factory "Zolotoy pochatok" LLC (Russia)	55.2	13.5	15.1	12.9	14.5	8.0
	Group average		59.0	16.0	20.2	15.1	18.7	11.1

Table 4. The group of hybrids with herbage yield of 40.0-50.0 t/ha.

Hybrids	FAO	Origin	Yield, t/ha		Dry solids content, %			Moisture-free herbage yield t/ha
			herbage	corncobs	in stalks and leaves	in corncobs	in herbage	
MAS 18L	200	Mas Seeds (France)	42.8	9.9	23.6	22.3	23.3	10.0
Zeta 105 S	95	LABOULET (France)	43.0	9.8	20.7	16.5	19.7	8.5
LG 30215	200	Lima Grain (France)	48.0	6.2	22.6	12.7	21.3	10.2
LG 31235	240		46.2	18.2	22.9	25.0	23.7	10.9
Nikita	260		40.3	16.4	22.8	17.8	20.8	8.4
Corifey	190	KWS (Germany)	40.0	16.2	23.4	32.9	27.2	10.9
ZP 190 SV	190	Feed factory	49.0	8.5	17.4	28.4	19.3	9.5
ZP 165 MV	160	"Zolotoy pochatok"	48.3	11.4	18.6	11.3	16.9	8.1
Voronezhskiy 158	160	LLC (Russia)	44.8	11.6	20.6	19.9	20.4	9.1
Kaskad 166 ASV	160		44.7	12.8	23.9	20.3	22.9	10.2
Kaskad 166 SV	170	"Rossosh Gibril"	45.0	10.1	24.7	20.6	23.8	10.7
Voronezhskiy 158	160	LLC (Russia)	42.1	11.3	23.0	10.6	19.7	8.3
Kaskad 195 SV	190		40.1	9.8	19.0	21.2	19.6	7.8
Group average			44.2	11.7	21.8	20.0	21.4	9.4

these hybrids (20.7% in Zeta 110S and 24.8% in LG 30189), which can be explained by the fact that corncobs in the Zeta 110S hybrid were filled with grain up to half the length of the cob.

Due to the different corn cob ripeness, the dry solids content in them in the studied hybrids ranged from 6.4% (Cromwell) to 32.9% (Corifey) (Figure 1). The yield of dry solids depended both on its content in herbage and on the crop yield. Hybrids of the first productivity group formed the highest solids yield (18.55 t/ha) and the fourth group formed the lowest solids yield (7.3 t/ha).

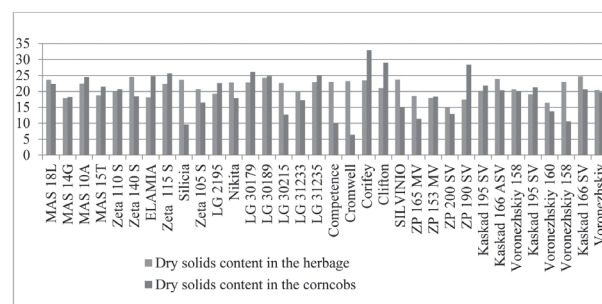


Fig 1. Dry solids content in the herbage and corncobs.

Among hybrids of Russian origin, the following had the highest corn cob and herbage yield and moisture-free herbage yield: Kaskad 166 SV ("Rossosh Hybrid"), ZP 190 SV ("Zolotoy pochatok"), and Voronezhskiy 158 ("Zolotoy pochatok"). The corn cob and herbage yields of these hybrids were 45.0 t/ha, 49.0 t/ha, and 44.8 t/ha,

respectively; the moisture-free herbage yields were 10.7 t/ha, 9.5 t/ha, and 9.1 t/ha, respectively. The productivity of Russian hybrids was 2.0 times lower than the productivity of the best hybrids of non-Russian production.

Conclusion

In the North-Eastern Tver Region, accumulated temperatures (higher than 10 °C) were 1,845°C and the amount of heat was 8.0 °C below the ecological optimum for corn during the formation of reproductive organs, optimal growth, and flowering, and it was 8-9 °C below the ecological optimum during maturity. In these conditions, corncobs in 14 hybrids (41.2%) reached milk-wax ripeness of grain. The ripest well-formed corncobs were obtained from the Zeta 115 S, LG 30189, LG 30179, and Clifton hybrids with FAO values from 115 to 180.

Hybrids differed in field germination rate and degree of density at the time of harvest, which affected productivity. Eight hybrids (23.5%) had a higher field germination rate (80.4-93.9%), higher degree of density (64.3-75.1 thousand units/ha), and higher productivity (50.5-91.8 t/ha of herbage).

The following hybrids had the highest dry matter content in the corncobs: Corifey (32.9%), Clifton (28.9%), ZP 190 SV (28.4%), LG 30179 (26.1%), Zeta 115 S (25.6%), LG 30189 and Elamia (24.8%), and MAS 10A (24.4%).

Four groups of hybrids with different productivity levels were identified. Average values of corncob and herbage yield and moisture-free herbage yield were the following: first group – six hybrids (17.6%), 79.48 t/ha and 18.55 t/ha; second group – six hybrids (17.6%), 58.97 t/ha and 11.1 t/ha; third group – 13 hybrids (38.2%), 41.1 t/ha and 9.4 t/ha; fourth group – nine hybrids (26.1%), 31.2 t/ha and 7.3 t/ha. Hybrids LG 30189 (Lima Grain, France) and Zeta 110 S (LABOULET, France) were the most productive: corncob and herbage yields were 87.5 t/ha and 91.8 t/ha, respectively, and moisture-free herbage yields were 21.39 t/ha and 18.52 t/ha, respectively. The highest yield and herbage quality were obtained from the LG 30189 hybrid (Lima Grain, France).

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