Potential of corn hybrids of universal use

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Abstract. This article presents the results of studies of corn hybrids of a universal direction. Their responsiveness to the application of mineral fertilizers, incrustation of seeds with biological preparations, and foliar fertilizing with zinc-containing preparations is shown. NK background at 60 t/ha + foliar application of Zn ensures maximum grain yield and better disclosure of the grain potential of hybrids of universal use (61.3 c/ha for the Nur hybrid, 67.41 c/ha for the Bilyar-160, 77, 39 c/ha for the Voronezhsky-279 hybrid). Early ripe hybrids in the conditions of the Fore- Kama region of the Republic of Tatarstan form stable grain yields due to lower pre-harvest moisture. Mid-early hybrids of universal use respond well to the application of mineral fertilizers and foliar feeding with zinc-containing preparations, providing high grain yields.

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1 Introduction

Corn has a huge potential to produce high yields of grain. Under production conditions, the gross harvest of corn grain is 1.5 times higher than winter wheat. Also, in comparison with other crops of the grain wedge, corn performs better in the conditions of more frequent spring-summer droughts [1]. It is the scientific approach when choosing a hybrid, precisely adjusted dates and seeding rates that minimizes the negative impact of dry periods of vegetation [2]. Therefore, a hybrid selected taking into account the soil and climatic conditions of the region, with the full disclosure of the genetic potential, is able to provide an increase in yield up to 40% [3].

Mineral fertilizers play an important role in the life of corn. The provision of mineral nutrition activates the growth of corn supporting roots, which increases stress resistance [4]. The dimensions of the leaf surface depend on nitrogen nutrition [5]. The introduction of macronutrients increases the photosynthetic potential of maize leaves [6]. And most importantly, changing the conditions of mineral nutrition increases the yield of corn, and single doses of mineral fertilizers provide a net income, the absolute value of which increases with the doses of their application [7].

Foliar fertilizing with microelements in crops of any agricultural crops has been popularized on a global scale [8, 9, 10]. On corn, foliar feeding is carried out starting from the 3-leaf phase. The positive effect is especially noticeable from zinc-containing preparations, since corn is a sensitive crop in relation to zinc, which, being part of enzymes, ensures the normal course of corn respiration processes [11].

The purpose of the research is to show the grain potential of corn hybrids of universal use when cultivated for fodder purposes.

2 Materials and methods

The studies were carried out in 2019-2021. on typical gray forest soils with a humus content of 3.8% according to Tyurin, mobile phosphorus of 288 mg/kg and exchangeable potassium of 153 mg/kg of soil (according to Kirsanov). The reaction of the soil environment was close to neutral (pH 6.6).

Sowing was carried out on May 22 in 2019, on May 15 in 2020 and on May 14 in 2021 with the Vesna-8 (Favorit) seeder with a row spacing of 70 cm and a seeding rate of 85 thousand pieces/ha of germinating seeds. The calculated norms of fertilizers were applied under pre-sowing cultivation in a scattered way (ammonium nitrate + potassium sulphate). To obtain the planned yield of 50 t/ha of green mass of corn, 157 kg of AI/ha of nitrogen and 267 kg of AI/ha of potassium were introduced. For the planned yield of 60 t/ha, 207 kg a.i./ha of nitrogen and 357 kg a.i./ha of potassium were applied. Before sowing, the seeds of individual variants were treated with the biopreparation GSN-2004 (0.5 l/t). This is an immunostimulant, an anti-stress preparation from enzymes of natural origin, which includes amino acids, humic acids. For foliar feeding, the drug Batr Zn (1 l/ha) was used in the phase of 5-6 leaves. Batr Zn is a microfertilizer with organic acids (succinic, citric, ascorbic) and 5% zinc in chelated form. Two early ripe hybrids Nur (FAO 150) and Bilyar-160 (FAO 160) and a mid-early hybrid Voronezhsky-279 (FAO 290) were sown. The studied hybrids, according to the recommendations of the authors, belong to hybrids of universal use. Two-factor field experience was laid. The first factor is hybrids. The second factor is nutrient backgrounds: 1) without fertilizers (control), 2) NK for 50 t/ha, 3) NK for 50 t/ha + foliar feeding, 4) NK for 60 t/ha, 5) NK for 60 t / ha + foliar application, 6) GSN-2004 incrustation, 7) GSN-2004 incrustation + foliar application.

During the research, the following methods were used:
- the yield in field experiments was taken into account on test plots (14.3 m) and at the same time the moisture content of corn grain was determined using a moisture meter. The recalculation of the yield of the studied options was carried out according to the basic moisture content of corn grain of 15%;
- height of the plant was measured in three accounting phases of corn development in two non-adjacent repetitions in five equidistant places of the plot;
- biometric analysis of corn cobs included measuring the length of the cob, the length of the unfinished part of the cob, the number of rows of grains in the cob, the number of grains in a row, the grain content, the weight of the cob, the weight of the grain from the cob, the yield of grain from the cob, the weight of 1000 seeds;
- statistical processing of the results of the experiment was carried out by the method of dispersion analysis.

3 Results and discussion

When conducting research to study the effect of nutritional backgrounds on the nutritional quality of corn hybrids of universal use, the grain potential of these hybrids was also taken into account. The analysis was done on average over three years of research. When growing corn for grain, it is important to form a vigorous plant with a strong, lodging-resistant stem in order to be able to keep the cob in time for the right harvest. The studied hybrids during the growing season form quite powerful plants (Table 1). Already by the phase of 7-8 leaves, the positive effect of nutrition backgrounds on the linear growth of plants became noticeable. If in the control plant height was from 76.5 to 79.3 cm, then the application of only mineral fertilizers increased the plants by 8-14% and 14-25% (by 8.3 cm and 15.3 cm).

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Carrying out only incrustation with GSN-2004 increases the growth of hybrids in height by 15 percent. Adding additional foliar feeding to each of the nutritional backgrounds increases the plant height by 4 cm (NK at 50 t/ha + foliar feeding), by 1 cm (NK at 60 t/ha + foliar feeding) and by 0.7 cm (encrustation GSN-2004 + foliar feeding).

The maximum height of plants in the heading phase was on the NK variant at 60 t/ha + foliar feeding for all the studied hybrids. The Nur hybrid had the highest value of 175.4 cm.

In the phase of milky ripeness, the grains of the plant reached the maximum values of linear growth in height. The mid-early hybrid Voronezhsky-279 in the control reached 194.5 cm. This is the highest value in this variant. The application of nitrogen-potassium fertilizers against the calculated background of NK by 50 t/ha increased the height of plants by 5-10%, compared with the control. And against the background of NK by 60 t/ha by 16-30%. During incrustation, the plant height was 171.4 cm for the Nur hybrid, 177.0 cm for the Bilyar-160 hybrid, and 213.4 cm for the Voronezh-279 hybrid. Carrying out additional foliar feeding in the phase of 5-6 leaves with a zinc-containing preparation provided an increase in plant height by 2.3% against the background of NK by 50 t/ha + foliar feeding, by 3.4% against the background of NK by 60 t/ha + foliar feeding, and by 2.8% on the GSN-2004 encrustation + foliar application. On all backgrounds of nutrition, the Voronezhsky-279 hybrid formed taller plants, in comparison with early-ripening hybrids.

Table 1. Average plant height for 2019–2021, cm.

Food backgrounds	Hybrids	Development phase		
		7-8 leaves	Balayage	Milky ripeness
Without fertilizer (control)	Bilyar -160	79.3	143.1	157.2
	Voronezhskiy -279	76.5	127.4	194.5
	Nur	76.6	143.1	152.4
NK per 50 t/ha	Bilyar-160	87.4	146.0	170.5
	Voronezhskiy -279	82.7	140.0	203.6
	Nur	87.2	154.5	167.3
NK per 50 t/ha + foliar feeding	Bilyar -160	90.6	152.1	173.9
	Voronezhskiy -279	86.8	156.7	206.4
	Nur	91.9	161.9	173.2
NK per 60 t/ha	Bilyar -160	94.9	160.6	184.0
	Voronezhskiy -279	87.3	168.4	225.7
	Nur	96.1	172.3	197.1
NK per 60 t/ha + foliar feeding	Bilyar -160	96.8	164.8	189.5
	Voronezhskiy -279	88.5	173.6	233.4
	Nur	96.2	175.4	204.4
Inlay GSN-2004	Bilyar -160	93.9	148.8	177.0
	Voronezhskiy -279	85.6	147.8	213.4
	Nur	87.8	160.6	171.4
Inlay GSN-2004 + foliar feeding	Bilyar -160	94.3	152.6	181.1
	Voronezhskiy -279	86.6	150.0	219.7
	Nur	88.6	168.6	176.7

The combined use of incrustation and foliar application produces plants similar to the NK variant at 50 t/ha + foliar application.

The biometric indicators of corn had a close relationship with nutritional backgrounds. Some indicators depended on the characteristics of the hybrid (Tables 2, 3). The length of the cob strongly correlated with nutritional conditions. If in the control the length of the cobs of the studied hybrids was from 15.6 to 18.0 cm, then when the calculated norms of mineral fertilizers were applied, the length of the cobs became 17.5 to 22.0 cm.

Encrustation GSN-2004 + foliar feeding Batr Zn 19.1 cm, in Voronezh-279 and Nur hybrids against the background of NK at 60 t/ha + foliar feeding of 23.0 cm and 19.0 cm.

The length of the unfulfilled part of the cob did not depend on the food backgrounds. This value is more related to climatic conditions and characteristics of the hybrid. The number of rows of grains on the cob is also a feature of the hybrid. In the studied hybrids, this value ranged from 13.4 to 15.5 pcs in the Bilyar-160 hybrid, from 14.0 to 15.7 pcs in the hybrid Voronezhsky-279 and from 12.7 to 14.2 pcs in the Nur hybrid.

Table 2. Biometric indicators of corn hybrids.

Food backgrounds	Hybrids	Cob length, cm	The length of the unfinished part of the cob, cm	Number of rows of grains on the cob, pcs.	Number of grains in a row, pcs.	Cob grain size, pcs.
Without fertilizer (control)	Bilyar -160	15.6	0.1	14.8	28.0	414.4
	Voronezhskiy -279	18.0	2.7	14.0	30.8	431.2
	Nur	15.7	1.1	13.4	32.6	436.8
NK per 50 t/ha	Bilyar-160	18.5	1.7	13.4	34.7	465.0
	Voronezhskiy -279	18.6	2.9	14.6	31.4	458.4
	Nur	15.5	0.5	12.7	30.8	391.2
NK per 50 t/ha + foliar feeding	Bilyar -160	17.9	1.5	14.6	32.8	478.9
	Voronezhskiy -279	19.1	2.8	14.4	33.3	479.5

	Nur	16.1	0.9	13.7	33.6	460.3
NK per 60 t/ha	Bilyar -160	17.5	1.4	14.8	32.0	473.6
	Voronezhskiy -279	22.0	2.8	15.4	37.8	582.1
	Nur	18.9	1.3	13.4	34.8	466.3
NK per 60 t/ha + foliar feeding	Bilyar -160	18.7	0.5	15.2	36.8	559.4
	Voronezhskiy -279	23.0	2.7	15.4	39.4	606.8
	Nur	19.0	1.5	13.6	35.0	476.0
Inlay GSN-2004	Bilyar -160	18.0	0.5	15.1	35.6	537.6
	Voronezhskiy -279	20.9	2.9	15.6	37.8	589.7
	Nur	16.0	0.9	13.8	33.7	465.1
Inlay GSN-2004 + foliar feeding	Bilyar -160	19.1	0.5	15.5	36.3	562.7
	Voronezhskiy -279	21.6	2.7	15.7	38.0	596.6
	Nur	16.3	1.0	14.2	34.1	484.2

Table 3. Biometric indicators of corn hybrids.

Food backgrounds	Hybrids	Cob mass, gr.	Mass of grain from the cob, gr.	Grain output from the cob, %	Weight of 1000 grains, gr.	Grain moisture content, %	Productivity , c/ha
Without fertilizer (control)	Bilyar -160	129.8	99.2	76.4	294	23.0	41.36
	Voronezhskiy -279	131.2	121.8	92.8	311	26.4	51.17
	Nur	111.1	91.6	82.4	270	21.5	45.74
NK per 50 t/ha	Bilyar-160	146.6	111.2	75.9	282	20.8	58.69
	Voronezhskiy -279	169.3	125.4	74.1	321	28.4	61.70
	Nur	120.9	94.9	78.5	320	23.1	47.53
NK per 50 t/ha + foliar feeding	Bilyar -160	147.1	113.5	77.2	288	20.5	59.37
	Voronezhskiy -279	174.1	128.5	73.8	334	29.3	67.25
	Nur	126.7	98.6	77.8	341.2	23.4	50.70
NK per 60 t/ha	Bilyar -160	148.1	114.6	77.4	312	20.3	61.18
	Voronezhskiy -279	204.1	155.7	76.3	313	23.8	74.73
	Nur	180.0	145.8	81.0	363	21.7	59.26
NK per 60 t/ha + foliar feeding	Bilyar -160	155.9	123.8	79.4	276.0	19.5	67.41
	Voronezhskiy -279	229.7	169.3	73.7	332	22.6	77.39
	Nur	182.5	147.6	80.9	365	21.5	61.30
Inlay GSN-2004	Bilyar -160	146.7	112.5	76.7	285	22.9	58.14
	Voronezhskiy -279	196.0	146.1	74.5	305	22.7	58.03
	Nur	131.0	110.3	84.2	281.0	19.9	57.87
Inlay GSN-2004 + foliar feeding	Bilyar -160	152.4	114.8	75.3	288	22.5	59.43
	Voronezhskiy -279	201.4	151.8	75.4	318.0	22.5	59.68
	Nur	134.6	124.7	92.6	301	20.0	59.80

Improving nutritional conditions increased the number of formed grains in a row. If in the control this value was 30.5 pcs on average for the studied hybrids, then on the NK variant per 50 t/ha, the value became 32.3 pcs, NK per 50 t/ha + foliar feeding - 33.2 pcs, NK per 60 t/ha of 34.9 pcs, NK per 60 t/ha + foliar application of 37.1 pcs. It can be said that with each subsequent increase in the rate of applied fertilizers, the number of formed grains in the cob increases. Without mineral fertilizers, the number of grains in a row was 35.7 pcs with inlay and 36.1 pcs when encrusting and foliar feeding. This means that biological preparations and zinc-containing preparations also increase the number of grains in a row. Among the hybrids studied, the Voronezhsky-279 hybrid was characterized by the largest number of grains in the row. On the NK variant at 60 t/ha + foliar application, the cultivation of this hybrid makes it possible to obtain 39.4 pcs grains in a row.

The more rows of grains and grains in a row, the higher the grain content of the cob. The studied hybrids were characterized by good cobs grain content. On the fertilized variants, the grain content was also better. The cobs of the medium-early hybrid Voronezhsky-279 turned out to be the most grainy - 606.8 gr. against the background of NK at 60 t/ha + foliar application.

Although, when only incrustation was carried out, the graininess of ears of the Voronezhsky-279 hybrid was only 17.1 g lower, and when incrustation and foliar feeding were lower, by 10.2 g. The graininess of the cobs of the studied hybrids on the variants with incrustation and foliar feeding is at the level of backgrounds with mineral fertilizers, and in the Bilyar-160 hybrid, it is even higher.

Despite the fact that the mass of the cob is a value that depends on the characteristics of the hybrid, it is strongly influenced by nutritional conditions, namely the calculated norms of mineral fertilizers. If in the control the mass of ears of the Bilyar-160 hybrid was 129.8 g, Voronezhsky-279 of 131.2 g, and Nur of 111, g, then the introduction of the calculated norms of NK by 50 t/ha increased these values by 16, eight; 38.1 and 9.8 gr. This is a significant increase of 10-30%. And the addition of foliar feeding with a zinc-containing preparation in the phase of 5-6 leaves additionally gives an additional 3-5%

increase in the weight of the cob. An increase in fertilizer rates to the calculated NK by 60 t/ha also increases the weight of the cob. When carrying out the incrustation with a biological product, the weight of the cob increased by 16.9-64.8 g, and in the variant GSN-2004 encrustation + foliar feeding by 17-50% g. The most responsive one to biopreparations and microfertilizers was the hybrid Voronezh-279.
The yield of grain from the cob was quite high. For all options, it did not fall below 73.7%. Grain yield did not depend on the methods studied.

The weight of 1000 grains correlated with the studied hybrids and nutrition backgrounds. The largest weight of 1000 grains was in the Bilyar-160 hybrid on the NK variant at 60 t/ha of 312 g. In the Voronezhsky-279 hybrid, the highest value of the weight of 1000 grains was 334 g against the calculated background of NK at 50 t/ha + foliar feeding, and in the Nur hybrid on the NK variant at 60 t/ha + foliar feeding 365 g. This is the highest value among the studied hybrids. Smallest value mass 1000 grains in the Voronezhsky-279 hybrid was 305 gr. in the variant with seed incrustation with a biological product, and in the Nur hybrid of 270 gr under control.

Despite the fact that early-ripening hybrids are inferior to the medium-early hybrid in a number of indicators, early-ripening ones are characterized by low pre-harvest grain moisture.

The biological yield in the control was 41.36 c/ha for the Bilyar-160 hybrid, 45.74 c/ha for the Nur hybrid, and 51.17 c/ha for the Voronezhsky-279 hybrid in the control. Let us pay attention to the potential of mid-early corn hybrids in the conditions of the Fore-Kama region of the Republic of Tatarstan. Against the calculated background of the NK variant at 50 t/ha, the grain yield increased by 1.8 c/ha (Nur), 10.5 c/ha (Voronezhsky-279), 17.3 c/ha (Bilyar-160). An increase in the application rate of mineral fertilizers makes it possible to obtain 59.26 centners/ha of grain in the Nur hybrid, 61.18 centners/ha in the Bilyar-160 hybrid and 74.73 centners/ha in the Voronezh-279 hybrid. When macroelements are introduced and foliar feeding is carried out, the yield additionally increases by 7-9% and 4-10%, compared with the options where only mineral fertilizers were applied. In the variant with incrustation with biological preparations, the yield was 57-58 centners/ha, which is higher than the control by 6-16 centners/ha. And when carrying out encrustation and foliar feeding, the yield level for the studied hybrids leveled up to 59.6 c/ha. As a result, the NK background at 60 t/ha + foliar application of Batr Zn provides the maximum grain yield and better disclosure of the grain potential of hybrids of universal use (61.3 c/ha for the Nur hybrid, 67.41 c/ha for the Bilyar-160 hybrid, 77.39 c/ha for the Voronezhsky-279 hybrid).

4 Conclusion

Hybrids of universal use have a fodder potential and are capable of producing high grain yields under equal conditions. Early ripe hybrids are characterized by lower pre-harvest grain moisture, which ensures stable yields. Mid-early hybrids respond well to the application of both mineral fertilizers and the use of biological products in the form of seed encrustation before sowing and foliar fertilization with microelements. As a result, the NK background at 60 t/ha + foliar application of Batr Zn (for green mass) provides the maximum grain yield and better disclosure of the grain potential of hybrids of universal use (61.3 dt/ha for the Nur hybrid, 67.41 dt/ha in the Bilyar-160 hybrid, 77.39 c/ha in the Voronezhsky-279 hybrid).

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