Cultivation of corn hybrids on the expected nutritional background in the Volga region of the Republic of Tatarstan

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Abstract. This article describes the specific conditions of nutrition of adaptive hybrid corn with ears to obtain high planned yields in the phase of milk-wax ripeness of grain on the gray forest soil of the Volga region of the Republic of Tatarstan in 2013-2015. As a result of the research it was found that the maximum increase in the area of the leaf surface was formed against the background of application of the calculated doses of fertilizers on 70 t/ha with sowing of corn hybrid Flint 200 (30.71 thousand tons). m²/ha), greater accumulation of plant biomass on the same background was observed on crops using the Newton hybrid (33.0 t/ha). The maximum yield formation (to 65.3 t/ha) was observed when making NPK 70 t/ha and the sowing of hybrid Newton, yield of green mass of corn on the background without fertilizers depending on sown hybrids amounted to 34.3-38.4 t/ha. In addition to this embodiment, it is noted the best nutritional value food and the best profitability 39.2 per cent, against 24.8 per on the background without fertilizers.

1. Introduction

The formation of a stable, high-value fodder base of animal husbandry, first of all, provides for an increase in the production of corn feed. Corn hybrids show different responsiveness to doses of nitrogen fertilizer. On average, for 3 years in the Stavropol region the largest increase in the yield of green mass of maize hybrids Mashuk 171, Mashuk 175 MV, Newton, Mashuk 355 MV, Mashuk 390 MV, Beshtau gave the use of nitrogen fertilizer (ammonium nitrate) in a dose of N60. The dose of N30 was sufficient for the hybrid Mashuk 250 SV, and increasing the dose to N90 was appropriate for the hybrid Mashuk 185 MV. The dose of N60 provided the largest increase in grain yield on maize hybrids Mashuk 171, Mashuk 175 MV, Mashuk 355 MV. The dose of N30 was sufficient for Mashuk 185 MV, Newton and Beshtau hybrids. Increasing the dose of fertilizer to N90 provided an increase in the increase in grain yield on the hybrid Mashuk 390 MV. Mashuk 185 MV and Newton hybrids are distinguished by the ability to provide a high increase in grain yield and payback of nitrogen fertilizer (ammonium nitrate) [1-3].

The use of growth promoters helps to increase the leaf apparatus of corn. Application of mineral fertilizers increases photosynthetic potential in early-maturing hybrids up to 1.92 million m²/ha days, mid-early hybrids – up to 1.95 million m²/ha days. When using growth promoters photosynthetic potential increases to 2.36-2.50 million m²/ha days. Application of mineral fertilizers and processing of maize crops with growth stimulants increases the feed dignity of maize grain. The digestible protein content reached 0.420 t/ha on the third background; the content of fodder units is 7.909 thousand/ha in the Krasnodar hybrid 194 with the use of the stimulator Megamixn10, the maximum amount of exchange
energy is accumulated on the third background of mineral nutrition by the hybrid Gitago – 88.65 GJ/ha [4-6].

The most important factor in increasing the yield of maize is the optimal provision of plants during the growth and development of nutrients, which largely provide high planned yields of maize. The most responsive to the introduction of mineral fertilizers and trace elements was a hybrid of Krasnodar 385 MV. Thus, his increase in grain weight was from 25.8 to 45.5 g compared to the control. The standard grain weight increase varied within 23.3–39.7 g. This is due to differences in the length of the growing season. The middle-matured hybrid Krasnodar 385 MV, thanks to the optimization of the diet, increased the largest biomass, and accordingly the linear dimensions of the reproductive organ also received the maximum development. Options using Planate, Politics and FSLM-2 had an advantage over the other variants with application of fertilizers and control of both hybrids. The greatest effect was found in the hybrid Krasnodar 385 MV [7-9].

Many elements of the system of fertilizers under maize are in need of adaptation to soil and climatic conditions of Volga region and require detailed scientific study.

The purpose of our research is to identify the most economical option of hybridization of caucuses in the gray forest soils of the Volga region of the Republic of Tatarstan.

2. Materials and methods

The studies were conducted in 2013-2015 on gray forest loamy soil in the conditions of the Volga region of the Republic of Tatarstan. The soil was characterized by the following indicators: humus - 2.3 % (according to Turin), mobile phosphorus – 151 mg/kg, exchangeable potassium – 172 mg/kg of soil.

Sowing of maize hybrid was carried out on may 10 grain drill Optima-6 with aisles of 70 cm. Calculated dose of fertilizer was made in two stages: the diammonium phosphate and potassium salt before planting made Assembly Amazone broadcast method, ammonium nitrate in rows when row processing KRN - 5.6.

To obtain the planned harvest of 50 t/ha of maize in the phase of milk-wax ripeness, 60 kg of a.s./ha of nitrogen, 54 kg of phosphorus and 168 kg of potassium were introduced. The planned yield of 70 t/ha was made of nitrogen 180 a.s. kg/ha, phosphorus - 154 kg and potassium 294 kg/ha. Accommodation plots consistent.

Scheme of field experience:

Factor A – the hybrid: 1. Krasnodar 194 MV; 2. Flint 200 SV; 3. Koenigs; 4. ROSS 140 SV; 5. Newton.

Factor B – backgrounds power: A) without fertilizers; B) N60P54K168 (50 t/ha); C) N180P154K294 (70 t/ha).

In some tables abbreviations will be used, as indicated in the scheme of experiments.

Laboratory studies were carried out by recommended methods, on certified equipment. Humus content – according to Tyurin in modification of TIN (GOST 26213-91), nitrate nitrogen was determined by the dynamics of the Express method on ion universal EV-74, mobile forms of phosphorus – colorimetric method in the hood – according to Kirsanov, exchange potassium – by flame photometer (GOST 26204-91); the acidity of the soil 5pH (Sol.) – potentiometric method (GOST 26212-91).

3. Results and discussion

The main parameters composing the crop of corn with ears in the phase of milk-wax ripeness are the growth of the leaf surface and the accumulation of biomass by plants during the growing season. The increase in leaf surface area and above-ground mass from mineral nutrition of maize plants by hybrids was significant (Table 1). On the variants of fertilizer application in all periods of accounting, the growth rate of the leaf surface area was higher than the background without fertilizers. Against the background of the calculated doses of NRK at 70 t/ha for the interfacial period 7-8 leaves – flowering maximum increase in plant biomass (30.71 thousand m²/ha) was observed in the hybrid Flint 200.

A low rate of biomass accumulation in this period was observed in the hybrid ROSS 140 without fertilization (13.08 thousand m²/ha). The increase in the area of the leaf surface on average for three
years on fertilized variants was: against the background of the introduction of N180P154K294 – from 1.92 to 10.39 thousand m²/ha, against the background calculated at 70 t/gan N180P154K294 – from 1.82 to 12.63 thousand m²/ha.

In the interphase period of flowering – milk ripeness, this trend has continued. More responsive to the improvement of the nutrient regime was a hybrid of Newton, the increase in the area of the leaf surface of which amounted to 10.23 thousand m²/ha and 9.79 thousand m²/ha. Worse responded hybrid Krasnodar 194 with a value of 4.97 thousand m²/ha on the estimated application of mineral fertilizers for the planned harvest of 50 t/ha.

Less growth in the interphase period of flowering – milk ripeness in comparison with 7-8 leaves – flowering is associated with the physiology of maize growth, when the maximum growth occurs before the flowering phase.

Table 1. Area of the leaf surface and the above-ground mass of maize hybrids depending on the doses of mineral fertilizers

| Hybrids | The area of leaf surface in thousand m²/ha | Aboveground mass, t/ha |
|---------|-----------------------------------|---------------------|
|         | without fertilizers | NPK 50 t/ha | NPK70 t/ha | without fertilizers | NPK 50 t/ha | NPK 70 t/ha |
|---------|---------------------|-------------|------------|---------------------|-------------|-------------|
| 1       | 18.75               | 25.92       | 25.23      | 10.1               | 19.8        | 28.2        |
| 2       | 26.01               | 29.14       | 30.71      | 13.2               | 22.8        | 29.0        |
| 3       | 25.24               | 30.27       | 30.27      | 12.3               | 18.8        | 26.5        |
| 4       | 13.08               | 23.46       | 25.71      | 11.7               | 16.5        | 24.7        |
| 5       | 23.89               | 25.80       | 25.70      | 10.5               | 19.5        | 27.1        |
|         | 7-8 leaves - flowering |         |            |                     |             |             |
| 1       | 5.88                | 4.97        | 6.28       | 10.9               | 18.4        | 28.1        |
| 2       | 7.90                | 5.37        | 6.21       | 8.6                | 16.5        | 29.6        |
| 3       | 5.39                | 9.67        | 8.70       | 7.5                | 12.8        | 29.0        |
| 4       | 7.78                | 8.97        | 8.78       | 7.1                | 18.1        | 29.3        |
| 5       | 7.07                | 9.79        | 10.23      | 14.8               | 20.8        | 33.0        |
| HCP05 A | 0.06                | 0.05        | 0.20       | 0.25               |             |             |
| B       | 0.05                | 0.07        | 0.28       | 0.34               |             |             |
| AB      | 4.55                | 6.79        | 2.43       | 4.77               |             |             |

Biomass accumulation occurred in parallel with height growth. The positive dynamics of greater accumulation of above-ground mass on fertilized backgrounds remained. In the period of 7-8 leaves – flowering also the best responsiveness was observed in the hybrid Flint 200. The increase in the above-ground mass was 29.0 t/ha. Less responsiveness on fertilized backgrounds in the hybrid ROSS 140 (16.5 t/ha and 24.7 t/ha).

During flowering – milk ripeness without fertilizers, the increase in the above-ground mass amounted to a limit of 7.1 to 14.8 t/ha with a maximum value in the Newton hybrid and a minimum in the ROSS 140 hybrid, in the variant with the introduction of calculated doses of NPK by 50 t/ha – from 12.8 to 20.8 t/ha. And at the maximum application of mineral fertilizers, the best responsiveness was also distinguished by the Newton hybrid with a value of 33.0 t/ha, the minimum value was noted in the Krasnodar hybrid 194 (28.1 t/ha).

High rates of maize dry matter accumulation in the phase of milk-wax ripeness for all variants of the experiment were obtained by the end of the growing season (Table 2). Against the background of no fertilizer corn plants have accumulated from 11.9 to 15.6 t/ha of dry biomass. In the background, making N180P154K294 this figure was the limit between 20.0 to 27.2 t/ha and the variant with the introduction N180P154K294 the accumulation of dry biomass was from a 33.6 to 41.2 t/ha.
Table 2. Yield of corn hybrids with ears in the phase of milk-wax ripeness depending on doses of mineral fertilizers on gray forest soil

| Hybrids            | Yield of green mass, t/ha |
|--------------------|----------------------------|
|                    | without fertilizers | NPK 50 t/ha | NPK 70 t/ha |
| 1. Krasnodar 194 MV| 25.1                  | 41.3        | 60.8        |
| 2. Flint 200 SV    | 24.2                  | 42.9        | 62.6        |
| 3. Koenigs         | 22.9                  | 35.3        | 59.2        |
| 4. 140 ROSS SV    | 22.6                  | 37.8        | 56.9        |
| 5. Newton          | 28.1                  | 43.9        | 65.3        |

HCP$_{0.5}$ A 0.23  
B 0.23  
AB 4.67

Two hybrids – Newton and Flint 200-have retained the trend of positive correlation from the application of mineral fertilizers. The maximum accumulation of dry biomass was observed in the Newton hybrid and amounted to 27.2 and 39.2 t/ha, and 26.4 and in the flint hybrid 200 41.2 t/ha.

Low rates on fertilized backgrounds in the accumulation of plant biomass were observed in the cultivation of the hybrid ROSS 140 (20.0 t/ha and 33.6 t/ha).

On the variant with the natural fertility of the soil the yield of corn amounted to the range of 22.6 to 28.1 t/ha. On the option of making estimated doses of fertilizers N$_{60}$P$_{54}$K$_{168}$ maximum the yield of the hybrid Newton to 43.9 t/ha and the lowest one in hybrid Koenigs – 35.3 t/ha. Maximum yield obtained on the background, designed to receive 70 t/ha in the cultivation of hybrid Newton (to 65.3 t/ha), minimum – in the cultivation of hybrid ROSS 140 (56.9 t/ha).

Agro technical measures to improve the nutrient regime of the soil reflects the rate of increase in the yield of hybrids. Of the studied hybrids, the most responsive were hybrids Flint 200 and Newton. The maximum yield increase of hybrids of corn cobs in the phase of milky-wax was stalactitical the hybrid Flint 200 and was 18.7 t/ha and of 38.4 t/ha and the hybrid Newton of 15.8 t/ha to 37.2 t/ha., the minimum yield increase was noted hybrid Koenigs in the background making NPK at 50 t/ha (12.4 t/ha) and hybrid ROSS 140 upon application of NPK at 70 t/ha -34.3 t/ha.

The results of laboratory studies of the content of fodder units in 1 kg of food waste was on the background of the power from 0.15 to 0.22 K. ed., against any N$_{60}$P$_{54}$K$_{168}$ – from 0.19 to 0.27. units. and in the background making N$_{180}$P$_{154}$K$_{294}$ – from 0.23 to 0.33 K. units (Table 3). More nutritious on this indicator turned feed from hybrids Koenigs and Newton.

More metabolizable energy contained feed, obtained in fertilized variants. Against the background of the introduction of NPK on 50 t/ha of exchange energy contained from 1.70 to 2.90 MJ, which is more than the background without fertilizers by 0.50 MJ. And on the background of the introduction of NPK on 70 t/ha of exchange energy contained in the stern from 2.20 to 3.10 MJ. These figures exceed the inconvenient background by 0.88 MJ.

The high content of sugar and digestible protein was observed in feeds grown on fertilized variants. The maximum content of digestible protein and sugar received on the estimated background capacity of 70 t/ha and amounted to hybrids Koenigs of 12.40 and of 6.73 g/kg and Newton 12.90 and 6.75 g/kg.

Cultivation of the Newton hybrid on the background of application of NPK on 70 t/ha was the most cost-effective. The cultivation of this hybrid was the most costly (28151.5 RUB/ha), but getting a high yield of green mass of corn milky-wax ripeness, the cost of 1 t was the smallest (431.1 RUB) among the studied hybrids and backgrounds which will provide the greater net income (11028.5 RUB/ha) with the highest level of profitability (39.2 %) (Table 4).
Table 3. Chemical composition and nutritional value of corn with ears in the phase of milk-wax ripeness of grain

| Hybrids | without fertilizers | NPK 50 t/ha | NPK 70 t/ha |
|---------|---------------------|-------------|-------------|
| The content of feed units in 1 kg of feed, K units |
| 1       | 0.18                | 0.23        | 0.28        |
| 2       | 0.16                | 0.20        | 0.25        |
| 3       | 0.22                | 0.27        | 0.33        |
| 4       | 0.15                | 0.19        | 0.23        |
| 5       | 0.19                | 0.24        | 0.29        |
| Content of exchange energy in 1 kg of feed, MJ |
| 1       | 1.60                | 2.20        | 2.70        |
| 2       | 1.10                | 1.70        | 2.60        |
| 3       | 2.50                | 2.90        | 3.10        |
| 4       | 1.90                | 2.00        | 2.20        |
| 5       | 1.50                | 2.20        | 2.40        |
| Digestible protein content in 1 kg of feed, g |
| 1       | 8.80                | 9.84        | 12.50       |
| 2       | 8.35                | 9.67        | 10.20       |
| 3       | 8.20                | 10.15       | 12.40       |
| 4       | 8.19                | 10.62       | 12.00       |
| 5       | 9.16                | 10.80       | 12.90       |
| Sugar content in 1 kg of feed, g |
| 1       | 5.57                | 5.80        | 6.20        |
| 2       | 5.59                | 6.07        | 6.62        |
| 3       | 5.47                | 6.10        | 6.73        |
| 4       | 5.82                | 6.06        | 6.53        |
| 5       | 5.65                | 6.12        | 6.75        |
| HCP_05 A | 0.03                | 0.47        | 0.22        | 0.42 |
|  B     | 0.02                | 0.24        | 0.25        | 0.13 |
|  AB    | 0.05                | 0.43        | 0.97        | 0.24 |

In the variant without application of mineral fertilizers lower cost of production was observed in the hybrid ROSS 140 (11183.1 RUB/ha), it is associated with having a lower corn yield of milky-wax ripeness (22.6 t/ha) and the costs of harvesting and lower seed cost (1180 RUB/ha seed).

4. Conclusion

Agrotechnical method to improve the nutritional regime in the gray forest soil has a positive impact on growth processes, yield, nutritional value of the feed, increased the economic efficiency of maize cultivation. The maximum growth of the leaf surface occurred against the background of the introduction of NPK on 70 t/ha and amounted to 30.71 thousand m²/ha in a hybrid of Flint 200 SV, and the accumulation of biomass of maize plants - on crops of Newton hybrid (33.0 t/ha). High yield of corn with ears in the phase of milk-wax ripeness was obtained against the background of application of NPK on 70 t/ha with sowing of hybrid Newton (65.3 t/ha), which exceeded the option without fertilization on 37.2 t/ha. On the same option, the maximum content of digestible protein in 1 kg of feed (12.90 g), sugar content in 1 kg of feed – 6.75 g, a high level of profitability of production – 39.2 %.
Table 4. Economic efficiency of corn cultivation with ears of milk-wax ripeness

| Hybrids | Power backgrounds | 
|---------|------------------|
|         | without fertilizers | NPK 50 t/ha | NPK 70 t/ha |
| 1       | 12167.6           | 18343.7     | 27069.1     |
| 2       | 12047.0           | 19004.4     | 27644.4     |
| 3       | 11515.0           | 16755.9     | 27000.6     |
| 4       | 11183.1           | 17666.9     | 26077.9     |
| 5       | 13499.9           | 19207.3     | 28151.1     |

Cost of 1 ton of green mass, RUB.

|       |       |       |
|-------|-------|-------|
| 1     | 484.8 | 444.2 |
| 2     | 497.8 | 442.9 |
| 3     | 502.9 | 474.7 |
| 4     | 494.8 | 467.4 |
| 5     | 480.4 | 437.5 |

Net income, RUB/ha

|       |       |       |
|-------|-------|-------|
| 1     | 2892.4| 6436.3| 9410.9|
| 2     | 2473.0| 6735.6| 9915.6|
| 3     | 2225.0| 4421.4| 8519.4|
| 4     | 2376.9| 5013.1| 8062.1|
| 5     | 3360.1| 7132.7| 11028.5|

Level of profitability, %

|       |       |       |
|-------|-------|-------|
| 1     | 23.7  | 35.1  | 34.8  |
| 2     | 20.5  | 35.4  | 35.9  |
| 3     | 19.3  | 26.4  | 31.5  |
| 4     | 21.3  | 28.4  | 30.9  |
| 5     | 24.8  | 37.1  | 39.2  |

Note: the price of 1 ton of corn in the phase of milk-wax ripeness – 600 rubles/t.

References
[1] Labyntsev A V, Pasko S V, Kravchenko A N 2012 Responsiveness of maize hybrids to fertilizer Grain economy of Russia 5 42–47
[2] Bagrintseva V N 2015 Responsiveness to nitrogen fertilizer of modern corn hybrids in the Stavropol region Agrochemistry 11 45–50
[3] Vasin V G, Kosheleva I K 2018 Productivity and fodder advantages of maize hybrids on grain at introduction of mineral fertilizers and growth stimulants Bulletin of the Ulyanovsk agricultural Academy 2(42) 45–53
[4] Moiseev A A, Ivoilov A V, Vlasov P N 2016 Efficiency of fertilizers for corn in the forest-Steppe of the Middle Volga region Bulletin of the Altai state agrarian Univ. 4(138) 28–33
[5] Talanov I P, Mikhailova M Yu 2015 The Influence of the calculated norms of mineral fertilizers on the formation of green mass of maize hybrids in the conditions of the Volga region RT Bulletin of Kazan state University 10-1(35) 137–140
[6] Makarov I P 1983 Improve the scientific basis of tillage Agriculture 1 12–15
[7] Korenkov D A 1990 Mineral fertilizers at intensive technologies. (Moscow: Rosagropromizdat) pp. 167–169
[8] Mineev V G 1987 Optimization of fertilizer application and ecological aspects of modern agriculture Bulletin of Agricultural Sci. 6 23–30
[9] Hlopenko A M 2006 The Effectiveness of chemicals on maize Corn and sorghum 4 18–20