PRODUTIVIDADE DE NOVOS HÍBRIDOS DE MILHO NAS CONDIÇÕES DOS URAIS

PRODUCTIVITY OF NEW MAIZE HYBRIDS IN CONDITIONS OF THE URALS

ПРОДУКТИВНОСТЬ НОВЫХ ГИБРИДОВ КУКУРУЗЫ В УСЛОВИЯХ ПРЕДУРАЛЬЯ

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RESUMO

Objetivos. A pesquisa teve como objetivo identificar os híbridos mais produtivos selecionados pelo Instituto *All-Russian* de Pesquisa de Milho para cultivar pela tecnologia de sementes de cereais nas condições naturais dos Cis-Urais. **Metodologia.** O milho foi cultivado para sementes e forragem verde para animais de fazenda nas condições dos Cis-Urais. A massa verde do milho, composta principalmente por caules e folhas, geralmente contém de 88 a 90% de água. A ensilagem preparada para isso possui menos matéria seca e proteínas. Essas forragens têm baixo valor nutricional e baixo retorno dos produtos pecuários. Os alimentos mais nutritivos e de alta qualidade podem ser recebidos a partir de sementes de milho ou de sua massa acima do solo, com grãos leitosos e maduros. Selecionar híbridos de maturação precoce com alto valor nutricional é a principal preocupação do estudo. **Resultados.** Os resultados demonstram que a produtividade dos híbridos de milho varia de 2,50 a 6,76 t/ha, dependendo do solo e das condições climáticas. Quando os híbridos de milho são cultivados por tecnologia de sementes, a massa acima do solo das culturas estudadas é de 30,68-68,80 t/ha. **Conclusões.** É necessário selecionar maturação anterior e híbridos altamente produtivos para aumentar a qualidade e nutrição da ração para milho. Os híbridos recomendados para a produção de grãos são Ural 150 (5,45 t/ha), Baikal (5,38 t/ha) e Mashuk 170 MV (4,98 t/ha); K-170 (56,7 t/ha), Shihan (55,67 t/ha) e Mashuk 170 MV (54,99 t/ha) que proporcionaram uma maior produção da massa verde na maturação grãos leitosos, melhores para produção de silagem. Os dados resultantes permitem selecionar híbridos de milho com alto rendimento e valor nutricional para fazendas com condições similares de solo e clima e desenvolver dietas para gado leiteiro e de corte altamente produtivo.

Palavras-chave: massa acima do solo; grão; híbridos; milho; produção.

ABSTRACT

Objectives. The research aimed to identify the most productive hybrids selected by the All-Russian Research Institute of Maize to cultivate by the cereal seed technology in the natural conditions of the Middle Cis-Urals. **Methodology.** Maize was cultivated for seeds and green fodder for farm animals in the conditions of the Middle Cis-Urals. The maize green mass, consisting mainly of stems and leaves, usually contains up to 88-90% water. Silage being prepared for it has less dry matter and protein. Such fodder has low nutritional value and poor return from livestock products. The most high quality and nutritious feed can be received from maize seeds or its above-ground mass with seeds of milky-wax and wax ripeness. To select early-maturing hybrids with high nutritional value is the primary concern for the studied area. **Results.** The results demonstrate that the productivity of maize hybrids ranges from 2.50 to 6.76 t/ha depending on soil and climatic conditions. When maize hybrids are grown by seed technology, the above-ground mass of the studied crops is 30.68-68.80 t/ha. **Conclusions.** It is necessary to select earlier ripening and highly productive hybrids to increase the quality and nutrition of corn feed. The recommended hybrids for grain production are Ural 150 (5.45 t/ha), Baikal (5.38 t/ha) and Mashuk 170 MV

(4,98 t/ha); K-170 (56,7 t/ha), Shihan (55,67 t/ha) and Mashuk 170 MV (54,99 t/ha) that provided a higher output of the green mass at milky-wax ripeness of grain are best for silage production. The resulting data make it possible to select maize hybrids with high yields and nutritional value for farms with similar soil and climate conditions and to develop diets for highly productive dairy and beef cattle.

Keywords: above-ground mass; grain; hybrids; maize; yield.

АННОТАЦИЯ

Цели. Данное исследование имело целью выявить наиболее высокопроизводительные гибриды кукурузы для выращивания в естественных условиях Среднего Предуралья среди отобранных Всероссийским научно-исследовательским институтом кукурузы образцов. Методология. Кукурузу выращивали на семена и зеленый корм для сельскохозяйственных животных в условиях Среднего Предуралья. Зеленая масса кукурузы, состоящая в основном из стеблей и листьев, обычно содержит в своем составе до 88-90% воды. Однако, в готовом силосе сухого вещества и белка содержится меньше. Соответственно, такой корм имеет низкую пищевую ценность и его использование влечет сокращение объемов производства продукции животноводства. Наиболее качественный и питательный корм можно получить из семян кукурузы в фазе молочно-восковой и восковой спелости. Выбор для изготовления корма раннеспелых гибридов с высокой питательной ценностью является основной задачей исследуемой агропромышленной области. Результаты. Результаты данного исследования показывают, что урожайность гибридов кукурузы колеблется от 2,50 до 6,76 т/га в зависимости от почвы и климатических условий. При выращивании гибридов кукурузы в соответствии с семенной технологией, надземная масса исследуемых культур составляет 30,68-68,80 т/га. Выводы. С целью повышения качества и питательности корма, необходимо выбирать более ранние и высокопроизводительные гибриды кукурузы. Рекомендованными для производства зерна являются гибриды Уральский 150 (5,45 т/га), Байкал (5,38 т/га) и Машук 170 MB (4,98 т/га); K-170 (56,7 т/га), Шихан (55,67 т/га) и Машук 170 MB (54,99 т/га), которые обеспечивали более высокую урожайность зеленой массы для производства силоса при созревании зерна молочно-восковой спелости. Полученные данные позволяют выбирать гибриды кукурузы с высокой урожайностью и питательной ценностью для ферм с аналогичными почвенными и климатическими условиями и разрабатывать рационы для эффективного функционирования молочного и мясного скотоводства.

Ключевые слова: надземная масса, зерно, гибриды, кукуруза, урожайность.

1. INTRODUCTION:

Maize growing is a traditional source of income and subsistence for many farmers and rural populations in rainfed areas. On an industrial scale, in large countries, maize is a cash crop with diverse applications (Novák *et al.*, 2019). It is grown for food, animal feed, as well as a raw material to produce industrial goods (Akinchin and Fedorov, 2015). This crop is cultivated on nearly 150 million hectares in about 160 countries with a wide variety of soils, climate, and management practices, contributing 36% (361.1 million tons) to world grain production (Dahlan *et al.*, 2014; Huato *et al.*, 2016). The United States of America (USA) is the largest maize producer in the world, accounting for about 35% of the total maize production. Corn growing is the driving force of the American economy. The United States has the highest productivity (9.5 tons per hectare) being twice as high as that in other countries. Thus, the average yield in India is 2.5 tons per 1 hectare.

Maize is the third most important food crop after rice and wheat in this country. Almost 80% of

India's cropland is used for maize growing. Maize provides 9% of the national food basket (Adedokun *et al.*, 2018; Barry *et al.*, 2017; Ismagilov *et al.*, 2019; Ngaboyisonga *et al.*, 2012). Russia ranks the twelfth among the world producers of maize with 11.3 million tons. The share of our country in cultivating this crop is just 0.9% of the total world production. North Caucasus and the Central Non-Black Soil Zone are the most productive regions to grow maize in open fields. The plants cultivated there to get enough sunlight and provide an abundant harvest. Some areas grow maize as a fodder crop. These are the Ural, Volga-Viatka, central regions, and Siberia (Sotchenko *et al.*, 2018).

Maize is the main crop with different applications. This cereal crop plays an integral part in agriculture. It enables us to address two challenges: to replenish grain stocks and produce nutritional feed for farm animals. This crop is also used to prepare silage well digested by animals. It is a good milk-making feed. Maize is used as green fodder as well (Akhiyarov *et al.*, 2018; Araya *et al.*, 2019; Lin *et al.*, 2019). The ten largest maize

producers accounted for 79.4% of the total world production in 2018. These are the USA, China, Brazil, Argentina, Ukraine, India, Mexico, Indonesia, South Africa, Romania (Barry *et al.*, 2017; Chung *et al.*, 2019; Venkatesha *et al.*, 2019). The share of the leading 30 producers of maize totals 92.4%. In 2018 this list included Canada, Russia, Nigeria, Hungary, Italy, Serbia, Philippines, Ethiopia, Tanzania, Turkey, Egypt, Vietnam, Germany, Thailand, Pakistan, Spain, Poland, Malawi, Kenya and Zambia (Chung *et al.*, 2019). The USA is a key producer and exporter of maize in the world. In 2018 the share of the country in the global production of this cereal crop accounted for 35.3%. The output was 361.1 mln tons. China is the second-largest maize producer in the world. In 2018 the share of China in the global production of the given cereal crop amounted to 21.1%. The output was 215.6 million tons. Brazil is the third world producer of maize. In 2018 its total output was 79.9 million tons. Argentina ranks the fourth among the largest maize producers in the world, its share in the structure of the global production was 3.2%, and the total output amounted to 33.0 million tons of maize. Ukraine is the fifth in the list of top five world producers of the very cereal crop, with 28.5 million tons.

The largest producers of maize in Russia were the Krasnodar and Stavropol territories, Rostov, and Voronezh regions (see Figure 1).

The area under maize amounted to 569.3 thousand hectares (23.2% of the total area) with an average yield of 64.9 kg/ha. The Stavropol territory (the area under maize is 197.5 thousand hectares with the share in the total cropland being 8.1%) has an average yield of 63.7 C/ha. The Rostov region (189.2 thousand hectares, 7.7%) harvests an average yield of 49.1 C/ha. The Voronezh region (184.6 thousand hectares, 7.5%) has an average yield of 77.2 kg/ha. The Kabardino-Balkar Republic (141.3 thousand hectares, 5.8%) gets, on average, 62.9 C/ha. In 2018, the maize yield for seeds in Russia amounted to 47.9 C/ha, which is 2.2% (1.1 C/ha) less than in 2017. It decreased by 4.4 % (2.2 C/ha) for five years. Over ten years, the yield growth was 24.1% (9.3 C/ha). The yield increased by 166.1% (29.9 C/ha) concerning 2001. The average annual yield of this type of cereal crop in Russia was 25.0 C/ha in 1991-2000. In 2001-2010 it increased to 32.7 C/ha. In 2011-2018 the average annual yield reached 47.6 C/ha (Sotchenko *et al.*, 2018; Ismagilov *et al.*, 2019).

The Food and Agriculture Organization of the United Nations (FAO) predicts that the cultivation of this grain crop will increase from year to year world-wide. Countries with the most favorable temperate climate will have the highest yields of maize (Kedir, 2018; Venkatesha *et al.*, 2019; Xu *et al.*, 2019b).

To produce maize seeds in the northern regions of Russia, it is necessary to develop ultra-early maturing and cold-resistant hybrids that can withstand the soil temperature below the biological minimum for a long time. In the northern zone of maize cultivation, more attention should be paid to the seed quality. Using seeds with low laboratory germination and spread resulted from their long-term storage can prevent the planned stand, delay the seedling emergence. It leads to the weak initial growth of plants and, consequently, to lower yields of seeds (Barry *et al.*, 2017; Pandurovic *et al.*, 2013). To get higher yields with a given population at the optimum sowing time, it is necessary to increase the seeding rate by 10-20% in conditions of the Maize Research Institute and by 20-30% in conditions of the northern parts of the region depending on the hybrid used. It requires taking into account the biological characteristics of maize hybrids to germinate in different conditions, seed reproduction, sowing qualities, and the seeding rate adjusted to specific growing conditions. Maize hybrid Nur turned to be the best hybrid to get guaranteed seeds at earlier sowing time in conditions of the Middle Cis-Urals. The stalk fragility below the ear is primarily determined by the hybrid's genotype and growing conditions. Ear infection with *Fusarium* varies differently from year to year. However, maize hybrid Nur is found to be resistant to this disease independently of other factors (Ismagilov *et al.*, 2019).

Maize hybrid productivity trends in the U.S. prove that the estimated annual improvement rates range from 1.2 to 2.4% (Barry *et al.*, 2017). Studies on the relationship between climate and human activities often place greater emphasis on the science of climate change. The savings were mostly due to temperature and precipitation. The phase transition of economic performance was positively affected by the long-term temperature change in combination with the trigger effect of short-term precipitation changes (Ismagilov *et al.*, 2019). From a more macroeconomic perspective, the climate movement for macroeconomic cycles has been mitigated by larger and slower processes such as social memory, spatial displacement of key economic areas, and socio-technological progress (Chung *et al.*, 2019).

These genetic changes are associated with improved management practices, including fertilizer use, irrigation, tillage, weed, and pest control, as well as crop rotation (Barry *et al.*, 2017; Chavas and Mitchell, 2018; Xu *et al.*, 2019a). The use of fertilizers eliminates the lack of nutrients in the soil, as the maize yield is very sensitive to nitrogen (Lamptey *et al.*, 2018). When possible, irrigation reduces soil water scarcity and drought. Pest and weed populations can be controlled and suppressed by tillage, crop rotation, and the use of pesticides (insecticides and herbicides). For centuries, farmers have used crop rotation to reduce pest and weed infestation and to restore soil fertility (Chavas and Mitchell, 2018).

One of the significant constraints in the middle Cis-Urals is the low nutritional value of feed (Ismagilov *et al.*, 2019). This issue can be addressed by developing new elements in conventional technologies to cultivate crops, paying particular attention to grain-forage crops (Mударисов *et al.*, 2019; Omokanye *et al.*, 2013; Xu *et al.*, 2019b). The main grain crops cultivated in the Russian Federation are maize, barley, oats, wheat, rye. The high concentration of digestible carbohydrates provides high grain energy nutrition for these crops. Maize occupies a special place among other cereal crops as a source of energy (12.2-12.8 MJ of metabolizable energy per 1 kg) (Araya *et al.*, 2019; Emmanuel and Mutimura, 2012).

The climate of the Middle Cis-Urals is sharp continental; the sum of active temperatures is 2000-2200 degrees. To produce high-quality maize fodder in the conditions of this region, it is necessary to cultivate early-maturing hybrids. The crop should have time to mature in a short summer. Maize is a heat-loving plant; it is not tolerant of the temperature decline. As a result of the work performed over many years, plant breeders have created hybrids that meet the requirements of the climate in the Middle Cis-Urals. Thus, the seeds of these hybrids after being sown withstand a decrease in temperature to minus 2° C. While maize seeds germinate within eight days in a warm climatic zone, early-ripening hybrids adapted to the natural conditions of the Middle Cis-Urals germinate at relatively low temperatures for the same time. To achieve milky ripeness, maize needs a period of effective temperatures above 10° C for at least 120 days, including about 70 days with an average daily temperature above 15° C (Sotchenko *et al.*, 2018).

To ensure a sufficiently high yield under variable weather conditions, it is recommended to grow several hybrids in each farm, being different in several properties (Barry *et al.*, 2017; Chung *et al.*, 2019; Emmanuel and Mutimura, 2012). The choice of varieties suitable for cultivation in this area, the correct selection and preparation of seed material are of great importance for the Middle Cis-Urals with its sharp differences in soil and climatic conditions (Akinchin and Fedorov, 2018; Chavas and Mitchell, 2018; Ngaboyisonga *et al.*, 2012). In recent years, several early-ripening hybrids have been created. They develop a seed of milky-wax ripeness even in adverse weather conditions of the Middle Cis-Urals (Sotchenko *et al.*, 2018).

In the conditions of the Middle Cis-Urals, maize is mainly cultivated for silage and green feeding of animals (Sotchenko *et al.*, 2018). However, the green mass of maize, consisting mainly of stems and leaves without ears, usually contains up to 88-90% water. Silage, being prepared from such a mass, has less dry matter and especially protein (Kedir, 2018; Xu *et al.*, 2019b). Such fodder has low nutritional value and relatively low return on livestock products (Lubova *et al.*, 2018). Maize seeds or a groundmass with seeds of milky-wax and wax ripeness can develop the most high-quality and nutritious feed (Hisse *et al.*, 2019).

A maize seed has a high starch content (up to 70%), compared with other cereal crops, it is rich in fat (up to 7%) (Kedir, 2018; Ngeno *et al.*, 2012; Omokanye *et al.*, 2013). Maize seeds contain less calcium (3,5 times less than oats and sorghum, three times less than barley and millet, two times less than rye and 1,5 times less than wheat) (Ngeno *et al.*, 2012; Wakili, 2012). Early-maturing hybrids on their morphological features do not differ in robust development, but they have a significant share of ears in the total harvest due to lack of heat (Barry *et al.*, 2017; Chavas and Mitchell, 2018; Kätterer *et al.*, 2019). When these hybrids are grown according to the cereal seed technology, farms receive high-quality raw material and prepare silage with nutrient content of 0.25-0.32 fodder units. It is found that in the conditions of the Middle Cis-Urals, it is advisable to grow varieties and hybrids with a period of 95-100 day germination-wax ripeness. It provides high yields of dry mass with ears of milky-wax and wax ripeness. Maize fodder with a high content of ears in the phase of milky-wax ripeness of seeds is characterized by a high content of metabolic energy, starch, and fat (Lin *et al.*, 2019; Ngaboyisonga *et al.*, 2012). Maize seed

digestibility is very high and reaches 90%. Digested nutrients are complete. It is not only the seed that is well digested but other parts of the plant as well. Thus, there are 30-40% of seeds, 10% of rods, and stalks without seeds, about 50% of the rest parts of the plant (Akhiyarov *et al.*, 2018; Kätterer *et al.*, 2019; Venkatesha *et al.*, 2019).

2. MATERIALS AND METHODS:

2.1. The research place

The study of hybrids was carried out on the territory of the Republic of Bashkortostan, occupying a significant part of the Middle Cis-Urals. There are six agricultural zones in the Republic: northern forest-steppe, north-eastern forest-steppe, southern forest-steppe, Cis-Ural steppe, trans-Ural steppe, and mountain-forest zone (Barry *et al.*, 2017; Chavas and Mitchell, 2018; Ismagilov *et al.*, 2019). Field studies of maize hybrids developed by the All-Russian research institute of maize were conducted in the northern forest-steppe ("Agro Tanyp" agricultural production cooperative, located in the Tatyshly district) and southern forest-steppe (scientific training center of the Bashkir State Agrarian University (BSAU)).

In the "Agro Tanyp" farm, the soil cover is represented by dark gray forest soils with medium loamy granulometric composition. The humus horizon depth is 18-22 cm, the humus content in the arable layer is 3.7-4.1 %. The soil medium reaction is slightly acidic pH (kcl) 4.8-5.2; the bulk unit weight of the soil in the arable layer is 1.10-1.14 g/cm³. The soil contains 70-80 mg/kg of easily hydrolyzable nitrogen, 111-118 mg/kg of mobile phosphorus, and 121-125 mg/kg of exchange potassium. The frost-free period is 120-125 days. The growing season precipitation is 236-284 mm, with the average annual rainfall being 587 mm. The soil cover in the scientific training center of the Bashkir State Agrarian University is represented by leached chernozem having medium loamy granulometric composition. The humus horizon layer is 58-69 cm; the humus content in the topsoil is 9.7-9.8%. The soil medium reaction is slightly acidic pH (kcl) 4.8-5.2; the bulk unit weight of the soil in the arable layer is 1.02-1.10 g/cm³. The soil contains 135-156 mg/kg of easily hydrolyzable nitrogen, 160-166 mg/kg of mobile phosphorus, 185-187 mg/kg of exchange potassium. The frost-free period is 110-135 days. The growing season precipitation is 225-275 mm, with the average annual rainfall being 523 mm.

During the growing season of 2019, meteorological conditions in the Republic of Bashkortostan as a whole, especially in May and June, were cold. The shortage of favorable temperatures amounted to 116 0C for these two months. Though the temperature was a bit higher than usual in the subsequent maize vegetation period, the heat shortage remained.

2.2. Equipment

Maize was cultivated according to the following management practice in experiments of the scientific training center of the BSAU: predecessor – spring wheat, tillage – autumn plowing with PN-4-35 to a depth of 26-28 cm, spring harrowing (3BZTS-1.0) and pre-sowing cultivation (CSO-4) to a depth of 5 cm, sowing was carried out on May 10-12 by seeder UPS-8. Row spacing was 70 cm, seeding rate – 80 thousand pieces of seeds per 1 ha to a depth of 5 cm.

2.3. Field experiments

In "Agro Tanyp" maize in the experiments was cultivated by the technology generally accepted for this zone. The registered area of plots is 150 m², the number of replication is fourfold. The variants are arranged in a line in the experiment. The field experience was conducted on the following hybrids: Mashuk 140, K-140, K-150, Uralskii 150, Nur, Mashuk 150, Biliar 160, K-160, K-170, Shikhan, Katerina, Baikal, Mashuk 170, Mashuk 175, Mashuk 171, Mashuk 185, Newton, Mashuk 220, Mashuk 250. The variants are arranged in a line in the experiment. The registered area of plots is 150 m², the number of replication is fourfold. The field scheme included hybrids: Mashuk 140, K-140, K-150, Uralskii 150, Nur, Mashuk 150, Biliar 160, K-160, K-170, Shikhan, Katerina, Baikal, Mashuk 170, Mashuk 175, Mashuk 171, Mashuk 185, Newton, Mashuk 220, Mashuk 250.

2.4. Data analysis

During the growing season, the height and weight of plants were determined. Yield accounting was performed by the continuous harvest method and weighing the mass of plants and seeds after maize ear threshing. To conduct laboratory analysis, seed samples were chosen. Seed moisture was determined with Wile-55 electronic moisture meter and the drying method in the drying chamber. The seed protein content

was tested with Infracum FT-10 infrared analyzer.

3. RESULTS AND DISCUSSION:

According to the results of field studies, it was revealed that maize hybrids mostly formed a pre-harvest height at the level of 160.0-280.0 cm. Better conditions for growth were in the BSAU's scientific training center in the Ufa district (Figure 2). Three hybrids had the maximum height: Mashuk 250 MV (275 cm); Mashuk 220 MV (260 cm), and Shikhan (250 cm). The hybrid K-140 had the minimum height indicators in this experiment (175 cm). In conditions of "Agro Tany" farm, located in the Tatyshly district, the highest height of plants was in hybrids Mashuk 250 SV (260 cm), Mashuk 175MV (250 cm) and Newton (250 cm). The minimum height was found in hybrid K-140 (185 cm).

Seed yield development in maize hybrids in the conditions of two zones were studied along with finding the above-ground mass of the crop in the phase of milky-wax ripeness of seeds. When maize is grown according to the cereal seed technology, the green mass yield of the studied hybrids in the conditions of the BSAU's scientific training center of the Ufa district ranges from 33.7 to 68.8 t/ha (see Figure 3). The top three hybrids in terms of yields included: Mashuk 175 MV (68.8 t/ha), Baikal (59.6 t/ha), and Shikhan (56.7 t/ha). The minimum yield was formed in Mashuk 140 hybrid (33.7 t/ha). There is a close correlation between plant height and yield of green mass ($r=0.823$). In the conditions of the "Agro Tany" farm in the Tatyshly district, the green mass yield of maize hybrids varied within 32.8-56.7 t/ha. The top three hybrids in terms of yields included: K-170 (56.7 t/ha), Shikhan (55.67 t/ha), and Mashuk 170 MV (54.99 t/ha). The K-160 hybrid had the lowest yield (32.8 t/ha).

In the conditions of the Middle Cis-Urals, it is essential to evaluate hybrids by seed moisture at the time of maize harvesting in this zone. Hybrid seeds had different moisture content depending on the group of ripeness (28-63.5%). 2 hybrids, namely Mashuk 140 and K-140, had the lowest moisture content at harvesting. Other hybrids had high moisture content (Table 1). With the standard moisture content being 14%, the seed yield of maize hybrids in the conditions of the "Agro Tany" farm ranged from 3.17 to 6.3 t/ha. The highest yield was received from the hybrid Uralskii 150 (5.45 t/ha). The yields of Baikal (5.38 t/ha) and

Mashuk 170 (4.98 t/ha) hybrids were a bit lower. Under the conditions of the BSAU's scientific training center, the seed yield of hybrids at 14 % moisture content was 2.50-6.76 t/ha. The highest grain yield was provided by the Uralskii 150 hybrid (6.76 t/ha). Relatively high productivity rates were observed for Mashuk 150 (6.57 t/ha), Baikal (6.16 t/ha), and Shikhan (5.89 t/ha) hybrids.

Thus, different soil and climatic conditions made it possible to evaluate and identify highly productive maize hybrids for the conditions of the studied farms. Nur, Uralskii 150, Mashuk 150 MV, Mashuk 170 MV short-season hybrids (FAO 150-199) are the most suitable for the conditions of the northern and southern forest-steppe of the Republic in terms of ripening and yields. To get high-quality as well as high-energy silage, it is advisable to grow short-season hybrids Mashuk 171, Mashuk 175 MV, Mashuk 185 MV, and Katerina SV.

Academician Sotchenko V.S., professor Shlapunov V.N., cytogeneticist McClintock Barbara, plant breeder Borlaug Norman Ernest argue that a higher nutritional value of feed for cows requires hybrids adapted to a particular soil and climate conditions (Barry *et al.*, 2017; Ismagilov *et al.*, 2019; Omokanye *et al.*, 2013). When there is insufficient heat, it is necessary to use early-maturing hybrids. Their yield is not high, but the nutrient content is much higher. These are hybrids of 140-150 FAO (Lin *et al.*, 2019). In conditions with heat security, hybrids of 170-200 FAO can be sown. In Northern Kazakhstan, the average yield of dry matter was 4.8 t/ha (Sotchenko *et al.*, 2018). However, there can be a sharp decline in yields in dry years and when summers are short and cold.

Maize productivity depends not only on climatic conditions but on soil factors and mineral nutrition (Falade *et al.*, 2017; Pandurovic *et al.*, 2013). Under the conditions of Ogallala Aquifer, the maize seed yield ranged from 5.2 ± 1.0 t/ha to 7.4 ± 0.7 t/ha with the highest value when treated with mineral fertilizer and the lowest value when composted with 100% fertilizer (Ayhan *et al.*, 2013; Barry *et al.*, 2017; Lin *et al.*, 2019). The maize productivity largely depended on the level of nutrient supply. Maize programs run by private companies typically conduct extended product testing in multiple growing environments to better recommend new hybrids, as well as providing farmers with an opportunity to evaluate their products by DuPont Pioneer in Minas Gerais and Goias States. The yield of the new hybrids was at

the standard level exceeding the control variants in some conditions (Xu *et al.*, 2019a, 2019b).

To increase the nutritional value of maize silage, there were carried out tests on adding legumes. The latter is considered to be an important element of sustainable agriculture. Legumes provide biological nitrogen fixation that increases the protein content in the diet. Thus, depending on the local conditions, it is necessary to select the elements of technology that increase the productivity of maize hybrids, thereby increasing the nutritional value of feed, taking into account their economic efficiency.

4. CONCLUSIONS:

The plant height of the studied maize hybrids selected by the All-Russian Research Institute in the conditions of the Middle Cis-Urals varies from 160.0 to 280 cm. The seed yield of maize hybrids studied in two soil-climatic zones of the Middle Cis-Urals ranges from 2.50 to 6.76 t/ha. Uralskii 150 (5.45 t/ha), Baikal (5.38 t/ha), and Mashuk 170 MV (4.98 t/ha) hybrids have relatively high seed productivity.

When cultivating maize hybrids on the seed technology, they develop a green mass at the level of 30.68-68.80 t/ha. The hybrids K-170 (56.7 t/ha), Shiha (55.67 t/ha), and Mashuk 170 MV (54.99 t/ha) showed the highest productivity with the milky-wax ripeness phase of seeds. The K-160 hybrid had the lowest yield (32.8 t/ha). The received data will allow selecting maize hybrids with high yield and nutritional value for farms with similar soil and climatic conditions and to prepare diets for highly productive dairy cows and beef cattle.

5. REFERENCES:

- Adedokun, I. I., Nwokeke, B. C., Onyeneke, E. N., Ojukwu, M., and Ekemenye, I. A. (2018). Bambaranut Protein Isolate: Effect of Incorporation on Nutrient Content and Sensory Properties of Enriched Indigenous Maize Noodle 'kokoro'. *Journal of Food Technology*, 16, 7-13.
- Akhiyarov, B. G., Ismagilov, R. R., Islamgulov, D. R., Kuznetsov, I. Y., Akhiyarova, L. M., Abdolvaleev, R. R., Alimgafarov, R. R., Pavlov, A. V., Valitov, A.V. and Sergeev, V. S. (2018). Yield and quality of table beet depending on cultivation technology elements. *Journal of Engineering and Applied Sciences*, 13(S11), 8752-8759.
- Akinchin, A. V., and Fedorov, A. S. (2015). Effect of green-manure crops on agrophysical properties of the soil and maize productivity for grain. *Bulletin of Kursk State Agricultural Academy*, 8, 143-145.
- Araya, A., Kisekka, I., Vara Prasad, P. V., and Gowda, P. H. (2017). Evaluating optimum limited irrigation management strategies for corn production in the Ogallala aquifer region. *Journal of Irrigation and Drainage Engineering*, 143(10), 04017041.
- Ayhan, A., Liu, Q., Alibas, K., and Unal, H. (2013). Biogas production from maize silage and dairy cattle manure. *Journal of Animal and Veterinary Advances*, 12(5), 553-556.
- Barry, M., Triulzi, G., and Magee, C. L. (2017). Food Productivity Trends from Hybrid Corn: Statistical Analysis of Patents and Field-test data. *arXiv preprint arXiv:1706.05911*.
- Chavas, J. P., and Mitchell, P. D. (2018). Corn Productivity: The Role of Management and Biotechnology. Chapter 2. In Amanullah D and Fahad S (Eds), *Corn: Production and Human Health in Changing Climate* (pp. 13-26). Intech, U.K.
- Chung, S. U., Sung, S. H., Zhang, Q. M., Jung, J. S., Oh, M., Yun, Y. S., ... and Moon, S. H. (2019). Assessment of Productivity and Vulnerability of Climate Impacts of Forage Corn (Kwangpyeongok) Due to Climate Change in Central Korea. *Journal of The Korean Society of Grassland and Forage Science*, 39(2), 105-113.
- Dahlan, S. S., Mappigau, P., and Khaerani, S. (2014). Human Capital Specific, Entrepreneurial Behavior and Integrated Maize Crop Management Adoption. *Research Journal of Applied Sciences*, 9(8), 481-488.
- Emmanuel, R., and Mutimura, M. (2012). Comparison of nutrient composition and in vitro digestion characteristics of four forage legumes from two agro-ecological zones of Rwanda. *Agricultural Journal*, 7(4), 264-269.
- Falade, A. T., Buys, E. M., and Taylor, J. R. (2017). Effect of Different Non-Wheat Bread Making Methods on the Quality of Maize Bread. *Journal of Food Technology*, 15(1), 1-6.
- Hisse, I. R., D'Andrea, K. E., and Otegui, M. E. (2019). Source-sink relations and kernel weight in maize inbred lines and hybrids: responses to contrasting nitrogen supply

- levels. *Field Crops Research*, 230, 151-159.
13. Huato, M. A. D., Arenas, O. R., Lopez-Reyes, L., Carcano-Montiel, M. G., Lezama, J. F., and Leon, A. C. (2016). Model: Producer-Innovator, Farmers Technologies, and Food Security in Rainfed Maize in Mexico Producers. *Research Journal of Biological Sciences*, 11, 98-104.
14. Ismagilov, R., Akhiyarov, B., Islamgulov, D., Ayupov, D., and Salnikov, V. (2019). Maize hybrid productivity and grain quality in conditions of the Cis-Ural forest-steppe. *AIMS Agriculture and Food*, 4(3), 604-612.
15. Kätterer, T., Roobroeck, D., Andrén, O., Kimutai, G., Karlton, E., Kirchmann, H., ... and de Nowina, K. R. (2019). Biochar addition persistently increased soil fertility and yields in maize-soybean rotations over 10 years in sub-humid regions of Kenya. *Field Crops Research*, 235, 18-26.
16. Kedir, M. (2018). Adoption and determinants adoption of improved maize in Ethiopia. *Agricultural Journal*, 13, 1-8.
17. Lamptey, S., Yeboah, S., Li, L., and Zhang, R. (2017). Dry matter accumulation and nitrogen concentration in forage and grain maize in dryland areas under different soil amendments. *Agronomy Research*, 15(4), 1646-1658.
18. Lin, H., Xie, Y., Liu, G., Zhai, J., and Li, S. (2019). Soybean and maize simulation under different degrees of soil erosion. *Field Crops Research*, 230, 1-10.
19. Lubova, T. N., Islamgulov, D. R., Ismagilov, K. R., Ismagilov, R. R., Mukhametshin, A. M., Alimgafarov, R. R., ... and Lebedeva, O. Y. (2018). Economic efficiency of sugar beet production. *Journal of Engineering and Applied Sciences*, 13(S8), 6565-6569.
20. Mudarisov, S., Khasanov, E., Rakhimov, Z., Gabitov, I., Badretdinov, I., Farchutdinov, I., ... and Jarullin, R. J. (2017). Specifying two-phase flow in modeling pneumatic systems performance of farm machines. *Journal of Mechanical Engineering Research and Developments*, 40(4), 706-715.
21. Ngaboyisonga, C., Njoroge, K., Kirubi, D., and Githiri, S. M. (2012). Quality protein maize under low N and drought environments: endosperm modification, protein and tryptophan concentrations in grain. *Agricultural Journal*, 7(5), 327-338.
22. Ngeno, V., Mengist, C., Langat, B. K., Nyangweso, P. M., Serem, A. K., and Kipsat, M. (2012). Measuring Technical Efficiency among Maize Farmers in Kenya's Bread Basket. *Agricultural Journal*, 7(2), 106-110.
23. Novák, P., Kovaříček, P., Hůla, J., and Buřič, M. (2009). Surface water runoff of different tillage technologies for maize. *Agronomy Research*, 17(3), 754-760.
24. Omokanye, A. T., Kelleher, F. M., and McInnes, A. (2013). Crop residues for mulch, feed yield and quality as influenced by low-input maize-based cropping systems and N fertilizer. *Agricultural Journal*, 8(5), 222-231.
25. Pandurovic, Z., Dragicevic, V., Glamoclija, D., and Dumanovic, Z. (2013). Possibilities of maize cropping for feed on acid soil. *Journal of Animal and Veterinary Advances*, 12(7), 813-822.
26. Sotchenko, Yu. V., Ismagilov, R. R., and Akhiyarov, B. G. (2018). Maize hybrid grain productivity and quality in conditions of the Bashkortostan Republic. *Vestnik of Bashkir State Agrarian University*, 4(48), 39-43.
27. Venkatesh, M. S., Hazra, K. K., Ghosh, P. K., and Mishra, J. P. (2019). Integrated phosphorus management in maize-chickpea rotation in moderately-alkaline Inceptisol in Kanpur, India: An agronomic and economic evaluation. *Field Crops Research*, 233, 21-32.
28. Wakili, A. M. (2012). Technical Efficiency of Maize Farmers in Gombi Local Government of Adamawa State, Nigeria. *Agricultural Journal*, 7(1), 1-4.
29. Xu, J., Han, H., Ning, T., Li, Z., and Lal, R. (2019). Long-term effects of tillage and straw management on soil organic carbon, crop yield, and yield stability in a wheat-maize system. *Field Crops Research*, 233, 33-40.
30. Xu, J., Meng, J., and Quackenbush, L. J. (2019). Use of remote sensing to predict the optimal harvest date of corn. *Field Crops Research*, 236, 1-13.

Figure 2. The height of maize plants in the "Agro Tany" agricultural production cooperative of the Tatyshly district and the scientific training center of the Bashkir State Agrarian University located in the Ufa district (before harvesting, 2019).

Figure 3. Maize green mass yield in "Agro Tany" of the Tatyshly district and the BSAU's scientific training center of the Ufa district (the milky-wax ripeness phase of seeds, 2019)

Table 1. Seed moisture content and yield depending on hybrids (2019)

Hybrid	“Agro Tany” agricultural production cooperative		the scientific training center of the BSAU	
	Seed moisture at harvesting	Seed yield at the standard moisture content(14%), t/ha	Seed moisture at harvesting	Seed yield at the standard moisture content(14%), t/ha
Mashuk 140	28.00	4.81	25.00	4.43
K-140	29.00	4.43	25.20	5.47
K-150	32.00	4.24	29.30	5.37
Uralskii 150	30.10	5.45	28.40	6.76
Nur	32.20	3.73	29.20	5.68
Mashuk 150	31.50	4.21	29.80	6.57
Biliar 160	42.00	4.13	35.30	4.74
K-160	43.60	4.12	36.20	5.21
K-170	54.30	4.98	38.60	5.05
Shikhan	54.00	4.53	38.00	5.89
Katerina SV	55.00	4.04	45.30	5.42
Baikal	54.30	5.38	46.20	6.16
Mashuk 175 MV	58.60	3.25	49.10	5.23
Mashuk 170 MV	58.40	4.45	47.60	5.27
Mashuk 171	62.00	4.27	48.10	5.75
Mashuk 220 MV	62.20	3.27	55.30	2.77
Newton	62.40	3.17	59.20	5.29
Mashuk 250 SV	63.50	3.43	59.30	2.50
HCP ₀₅	0.28	0.15	0.31	0.16