Corn yield per silo depending on the elements of cultivation technology in Western Siberia

R R Akhtariev, E I Miller, S S Miller and V V Rzaeva
Northern Trans-Ural State Agricultural University, Republiki Str., 7, Tyumen, 625003, Russia

E-mail: millerss@gausz.ru

Abstract. The research was carried out in order to identify the best method of basic tillage in the cultivation of corn per silo in 2016-2019 on two experimental fields of the Tyumen region in two repeated experiments: factor A – soil cultivation methods (moldboard, nonmoldboard, differentiated), factor B – (without fertilizers, with the use of organic fertilizers – manure) in the first experiment, factor B – corn hybrids (Katerina SV, Ross 140 SV) in the second experiment. Sowing of corn was carried out in the second decade of May with a STV 8KU seeder. In the first experiment over the years of research, the best option was the moldboard method of processing with the introduction of organic fertilizers, where the highest yield was obtained – 39.9 t/ha. With refusal of organic fertilizers, the corn yield decreased by 10.5 t/ha for moldboard and by 9.3 t/ha for nonmoldboard methods. In the second experiment, the yield of corn hybrids over the years of research varied from 28.1 to 35.6 t/ha. The moldboard method was the best option for cultivating both hybrids, where the yield for Katerina SV hybrid is 35.6 t/ha, for the Ross 140 SV hybrid – 32.1 t/ha.

1. Introduction
Land is the main means of production in agriculture, ability to satisfy plants in nutrients, air, water, heat and provide consistently high yields [3; 4; 19].

In the Tyumen region, agriculture is intensively developing, especially livestock breeding [5]. In the region there is a need to use new high-yield and high-quality varieties to increase the production of agricultural crops [7].

Rejection of the system of justified crop rotations brings significant damage to modern domestic agriculture. In this regard, it becomes necessary to introduce new, as well as previously widespread crops, such as corn [15], into crop rotations; it is one of the main crops in the world. It is mainly grown for grain and for forage. Fresh and especially ensiled, it is an excellent animal feed in many regions of the world. High yield and low costs in cultivation determine its widespread distribution throughout the world [20].

Corn during its development consumes a large amount of nutrients and responds well to the level of agricultural technology. Therefore, to obtain a high yield of corn, it is necessary to comply with the entire cultivation technology, and mainly scientific substantiation of fertilization system [10].

Corn is a good precursor in crop rotation, it clears the fields from weeds, has almost no pests and diseases in common with cereals [9].
Corn is a promising industrial and forage crop. It is high-yielding and fairly drought-resistant. An increase in the area of corn cultivation will allow obtaining a more balanced structure of crop rotation, effectively dealing with certain types of weeds and diseases [15].

Corn is one of the most demanded crops in world agriculture. This is due to the fact that it can be used both for grain production and for preparation of high-energy green fodder. Corn silage, as noted by many researchers, has a positive effect on the milk production of a dairy herd and accelerates the weight gain of beef cattle for fattening. An important factor for obtaining large and high-energy yields of green corn mass is compliance with farming system, selection of hybrids and control of weeds, aimed at obtaining silage with a high grain content [11].

An important issue that needs to be addressed in the cultivation of maize is the choice of optimal method of basic soil cultivation [17]. It has been established that the most important factor limiting the formation of corn yields is the main tillage [13].

In Western Siberia, the best method of basic soil cultivation is a moldboard and differentiated method, in which the highest yield of corn [8] and other agricultural crops [6] is obtained.

Considering the soil cultivation methods, ploughing contributes to formation of the highest productivity of cultivated crops, and a decrease in the depth of cultivation leads to its decrease [16].

Due to the fact that there are contradictory data on the methods of tillage for almost all parameters and for all zones of the country, it is necessary to study them further, or to develop new methods of cultivation [18].

Organic fertilizers are used to improve conditions of nutritional regime. They not only increase the nutrients supply to plants, but also contribute to the accumulation of organic matter in the soil, the growth of resistance against erosion, and prevent excessive overconsolidation of ploughed horizon. The fertilizers application allows more economical use of water for formation of plant biomass, thereby providing for a greater yield of maize silage mass [12].

2. Materials and methods
The research was carried out on two experimental plots in the conditions of Western Siberia of the Tyumen region in grain-row crop rotations (the first crop rotation: corn-spring wheat-oats; the second crop rotation: corn-spring wheat) using field and laboratory methods. The soils of the experimental fields are leached medium-thick chernozem, medium-humus, heavy loamy. In terms of agrophysical and agrochemical indicators, it corresponds to the average values of these soils in Western Siberia [2; 1]. Two factors were studied in the experiment: factor A – basic tillage (1. Moldboard method of tillage, 2. Nonmoldboard method of tillage, 3. Differentiated method of tillage), factor B – (without fertilizers, with the use of organic fertilizers – manure) in the first experiment, factor B – corn hybrids (Katerina SV, Ross 140 SV) in the second experiment.

In the spring, with the onset of physical ripeness of the soil, early spring harrowing with tooth harrows BZSS-1.0 was carried out in two tracks across the direction of the main cultivation. At the onset of the optimal sowing time for row crops, pre-sowing cultivation of the soil was carried out with a KPS-4 cultivator to a depth of 7-8 cm under corn, after which sowing was carried out with a seeder – STV 8KU at a depth of 6-8 cm. Accounting for the yield of green mass of corn was carried out in 4-fold repetition, the size of the accounting plot is 50 m2. The total yield of green mass of corn was taken into account (the stalks with cobs were mowed and the whole mass was weighed). After harvesting, the main soil cultivation was carried out according to the experimental schemes, taking into account the options for applying organic fertilizers after the predecessor for corn.
Table 1. Experiment Design 1 – Influence of basic tillage and fertilization methods on corn yield.

| Tillage method          | Corn without fertilizers | organic fertilizers (manure) | Spring wheat | Oats |
|-------------------------|--------------------------|------------------------------|--------------|------|
| Moldboard (control)     | Ploughing, 28-30 cm      | Ploughing, 28-30 cm          | Ploughing, 20-22 cm | Ploughing, 20-22 cm |
| Nonmoldboard            | Loosening, 28-30 cm      | Loosening, 28-30 cm          | Loosening, 20-22 cm | Loosening, 20-22 cm |
| Differentiated          | Ploughing, 28-30 cm      | Ploughing, 28-30 cm          | Ploughing, 20-22 cm | Loosening, 20-22 cm |

Table 2. Experiment Design 2 – Influence of basic tillage methods on corn hybrids yield.

| Tillage method | Corn Katerina SV | Corn Ross 140 SV | Spring wheat |
|----------------|------------------|------------------|--------------|
| Moldboard      | Ploughing, 20-22 cm | Ploughing, 20-22 cm | Ploughing, 20-22 cm |
| Nonmoldboard   | Loosening, 20-22 cm | Loosening, 20-22 cm | Loosening, 20-22 cm |
| Differentiated | Ploughing, 20-22 cm | Ploughing, 20-22 cm | Loosening, 23-25 cm |

3. Results and discussion
The yield of an agricultural crop is an effectiveness indicator of the applied agrotechnical method [14].

The corn yield over the years of research (2016-2018) varied from 25.3 to 39.9 t/ha for all studied options for basic tillage. The highest yield of 39.9 t/ha was observed on the moldboard method with the introduction of organic fertilizers, by the nonmoldboard method it was 5.3 t/ha less than the moldboard method, and 2.5 t/ha less by the differentiated method. As a result of organic fertilizers use, the corn yield significantly increased from 9.3 to 10.5 t/ha according to the studied options, i.e. with the rejection of organic fertilizers, the yield decreased by 10.5 t/ha for moldboard, by 9.3 t/ha for nonmoldboard and 8.1 t/ha for differentiated tillage methods (Fig. 1).

On options without fertilizers, the yield by the moldboard method is slightly higher than the differentiated one by 0.1 t/ha and significantly higher by 4.1 t/ha by the nonmoldboard method of tillage. According to the moldboard method with organic fertilizers, the yield is higher than with the nonmoldboard method by 5.3 t/ha and by 2.5 t/ha with the differentiated one.
**Figure 1.** Yield of green mass of corn per silo, t/ha, 2016-2018

Productivity of corn hybrids over the years of research (2017-2019) varied from 28.1 to 35.6 t/ha (Fig. 2). The moldboard method was the best option for cultivating both hybrids, where the yield for the Katerina SV hybrid was 35.6 t/ha, for the Ross 140 SV hybrid – 32.1 t/ha, the difference in yield between these hybrids with the moldboard method was 3.5 t/ha.

According to the nonmoldboard method of tillage, the yield of Katerina SV hybrid exceeded the Ross 140 hybrid by 1.9 t/ha, with the differentiated method – by 3.1 t/ha.

**Figure 2.** Yield of green mass of corn hybrids per silo for the basic tillage, t/ha, 2017-2019
The lowest yield was noted on the nonmoldboard option of Katerina SV – 30.0 t/ha, Ross 140 SV – 28.1 t/ha, which is less than by the moldboard method by 4.0-5.6 t/ha and by the differentiated method by 2.1-3.3 t/ha.

Comparing the hybrids with each other, it should be noted that the highest yield of 35.6 t/ha was obtained during the cultivation of Katerina SV, while the Ross 140 hybrid had a yield lower by 3.5 t/ha.

4. Conclusion
Thus, in the maize cultivation by the basic tillage methods in Western Siberia over the years of research, the advantage was observed for the moldboard method, which was characterized by the highest yield – 35.6-39.9 t/ha. The use of organic fertilizers led to an increase in yield by 9.3-10.5 t/ha for the studied methods of basic soil cultivation. When comparing the hybrids with each other, it should be noted that the highest yield of 35.6 t/ha was obtained during the cultivation of Katerina SV, while the yield of the Ross 140 hybrid was 3.5 t/ha lower by the moldboard method of tillage.

References
[1] Chelovechkova A V, Komissarova I V and Eremin D I 2018 Forecasting water saturation of fill grounds in urban infrastructure conditions by mathematical modeling based on the main hydrophysical characteristic J. of Environmental Management and Tourism 9 3(27) 485-90 DOI 10.14505/jemt.v9.3(27).08
[2] Eremin D I 2016 Changes in the content and quality of humus in leached chernozems of the Trans-Ural forest-steppe zone under the impact of their agricultural use Eurasian Soil Science 49(5) 538-45 DOI 10.1134/S1064229316050033
[3] Iglovikov A, and Motorin A 2019 Methods of optimizing the phosphate regime of drained peat soils in the northern trans-Urals E3S Web of Conferences: conf. proceedings Innovative Technologies in Environmental Science and Education, Divnomorskoe village, Russian Federation 01003 DOI 10.1051/e3sconf/201913501003
[4] Iglovikov A 2020 Potash regime for restoration of disturbed lands in the Far North E3S Web of Conferences 03006 DOI 10.1051/e3sconf/202021503006
[5] Loginov Y P, Kazak A A, Yakubshina L I, Falaleeva T N, Yashchenko S N and Yarova E T 2018 Breeding value of collection varieties of potato in the forest-steppe zone of the Tyumen region J. of Pharmaceutical Sciences and Research 10(1) 377-80 DOI: 2-s2.0-85042770895
[6] Rzaeva V 2021 Productivity of crop rotation by the main tillage in the Tyumen region IOP Conf. Series: Earth and Environmental Science 677 52079 DOI 10.1088/1755-1315/677/5/052079
[7] Yakubshina L I, Kazak A A and Loginov Y P 2018 Using the method of electrophoresis in farming seeds of barley varieties of Grade Odessa 100 Ecology, Environment and Conservation 24(2) 1001-7 DOI: 1001-1007, 2-s2.0-8505884161
[8] Akhtariev R R, Rzaeva V V and Miller S S 2019 Productivity of corn hybrids in the northern forest-steppe of the Tyumen region In the collection: innovative technologies in field and ornamental crop production, a collection of articles based on the materials of the III All-Russian (national) scientific and practical conference pp 28-31
[9] Beltyukov L P 2007 Variety, technology, harvest (Rostov-on-Don: Terra Print LLC) p 160
[10] Demin E A and Drumshchikova L N 2020 Influence of inter-row cultivation of corn on the dynamics of nitrate nitrogen of leached chernozem in the conditions of the forest-steppe zone of the Trans-Urals Bulletin of Krasnoyarsk State Agrarian University 12(165) 32-9 DOI 10.36718/1819-4036-2020-12-32-39
[11] Demin E A and Eremina D V 2020 Influence of mineral fertilizers and sowing dates on the yield of green mass of corn in the forest-steppe zone of the Trans-Urals Bulletin of Krasnoyarsk State Agrarian University 10(163) 27-33 DOI 10.36718/1819-4036-2020-10-27-33
[12] Kokhan A V, Glushchenko L D, Olepir R V and Eremko L S 2017 The productivity of corn depending on the main tillage and fertilization in the zone of the Left-Bank forest-steppe of Ukraine Bulletin of Belarusian State Agricultural Academy 4 109-13

[13] Miller E I, Rzayeva V V and Miller S S 2019 The use of organic fertilizers against the background of the main soil cultivation in the cultivation of corn for silage in Western Siberia Bulletin of Michurinsk State Agrarian University 1 60-3

[14] Miller S S, Rzayeva V V and Akhtariev R R 2019 Productivity and infestation of corn hybrids depending on the main tillage in Western Siberia AgroEkoInfo 1(35) 14

[15] Nesmiyan A Yu and Galayan A G 2015 Influence of soil cultivation system on efficiency of corn cultivation technologies Bulletin of Agrarian Science of the Don 31(3) 5-12

[16] Rzayeva V V 2019 The influence of agrotechnical practices on the productivity of crop rotation Bulletin of the Orenburg State Agrarian University 4(78) 18-20

[17] Semenenko N N, Karankevich E V and Avramenko N M 2014 Influence of basic tillage methods on water-physical properties of anthropogenically transformed peat soil, weediness of crops and corn yield on green mass Melioration 1(71) 59-66

[18] Turusov V I, Garmashov V M, Kornilov I M, Nuzhnaya N A, Kryachkova M P and Govorov V N 2018 Agrophysical properties of soil depending on the main cultivation during the growing season of corn Bulletin of Kursk State Agricultural Academy 6 5-10

[19] Fisunov N V and Shulepova O V 2019 Weediness and productivity of annual grasses with different basic tillage in the northern forest-steppe of the Tyumen region In the collection: innovative technologies in field and ornamental plant growing, a collection of articles based on the materials of the III All-Russian (national) sc. and pract. conf. pp 273-9

[20] Shakhova O A and Oznobikhina L A 2019 Potential stock of seeds in the soil as one of the factors that determine the species composition and number of weeds in resource-saving technologies for the cultivation of spring wheat in the Northern Trans-Urals Bulletin of Michurinsky State Agrarian University 1 34-7