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THE BIOLOGICAL CHARACTERISTICS OF GRAIN PRODUCTION AND SILAGE FROM CORN (ZEA MAYS)

Abstract. Improvement of technology of cultivation of maize in the Northern Kazakhstan was based on the principles of soil-protective arable farming and harvesting silage was the main purpose. The advanced technology with the use of early-maturing hybrids (FAO (Food and Agriculture Organization) 150-199) on the basis of minimizing of the technological cycle has been developed in the North Kazakhstan Research Institute of Agriculture in the period from 1987 to 1997. The average output of absolutely dry substance for this period was 4.8 t/ha, that is 45.1% higher than in the previous period (1977–1986). However, the advanced technology based on the cultivation of the only silage crop (monoculture) cannot exclude a sharp decrease of the yields in droughty years and in years when the summer is short and cool. The silage conveyor as an alternative to monoculture of maize was substantiated by the selection of crops with different biological requirements for growth conditions. The yields of the silage conveyor crops (sunflower-maize-sweet sorghum) were 5.14 t/ha (absolutely dry substance), that is 0.73 t/ha higher than the yields of monoculture of maize in the period from 2007 to 2009.

Key words: maize, silage, fodder, grain, early maturing hybrids, dry substance, the cultivation technology, methods of cultivation, crop productivity, silo conveyor, monoculture, the Northern Kazakhstan.

Introduction. Maize cultivation in the northern regions of Kazakhstan originates from the 1950s when the maize began to sow to produce silage. The large areas were sowed for the first time (more than 75 thousands of hectares) in 1954 and the areas about 1.5 mln hectares, which is 2/3 of the total area of Kazakhstan, were sowed in the next 5 years [1, 2].

Large-scale introduction of maize and implementation of tilled farming system were carried out simultaneously. The maize field was the main one in crop rotations in this farming system [3].

The introduction of maize was carried out rapidly and over the large areas, so the zonal features of the new region of cultivation were not taken into account. Agricultural techniques, the system of agricultural implements and hybrids of maize were carried over unchanged. Agro techniques were based on late-ripening hybrids and the use of moldboard plowing, disk plough-harrows and checkrow planting ensured the ability of two inter-row processing in two directions during the period of vegetation.

Such unreasonable transfer of a tilled technology into the steppe zone, not protected from destructive influence of wind, led to the widespread deflation and systematic damage of the plants in the fields [4, 5].

The agricultural science faced a challenge of development of soil-protecting activities to overcome destructive influence of drought, wind erosion. These methods would guarantee the preservation of soil fertility. However, there were positive results. A practical expediency and economic efficiency of maize cultivation to harvest silage on the basis of imported seeds was proven during the period of introduction of maize in the Northern Kazakhstan [6-8].

Dairy farming was now based on a fundamentally new type of feeding in virgin areas. The basis of the ration was silage and concentrates [9]. Scientific research of that period lasted until 1986. Soil-protective technologies were specified for each agricultural zone. The main tasks of the scientific research were to protect the plants in the fields from wind erosion and a decrease in the amplitude of fluctuations of the yields of maize. Researchers of the Northern Kazakhstan have proven that maize is not a tilled crop and there is no need for continuous loosening of row-spacing [10, 11].

Agro-physical parameters of the soil after plowing do not meet the biological requirements for the growth of maize. This fact was experimentally determined for the first time in the conditions of Northern Kazakhstan. When the density of the soil in the rooting zone is 1.05-1.1 g/cm^3, the optimum water, air and food mode for the root system is created [12, 13], whereas after the plowing it is 0.9-0.95 g/cm^3. Full substantiation of this theory was given by scientists of Agrophysical Scientific and Research Institute (Russian Federation) and in the countries of Western Europe [14, 15].

Materials and methods. The trends in change of the yields for a period of 1969-1986 were determined on the basis of statistical reporting in the administrative districts, which are included in the appropriate agricultural zone. Mathematical processing of data was performed by the method of equal squares [16].

The analysis of the chemical composition of the biomass was performed according to the conventional technique:

– the protein content - by the method of Kjeldahl;
– the determination of cellulose - by the method of Ganneberg-Shtoman;
– the determination of sugars - by the centrifuge micromethod of Bertrand-Bieri;
– the determination of crude fat - by extracting with ethyl ether;
– the definition of carotene - on the SF-596 spectrophotometer.

Results and discussion. Soil-protective farming system included new crop rotations with the "corn-wheat" crop group. The highest yield (absolutely dry substance) per 1 ha was obtained in this group.

Wide-row method of sowing (70 cm) has become an alternative to a checkrow sowing, where the integrated protection of maize was carried out by applying of soil herbicides and surface treatment the most littered plots on the field. A distinctive feature of the soil-protective technologies that had already been developed was at the zonal level, to minimize a technological cycle by consolidating of manufacturing operations, increasing the width of capture of units and decreasing of the depth of processing.

We carried out a comparative assessment of energy consumption for a tilled technology (during the period OF 1969-1976) and for a soil-protective technology (during the period OF 1977-1986) at the experimental field of the North-Kazakhstan Scientific and Research Institute of Agriculture. The experimental field is located in agricultural steppe zone of the Northern Kazakhstan. Abandoning the plough began to use the cultivator and this led to increased productivity of labor and to reducing of material resources. The maize seeder has been upgraded for stable operation after treatment of the ground with a cultivator and performed a number of operations in a single pass: seed placement, fertilizing, introduction of soil herbicides and soil loosening in the row zone [17].

Thus, the number of passes on the field has decreased almost by half (table 1).

A labor costs per unit of area has decreased respectively. The average yield for the period of improving soil-protective technology (1977-1986) increased 1.5 times in comparison with the previous period (1969-1976) and amounted to 3.3 t/ha (absolutely dry substance).

However, soil-protective technology did not guarantee an annual maturation to milky-wax ripeness. Only in this phase maize is the standard raw material (more than 25% of absolutely dry substance) for the production of high-quality silage [18].

There are not enough effective temperatures for late-maturing hybrids to reach the milky-wax ripeness until the autumn frosts in the climatic conditions of the Northern Kazakhstan.

The dynamics of the yield of maize in selected agricultural areas during this period and quality of the yield can be seen in a typical example of the North-Kazakhstan region. We analyzed the maize cultivation in the region by the equal squares method during the 17-year period.

As convincingly demonstrated by mathematical analysis (table 2), in all agricultural areas during the period of years 1969-1986 the transition to soil-protective technology has affected the trend of growth of the yields, expressed as a positive value of the parameter x (average annual factor).

Table 1 – The technological cycles in the different periods of cultivation of maize at the experimental field of the North-Kazakhstan Scientific and Research Institute of Agriculture

Technological operation	Technology	
	Tilled (1969-1976)	Soil-protective (1977-1986)
Ploughing	+	–
Treatment of the ground with a cultivator	–	+
Harrowing with spike-tooth harrows	+	–
Harrowing with needle harrows	–	+
Treatment of the ground by disk plough-harrow before sowing	+	–
Treatment of the ground with a cultivator before sowing	–	+
Packing soil before sowing	+	–
Checkrow planting	+	–
dotted sowing with fertilizers and herbicides	–	+
Packing soil after sowing	+	–
Double harrowing	++	++
Treatment of soil in row-spacing	+	+
Treatment of soil in row-spacing with introduction of fertilizers	+	–
Treatment of soil in row-spacing crosswise the direction of sowing, 2 passes	++	–
Treatment of plants with herbicides	+	–
Harvesting	+	+
The number of treatments	14	8
The average yield for the period, t/ha	2.2	3.3

Table 2 – The tendency in dynamics of the yield of maize in agricultural areas of the North-Kazakhstan region (during the period of years 1969-1986)

Agricultural zone	The tendency in dynamics of the yield	Yield		
		Natural humidity, t/ha	Absolutely dry substance	
			Concentration, %	Yield, t/ha
Moderately arid steppe	92.6 +4.4 x	14.9	20.4	3.03
Arid steppe	76.0 +5.5 x	13.2	23.0	3.03
Forest-steppe	112.0 +1.5 x	13.6	21.4	2.91
Hilly steppe	121.0 +2.7 x	15.6	19.5	3.04
Steppe on chernozem soils	105.0 +2.3 x	13.4	19.2	2.57
Steppe on chestnut soils	37.9 +2.2 x	7.09	20.0	1.41
Experimental field of The North-Kazakhstan Scientific and Research Institute of Agriculture (hilly steppe)	169.3 +5.7 x	22.6	23.1	5.22

Despite the fact that high technological discipline was maintained on the experimental field, as evidenced by the highest yield here, there was no guarantee for the milk-wax ripeness also on this field. The concentration of absolutely dry substance was lower than 25% that did not provide a producing of high-quality silage.

The concentration of absolutely dry substance in mid-season hybrids (FAO 200-250) which have been approved for use in the Northern Kazakhstan was reaching 20-23% before the first frost. The main cause of low-quality silage is the biomass with high humidity.