АУЫЛ ШАРУАШЫЛЫҒЫ, АГРОХИМИЯ, АЗЫҚ ӨНДІРУ, АГРОЭКОЛОГИЯ
ЗЕМЛЕДЕЛИЕ, АГРОХИМИЯ, КОРМОПРОИЗВОДСТВО, АГРОЭКОЛОГИЯ
AGRICULTURE, AGROCHEMICAL, FEED PRODUCTION, AGROECOLOGY

IRSTI 68.35.47 **DOI https://doi.org/10.37884/3-2022/06**

M.K. Tynykulov

L.N. Gumilev Eurasian National University, Astana, Republic of Kazakhstan, tynykulov@list.ru

CORN PRODUCTIVITY IN NORTHERN KAZAKHSTAN

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 1997 to 2015. 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 (1987-2008).

However, the advanced technology, based on the cultivation of the only silage crop (monoculture) can not 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 for monoculture of maize was substantiated by the selection of crops with different biological requirements for growth conditions. The yields of crops of the silage conveyor (sunflower - maize - sweet sorghum) was 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 2016 to 2019.

***Key words**: maize, silage, productivity, the cultivation technology, 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 that are 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 field 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 has faced a challenge of development of soil-protecting activities to overcoming destructive influence of drought, wind erosion. These methods will guarantee the preservation of soil fertility.

However, there were positive results. A practical expediency and economic efficiency of cultivation of maize to harvest silage on the basis of imported seeds has been 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 1996. 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 of 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/cm3, 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/cm3. 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 the years 1979-1996 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 group of crops "corn-wheat". 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 were being developed already now at the zonal level, is 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 1979-1996) and for a soil-protective technology (during the period 1997-1996) 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 has 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 accordingly. The average yield for the period of improving of soil-protective technology (1987-1996) increased 1.5 times in comparison with the previous period (1979-1996) 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.

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 (1979-1996)	Soil-protective (1987-1996)
Ploughing	+	–
Treatment of the ground with a cultivator	–	+
Harrowing with spike-tooth harrows	+	–
Harrowingwithneedleharrows	–	+
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 sowingwith 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	+	+
Thenumberoftreatments	14	8
The average yield for the period, t/ha	2,2	3,3

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 1979-1996 the transition to soil-protective technology has affected on the trend of growth of the yields, expressed as a positive value of the parameter x (average annual factor).

Table 2 - The tendency in dynamics of the yield of maize in agricultural areas of the North-Kazakhstan region (during the period of years 1979-1996)

Agriculturalzone	The tendency in dynamics of the yield	Yield		
		Natural humidity, t/ha	Absolutelydrysubstance	
			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.

Since 1997, the team of scientists of The North-Kazakhstan Scientific and Research Institute of Agriculture started to develop an improved technology. This technology was based on the introduction of early-maturing hybrids (FAO 150...199).These hybrids had milky-wax ripeness every year in this region [19].

The yield of early-maturing hybrids was higher than that of the mid-season hybrids, as was proven by our research and confirmed by verification in production.

It is well known that the maximum daily gain of maize falls on the phase of milky-wax ripeness and significantly exceed the rates of all the previous phases [20-22].

Early maturing hybrids grow intensively 12...15 days until frost, while for the mid-season hybrids this period is 1-3 days and is interrupted by frost. Therefore, the mid-season hybrids who have a higher potential of productivity in comparison with the early-maturing hybrids, inferior to them in the yield of absolutely dry substance in the short summer.

The average yield for the 1997-2005 period was higher (advanced technology) than for the prior periods (Fig.1).

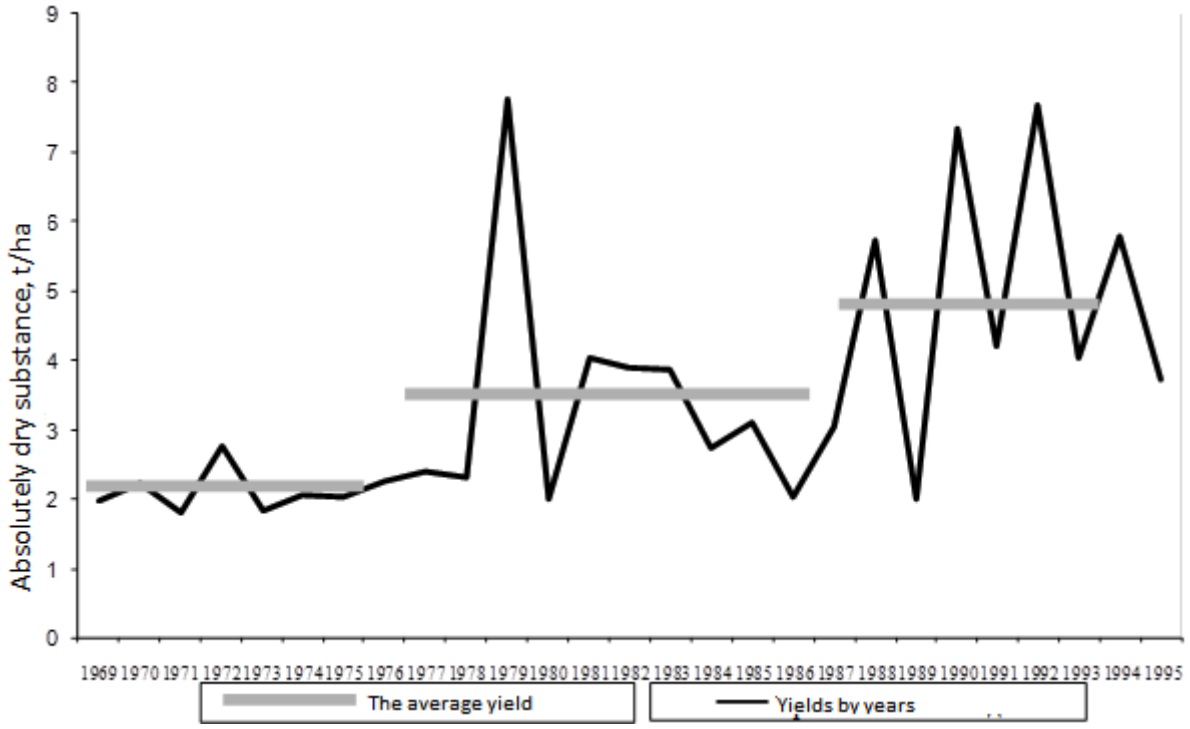

Figure 1 - Dynamics of the yield of maize in the experimental field of The North-Kazakhstan Scientific and Research Institute of Agriculture as shown by the periods of cultivation

However, the improved technology does not guarantee the annual high yields in difficult climatic conditions of the Northern Kazakhstan. Maize was the main silo crop in the region, other silage crops occupied 6...17% of the total area. Therefore, fluctuations in yield depended only on one culture. Maize harvest is increasing slowly in years with cool summers; the moisture content of the plants will be high. Maize also gives low yields in dry years (Table 3).

Table 3 - The amplitude of fluctuations of yield of maize in the experimental field of The North-Kazakhstan Scientific and Research Institute of Agriculture

Year	The sum of temperatures above +10ºC, ºC	The amount of precipitation (May-August), mm	The period without effective rainfall,(days)	Absolutely dry substance, t/ha	The decrease in yield, t/ha
1997	1775	132,2	30.VI – 7.VII (37)	3,0	1,8
1998	2120	129,3	27.VI – 10.VII (15)	5,7	-
1999	2178	133,1	27.VI – 21.VIII (51)	2,0	2,8
2000	2077	304,2	29.V – 15.VI (16)	7,3	-
2001	2124	132,2	31.V – 7.VII (37)	4,2	0,6
2002	1890	281,4	8.VI – 21.VI (12)	7,6	-
2003	1951	238,9	3.VI – 5.VII (32)	4,0	0,8
2004	1960	287,6	20.VI – 7.VII (16)	5,8	-
2005	1627	122,4	20.VI – 9.VII (19)	3,7	1,1
2006	1886	219,0	21.VI – 8.VII (16)	4,8	-
2007	2230	144,0	17.VI – 5.VII (18)	4,7	0,1
1997-2006	1983	194,5	(24)	4,8	

Note: Rainfall of more than 5 mm per day classified as effective

To the main silo crop needs a set of other cultures for a particular agricultural zone. This set of other cultures will reduce the fluctuations of annual yield. Average yield of these crops should be higher than the yield of maize. In this case, we obtain the optimal set of crops.

The optimal period for harvesting of maize corresponds to the phase of milky-wax ripeness and lasts 8-10 days. In fact, this period lasts 18-20 days, if maize is a monoculture. Therefore, harvesting silage ends, usually at subzero temperatures, which affect the quality of biomass. Typical results were obtained by us in 2006, when the first frost was on August, 26 (Table 4).

Table 4 - Chemical composition of maize in different periods of harvesting (2006)

Indicators of the quality of the yield	Unit of measurement	Period of harvesting		
		Milk ripeness	Milky-wax ripeness	
			Before the frost	After the frost
Date of sampling		20.VIII	25.VIII	30.VIII
Humidity	%	79,3	75,3	77,8
Absolute dry substunce	%	20,7	24,7	22,2
Including				
Protein	%	3,0	2,6	2,5
Fat	%	0,4	0,8	0,2
Cellulose	%	7,4	6,9	11,5
Nitrogen-free extractives	%	8,0	12,6	6,6
Ash	%	1,9	1,8	1,4
The amount of carotene	mg / kg	23,5	15,9	8,6

The researchers had to find the set of crops in the system of silage conveyor to decrease the amplitude of harvest variations in years with extreme conditions. At the same time maize should remain the main silo crop. The results of the research (2011-2019) showed that in years with cool summers, when the number of active temperatures is insufficient, sunflower gives the greatest yield. The yield of sugar sorghum is much greater than yield of maize and sunflower in dryland conditions

when the period of vegetation is prolonged. The yield of maize, sweet sorghum and sunflower differ from each other and depended on the period of harvesting (Table 5).

Table 5 - The yield of silage crops by calendar dates(absolutely dry substance), t/ha

Year	Date of harvesting			
	August, 20	August, 25	August, 30	September, 5
Maize (control)				
2017	18,2	40,1	48,0	-
2018	30,2	62,3	68,4	-
2019	24,6	50,3	55,5	-
2017-2019	24,0	50,2	57,3	-
Sun flower				
2017	59,1	65,2	-	-
2018	38,3	45,0	-	-
2019	49,5	56,9	-	-
2017-2019	48,0	55,0	-	-
Sweet sorghum				
2017	19,3	24,5	26,3	38,5
2018	24,5	36,0	47,6	69,2
2019	22,4	35,2	44,7	62,4
2017-2019	21,0	31,2	39,6	56,7

Yield of sunflower, compared with yield maize and sorghum, has the maximum value on the 25 of August. Because the maize has not reached milk-wax ripeness yet, as well as sorghum has not reached the stage of flowering. Maize has reached milky-wax ripeness on the 30 of August, and on this day the yield of maize was higher than that of sunflower and sugar sorghum. In turn, sweet sorghum has reached its maximum yield in the first five days of September.

The interpretation of these data allows to calculate the yield of silage crops in the system of silage conveyor, if the harvesting period will fit: for sunflower - August, 20...25 (flowering stage); for maize - August, 26...30 (milky-wax ripeness), sweet sorghum - August, 31 … September, 5 (flowering of panicles).

We compared the average yield of crops in the system of silage conveyor (maize, sunflower and sugar sorghum) with a yield of monoculture of maize over 3 years (2017-2019). It was found (table 6) that the amplitude of fluctuation of yield for the monoculture of maize higher from year to year. The average yield of monoculture (2017-2019) was lower, because the harvesting period was prolonged. Harvesting of monoculture of maize began before reaching the milk-wax ripeness.

Table 6 - Comparison of different systems for the production of silage

The system of the production	2017	2018	2019	2017-2019
Monoculture of maize, t/ha	3,54	5,36	4,34	4,41
The deviation from the mean value				
t/ha	- 0,87	+ 0,95	- 0,07	-
%	- 19,7	+ 21,5	- 1,5	
The system of silage conveyor, t/ha	4,61	5,51	5,32	5,14
The deviation from the mean value				
t/ha	- 5,53	0,37	0,18	
%	- 10,3	+ 7,1	+ 3,5	

The yield of crops in system of silage conveyor will be higher if corn, sunflower and sweet sorghum will not occupy equal areas. They should occupy the acreage according to the probability of occurrence of certain weather conditions.

It was established by us that the number of years with high solar activity and prolonged summer in the hilly-steppe zone was 8 of 30 (1971…2000).Therefore, the acreage of sweet sorghum should be no more than 25%, which corresponds to the theoretical frequency of coming of favorable years. The theoretical frequency of coming of favorable years for sunflower corresponds to 25-27%

Conclusion

Scientific search has developed from tilled technology to soil-protective and further to advanced technology on the principles of the increasing yield, the quality of yield and minimizing of the technological cycle during the 5 decades of cultivation of maize in the Northern Kazakhstan.

The average yield was 4.8 t/ha (absolutely dry substance) over the years of the introduction of improved technology (1977-2007) at the experimental field of the North-Kazakhstan Scientific and Research Institute of Agriculture. Yields increased 2.2 times compared to the tilled technology (1979-1986). Labor costs decreased 4.9 times per 1 ton of product.

Silage conveyor was developed on the basis of the set of crops, which supplemented maize, for production of sustainable by years raw material silage. Yields of maize as a monoculture for production of silage amounted to 4.41 t / ha during 2017-2019, that is 0.73 t / ha less than the average yield of crops of the system of silage conveyor (sunflower - corn - sugar sorghum). The amplitude of fluctuation of yield decreased from 19.7% (monoculture) to 10.3% (silage conveyor).

Gratitude

I express my gratitude to the Doctor of Agricultural Sciences, Professor Kostikov Ivan Fedorovich. The article was executed as part of a grant on corn for grain and silage in the conditions of Northern Kazakhstan.

References

1. Sazanova L. 1964. The history of distribution of maize in our country. Urozhaj, Minsk. p. 219. (in Russian).
2. Goodman M M. 1965. The history and origin of maize: current theories on the relationships between maize and some of its relatives. North Carolina Agricultural Experiment Station. pp. 170.
3. Nalivaiko G A. 1962. About the tilled farming system. The Publishing House of the Ministry of Agriculture of the RSFSR (Russian Soviet Federative Socialist Republic), Moscow. pp.112. (in Russian).
4. Berestovsky G G. 1969. Wind erosion of soils and control measures against itin the north-east of the Kazakhstan: abstract of dissertation of Ph.Ds. in agricultural sciences. Alma-Ata. pp. 28.
5. Gossen E F. 2014. Soil-protective farming and sustainability of grain production. Poligrafija, Kokshetau. pp. 135. (in Russian).
6. Kozhevnikov A R, Popova G I. 1965. Maizein the Virgin Lands region and in the Western Siberia. Kolos, Moscow. pp. 144. (in Russian).
7. Khlebov P I. 1966. The characteristics of varietal farming of maize in the steppe zone of Northern Kazakhstan: dissertation of Ph.Ds. in agricultural sciences. Shortandy. pp. 153.
8. Rabinovich N M. 1968. Agro-technical and organizational-economic features of maize cultivation in Kazakhstan: dissertation of Ph.Ds. in agricultural sciences. Alma-Ata. pp. 103.
9. Erlepesov M N. 1964. The cultivation of maize in Kazakhstan. The Publisher of agricultural literature, Alma-Ata. pp. 228. (in Russian).
10. Zinchenko I G. 1970. The influence of different systems of primary tillage on some elements of fertility and maize yield. Collection of scientific papers of The All-Union Scientific Research Institute of Grain Farming. pp. 66-67. (in Russian)
11. Krumin A V. 1974. Maize in soil-protective system of farming. Maize, 8. 14-15.

12. Kudaybergenov G K. 1978. The system of primary tillage in the grain crop rotation. Kainar, Alma-Ata. pp. 14-16. (in Russian).

13. Hall A J, Lemcoff J H, Trapani N. 1981. Water stress before and during flowering in maize and its effects on yield, its components, and their determinants. Maydica, 26. p.19-38.

14. Revut I B. 1969. Theoretical foundations of elements of technological treatment of soil. Theoretical questions of treatment of soils. Leningrad. p. 47-49. (in Russian).

15. Pant M M. 1979. Dependence of plant yield on density and planting pattern. Annals of Botany, 44(4), p. 513-516.

16. Bugutsky A A. 1963. Use of the least squares method in studying the dynamics of the yield, cost value and productivity of labor. The Bulletin of Agricultural Science, 6, p. 138-144.

17. Kostikov I F. 1993. Combined furrow-opener: the patent of the Republic of Kazakhstan № 17020, was declared 08.09.2004.

18. GOST 23638-90 1991. Silage from the green plants. Technical requirements. Interstate standard, M., p. 7. (in Russian).

19. Murzhanov I T, Kostikov I F. 2000. Improvement of the technology of production of maize for silage. Proceedings of the Republican Scientific and Practical Conference. Kokshetau, p. 84-86. (in Russian).

20. Hrushka J. 1965. A Monograph about the maize. Kolos, Moscow. pp. 751. (in Russian).

21. Yugenhaymer R U. 1979. Maize: Improvement of varieties. Seed production. The use of. Moscow. pp. 518. (in Russian).

22. Srinivasan G. 2000. International Maize and Wheat Improvement Center (CIMMYT), Mexico. Maize Production and Improvement in Central Asia and Caucasus, 135(3.85), 6.

М.К. Тыныкулов

Л. Н. Гумилев атындағы Еуразия ұлттық зерттеу университеті,
Астана қ., Қазақстан Республикасы, tynykulov@list.ru

СОЛТҮСТІК ҚАЗАҚСТАНДА ЖҮГЕРІНІҢ ӨНІМДІЛІГІ

Аңдатпа

Солтүстік Қазақстанда жүгері өсіру технологиясын жетілдіру топырақты қорғайтын егін шаруашылығы қағидаттарына негізделді және негізгі мақсаты сүрлем дайындау болды.

Солтүстік Қазақстан ауыл шаруашылығы ғылыми-зерттеу институтында 1997-2015 жылдар аралығында ертерек жетілу будандарын пайдалана отырып озық технология әзірленді (ФАО) 150... 199) технологиялық циклды барынша азайту негізінде. Осы кезеңде мүлдем құрғақ заттың орташа өндірісі 4,8 т/га құрады, бұл өткен кезеңге (1987-2008 жылдар) қарағанда 45,1% -ға жоғары.

Алайда жалғыз сүрлем дақылын (монодақыл) өсіруге негізделген озық технология қуаңшылық жылдары және жаз қысқа және салқын болған жылдары өнімділіктің күрт төмендеуін жоққа шығара алмайды.

Сүрлем конвейері жүгерінің монодақылына балама ретінде өсу жағдайына қойылатын әртүрлі биологиялық талаптары бар дақылдарды іріктеуге негізделген. Сүрлем конвейері (күнбағыс - жүгері – қантты шай жүгері) дақылдарының өнімділігі 5,14 т/га (мүлдем құрғақ зат) құрады, яғни 2016-2019 жылдар аралығында жүгері монодақылынан 0,73 т/га жоғары.

Кілт сөздер: жүгері, сүрлем, өнімділік, өсіру технологиясы, Солтүстік Қазақстан, құрғақ зат, астық.

М.К. Тыныкулов
Евразийский национальный исследовательский университет им. Л.Н. Гумилева,
г. Астана, Республика Казахстан, tynykulov@list.ru

ПРОДУКТИВНОСТЬ КУКУРУЗЫ В СЕВЕРНОМ КАЗАХСТАНЕ

Аннотация

Совершенствование технологии возделывания кукурузы в Северном Казахстане базировалось на принципах почвозащитного пахотного земледелия и основной целью было заготовление силоса.

В Северо-Казахстанском научно-исследовательском институте сельского хозяйства в период с 1997 по 2015 год разработана передовая технология с использованием гибридов раннего созревания (ФАО) 150... 199) на основе минимизации технологического цикла. Средняя выработка абсолютно сухого вещества за этот период составила 4,8 т/га, что на 45,1% выше, чем за предыдущий период (1987-2008 годы).

Однако передовая технология, основанная на выращивании единственной силосной культуры (монокультуры), не может исключить резкого снижения урожайности в засушливые годы и в годы, когда лето короткое и прохладное.

Силосный конвейер в качестве альтернативы монокультуре кукурузы был обоснован отбором культур с различными биологическими требованиями к условиям роста. Урожайность культур силосного конвейера (подсолнечник - кукуруза - сладкий сорго) составляла 5,14 т/га (абсолютно сухое вещество), то есть на 0,73 т/га выше урожаев монокультуры кукурузы в период с 2016 по 2019 год.

Ключевые слова: кукуруза, силос, продуктивность, технология возделывания, Северный Казахстан, сухое вещество, зерно.