KAPITEL 6 / *CHAPTER 6* [6]

MAIZE AS A SOURCE OF STARCH AND BIOETHANOL: CONDITIONS AND CULTIVATION ELEMENTS

КУКУРУДЗА ЯК ДЖЕРЕЛО КРОХМАЛЮ І БІОЕТАНОЛУ: УМОВИ ТА ЕЛЕМЕНТИ ВИРОЩУВАННЯ

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Introduction

In the context of a shortage of energy carriers and rising prices for them in Ukraine, a significant share of which Ukraine imports, one of the reserves of the country's energy independence is the search for reserves for the production of alternative types of energy. One of these types of energy, provided that the yield increases, is the production of bioethanol from corn grain. The potential opportunities of this direction are huge: only due to the processing of 10 million tons. Ukraine can produce at least 4 million tons of corn. tons of this biofuel. Over the past half – century, the acreage under corn has increased 1.6 times, the yield increased 3 times, and the gross grain harvest increased 4.8 times [1-3]. Growing corn along with food and feed, at the moment, is associated with a new direction of use the processing into bioethanol. As corn grain has a high starch content (60-85%). The starch contained in the grain is first decomposed to sugar, then this sugar is converted to alcohol during fermentation, after which the solution is purified and evaporated [4].

6.1. Current state of research on the use of bio-raw materials in the field of bioethanol production

The US has about 40% of the corn crop (130 million tons). tons per year) is processed to produce corn ethanol [5]. The resulting bioethanol is effectively used as a component of high-octane gasoline. Compared to other crops, corn has a high starch content in the grain and provides the highest level of bioethanol production per hectare [6]. From one ton of corn grain, you can get 325-470 l of ethanol, while from 1 ton of barley you get 240-330, from Rye you get 280-357, from wheat you get 375-445 l [4], from triticale you get 428 l, from soriz you get 464 l. Although soriz has a higher starch content in the grain, it is more difficult to hydrolyze it, and therefore the

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yield of bioethanol from corn is higher [7]. For the production of 1.0 tons of bioethanol, 0.64 hectares of wheat or 0.47 hectares of corn are needed [4].

Table 1-approximate yield of various agricultural crops and possible yield of bioethanol from bio-raw materials [8]

Culture (bio-raw materials)	Planned yield, t / ha	Ethanol yield	
		per ton of raw materials, l / t	per hectare, l/ha
Sugar beet	90	100	9000
Jerusalem artichoke	30	87	2610
Corn for grain	7	416	2912
Sugar sorghum	80	50	4000
Wheat	5	395	1975
Barley	5,8	370	2150
Sugar cane	65	70	4550
Cassava	12	180	2160

The total production capacity of bioethanol in Ukraine can be about 200 thousand tons per year (5% of the total type of fuel), but, in 2013-2014 yrs, its production was almost destroyed (up to 42 thousand tons per year, in 2016 yr, that is, about 1% of all fuel), the introduction of an excise tax of 99 euros on alternative motor fuels, which is 49% of the excise tax on gasoline a-95. This excise rate led to the shutdown of 11 of the 14 plants that produced bioethanol. The state plans to remove the excise tax on the production of bioethanol and exempt from VAT when purchasing imported machinery, equipment, and equipment of enterprises for the production of biofuels [9].

The sale price of bioethanol in 2019 in Ukraine is 0.61 euros/l, in Europe it is 0.96 euros/L [10], while gasoline is 1.2-1.6 euros/L. in this regard, the assessment of modern corn hybrids by the suitability of using their grain for the production of bioethanol is of great importance in the production sector [11, 12]. In corn grain, the predominant component is carbohydrates (starch, sugars, fiber, hemicellulose and pentosans), the content of which can be, depending on the subspecies, 60-80 %. For the production of ethanol, four subspecies of corn are of practical value starchy (71.5-82.0%), tooth-shaped (68.0-75.5 %), semi-tooth-shaped (66.9-74.2%) and siliceous (65,0-73,0 %) [13].

According to Ya. Gadzalo, in 2018, corn hybrids were created with a yield of

8.14 t/ha, and a starch yield of 6 tons per ha. According to him, one of the most promising areas of corn breeding is the creation of varieties with a high starch content for the production of bioethanol [14].

According to O. L. Sirokhi [15], the combination of nitrogen fertilizers with foliar top dressing with trace elements increases the adaptability of plants to adverse environmental stress factors and improves the intensity of growth processes and productivity. The leaf surface is the main organ of photosynthesis, so the increase in the leaf surface is largely determined by the amount of nutrients in the soil, including trace elements (copper, zinc, iron, etc.) [16, 17, 18].

A special feature of the biology of corn is the slow development of the root system at the beginning of the growing season, when it needs more nutrients. In corn, before the 4th leaf phase, the roots are placed in a soil layer of up to 30 cm within a radius of less than 30 cm. Because of this, it is at the stage of formation of such a small-volume root system that corn plants consume almost 10% of the total need for phosphorus (P), 15% magnesium (Mg), 29% nitrogen (N) and potassium (K) [23, 24, 19, 20, 21, 22]. There is a close relationship between the development of the underground and aboveground parts of the plant. The root system of corn has a high absorption capacity and it absorbs water 3-6 times faster than the root system of other crops, in particular barley, oats or wheat [25].

Macronutrients magnesium (Mg) and sulfur (S) and trace elements such as zinc (Zn), boron (B) and manganese (Mn) have a significant effect on the intensive growth and development of the root system. Due to these trace elements the corn plants increase the root system by 20 percent or more [16, 17, 20, 21, 22]. Absorption of nutrients begins with adsorption, which occurs on the surface of the cells of the root system. After that, a complex process of active and passive transport to the cell begins [16, 26]. So, the importance of nutrients for corn allows us to note their influence not only on growth and development, but also on the formation of individual organs and parts of the plant, as well as on the quality of grain. Nutrition elements play special attention during critical periods of corn growth and development, in particular in the phase of 4-6 and 8-12 corn leaves, providing plants with macro - and microelements during these periods is possible primarily through foliar top dressing [9, 27]. Therefore, a further increase in the yield of corn hybrids and an increase in its quality while minimizing the cost of cultivation makes it necessary to use foliar top dressing with microfertilizers, plant growth regulators and bacterial preparations.

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The starch content in the grain depends on both varietal characteristics and the technology of growing corn for grain. Therefore, the development of a complex of technology elements that ensure an increase in the yield and quality of corn grain is relevant.

6.2. Conditions and methods of conducting research on the formation of productivity of corn crop as a bioenergetic raw material

Field experiments were conducted during 2011-2016 yrs in the experimental field of the Department of crop production, breeding and bioenergetic crops of the state enterprise DG "Kordelevskoe" of the potato growing Institute of the National Academy of Sciences of Vinnytsia National Agrarian University.

Soils-deep medium loamy chernozems on the forest. The humus content (by Tyurin) in the arable layer was 4.60 %. The reaction of the soil solution is PH (salt) 5.7. The soils contain easily hydrolyzed nitrogen (by Kornfield) 106 mg per 1 kg of soil, mobile phosphorus and exchange potassium (by Chirikov) 186 and 160 mg per 1 kg of soil, respectively. The content of trace elements in these soils is high as boron (calorimetric analysis)-0.76 mg per 1 kg of soil; manganese, copper and zinc (Atomic adsorption spectrophotometric analysis) is also high as 77.17, 6.07 and 8.01 mg per 1 kg of soil.

According to agrometeorological observations, the main indicators of climatic conditions in the years of research were not close to the long-term average data. In 2011 yr, initially cold weather with frosts in the first or second decade of April limited the use of the first (early) sowing period, so it was held on April 25th. In the future, the climatic conditions of 2011yr did not differ much from the long-term ones and were favorable for the growth and development of corn. Early spring 2012 yr and high temperatures in April (5.4-16.3°C) created unfavorable agroclimatic conditions for the development of corn. Thus, starting from May to the second decade of August, there was a lack of moisture, as evidenced by a significant deviation in the amount of precipitation (207 mm) during this period from the long-term average (297 mm). In 2013 yr, a small number of temperature indicators limited the use of early sowing, especially in the first decade of April 3.0 °C. In the future, the climatic conditions of 2013 did not differ much from long-term ones and were favorable for the growth and development of corn. In 2014 yr, frosts on May 5-6 were a negative phenomenon. In some areas, early corn shoots were damaged up to 30% of the sown area. The conditions for the growth and development of corn during the leaf fall period in 2014 were characterized by an increased temperature regime and sufficient moisture supply. In 2015 yr, the weather conditions of the spring-summer period were characterized by a significant uneven distribution of precipitation by month. Even with a favorable thermal regime in the spring of this year, the beginning of corn sowing due to waterlogging of the soil was carried out 6 days later than the early calendar dates of its beginning. In 2016 yr, a rapid increase in heat and dry weather contributed to the drying of the soil, as of April 10, the sum of effective temperatures above +5 °C was in the range of 85-100 °C. High maximum temperatures up to +35 °C, sometimes higher, in the second and third decades of July, negatively affected the turgor of plants, the quality of fertilization in corn. In September, weather conditions contributed to the end of the growing season of corn hybrids.

Field experiments were conducted in accordance with the recommendations set out in the "method of field experiments with corn" [28]. The experiments established an economic and biological assessment of corn hybrids depending on the sowing period, the size of the fraction and the depth of seed embedding, foliar top dressing with microfertilizers.

The research used field and laboratory methods for studying hybrid corn material. The registered area of plots for hybrids was 10.5 m^2. Repetition in experiments for hybrids was 3 times. Placement of land plots was using the method of randomized blocks.

Sieves with round holes of different diameters were used to form the seed fraction according to the grain size. The large fraction included seeds of a hybrid of sieves with holes of 8 and 9 mm, its share was 13.2 and 13.4% of the total mass, respectively. The proportion of the medium (sieves with holes of 6; 7 mm) fraction was 71.7-78.8 %, and the small (5.0; 5.5 mm) – 7,8-15,1 % [29].

Determination of the starch content was carried out using a polarimeter – (manufacturer CARL ZEISSJENA, Germany) with an accuracy of 0.1% in accordance with the requirements of DSTU 46.045:2003 "grain. Methods for determining conditional starchiness" 25.07.2003 №250 [30]. The polarimetric method is based on the ability of sugar solutions to rotate the plane of polarization of polarized light. The starch content was calculated by the formula: $x = a \times K$,

where x – starch content as a percentage, α – sugar meter indicator, %; К –

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Evers coefficient (=1,898) [30, 31].

The yield of bioethanol from grain was calculated as the yield of ethanol. The yield of ethanol is its amount obtained from a ton of carbohydrates in terms of starch. The theoretical yield is calculated by the equation of alcoholic fermentation: $C_6H_{12}O_6=2C_2H_5OH+2CO_2$.From 100 kg of hexose, 51.14 kg of anhydrous ethanol and 48.86 kg of carbon dioxin are formed. At the relative density of ethanol d420=0.78927, its theoretical yield is 64.79 l [32, 33].

The cultivation technology is generally accepted, with the exception of the elements that were studied. The predecessor was winter wheat. After harvesting the predecessor, tillage consisted of peeling stubble with heavy BDT-7 harrows and plowing with a stump-5-40 plow in a unit with a KHTZ-121 tractor for pre-sowing tillage, a KPS-4 row cultivator was used in a unit with tooth harrows. Sowing was carried out with an updated SUPN-8 seed drill, with a seeding rate of 75 thousand units. seeds per hectare.

The studies used hybrids of domestic selection (Kharkivsky 195mv and Pereyaslavsky 230sv) and Monsanto DKS 2870, DKS 2960, DKS 2949, DKS 2787, DKS 2971, DKS 3476, DKS 3795, DKS 3472, DKS 3420, DKS 3871, DK 391, DKS 3511, DK 440, DKS 4964, DKS 4626, DK 315, DKS 4082.

In Phase 5 of real corn leaves, the post-emergence herbicide of systemic action Melagro (D. R. nicosulfuron) was used to control annual and perennial grass weeds at a rate of 1.25 l/ha. Spraying of the experimental areas was carried out in the morning or evening at wind speeds up to 4-5 m/s, preventing demolition of the drug, with a satchel sprayer.

The fertilizer system provided for the introduction of only lowercase fertilizer of 60 kg in physical weight of ammonium nitrate simultaneously with sowing. Application of microfertilizers Rostok corn, Ecolist Mono zinc, plant growth regulator Vympel, bacterial preparation Biomag was carried out in two phases of 5-7 and 10-12 corn leaves with a satchel sprayer with a liquid consumption rate of 500 l/ha, or 5 l per acre.

Harvesting was carried out manually with 10 heads from each repetition, for which structural analysis and yield determination were carried out [28].

6.3. Starch formation by corn plants and bioethanol yield depending on the growing conditions and elements of agricultural technology

The yield of bioethanol depends primarily on the starch content in the grain, which in turn is determined by the ripeness group, hybrid subspecies and agricultural cultivation technology. Thus, early-ripened hybrids in the forest-steppe zone of Ukraine do not have a high grain yield and starch yield, although in some of them the starch content in the grain is high. The higher starch content in medium-early and medium-ripened hybrids can be explained by the fact that they are represented by a tooth-shaped subspecies, the grain of which contains more starch [7].

The starch content and yield significantly depended on the ripeness group of hybrids (Table. 2). So, on average for three years, the starch content and yield in the early – ripened group was 72.17% and 5.797 t/ha, the medium-early group was 73.05% and 6.576 t/ha and the medium-ripened group was 74.39% and 7.666 t/ha (HIP05 ripeness Group = 0.30% and 0.16 t/ha). There is an increase in the starch content and yield (1,090-1,869 t/ha) in the group of corn hybrids with a longer growing season compared to the early-ripened group, which fully confirms the data from literature sources.

Table 2 - starch content and yield in corn grain depending on the sowing period (average for 2011-2013 yrs),%

Ripeness group (A)	Hybrid (B)	Sowing dates (C)	Starch content in ACP,%	Starch yield, t / ha
1	2	3	4	5
Early ripened group	Kharkivsky 195MB	Early (RTG* t=+8°C)	72,00	6,288
		Medium (RTG t=+10°C)	72,65	5,984
		Late (RTG t=+12°C)	73,78	5,021
	DKC 2870	Early (RTG* t=+8°C)	72,74	6,499
		Medium (RTG t=+10°C)	73,62	5,915
		Late (RTG t=+12°C)	74,16	4,920
	DKC 2960	Early (RTG* t=+8°C)	70,26	6,630
		Medium (RTG t=+10°C)	72,19	6,093
		Late (RTG t=+12°C)	72,64	5,354
	DKC 2949	Early (RTG* t=+8°C)	70,45	5,875
		Medium (RTG t=+10°C)	70,75	5,073
		Late (RTG t=+12°C)	71,72	4,577
	DKC 2787	Early (RTG* t=+8°C)	70,61	6,379
		Medium (RTG t=+10°C)	71,80	5,986

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Ripeness group (A)	Hybrid (B)	Sowing dates (C)	Starch content in ACP,%	Starch yield, t / ha
1	2	3	4	5
		Late (RTG t=+12°C)	72,99	5,435
	DKC 2971 **(st)**	Early (RTG* t=+8°C)	71,23	6,366
		Medium (RTG t=+10°C)	71,88	6,303
		Late (RTG t=+12°C)	73,64	5,648
	DKC 3476	Early (RTG* t=+8°C)	73,38	7,124
		Medium (RTG t=+10°C)	74,59	6,870
		Late (RTG t=+12°C)	75,16	5,845
Early-medium group	DKC 3795	Early (RTG* t=+8°C)	72,43	7,491
		Medium (RTG t=+10°C)	73,12	6,493
		Late (RTG t=+12°C)	74,02	5,365
	DKC 3472	Early (RTG* t=+8°C)	70,89	7,753
		Medium (RTG t=+10°C)	71,49	7,174
		Late (RTG t=+12°C)	72,31	6,248
	DKC 3420	Early (RTG* t=+8°C)	73,31	7,558
		Medium (RTG t=+10°C)	74,39	6,454
		Late (RTG t=+12°C)	75,60	5,864
	Pereyslavsky 230CB	Early (RTG* t=+8°C)	71,63	7,000
		Medium (RTG t=+10°C)	72,29	6,338
		Late (RTG t=+12°C)	72,91	5,480
	DKC 3871 **(st)**	Early (RTG* t=+8°C)	71,85	7,070
		Medium (RTG t=+10°C)	72,69	6,451
		Late (RTG t=+12°C)	72,90	5,791
Medium ripened group	DK 391	Early (RTG* t=+8°C)	72,50	8,211
		Medium (RTG t=+10°C)	73,21	7,080
		Late (RTG t=+12°C)	73,30	6,650
	DKC 3511	Early (RTG* t=+8°C)	74,34	7,866
		Medium (RTG t=+10°C)	75,50	7,525
		Late (RTG t=+12°C)	76,20	6,565
	DK 440	Early (RTG* t=+8°C)	72,40	8,300
		Medium (RTG t=+10°C)	74,95	7,620
		Late (RTG t=+12°C)	75,84	7,054
	DKC 4964	Early (RTG* t=+8°C)	74,95	8,845
		Medium (RTG t=+10°C)	76,30	8,295
		Late (RTG t=+12°C)	77,66	7,303
	DKC 4626	Early (RTG* t=+8°C)	72,48	8,602
		Medium (RTG t=+10°C)	73,49	7,642
		Late (RTG t=+12°C)	74,10	7,041
	DK 315 **(st)**	Early (RTG* t=+8°C)	73,13	8,835
		Medium (RTG t=+10°C)	74,12	7,564

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Ripeness group (A)	Hybrid (B)	Sowing dates (C)	Starch content in ACP,%	Starch yield, t / ha
1	2	3	4	5
		Late (RTG t=+12°C)	74,53	6,986
HIP$_{05\ \text{ripeness group}}$			0,30	0,16
HIP$_{05\ \text{hybrid}}$			0,42	0,23
HIP$_{05\ \text{sowing dates}}$			0,30	0,16

***Note**: RTG – the level of soil temperature regime at the depth of seed embedding*

The highest starch content (HIP05 hybrid = 0.42 %), on average for three years, was observed in the group of early – ripened hybrids: DKS 2870 – 73.51%, Kharkivsky 195mv – 72.81% and DKS 2971 – 72.25%, mid – early: DKS 3420 – 74.43%, DKS 3476 – 74.38% and DKS 3795 – 73.19%, medium – ripened: DKS 4964 – 76.30%, DKS 3511 – 75.35% and DK 440 – 74.39%, and starch yield in the early – ripened group (HIP05 hybrid = 0.23 t/ha): DKS 2971 – 6.105 t/ha, DKS 2960 – 6.026 t/ha and DKS 2787 – 5.933 t/ha, medium-early-DKS 3472-7,058 t/ha, DKS 3420-6,625 t/ha and DKS 3476-6,613 t/ha and in medium-ripened – DKS 4964 – 8,147 t/ha, DK 315 – 7,795 t/ha and DKS 4626-7,762 t/ha.

The starch content in the grain depended not only on the ripeness group of hybrids, but also on the timing of their sowing. At the early sowing period, the lowest starch content, and at the late sowing period, was the highest. Thus, the early sowing period (HIP05 sowing periods = 0.30 %) provided the starch content in early – ripened hybrids – 71.22 %, in medium – early it was 72.25% and medium – ripened ones it was 73.30 %, the application of the average sowing period was72.15%, 73.1 and 74.6% and late it was 73.15 %, 73.82 and 75.27 %, respectively, for early-ripened, medium-early and medium-ripened hybrids. Sowing in the early stages (HIP05 sowing period = 0.16 t/ha), due to the high yield, contributed to the highest starch yield (7,372 t/ha) compared to the average (6,714 t/ha) and late (5,953 t/ha) sowing periods. That is, the use of late sowing periods contributed to an increase in the starch content and yield by 1.57-1.97% and 1.181-1.567 t/ha relative to the early sowing period.

It was found that in dry 2012 yr there was a general decrease in starch content (72.06%) regardless of the sowing period, while in 2011 and 2013, due to favorable conditions for temperature and moisture supply, there was a general increase in starch content in corn up to 73.00 and 74.56 %.

The fact that the starch content increases with late sowing periods is indicated in their studies by Yu. M. Pashchenko and O. I. Kordin [34], while the difference between the first and third sowing periods in terms of starch content can range from 0.8 up to 2.0% with a total grain content of 68.0 - 72.8%.

Studies have shown that the starch content can vary significantly depending on the subspecies of corn (table. 3). Other researchers also point out this dependence in their research [13].

In the process of dividing into subspecies, 10 hybrids of the siliceous-tooth – like subspecies and 8 hybrids of the tooth-like subspecies were obtained. It was found that the starch content increased from early to late sowing in both siliceous-tooth-shaped and tooth-shaped subspecies of corn. Thus, at the early sowing period, the starch content was 71.56% in the siliceous-toothed subspecies, it was 73.13% in the tooth – shaped subspecies, it was 72.44 and 74.21% in the average sowing period, and it was 73.33 and 75.06% in the late sowing period. A similar relationship was observed in the tooth-shaped subspecies of corn.

Table 3 - Starch content in corn grain depending on the subspecies and sowing period,% (average for 2011-2013 yrs)

Name of subspecies	Number of hybrids, Pcs.	Dates of sowing		
		early (RTG* t=+8°C)	medium (RTG t=+10°C)	late (RTG t=+12°C)
siliceous-tooth-shaped	10	71,56±1,06	72,44±1,11	73,33±1,01
Tooth-shaped	8	73,13±0,93	74,21±1,10	75,06±1,43

The effect of foliar top dressing with microfertilizers Ecolist Mono zinc and Rostok corn, bacterial preparation Biomag and plant growth regulator Vympel on the starch content and yield was noted. This effect varied significantly depending on the availability of heat and moisture in corn plants, as evidenced by the results of a qualitative analysis of grain for starch content and yield (table. 4).

Foliar top dressing of hybrids of the early-ripened group significantly increased the starch yield per unit area by 0.2-1.9 t/ha (HIP05 top dressing = 0.24 t/ha) and the starch content compared to the control (water top dressing).

This dependence is also indicated in their studies by E. D. Adinyev [35] and A. Kapustin, M. Kovtun, S. Kapustin [36]. In particular, the use of nutrition elements leads to an increase in the starch content in corn grain from 70.5% up to 71.68%, fat increased from 3.12% up to 3.50%, as well as nitrogen increased (from 1.58 up to

Table 4 - Starch content and yield in early-ripened corn hybrids depending on foliar top dressing (average for 2011-2013 yrs)

Hybrid (A)	Foliar top dressing (B)	Number of treatments(C)	Starch content in ACP, %	Starch yield, t / ha
Kharkivsky 195 MB	Control (top dressing with water)	-	72,00	6,298
	Biomag	I*	71,69	7,038
		II*	72,40	7,314
	Ecolist Mono Zinc	I*	72,62	7,281
Kharkivsky 195 MB	Ecolist Mono Zinc	II*	74,13	7,848
	Rostok corn	I*	72,80	7,150
		II*	73,65	7,632
	Vympel	I*	72,22	7,091
		II*	72,50	7,411
DKC 2960	Control (top dressing with water)	-	70,26	6,642
	Biomag	I*	71,00	7,086
		II*	71,87	7,851
	Ecolist Mono Zinc	I*	71,72	7,823
		II*	72,33	8,548
	Rostok corn	I*	70,92	7,713
		II*	71,45	8,237
	Vympel	I*	70,77	7,145
		II*	71,32	7,634
DKC 2949	Control (top dressing with water)	-	70,45	5,889
	Biomag	I*	70,71	6,093
		II*	71,67	6,585
	Ecolist Mono Zinc	I*	72,25	6,663
		II*	72,38	7,131
	Rostok corn	I*	71,28	6,528
		II*	72,06	6,891
	Vympel	I*	70,45	6,098
		II*	69,99	6,469
DKC 2971	Control (top dressing with water)	-	71,23	6,390
	Biomag	I*	71,37	6,673
		II*	72,34	7,463
	Ecolist Mono Zinc	I*	73,56	7,352
		II*	74,45	7,858
	Rostok corn	I*	72,28	7,019
		II*	73,18	7,571
	Vympel	I*	70,84	6,873
		II*	71,95	7,189
HIP_{05} hybrid			0,57	0,21
HIP_{05} top dressing			0,64	0,24
HIP_{05} number of dressings			0,40	0,15

***Note**: I* - one - time application of the drug in the phase 5-7 of corn leaves; II* - two-time application of the drug in the phase 5-7 and 10-12 of corn leaves;* * - a variance analysis was made in alignment for equal dispersions to establish the materiality of foliar top dressing variants source: formed on the basis of our own research.*

1.68%), phosphorus increased (from 0.21 up to 0.24 %) and potassium increased (from 0.36 up to 0.39 %). The starch content and yield in early – ripened corn hybrids was determined by the biological characteristics of a particular hybrid (HIP05 hybrid = 0.57% and 0.21 t/ha) and on average for three years significantly differed in hybrids and amounted to Kharkivsky 195 MV – 72.7% and 7.229 t/ha, DKS 2960 – 71.3% and 7.631 t/ha, DKS 2949 – 71.3% and 6.483 t/ha and DKS 2971-72.4% and 7.154 t/ha. Foliar top dressing of hybrids of the early-ripened group significantly increased the starch yield per unit area by 0.2 - 1.9 t/ha (HIP05 top dressing = 0.24 t/ha) and the starch content compared to the control (water top dressing). The highest starch content and its yield per unit area was provided by double foliar top dressing of all hybrids with Ecolist Mono zinc microfertilizer. One foliar top dressing in the phase of 5-7 corn leaves provided a significant increase in starch content and starch yield compared to the control, which on average for three years for hybrids were, Kharkivsky 195 MV – 72.3% and 7,140 t/ha, DKS 2960 – 71.1% and 7,442 t/ha, DKS 2949 – 71.2% and 6,345 t/ha and DKS 2971 – 72.0% and 6.979 t/ha, and with double top dressing in the phase of 5-7 and 10-12 corn leaves, these indicators were significantly higher both in comparison with the control and with a single top dressing and amounted to hybrids, respectively – 73.2% and 7.55 t/ha, 71.7% and 8.07 t/ha, 71.5% and 6.77 t/ha and 73.0% and 7.52 t/ha. Foliar top dressing in the group of early-ripened hybrids revealed a slight decrease in the starch content (0.1 - 0.46 %) when treating plants with bacterial fertilizer Biomag in the phase of 5-7 corn leaves compared to the control. The highest starch yield (0.6-1.9 t/ha) was determined by double foliar top dressing with microfertilizers Ecolist Mono zinc and Rostok corn.

In the grain of corn hybrids of the medium-early ripeness group, the starch content significantly differed in hybrids. Foliar top dressing provided an increase in the starch content and its yield relative to the control – top dressing with water (HIP05 top dressing = 0.65% and 0.27 t/ha) in medium-early hybrids by 0.7 - 1.2% and 0.2 - 1.8 t/ha (Table. 5). A single foliar top dressing in the phase of 5-7 corn leaves provided a significant increase in the starch content for hybrids compared to

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Table 5 - Starch content and yield in medium-early corn hybrids depending on foliar top dressing, (average for 2011-2013 yrs)

Hybrid (A)	Foliar top dressing (B)	Number of treatments(C)	Starch content in ACP, %	Starch yield, t / ha
DKC 3472	Control (top dressing with water)	-	70,89	7,763
	Biomag	I*	71,09	8,338
		II*	71,94	9,209
	Ecolist Mono Zinc	I*	72,47	8,693
		II*	73,32	9,227
	Rostok corn	I*	71,43	8,812
		II*	72,89	9,568
	Vympel	I*	70,97	8,390
		II*	71,35	8,812
DKC 3420	Control (top dressing with water)	-	73,31	7,575
	Biomag	I*	73,41	8,019
		II*	73,99	8,954
	Ecolist Mono Zinc	I*	74,26	8,356
		II*	74,93	9,263
	Rostok corn	I*	73,71	8,416
	Rostok corn	II*	74,73	8,952
	Vympel	I*	72,95	7,790
		II*	73,71	8,047
Pereyslavsky 230 CB	Control (top dressing with water)	-	71,63	7,017
	Biomag	I*	71,88	6,989
		II*	72,58	7,919
	Ecolist Mono Zinc	I*	72,71	7,911
		II*	73,12	8,926
	Rostok corn	I*	72,12	7,854
		II*	72,74	8,365
	Vympel	I*	71,52	7,365
		II*	72,72	7,774
DKC 3871	Control (top dressing with water)	-	71,85	7,065
	Biomag	I*	72,60	7,610
		II*	73,72	7,955
	Ecolist Mono Zinc	I*	73,34	7,923
		II*	75,04	8,797
	Rostok corn	I*	72,38	7,694
		II*	72,87	8,504
	Vympel	I*	71,80	7,556
		II*	72,54	7,925
HIP_{05} hybrid			0,58	0,24
HIP_{05} top dressing			0,65	0,27
HIP_{05} number of dressings			0,41	0,17

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***Note**: I* - one - time application of the drug in the phase 5-7 of corn leaves; II* - two-time application of the drug in the phase 5-7 and 10-12 of corn leaves;* * - a variance analysis was made in alignment for equal dispersions to establish the materiality of foliar top dressing variants source: formed on the basis of our own research.*

the control, which on average for three years was – DKS 3472 – 71.5%, DKS 3420 – 73.6%, Pereyaslavsky 230SV – 72.1% and DKS 3871 – 72.5%, and a double – DKS 3472 – 72.4%, DKS 3420 – 74.3%, Pereyaslavsky 230SV – 72.1% and DKS 3871 – 73.5 % (HIP 05 number of top dressing = 0.41 %). A decrease in the starch content during foliar top dressing was observed in variants where the plant growth regulator Vympel was used in the phase of 5-7 corn leaves in the hybrid DKS 3420 by 0.36%, Pereyaslavsky 230sb by 0.11% and DKS 3871 by 05%, relative to the control (water top dressing).

In the group of medium-ripened corn hybrids, there was an overall increase in the starch content and yield, on average over the years, compared to the early-ripened and medium-early ripeness groups (Table. 6). The starch content in hybrids of the medium – ripened group depended on the biological characteristics of the hybrid (HIP05 hybrid = 0.59 %) and amounted to DC 391 – 72.9 %, DC 440 – 73.2 %, DKS 4964 – 75.5% and DC 315-73.8 %. The use of such hybrids as DKS 4964 and DK 315 for growing will significantly increase the starch yield per unit area. Foliar top dressing resulted in an increase in starch yield per unit area by 0.2 - 1.8 t/ha (HIP05 top dressing = 0.44 t/ha) compared to the control (without foliar top dressing).

One-time foliar top dressing provided an increase in the starch content by 0.1 – 0.5%, two-time one provided increase by 0.85 - 1.30 %. The starch yield was at a single top dressing in hybrids DC 391 – 8,748 t / ha, DC 440 - 8,821 t / ha, DKS 4964 - 9,559 t/ha, DC 315 - 9,314 t/ha and with double top dressing it was significantly higher and amounted to 9,220 t/ha,– 9,384 t/ha, 10,142 t/ha, 9,993 t/ha (HIP05 number of top dressing = 0.28 t / ha), respectively.

The highest starch yield in all hybrids was provided by double application of Microfertilizer Ecolist Mono zinc (8,983-10,595 t/ha) and Rostok corn (8,721-10,597 t/ha), the increase in starch yield with the use of these microfertilizers was 0.5 - 1.8 t/ha, relative to the control.

The highest starch content and its yield per unit area was provided by double foliar top dressing of all hybrids with Ecolist Mono zinc microfertilizer.

Foliar top dressing in the group of early-ripened hybrids revealed a slight fertilizer Biomag in the phase of 5-7 corn leaves compared to the control. The highest

Table 6 - Starch content and yield in medium-ripened corn hybrids depending on foliar top dressing (average for 2011-2013 yrs)

Hybrid (A)	Foliar top dressing (B)	Number of treatments (C)	Starch content in ACP, %	Starch yield, t /ha
DK 391	Control (top dressing with water)	-	72,50	8,204
	Biomag	I*	72,58	8,867
		II*	72,76	9,089
	Ecolist Mono Zinc	I*	72,98	8,983
		II*	74,27	9,708
	Rostok corn	I*	72,52	8,721
		II*	73,78	9,318
	Vympel	I*	72,37	8,420
		II*	72,59	8,767
DK 440	Control (top dressing with water)	-	72,40	8,283
	Biomag	I*	72,56	8,500
		II*	73,36	9,113
	Ecolist Mono Zinc	I*	74,15	9,132
		II*	74,82	9,665
	Rostok corn	I*	72,83	9,044
		II*	73,47	9,686
	Vympel	I*	71,91	8,610
		II*	73,26	9,074
DKC 4964	Control (top dressing with water)	-	74,95	8,864
	Biomag	I*	74,59	9,297
		II*	74,96	9,677
	Ecolist Mono Zinc	I*	76,12	9,812
		II*	76,72	10,597
	Rostok corn	I*	75,58	9,874
		II*	76,10	10,597
	Vympel	I*	74,79	9,254
		II*	75,25	9,696
DK 315	Control (top dressing with water)	-	73,13	8,811
	Biomag	I*	72,90	8,999
		II*	73,31	9,336
	Ecolist Mono Zinc	I*	74,46	9,579
		II*	75,34	10,593
	Rostok corn	I*	74,04	9,609
		II*	74,57	10,434
	Vympel	I*	72,78	9,069
		II*	73,37	9,610
HIP$_{05}$ hybrid			0,59	0,39
HIP$_{05}$ top dressing			0,66	0,44
HIP$_{05}$ number of dressings			0,42	0,28

***Note**: I* - one - time application of the drug in the phase 5-7 of corn leaves; II* - two-time application of the drug in the phase 5-7 and 10-12 of corn leaves;* * - a variance analysis was made in alignment for equal dispersions to establish the materiality of foliar top dressing variants source: formed on the basis of our own research.*

decrease in the starch content (0.1-0.46 %) when treating plants with bacterial starch yield (0.6-1.9 t/ha) was determined by double foliar top dressing with microfertilizers Ecolist Mono zinc and Rostok corn.

In the grain of corn hybrids of the medium-early ripeness group, the starch content significantly differed in hybrids. Foliar top dressing provided an increase in the starch content and its yield relative to the control – water top dressing (HIP05 top dressing = 0.65% and 0.27 t/ha) in medium-early hybrids it provided increase by 0.7 - 1.2% and 0.2 - 1.8 t/ha.

A single foliar top dressing in the phase of 5-7 corn leaves provided a significant increase in the starch content for hybrids compared to the control, which on average for three years was DKS 3472 as 71.5%, DKS 3420 as 73.6%, Pereyaslavsky 230SV as 72.1% and DKS 3871 as 72.5%, and a double – DKS 3472 as 72.4%, DKS 3420 as 74.3%, Pereyaslavsky 230SV as 72.1% and DKS 3871 as 73.5 % (HIP 05 number of top dressing = 0.41 %).

A decrease in the starch content during foliar top dressing was observed in variants where the plant growth regulator Vympel was used in the phase of 5-7 corn leaves in the hybrid DKS 3420 by 0.36%, Pereyaslavsky 230sb it was by 0.11% and DKS 3871 it was by 05%, relative to the control (water top dressing).

In the group of medium-ripened corn hybrids, there was an overall increase in the starch content and yield, on average over the years, compared to the early-ripened and medium-early ripeness groups.

Foliar top dressing resulted in an increase in starch yield per unit area by 0.2 - 1.8 t/ha (HIP05 top dressing = 0.44 t/ha) compared to the control (without foliar top dressing).One-time foliar top dressing provided an increase in the starch content by 0.1 – 0.5 %, two-time it was by 0.85 - 1.30 %. The highest starch yield in all hybrids was provided by double application of Microfertilizer Ecolist Mono zinc (8,983-10,595 t/ha) and Rostok corn (8,721 - 10,597 t/ha), the increase in starch yield with the use of these microfertilizers was 0.5 - 1.8 t/ha, relative to the control (top dressing with water).

The size of the seed directly determines the size of not only the embryo but also the endosperm in which the main reserve substance is starch. In this regard, the actual question remains how the nature of endosperm formation and starch yield will change depending on the ripeness groups of the hybrid, their varietal characteristics and changes in the elements of cultivation technology – the seed fraction and the depth of their embedding (Table. 7).

Table 7 - Starch content and yield in corn hybrids depending on the size of the fraction and the depth of seed embedding (average for 2014-2016 yrs)

Ripeness group A)	Hybrid (B)	Seed fraction (C)	Sealing depth of seeds (D)	Starch content in ACP,%	Starch yield, t / ha
1	2	3	4	5	6
Early ripened hybrids	DKC 2960	M* (187 g)	4-5 cm	71,68	5,551
			7-8 cm	72,00	5,563
			10-11 cm	71,87	5,176
		S** (238 g)	4-5 cm	72,71	6,190
			7-8 cm	73,35	6,245
			10-11 cm	73,07	6,129
		V*** (277 g)	4-5 cm	72,32	6,196
			7-8 cm	72,87	6,175
			10-11 cm	73,11	6,348
	DKC 2971	M* (194 g)	4-5 cm	71,64	5,570
			7-8 cm	71,74	5,476
	DKC 2971		10-11 cm	71,46	5,063
		S** (256 g)	4-5 cm	72,47	6,014
			7-8 cm	72,22	5,983
			10-11 cm	72,54	5,954
		V*** (279 g)	4-5 cm	72,12	6,105
			7-8 cm	72,61	6,101
			10-11 cm	72,12	6,024
Early-medium hybrids	DKC 3472	M* (249 g)	4-5 cm	73,66	6,724
			7-8 cm	74,04	6,607
			10-11 cm	74,26	6,420
		S** (326 g)	4-5 cm	74,60	7,280
			7-8 cm	75,13	7,255
			10-11 cm	74,93	7,255
		V*** (385 g)	4-5 cm	73,71	7,151
			7-8 cm	74,38	7,224
			10-11 cm	73,95	7,096
	DKC 3795	M* (166 g)	4-5 cm	73,65	6,163
			7-8 cm	73,94	6,074
			10-11 cm	73,62	5,779
		S** (207 g)	4-5 cm	74,40	6,836
			7-8 cm	74,92	6,515
			10-11 cm	75,36	6,637
		V*** (287 g)	4-5 cm	74,85	6,946
			7-8 cm	75,73	6,778
			10-11 cm	75,49	6,890
Medium ripened hybrids	DK 315	M* (223 g)	4-5 cm	74,46	7,100
			7-8 cm	74,72	7,072
			10-11 cm	74,32	6,778
		S** (294 g)	4-5 cm	75,70	7,594
			7-8 cm	76,16	7,776
			10-11 cm	75,69	7,728
		V*** (327 g)	4-5 cm	75,53	7,787

Ripeness group A)	Hybrid (B)	Seed fraction (C)	Sealing depth of seeds (D)	Starch content in ACP,%	Starch yield, t / ha
1	2	3	4	5	6
			7-8 cm	75,66	7,969
			10-11 cm	75,36	7,774
	DKC 4082	M* (172 g)	4-5 cm	73,80	7,001
			7-8 cm	74,62	6,971
			10-11 cm	74,36	6,732
		S** (227 g)	4-5 cm	76,13	7,657
			7-8 cm	76,78	8,117
			10-11 cm	76,46	8,127
		V*** (278 g)	4-5 cm	74,93	7,573
			7-8 cm	76,64	8,048
			10-11 cm	75,92	7,997
$HIP_{05 \text{ ripeness group}}$				2,45	0,18
$HIP_{05 \text{ hybrid}}$				3,57	0,97
$HIP_{05 \text{ seed fraction}}$				2,31	0,63
$HIP_{05 \text{ sealing depth}}$				0,22	0,64

***Notes**: * – fine seed fraction; ** – average seed fraction; *** – large seed fraction.*

Starch content and yield in corn grain depending on the weather conditions of the growing season. Over the years of the study, it is necessary to note a decrease in the amount of starch in 2015 yr by 72.17% and 6.10 t/ha. The average starch content and yield in 2014 yr in the studied hybrids was 75.46% and 6.76 t/ha, and in 2016 yr it was 74.58% and 7.32 t/ha. This is due to the fact that this year was the least evenly supplied with moisture with the presence of a long dry period, which ultimately affected the accumulation of starch (Fig. 1).

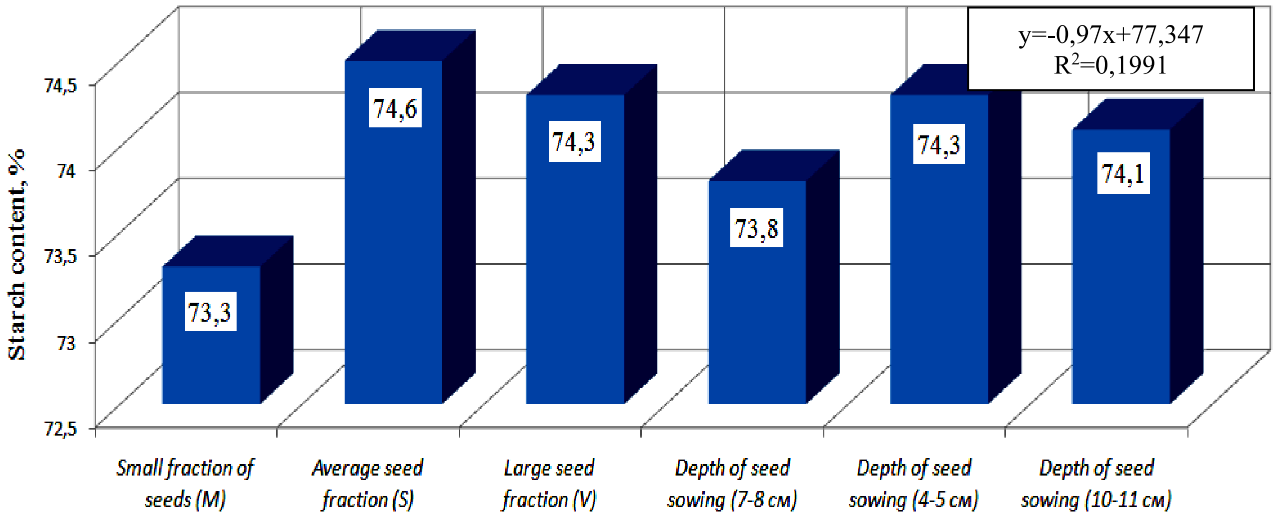

Figure. 1 - Starch content in corn grain depending on the size of the fraction and the depth of seed embedding (average for 2014-2016 yrs), %

This dependence is confirmed by the results of research by other authors. In particular, studies by A. N. Pavlov [37] indicate that an increase in the average annual temperature and a decrease in the annual amount of precipitation increases the protein content in grain, while the starch content decreases.

The highest starch content and yield, on average for three years as 75.40% and 7.54 t/ha, was observed in the group of medium-ripened hybrids, they significantly (HIP05 ripeness group = 1.99% and 0.226 t/ha) differed from its content and yield in the group of early-ripened hybrids (72.33% and 5.88 t/ha) and medium-early hybrids (74.48% and 6.76 t/ha). There was an increase in starch content in later-ripened forms of corn, which were overwhelmingly represented by a tooth-shaped subspecies.

The yield of starch per unit area was also affected by the characteristics of hybrids. The highest starch yield was obtained in hybrids DKS 4082 as 7.58 t/ha and DK 315 – 7.51 t/ha, and other hybrids had significantly lower starch yield, which was: such as DKS 2960 as 5.95 t/ha, DKS 2971 as 5.81 t/ha, DKS 3472 as 7.00 t/ha, DKS 3795 as 6.51 t/ha (HIP05 hybrid = 0.16 t/ha).

The difference in starch yield in the group of medium-early and medium-ripened hybrids was 0.88 - 1.66 t/ha compared to the early-ripened group. That is, there is a trend similar to the starch content as an increase in the duration of the growing season contributes to an increase in the yield of starch per unit area.

The starch content and yield were significantly affected by the size of the seed fraction. These indicators were highest when sowing seeds of a large fraction. Thus, when sowing small-fraction seeds, the starch content in the grain was at the level of 73.33%, and its yield was in the range of 5.43 – 6.98 t/ha, which averaged 6.21 t/ha, medium-fraction seeds as 74.59% and 5.98 – 7.97 t/ha and 6.96, large-fraction seeds as74.3% and 6.08-7.87 t/ha and 7.01 t/ha (HIP05 seed fraction = 0.28% and 0.558 t/ha).

The use of shallow (4-5 cm) grain embedding depth provided starch content and yield of 72.08 - 75.23% and 5.9 - 7.49 t/ha, or an average of 6.75 t/ha, average 7-8 cm embedding it was 72.19-76.02% and 5.85-7.71 t/ha, or an average of 6.78 t/ha, deep embedding 10-11 cm it was 72.04-75.58% and 5.68-7.62 t/ha, or an average of 6.66 t/h (HIP05 embedding depth = 0.22% and 0.213 t/ha). Accordingly, the highest starch content in grain, on average for three years, was 74.31% at a depth of 7 - 8 cm, while it was 73.8% at a depth of 4-5 cm, and 74.11% at a depth of 10-11 cm.

Studies established the dependence of bioethanol yield on the ripeness groups of hybrids, their varietal characteristics, technology elements (sowing time, foliar top dressing and seed depth and size of its fraction) (Table. 8).

The yield of bioethanol in the group of early – ripened hybrids was 3,131 thousand l/ha, medium early it was 3,551 thousand l/ha and medium-ripened it was 4,139 thousand l/ha (HIP05 ripeness group = 0.09 thousand l/ha). That is, the use of medium-ripened corn hybrids provides an additional yield of this biofuel of 0.588 - 1,008 thousand l/ha compared to early-ripened forms.

The use of such hybrids of the early-ripened group as DKS 2971, DKS 2960, DKS 2787, the medium-early group DKS 3472, DKS 3420, DKS 3476 and the medium-ripened group DKS 4964, DC 315, DKS 4626 and DC 440 will significantly increase the yield of bioethanol per unit area.

Table 8 - Bioethanol yield per unit area depending on sowing period (for 2011-2013 yrs), thousand l / ha

Ripeness group (A)	Hybrid (B)	Sowing dates (C)	Years of research			Average
			2011	2012	2013	
1	2	3	4	5	6	7
Early ripened group	Kharkivsky 195MB	Early (RTG* t=+8°C)	3,763	3,092	3,386	3,414
		Medium	3,529	2,891	3,275	3,232
		Late (RTG t=+12°C)	3,003	2,390	2,741	2,711
	DKC 2870	Early (RTG* t=+8°C)	3,780	3,242	3,507	3,510
		Medium	3,257	2,817	3,508	3,194
		Late (RTG t=+12°C)	2,966	2,439	2,566	2,657
	DKC 2960	Early (RTG* t=+8°C)	4,290	3,012	3,439	3,580
		Medium	3,592	2,776	3,502	3,290
		Late (RTG t=+12°C)	3,142	2,450	3,081	2,891
	DKC 2949	Early (RTG* t=+8°C)	3,526	2,700	3,291	3,172
		Medium	2,932	2,451	2,835	2,739
		Late (RTG t=+12°C)	2,625	1,966	2,824	2,472
	DKC 2787	Early (RTG* t=+8°C)	3,745	3,110	3,480	3,445
		Medium	3,429	2,876	3,392	3,232
		Late (RTG t=+12°C)	3,217	2,352	3,236	2,935
	DKC 2971 **(st)**	Early (RTG* t=+8°C)	3,845	2,965	3,503	3,438
		Medium	3,784	2,959	3,468	3,404
		Late (RTG t=+12°C)	3,524	2,483	3,142	3,050
Early-medium group	DKC 3476	Early (RTG* t=+8°C)	4,128	3,387	4,025	3,847
		Medium	4,213	3,005	3,912	3,710
		Late (RTG t=+12°C)	3,346	2,491	3,632	3,156
	DKC 3795	Early (RTG* t=+8°C)	4,486	3,335	4,315	4,045
		Medium (RTG	3,661	3,007	3,850	3,506
		Late (RTG t=+12°C)	3,339	2,150	3,203	2,897
	DKC 3472	Early (RTG* t=+8°C)	4,505	3,616	4,440	4,187
		Medium (RTG	4,147	3,507	3,968	3,874
		Late (RTG t=+12°C)	3,630	2,850	3,642	3,374
	DKC 3420	Early (RTG* t=+8°C)	4,518	3,363	4,362	4,081
		Medium	3,736	3,024	3,696	3,485
		Late (RTG t=+12°C)	3,397	2,457	3,646	3,167

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	Pereyslavsky 230CB	Early (RTG* t=+8°C)	4,353	3,326	3,661	3,780
		Medium	3,560	3,297	3,410	3,422
		Late (RTG t=+12°C)	3,281	2,243	3,354	2,959
	DKC 3871 **(st)**	Early (RTG* t=+8°C)	4,124	3,326	4,004	3,818
	DKC 3871 **(st)**	Medium	3,736	3,017	3,697	3,483
		Late (RTG t=+12°C)	3,185	2,604	3,593	3,127
Medium ripened group	DK 391	Early (RTG* t=+8°C)	4,863	4,067	4,372	4,434
		Medium	4,150	3,373	3,946	3,823
		Late (RTG t=+12°C)	3,903	3,072	3,799	3,591
	DKC 3511	Early (RTG* t=+8°C)	4,400	3,783	4,560	4,248
		Medium	4,080	3,924	4,186	4,063
		Late (RTG t=+12°C)	3,749	2,933	3,953	3,545
	DK 440	Early (RTG* t=+8°C)	4,552	4,501	4,392	4,482
		Medium	3,965	4,105	4,275	4,115
		Late (RTG t=+12°C)	3,740	3,695	3,992	3,809
	DKC 4964	Early (RTG* t=+8°C)	4,792	4,688	4,848	4,776
		Medium	4,811	4,182	4,444	4,479
		Late (RTG t=+12°C)	4,267	3,667	3,896	3,943
	DKC 4626	Early (RTG* t=+8°C)	4,560	4,458	4,918	4,645
		Medium	4,186	4,085	4,109	4,127
		Late (RTG t=+12°C)	3,814	3,640	3,953	3,802
	DK 315 **(st)**	Early (RTG* t=+8°C)	5,454	3,771	5,088	4,771
		Medium	4,276	3,462	4,515	4,084
		Late (RTG t=+12°C)	3,961	3,155	4,202	3,773
HIP$_{05\ \text{ripeness group}}$			0,07	0,03	0,05	-
HIP$_{05\ \text{hybrid}}$			0,14	0,07	0,11	-
HIP$_{05\ \text{sowing dates,}}$			0,07	0,05	0,06	-

***Note**: RTG – the level of soil temperature regime at the depth of seed embedding*

Late sowing dates of corn hybrids lead to a decrease in the yield of bioethanol (HIP05 sowing time = 0.09 thousand l/ha) by 0.640 - 0.847 thousand l/ha compared to the early sowing period.

The yield of bioethanol in the group of early – ripened hybrids was 3,903 thousand l/ha, medium – early hybrids it was 4,495 thousand l/ha and medium-ripened hybrids it was 5,097 thousand l/ha (HIP05 ripeness group = 0.11 thousand l/ha). The use of corn hybrids with a long growing season provides an increase in bioethanol yield by 0.602 - 1.194 thousand l/ha compared to precocious forms.

The use of such hybrids as DKS 2960, DKS 3472 and DKS 3420, DKS 4964 and DK 315 will increase the yield of bioethanol by 0.462-0.629 thousand l/ha (HIP05 hybrid = 0.93 thousand l/ha). Foliar top dressing provided an increase in the yield of bioethanol, which on average for three years of research amounted to 0.1 - 1.04 thousand l/ha (HIP05 top dressing = 0.35 thousand l/ha) relative to the control (water top dressing).

The increase in bioethanol yield with a single foliar top dressing was 0.10 - 0.65 thousand l/ha, and with a double foliar top dressing it was 0.30 - 1.04 thousand l/ha compared to the control –water top dressing (HIP05 number of top dressing = 0.36 thousand l/ha).

In the group of early – ripened hybrids, the approximate yield of bioethanol (HIP05 ripeness group = 0.124 thousand l/ha), on average for three years was 3.22 thousand l/ha, medium – early hybrids it was 3.70 thousand l/ha and medium-ripened hybrids it was 4.13 thousand l/ha (table. 9).

Over the years of research, the estimated yield of bioethanol varied depending on the conditions of the year. On average, in the studied hybrids, in 2014 yr it amounted to 3.70 thousand l/ha, in 2015 yr it was 3.34 thousand l/ha and in 2016 yr it was 4.01 thousand l/ha. The most favorable year for this indicator in terms of moisture supply and temperature indicators was 2016 yr.

Table 9 - Estimated bioethanol yield per unit area sowing of corn hybrids depending on the growing conditions and factors of cultivation technology (for 2014-2016 yrs), thousand / ha

Ripeness group (A)	Hybrid (B)	Seed fraction (C)	Sealing depth of seeds (D)	Year			Average
				2014	2015	2016	
1	2	3	4	5	6	7	8
Early ripened hybrids	DKC 2960	M* (187 g)	4-5 cm	3,001	2,748	3,375	3,041
			7-8 cm	3,162	2,804	3,178	3,048
			10-11 cm	2,930	2,678	2,901	2,836
		S** (238 g)	4-5 cm	3,763	2,811	3,600	3,391
			7-8 cm	3,760	2,991	3,513	3,421
			10-11 cm	3,627	2,968	3,479	3,358
		V*** (277 g)	4-5 cm	3,659	2,803	3,722	3,395
			7-8 cm	3,595	2,927	3,628	3,383
			10-11 cm	3,637	3,041	3,756	3,478
	DKC 2971	M* (194 g)	4-5 cm	2,938	2,805	3,413	3,052
			7-8 cm	2,832	2,791	3,377	3,000
			10-11 cm	2,746	2,658	2,918	2,774
		S** (256 g)	4-5 cm	3,254	3,170	3,461	3,295
			7-8 cm	3,227	3,047	3,560	3,278
			10-11 cm	3,341	2,966	3,481	3,263
		V*** (279	4-5 cm	3,400	3,112	3,524	3,345
		V*** (279 g)	7-8 cm	3,364	3,030	3,635	3,343
			10-11 cm	3,449	2,981	3,471	3,300
Early medium hybrids	DKC 3472	M* (249 g)	4-5 cm	3,374	3,181	4,497	3,684
			7-8 cm	3,445	3,140	4,275	3,620
			10-11 cm	3,345	3,109	4,098	3,517
		S** (326 g)	4-5 cm	3,776	3,634	4,556	3,989

Ripeness group (A)	Hybrid (B)	Seed fraction (C)	Sealing depth of seeds (D)	Year			Average
				2014	2015	2016	
1	2	3	4	5	6	7	8
			7-8 cm	3,779	3,527	4,619	3,975
			10-11 cm	3,846	3,536	4,543	3,975
		V*** (385 g)	4-5 cm	3,722	3,488	4,544	3,918
			7-8 cm	3,812	3,587	4,475	3,958
			10-11 cm	3,829	3,373	4,462	3,888
	DKC 3795	M* (166 g)	4-5 cm	3,388	3,121	3,621	3,377
			7-8 cm	3,258	3,169	3,558	3,328
			10-11 cm	3,230	2,988	3,280	3,166
		S** (207 g)	4-5 cm	3,679	3,627	3,930	3,745
			7-8 cm	3,723	3,308	3,678	3,570
			10-11 cm	3,808	3,364	3,736	3,636
		V*** (287 g)	4-5 cm	3,782	3,688	3,948	3,806
			7-8 cm	3,879	3,236	4,025	3,713
			10-11 cm	3,865	3,410	4,050	3,775
Medium ripened hybrids	DK 315	M* (223 g)	4-5 cm	3,816	3,509	4,345	3,890
			7-8 cm	3,901	3,477	4,247	3,875
			10-11 cm	3,863	3,230	4,048	3,714
		S** (294 g)	4-5 cm	4,184	3,845	4,452	4,160
			7-8 cm	4,366	3,841	4,574	4,260
			10-11 cm	4,446	3,758	4,498	4,234
		V*** (327 g)	4-5 cm	4,195	4,011	4,594	4,267
			7-8 cm	4,496	3,932	4,671	4,366
			10-11 cm	4,289	3,854	4,636	4,260
	DKC 4082	M* (172 g)	4-5 cm	3,724	3,701	4,083	3,836
			7-8 cm	3,779	3,617	4,062	3,819
			10-11 cm	3,685	3,406	3,974	3,688
		S** (227 g)	4-5 cm	3,971	3,923	4,691	4,195
			7-8 cm	4,441	3,996	4,905	4,447
			10-11 cm	4,625	3,890	4,843	4,453
		V*** (278 g)	4-5 cm	4,088	3,903	4,457	4,149
			7-8 cm	4,437	3,976	4,816	4,410
			10-11 cm	4,488	3,904	4,753	4,382
$HIP_{05\ ripeness\ group}$				0,08	0,03	0,03	-
$HIP_{05\ hybrid}$				0,03	0,03	0,04	-
$HIP_{05\ seed\ fraction}$				0,05	0,04	0,04	-
$HIP_{05\ sealing\ depth}$				0,05	0,05	0,06	-

***Notes**: * – fine seed fraction; ** – average seed fraction; *** – large seed fraction*

The estimated bioethanol yield was affected by the seed fraction (HIP05 seed fraction = 0.306 thousand l/ha). In particular, the yield of bioethanol for sowing seeds of small fraction, on average for three years of research ranged from 2.94 up to 3.78 thousand l/ha, or on average for the fraction of 3.41 thousand l/ha, for sowing seeds of medium fraction it was 3.28 – 4.36 thousand l/ha or on average for the fraction of

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3.81, and for sowing seeds of large fraction it was 3.33-4.31 thousand l/ha or on average for the fraction of 3.84 thousand l/ha (Fig. 2).

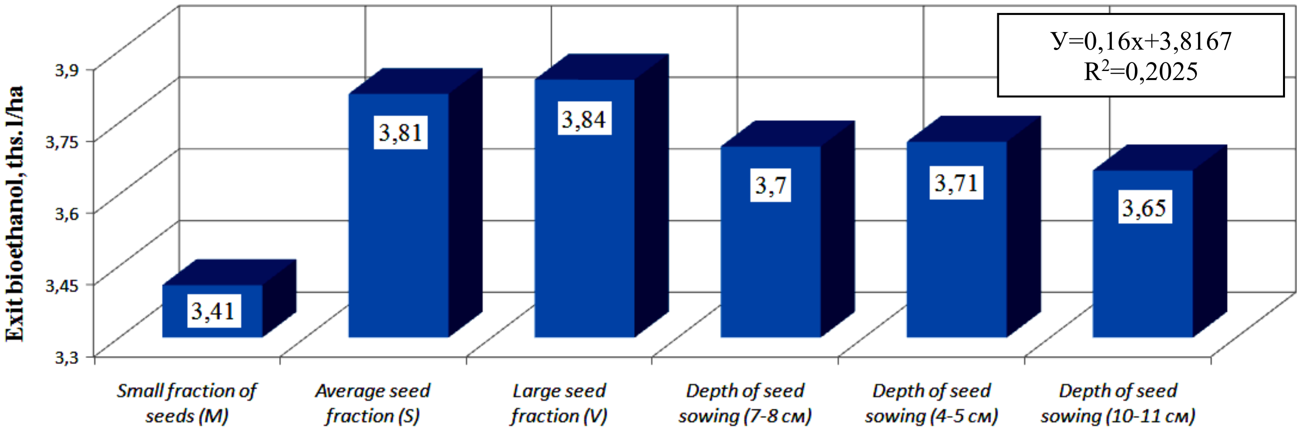

Figure 2 - Approximate yield of bioethanol per unit area of corn hybrids sown, depending on growing conditions and factors of cultivation technology (average for 2014-2016 yrs), thousand l/ha

The depth of embedding of corn seeds ambiguously (HIP05 seed embedding depth = 0.117 thousand l/ha) affected the yield of bioethanol from grain.

Thus, the use of not deep (4-5 cm) seed embedding contributed to the yield of bioethanol, on average for three years, in the range of 3.23 - 4.11 thousand l/ha, or on average for this depth of 3.697 thousand l/ha, for the use of average (7-8 cm) depth of embedding it was 3.21-4.23 thousand l/ha, or on average as 3.713 thousand l/ha, and for the use of deep (10-11 cm) embedding it was 3.11-4.17 thousand l/ha, or an average of 3.648 thousand l/ha. That is, an increase in the depth of seed embedding leads to a decrease in the yield of bioethanol per unit of sowing.

Conclusions based on research results

The starch content and yield per unit area significantly depended on the ripeness group of hybrids. The use of corn hybrids with a long growing season of the tooth-shaped subspecies provided an increase in bioethanol yield by 0.602 - 1.194 thousand l/ha and starch content in grain by 1.53-2.56% compared to precocious forms. Early-ripened hybrids, mainly siliceous-toothed and siliceous subspecies, have high early-ripened and cold resistance, but low starch content (71.56-73.33%), while tooth-like hybrids have an extended growing season, high grain yield and increased starch content (73.13 - 75.06%).

An increase in the content and yield of starch and bioethanol per unit area was observed in hybrids DKS 2870, Kharkivsky 195mv and DKS 2971 of the early-ripened group, DKS 3420, DKS 3476 and DKS 3795 of the medium-early group, DKS 4964, DKS 3511 and DK 440 of the medium-ripened group. The use of these hybrids will increase the yield of bioethanol by 0.462 - 0.629 thousand l/ha.

The use of late sowing periods contributes to an increase in the starch content by 1.57 and 1.97% and leads to a decrease in the yield of bioethanol by 0.640 - 0.847 thousand l/ha compared to the early sowing period due to a reduction in the yield level when sowing is late. It was found that in dry years with high temperatures (2012 and 2015 yrs), the starch content decreased (72.06 - 74.39% and 69.43 - 74.56%), regardless of the studied vegetation factors and cultivation technology.

Foliar top dressing contributed to an increase in the starch content in grain (by 0.1 - 0.46% in 2011-2013 yrs) and bioethanol yield by 0.1 - 1.04 thousand l/ha compared to the control (without foliar top dressing). The increase in bioethanol yield with a single foliar top dressing was 0.10 - 0.65 thousand l/ha, and double top dressing it was 0.30 - 1.04 thousand l/ha relative to the control. The highest starch content in the grain of the studied corn hybrids (70.92 - 76.72% and 71.45 - 76.72 %) was provided by foliar top dressing with microfertilizers Ecolist Mono zinc and Rostok corn. A decrease in the starch content was observed when crops were treated with the Vympel plant growth regulator in Phase 5 - 7 of corn leaves on hybrids DKS 3420 by 0.36 %, Pereyaslavsky 230sb by 0.11% and DKS 3871 by 0.5 %, respectively.

When sowing seeds of medium and large fractions, the highest starch content of 74.59 and 74.30% was obtained compared to the use of a small fraction of seeds (73.33 %). The increase in starch content when using the average seed fraction was 0.8 and 2.2%, with large fraction it was 0.02 and 1.67% relative to small. Seed embedding to a depth of 7-8 cm provides the highest starch content of 74.31 %, while embedding to a depth of 4-5 cm – 73.80% and to a depth of 10-11 cm – 74.11 %.