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PRODUCTIVITY OF CORN HYBRIDS DEPENDS ON GROWING TECHNOLOGICAL METHODS

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The main methods of growing new corn hybrids of different maturity groups in the forest-steppe remain insufficiently studied, and there are also few studies on the development and adaptation to specific soil and climatic conditions of integral technological systems, which would be based on the use of the biological potential of the culture and the application of resource-saving measures; to scientifically justify the principles of hybrid selection for specific subzones of the Forest Steppe and to theoretically argue the directions of resource saving in varietal technologies for growing different biotypes.

The article presents the results of studies on the influence of sowing dates on the grain productivity of various corn hybrids in the conditions of the right-bank forest-steppe of Ukraine.

Research has established that sowing dates affect the passage of phenological phases in corn. Late sowing times contribute to the shortening of the growing season and grain ripening period. The vegetation period of corn hybrids at the early sowing period varied between 117-134 days, medium - 115-136 days, and late - 113-132 days.

A delay in sowing corn hybrids led to a decrease in yield, but this trend was not followed for all studied hybrids. So, in particular, in hybrid P 9619, early sowing led to a decrease in productivity. Therefore, it must be sown later in order to obtain high productivity.

On the basis of two-year observations, it was established that the highest grain yield was formed on variants with mid-early hybrids: P 8904 – 15,1 t/ha, 10,7 and 13,4 t/ha; P 8666 – 14,5 t/ha, 12,6 and 13.0 t/ha, respectively, when sowing in the early, middle and late season.

The realization of the genetic potential of its productivity in the conditions of the right-bank forest-steppe of Ukraine depends on the selection of a corn hybrid of a certain maturity group with the available zoning and sowing dates.

Key words: *corn, hybrids, grain, sowing dates, maturity group, growing technology, productivity.*

Table 6. Lit. 15.

Formulation of the problem. Maize is one of the most important fodder crops. In recent years, there has been a tendency to increase the areas devoted to corn cultivation. As a high-energy feed, corn grain is used in agriculture to feed livestock and poultry. In terms of characteristics and quality standards, corn grain is superior to other fodder crops, therefore it is an integral part of compound feed. In the food industry, corn grain is used for the production of flour, oil, starch, and alcohol.

In terms of cultivated area, corn ranks second in the world, second only to wheat. Maize is also the main fodder crop in the world. In terms of yield and gross harvest, it has now taken the first place, ahead of wheat and rice.

In terms of nutrition, corn surpasses all cereal crops. 1 kg of its grain contains 78 g of digestible protein and 1,34 k. units, and in rye grain – 1,18, barley – 1,20, oat – 1,00 k. units. The grain contains carbohydrates (65-70%), fat (9-12%), mineral salts and vitamins. The yield of corn is 1,3-1,5 times higher than the yield of the main grain crops traditionally grown. Growing corn for grain gives agricultural producers an advantage even in years with adverse climatic conditions [1].

According to state statistics, the corn harvest in 2022 will amount to about 27 million tons. For comparison, last season Ukraine harvested about 40 million tons. According to experts of the domestic agricultural market, with the beginning of a full-scale war, corn remained the leader in exports. Because European consumers use it to meet their own needs. In contrast to wheat and barley, which are mainly transited through the EU. Or they are bought for domestic consumption only in case of a significant discount compared to domestic prices.

Ukrainian business exported 99.8 million tons of goods worth $44.1 billion last year during the war. Under normal conditions, trade indicators could seem catastrophic, because the value of exports is 35% lower than in 2021. And physical volumes decreased by 38 .4%. Among the goods, corn is the leader in monetary terms (and in terms of volume), while last year's exports, despite Russia's armed aggression against Ukraine, amounted to 24,99 million tons worth $5,94 billion. Although by 1%, this more than in 2021, which against the background of all indicators is a sensation [2].

Maize, by its potential, is the most productive among other grain crops, and in recent years there has been a tendency to increase the area of its cultivation, both in the world and in our country, primarily in the southern regions of Ukraine. However, when growing this valuable crop, it is far from always possible to realize its high potential, and therefore domestic producers of agricultural products should pay special attention to increasing the productivity of corn.

The productivity of a cornfield is a consequence of the complex interaction between plants and the environment. One of the essential characteristics of crop productivity is its yield. During the entire period of corn cultivation, the main task of breeders was to create and introduce into production high-yielding hybrids, with quick moisture release, high resistance to various harmful organisms and lodging, high-tech when harvesting for grain [3].

At the same time, in order to realize the maximum potential of each hybrid, it is necessary to choose certain varietal agricultural techniques, since individual hybrids differ not only in morphological features and biological properties, but also react differently to the length of the daylight hours, the quality of solar insolation, the degree of moisture, and the temperature regime air and other environmental conditions [4].

Sowing dates are one of the main factors in obtaining high yields of agricultural crops, including corn. This element of technology determines the processes of growth and development of plants, as well as the formation of their productivity in general. When breeders breed new hybrids of corn, which differ not only in early maturity and in a number of morphological features, biological properties, but also react differently to the length of the daylight hours, the quality of solar insolation, the degree of moisture, the air temperature and other environmental conditions, require further clarification varietal agricultural machinery.

In connection with this, the main task of the conducted research was to study the influence of sowing dates on the grain productivity of various corn hybrids in the conditions of the right-bank forest-steppe of Ukraine.

The purpose and tasks of the research. The purpose of the work was to develop the main methods of growing new corn hybrids of different maturity groups, as well as integral technological systems, which would be based on the use of the biological potential of the crop and the application of resource-saving measures; to scientifically justify the principles of hybrid selection for specific subzones of the Forest Steppe and to theoretically argue the directions of resource saving in varietal technologies for growing different biotypes.

Analysis of recent research and publications. Maize (Zea mais L.) occupies an important place among strategic crops, therefore it is widely used in various industries, processing into feed and biofuel, food products, and others. In terms of potential productivity and energy nutrition, it surpasses all forage crops [5].

According to Yu.O. Lavrynenko, the further increase in productivity is largely (by 50% or more) due to the optimization of the "genotype-environment" interaction. Varieties and hybrids adapted to local environmental conditions can provide the highest productivity. The selection of genotypes with high adaptability is a rather urgent task, since the efficiency of non-renewable energy costs depends on the fact that the cultivated crops will be able to increase the level of transformation and accumulation of solar energy and other natural resources [6].

Modern corn hybrids have a high potential for productivity, which will ensure substantial profits from the cultivation of this crop. The growth of the area of this crop in our country and the intensification of cultivation technologies prompts the producers of the corn belt to select hybrids capable of providing grain yield in basic parameters at the level of 15 t/ha and more [12].

Different corn hybrids show different reactions not only to hydrothermal conditions, but also to agricultural techniques aimed at maximizing the potential productivity of hybrids. According to many researchers, when the effect of heterosis is fully implemented, the yield of corn increases up to 20%, and in some cases up to 50%, compared to the control, where the individual needs of the hybrid were ignored [7].

Scientific research data and practical experience show that the contribution of breeding to increasing the level of crop yield is 35-50%. As a result of the realization of the genetic potential, modern corn hybrids of various FAO groups in Ukraine are able to provide a grain yield of 5-8 tons, and when irrigated in the southern regions of the country, it is about 10-12 tons/ha [8].

According to V. Rybka and others, it is possible to sow corn almost everywhere in Ukraine, but several natural and climatic zones that differ significantly should be taken into account, and therefore it is necessary to select hybrids that can grow in certain soil and climatic zones. This is explained by the fact that even in the conditions of the same massif, fields can differ among themselves in terms of fertility, crop rotation, moisture availability, etc. The authors recommend growing different hybrids, different in FAO, diversity, reaction to the effect of fertilizers, resistance to harmful organisms, and thickening [9].

Sowing dates are one of the main factors in obtaining high yields of agricultural crops, including corn. The productivity of hybrids with different precociousness and the harvesting moisture content of the grain largely depend on the timing of corn sowing and weather conditions during the growing season. Both early and late periods lead to a decrease in plant productivity. The temperature of the soil at the depth of seed wrapping, sufficient for germination and emergence of seedlings, is decisive for the sowing time [10].

When breeders create new hybrids of corn, which differ not only in early maturity and a number of morphological features and biological properties, but also react differently to the length of the daylight hours, the quality of solar insolation, the degree of humidity, the temperature regime of the air and other environmental conditions, further clarification of the optimal parameters of varietal agricultural technology [11].

Conditions and methodology of conducting research, research methodology. The Vinnitsa region, within which the research was conducted, has a favorable climate for agricultural production: a long warm and rather humid summer, early spring, dry autumn, winter with moderate frosts and significant snow cover - all this has a positive effect on the growth and development of grain, technical and garden crops.

Our research was conducted in the Farming "Yurchenko-N" of the Vinnytsia district on the fields of forage crop rotation during 2020–2021.

The soil cover is represented by gray forest medium loamy soils. According to physico-chemical and physical indicators, they are typical for the Vinnytsia region and the right-bank forest-steppe, and are favorable for growing corn.

According to the agrochemical survey, it was established that the arable layer of the soil has the following physicochemical parameters: humus content 1,97 – 2,16% (according to Tyurin), alkaline hydrolyzed nitrogen in the range of 65 - 77 mg/kg (according to Kornfield), mobile phosphorus (according to Chirikov)

– 149-251 mg/kg of soil, exchangeable potassium (according to Chirikov) – 80-95 mg/kg of soil. Hydrolytic acidity – 1,10 – 1,21 mg-eq per 100 g of soil. The reaction of the soil solution is 5,5 – 6,7 pH. The assessment of hydrothermal conditions was carried out on the basis of the data of the Vinnytsia Regional Center for Hydrometeorology.

The experiment is two-factor, laboratory-field. Factor A - sowing dates. Factor B - the method of creating a grass stand (without cover and sowing under cover). The experiment was repeated four times. Placement of options is systematic, in four tiers. The area of the accounting plot is 50 m^2, the total area is 66 m^2. The preparation and cultivation of the soil for corn in the experiment was carried out in accordance with the recommended technologies for the conditions of the right-bank forest-steppe of Ukraine, except for the factors that were studied.

Field experiments were carried out in the general massif of sowing corn for grain. The experiments determined the economic and biological evaluation of corn hybrids of foreign selection of the Corteva Agriscience company Pioneer® brand (which is one of the leaders in the corn market of Ukraine, because almost 1/5 of all areas are sown with the seeds of this company, depending on the maturity groups and the timing of their sowing. For this, production field experiments were laid, in which 9 hybrids of corn of different maturity groups were sown in three terms.

The cultivation of corn for grain was carried out according to the technology adopted for the right-bank forest-steppe zone. The predecessor of corn is winter wheat, harvested for grain.

Vegetation periods during the research years were generally characterized by favorable hydrothermal conditions for the growth and development of corn hybrids. No significant deviations in air temperature and amount of precipitation were observed.

Harvesting of corn hybrids of different maturity groups was carried out in the phase of waxy grain maturity. In the phase of 5 true leaves of corn, a post-emergence (insurance) herbicide of the "Syngenta" company - Milagro 040 SC, k.s. was used to control annual and perennial cereal weeds. To prevent the appearance of caterpillars of the corn moth or cotton bollworm in corn crops, spray the crops with Twix at the rate of 1,0 l/ha.

Field and laboratory methods of studying hybrid corn material were used in the research. Field research was accompanied by phenological observations, measurements and analyzes in accordance with the "Methodology of state variety testing of agricultural crops" [13].

Presenting main material. Taking into account the world's need for food products, as well as to ensure one's own food security, obtaining stable grain harvests is one of the priority directions for the development of domestic agriculture. The leading place among grain crops is occupied by corn. It is gaining more and more popularity among manufacturers in connection with its use for the production of environmentally friendly fuel - ethanol. In this regard, conducting experimental research aimed at the development and improvement of varietal agricultural

techniques and the determination of the most adaptive forms of corn for cultivation in the conditions of the right-bank forest-steppe of Ukraine is of practical interest and relevance both for agricultural science and agricultural production [3, 4].

The data of scientific research and the practical experience of advanced agricultural producers show that the contribution of breeding to increasing crop yield is 30-50%. As a result of the realization of the genetic potential of modern corn hybrids of various FAO groups, in the conditions of the forest-steppe of Ukraine, they are able to provide grain yield within the range of 10-12 t/ha [7].

The yield of corn, like other agricultural crops, is determined by the genetic potential of varieties (hybrids) and the level of technology of their cultivation against the background of a high general culture of agriculture. In order to more fully realize their potential productivity, growing technologies should maximally satisfy the requirements of plants for soil and air nutrition, moisture supply, and temperature during the growing season. To develop the optimal technology, it is necessary to know and take into account the patterns of changes in environmental factors under the influence of technological techniques, growth and development of plants, as well as their requirements for certain factors at each period of life. The study of the needs of field crops by phenological phases and stages of organogenesis has gained the greatest importance.

It should be noted that the problems of obtaining high harvests of corn grain have become more acute in the conditions of market economic relations in agriculture. The role of breeding in ensuring the growth of yield and profitability increased; the importance of scientifically based use of environmental factors in order to obtain the maximum yield has increased. With the current economic state of agriculture, the importance of agricultural techniques that do not require significant material costs is particularly important. Such agrotechnical techniques aimed at obtaining the largest harvests of grain without additional costs include scientifically based sowing dates and plant density.

The analysis of literary sources and many years of research work with heat-loving crops (corn and sorghum), as well as the experience of growing them in production allow us to state that several factors must be taken into account when determining the most appropriate terms for sowing corn. The main one of these factors is the average daily temperature of the soil at the depth of seed wrapping [3,10].

In the process of growth, plants adjust to changing vegetation conditions (adapt). This is facilitated by the hereditary biophysical and biochemical features of the cells, which ensure the vital activity of the organism, including growth within wide temperature, light and other conditions for each type of plant.

The first period of corn growth and development is characterized by the fact that young seedlings are fed by the plastic substances of the seed and only after the appearance of the 3-4th leaf, the plant begins to absorb nutrients from the soil. Nutrient absorption from the soil occurs most intensively during the formation of the secondary root system. Because of this, the creation of favorable conditions during

this period of development will significantly improve plant productivity.

In the process of conducting research, we noted a significant influence of the duration of the growing season on the indicators of the linear dimensions of the plant, the height of the laying of cobs. Research has established that corn forms characterized by a long vegetation period and an extended period from flowering to full grain maturity have increased resistance to damage by stem rot, compared to self-pollinated lines with a short vegetation period and a short second period of plant development (flowering-full grain maturity).

The duration of the growing season depending on the timing of sowing of corn hybrids is given in table 1.

Table 1

The duration of the growing season in corn hybrids depends from sowing dates, days (average for 2020-2021)

Name hybrid	Duration of the growing season					
	Early (at a soil temperature of 6-8°C)		Average (at temperature soil 8-10°C)		Late (at a soil temperature of 10-12°C)	
	2020	2021	2020	2021	2020	2021
Early ripening						
P 8307 FAO 240	119	123	115	116	113	116
P 8521 FAO 220	117	119	116	120	116	114
P 8271 FAO 240	123	126	117	119	118	121
Mid-morning						
P 8904 FAO 280	124	125	120	119	117	116
P 8666 FAO 250	122	125	121	131	119	123
P 8834 FAO 280	125	128	126	132	124	132
Medium ripe						
P 9074 FAO 310	127	126	122	124	118	121
P 9234 FAO 320	128	130	125	129	124	129
P 9610 FAO 340	131	134	130	136	128	131

the source is formed on the basis of own research results

The duration of the periods of sprouting - flowering of cobs and flowering of cobs - full maturity of grain with late sowing dates generally decreased, which was reflected in the shortening of the vegetation period at later sowing dates. The vegetation period of corn hybrids at the early sowing period varied between 117-134 days, medium - 115-136 days, and late - 113-132 days.

Sowing dates significantly affect the duration of the growing season and individual phenological phases in corn. The duration of separate vegetation periods «sowing-seedlings», «seedlings-flowering of cobs», «flowering of cobs-full maturity» and «seedlings-full maturity» depended on the maturity group and biological characteristics of the hybrid.

The use of early-ripening hybrids ensured the duration of the «sowing-seedling» period, an average of 9,7 days over three years, medium-early and medium-ripening hybrids – 10,1 days; «seedlings-flowering of cobs» – 56,0 days, 64,4 and 67,6 days, «flowering of cobs-full ripeness of grain» - 50-54 days, 57-64 and 59-68 days, «seedlings-full maturity» – 108,7 days, 123,4 and 129,9 days, respectively.

Sowing corn hybrids in the early period contributed to the germination of seeds for 15–20 days, medium - 8–13 days, late - 6–9 days. The best provision of temperature during the late sowing period ensured a reduction of the period of seed germination in corn hybrids by an average of 9–14 days.

Thus, the results of the conducted research established that the timing of sowing significantly affects the duration of the growing season and individual phenological phases in corn. A delay in the timing of sowing leads to a reduction in the period of seed germination and the duration of the vegetation period of the studied corn hybrids.

Reparability of corn is the key to high yield under unfavorable growing conditions. Stay green is the ability of corn plants to keep the vegetative parts of the plants green in color and high humidity after the full maturity of the seeds. Remontant hybrids are characterized by increased viability of the leaf-stem mass, which leads to an extension of the period of photosynthetic activity. This is especially relevant for growing corn in arid regions, where ordinary hybrids "burn" under the influence of high temperatures.

The advantages of Remontant hybrids over ordinary ones are:

- increased productivity of the plant in general;
- better pouring of grain and as a result - a large mass of thousands of seeds;
- increased tolerance to drought;
- resistance to stem diseases, pests and stem lodging;
- the maximum accumulation of dry matter during the cultivation of silage corn.

There is an opinion that Remontant hybrids release moisture more slowly, compared to hybrids with the usual type of plant. But here it is necessary to distinguish the type of repair. Thus, in some hybrids, upon the onset of physiological ripeness, the cob wrappers remain intact and tightly adhere to it. Undoubtedly, such hybrids have somewhat worse moisture transfer. But there is another type of hybrids in which the cob wrappers dry out with the onset of physiological ripeness - they open, and the cob quickly releases moisture. Such hybrids are the most suitable for grain cultivation [13].

After harvesting remontant corn for grain, you can use the green and juicy leaf mass for silage or green fodder. remontant hybrids of corn are also characterized by higher productivity, better quality of grain and vegetative organs significantly differ from conventional forms in their high resistance to disease, damage by pests, and are characterized by higher resistance to lodging. Thus, corn repairability is an important

feature that, according to most leading scientists and scientists, modern corn hybrids should possess.

The characteristics of corn hybrids of different maturity according to the feature of repairability are given in table 2.

Table 2

Characteristics of repairability and drought resistance in corn hybrids, score (average for 2020-2021)

Name hybrid	Tempo growth	Repairability	Type repairability	Drought resistance
Early ripening				
P 8307	6	6	1	9
P 8521	8	6	1	8
P 8271	9	8	1	9
Mid-morning				
P 8904	7	9	1	9
P 8666	9	6	1	9
P 8834	6	7	1	6
Medium ripe				
P 9074	9	9	1	7
P 9234	7	7	1	8
P 9610	8	9	2	7

the source is formed on the basis of own research results

The analysis of the data in table 2 showed that the highest growth rates at the initial stages of development were observed in such corn hybrids as P 8271, P 8666, and P 9074. The listed hybrids have a higher competitiveness against weeds in the fight for the life and development factors of corn.

The studies recorded relatively slow initial growth and development in the following corn hybrids: early-ripening P 8307 and mid-early hybrid P 8834. In relation to remontantness, the highest score was established in mid-ripening hybrids: P 9074 and P 9610 (9), the lowest in early-ripening hybrids: P 8307, P 8521 and mid-early hybrid P 9074 (6).

The resistance of different genotypes to drought is determined by the change in grain yield, which is directly or indirectly influenced by various morphological and biological characteristics. Therefore, a set of features should be taken into account during the evaluation and selection of drought-resistant forms.

Drought resistance is a complex integrated feature that is controlled not by individual features of plants, but by the whole system of the organism, which reacts differently to the lack of moisture, and consists of several levels.

In our research, the following hybrids were found to be resistant to moisture deficiency (arid conditions of growth and development) in the 5-7 leaf phase: early-ripening P 8271, P 8307 and mid-early P 8904, P 8666.

Repair corn has significant yield advantages when grown in dry conditions, as well as in windy and rainy conditions in the fall, and even in the case of winter or spring harvest. Remontant hybrids have a better ability to resist damage by stem fusarium rot (the causative agent of the disease is imperfect fungi from the genus *Fusarium Link*) due to the passage of immune processes in plant tissues.

In the autumn period, such hybrids are distinguished by increased resistance to laying, as they have increased cell turgor, and they are able to withstand even stormy winds. Our research has established that corn-growing conditions have a significant impact not only on gross grain yield, but also on leaf mass of corn plants.

Thus, the results of our scientific research give reason to assert that the corn hybrids studied, which differ in maturity, differed significantly in terms of such characteristics as growth rates, drought resistance, and remontantness. The correct selection of hybrids according to the listed characteristics will allow domestic agricultural producers to effectively use the adaptive properties of various corn hybrids when growing them in different soil and climatic zones of the country.

Conducting experiments on the timing of corn sowing, as we noted, is caused by global warming and earlier warming of the seed layer of the soil, which has become more frequent over the last three decades.

The productivity of cultivated crops is determined by a number of plant parameters, among which the main ones are: height, density of grass, leafiness, and thickness of stems, accumulation of root remains and a number of other equally important indicators.

The height of plants (linear growth) affects the formation of the leaf surface, the assimilation of FAR by plants, the productivity of plants and their nutritional value. In turn, the height of plants is affected by such factors as the degree of mineral nutrition, conditions of moisture supply, density of sowing, type of crop in the mixture, varietal characteristics, etc.

In our experiments, the height of corn plants varied widely depending on the main agrotechnical factors and climatic conditions during the years of research. It was established that the height of the plants and the drooping of the cobs affect the quality of harvesting, its speed and energy consumption. The taller the plant, the higher the harvesting costs. Therefore, for grain-type hybrids, it is important to have a small plant height (150-180 cm) and an optimal (at least 50 cm) attachment of the economically valuable cob [13].

Due to the low and uneven attachment and drooping of the cobs in the conditions of the forest-steppe of Ukraine, grain losses amounting to 15-20% or more are observed during combine harvesting of corn.

The conducted research established that most of the morphological characteristics, in particular the height of plants and the height of attachment of cobs, are genetically determined, although they are also influenced by environmental conditions. Corn hybrids with optimal plant height and significant cob laying can be harvested with conventional grain harvesters with simultaneous cob threshing.

The obtained experimental data show that at the beginning of their growth and development (up to the phase of 6-8 leaves) sowing methods, plant density, fertilization level and type of hybrid by maturity group do not significantly affect the height of corn plants, but in the following phases of plant growth and development study factors had a certain influence on the dynamics of linear growth of corn plants (Table 3).

Table 3

Plant height of corn hybrids depending on sowing dates, sm (average for 2020-2021)

Name hybrid	Early (at a soil temperature of 6-8°C)			Average (at a soil temperature of 8-10°C)			Late (at a soil temperature of 10-12°C)		
	2020	2021	among-not	2020	2021	among-not	2020	2021	among-not
Early ripening									
P 8307	242,6	248,9	245,8	288,7	291,8	290,3	275,2	281,5	278,4
P 8521	229,5	234,9	232,2	260,4	265,6	263,0	266,7	269,8	268,3
P 8271	262,8	279,6	271,2	271,3	278,1	274,7	280,4	283,5	282,0
Mid-morning									
P 8904	268,3	272,0	270,2	276,2	283,8	280,0	282,5	286,2	284,4
P 8666	270,9	276,8	273,9	285,4	306,8	296,1	283,4	285,3	284,4
P 8834	281,7	286,2	284,0	284,5	290,9	287,7	277,7	279,9	278,8
Medium ripe									
P 9074	269,5	278,6	274,1	303,2	309,0	306,1	280,1	288,5	284,3
P 9234	283,2	290,4	286,8	298,9	306,8	302,9	278,5	285,6	282,1
P 9610	287,7	291,3	289,5	295,6	300,5	298,1	288,8	294,7	291,8

the source is formed on the basis of own research results

We found that the studied factors significantly affect the linear growth of corn. The indicators presented in table 3 show that the largest linear growth of the corn plant was in the second sowing period (at a soil temperature of 8-10°C), respectively, the average indicators for two years ranged from 274,7 to 306,1 cm In the variants of the experiment, where the early and late sowing period were used, the height of the corn hybrid plants was almost the same.

Such medium-ripe corn hybrids as: P 9610, P 9074 and P 9234 had the highest height, respectively 298,1; 302,9 and 306.1 cm when sowing at a soil temperature of 8-10°C (second season).

In our studies, the early-ripening corn hybrid P 8521 turned out to be the least tall. With early, middle and late sowing periods, the average height of his plants for two years was 232,2 cm, 263,0 and 268,3 cm, respectively.

Thus, the greatest linear growths were provided by variants where sowing was applied at the optimal time (at a soil temperature of 8-10°C) - from 263,0 to 306,1 cm. The height of corn plants at a later time of sowing (at a soil temperature of 10-12°C), the height of the plants was in the range of 268,3 – 291,8 cm, and the smallest

height was noted for the corn plants on the variants where the early sowing method was used, from 232,2 to 289,5 cm, respectively.

The elements of the crop structure have a complex relationship; an increase in one of the indicators does not always increase the clover yield. Only the optimal ratio of all components of the crop structure against the background of the rational ratio of agrotechnical methods ensures the high productivity of corn hybrids.

The ratio of stems, leaves and cobs during the growing season is subject to significant changes depending on the environmental conditions. Agrotechnical methods of growing plants can to some extent change the gross ratio of stems and leaves in the direction of increasing the latter. Among the significant number of economically important characteristics of corn hybrids, which have a significant impact on the formation of actual and potential yield, the last place is occupied by indicators such as "number of rows of grains" and "number of grains in a row".

The study of the correlation dependence between them and between the main economic and valuable traits is of practical importance for determining the optimal parameters when developing models of corn hybrids for specific agro-climatic growing zones [14,15].

The individual productivity of plants depends on providing them with life factors, which ultimately results in a change in the main elements of the crop structure.

The elements of the crop structure have a complex relationship; an increase in one of the indicators does not always increase the yield of corn hybrids. Only the optimal ratio of all components of the crop structure against the background of the rational ratio of agrotechnical methods ensures high productivity of corn. The ratio of stems, leaves and cobs during the growing season is subject to significant changes depending on the environmental conditions. The individual productivity of plants depended on providing them with life factors, which ultimately results in a change in the main elements of the crop structure.

In our research, corn hybrids of different groups of ripeness showed individual features of the formation of structural elements of the crop depending on the hybrid and the time of sowing. Thus, the sizes of the cobs formed on the plants varied little under the influence of this factor and their parameters were characteristic of a certain biotype of corn.

The productivity of hybrids with different precociousness and the harvesting moisture content of the grain largely depend on the timing of sowing and weather conditions during the growing season. The yield of corn in Ukraine fluctuates significantly. One of the reasons for the low realization of the biological potential of the crop is the insufficient adaptation of corn hybrids of different maturity groups to the appropriate agro-climatic conditions and imperfect growing technology [7].

The results of the research showed that the type of hybrid by maturity group, the time of sowing significantly affect the individual productivity of plants and the structural elements of corn productivity (Table 4).

Table 4

Characteristics of the crop structure of corn hybrids depending on the sowing dates, (average for 2020-2021)

Name hybrid	Number of rows of grains, pcs.			Number of grains in a row, pcs.			Weight of 1000 grains, g		
	early	middle	late	early	middle	late	early	middle	late
Early ripening									
P 8307	15,8	15,7	15,5	37,0	35,5	36,5	343,0	285,0	284,9
P 8521	13,9	13,9	14,7	36,0	34,2	31,6	309,1	311,0	254,2
P 8271	12,8	12,9	13,3	41,9	39,9	39,8	322,5	316,4	279,2
Mid-morning									
P 8904	15,1	15,4	16,3	41,5	37,8	37,6	332,4	327,3	285,5
P 8666	15,2	15,5	14,8	38,9	37,6	38,5	310,4	267,8	260,5
P 8834	16,0	14,8	15,5	40,8	37,2	37,4	352,2	306,2	290,1
Medium ripe									
P 9074	13,7	13,6	13,9	39,3	35,8	38,0	327,9	296,1	271,6
P 9234	14,1	13,2	13,9	38,3	35,6	35,2	358,4	314,2	286,4
P 9610	15,9	15,3	16,0	39,9	40,6	39,1	301,1	309,5	264,3

the source is formed on the basis of own research results

The experimental data we received indicate the corresponding dependence of the yield structure of corn hybrids of different maturity groups on the sowing dates.

It was found that, with late sowing dates, the number of grain rows decreased in the following hybrids: P 9234, P 8834, and increased, respectively, in hybrids - P 8271, P 8904, P 8521 and P 9610.

The value of NRG (the number of rows of grains), when sowing in the early season, in the studied corn hybrids ranged from 12,8 to 16,0 pcs., when sowing in the second season – 12,9-15,7 pcs., and when sowing in the third term – 13,3-16,3 pcs. The number of grains in a row also depended significantly on the timing of grain corn sowing. In general, a decrease in this indicator was observed when corn was sown late in almost all hybrids, except for P 9610, in which the number of grain rows was smaller at early sowing times than at late ones. The amount of decrease in the number of grain rows at later sowing times was on average 2-8 pcs.

In the process of research, we discovered a dependence, which consisted in the fact that the weight of 1000 grains decreased with a delay in the sowing time of hybrids. So, in particular, when sowing in the early season, it ranged from 301,1 to 358,4 g, when sowing in the middle season - from 285,0 to 327,3 g, and when sowing in the late season, it was 254,2-290,1 g. The most significant decrease in the weight of 1000 grains with late sowing was observed in such hybrids as P 8521, P 8666, P 9610, etc. In these hybrids, the difference in mass of 1000 grains between early and late sowing was more than 48 g.

The largest number of rows of grains is 15,2-17,2 pcs. determined in the group of mid-ripe corn hybrids. Carrying out foliar fertilization ensured an increase in the number of rows of grains by 0,1-0,9 pcs, and increasing the grain yield of corn hybrids

by 0,3-1,9 t/ha, compared to the control. The largest number of grains in a row was found during the lengthening of the growing season, which increased the number of grains in a row by 0,6-3,6 pcs, and the weight of 1000 grains by 12,2-27,6 g, compared to the control.

The conducted research allows us to state that at late sowing dates of corn hybrids, there is a significant decrease in the weight of 1000 grains and the number of grains in a row. The studied hybrids of corn reacted ambiguously by changing the index of the number of rows of grains when applying different sowing times.

One of the urgent problems of biological science is increasing the photosynthetic productivity of plants. The productivity of corn, like other crops, is entirely determined by the work of the photosynthetic apparatus. Moreover, in the process of photosynthesis, 90-95% of the entire dry weight of the crop is formed. Determining the total leaf area has an independent scientific value when identifying the correlation between it and the productivity of the crop, so there is a need to determine this indicator.

The research of domestic and foreign scientists established that the photosynthetic productivity of plants depends on the size of the assimilation surface and the intensity of the photosynthesis process, which is manifested in the daily increase in biomass, the change in the coefficient of solar energy use, and other functional indicators. Therefore, it can be stated that the larger the area of the leaf surface formed by grasses, the more productive, with the exception of certain cases, is the unit of the sowing area[15].

Considering the final yield of each crop as a function of the photosynthetic activity of plants, it should be taken into account that it is a component integral quantity. Productivity of plants depends not only on the size of the assimilation surface, but also on the intensity of photosynthetic processes per unit of its area. In turn, the intensity of photosynthesis is determined by its net productivity, or the number of grams of dry above-ground mass that is formed on 1 m^2 of leaf area in a certain period of time.

In this regard, it can be argued that by means of agricultural techniques and the selection of varieties (hybrids) of crops and the norms of their sowing, it is possible, on the one hand, to quickly create the necessary area of leaves in the spring, on the other hand, to increase the intensity of photosynthesis (absorption of solar radiation by them), and hence and productivity of each square meter of their area.

The theoretical material presented above determines the need to determine the features of the formation of the assimilation surface of corn hybrids of different maturity groups (Table 5).

The conducted studies established that the area of the leaf surface in all periods of determination depended on the time of sowing the hybrid and the weather conditions of the year. Analyzing the dynamics of the increase in the area of the leaf surface of corn in the ontogenesis of plants, it should be noted that the largest area of the leaves of the plant was formed in the phase of flowering and milk-wax maturity. On average, among

Table 5

Dynamics of leaf surface growth by corn plants of different maturity groups, thousand m2 /ha (average for 2020-2021)*

Name hybrid	Phase of plant growth and development				
	6-8 leaves	throwing out panicles	flowering	milk ripeness	waxy maturity
Early ripening					
P 8307	7,7	26,3	29,5	36,5	33,3
P 8521	7,5	24,6	28,2	34,9	31,3
P 8271	8,0	28,9	31,9	37,9	34,4
Mid-morning					
P 8904	9,1	31,5	37,7	43,2	39,7
P 8666	8,8	35,0	38,7	45,0	42,5
P 8834	8,2	30,1	35,2	40,6	38,8
Medium ripe					
P 9074	8,5	29,2	34,4	41,9	37,7
P 9234	9,0	30,5	37,2	43,9	40,8
P 9610	8,1	29,5	34,8	38,5	36,5

***Average sowing period**

the source is formed on the basis of own research results

he hybrids, this showiness in the flowering phase was within 28,2 – 46,4 thousand m^2/ha, and in the milk ripeness phase, respectively, 34,9 – 45,0 thousand m^2/ha. Mid-early hybrids also formed a fairly high assimilation surface area, which, depending on the type of hybrid, ranged from 43,9 to 38,5 thousand m^2/ha (milk ripeness phase).

Domestic scientific experience has shown that in terms of the productivity potential of grain and green mass, forage and energy value, corn has no equal and is indispensable in fodder rations for livestock, especially pigs and poultry. But the methods of technological operations nowadays do not fully contribute to the realization of the yield potential of new morpho-biotypes of this culture, which is connected with the insufficient compliance of agricultural cultivation techniques with the morpho-biological features of the hybrid [4].

Grain moisture content of all hybrids of different maturity groups of corn at the time of harvesting ranged from 13,1 to 16,6%. The variation of this indicator is explained by different sowing dates and maturity groups of hybrids.

The experimental studies conducted by us in the conditions of the right-bank forest-steppe of Ukraine showed that the timing of sowing significantly affects the growth and development of plants, their yield and grain quality of corn hybrids of different maturity groups. Depending on the experimental factors, crop plants fall into different agrometeorological conditions, grow and develop differently, that is, they form different productivity [5].

Productivity is the result of a complex interaction of plants in accordance with their genetic potential and a complex of environmental factors. The effect of a complex of growth and development conditions on plants manifests itself in changes in the parameters of the elements of their productivity. The yield of corn mainly depends on many internal and external factors. Among them, in addition to light, heat, moisture, the hybrid composition of plants of corn hybrids of different maturity has an effect on productivity.

The results of yield accounting showed that, under the influence of agrotechnical elements, the productivity of the investigated corn hybrids, on average for 2020-2021, ranged from 8,3 to 15,1 t/ha (Table 6).

Table 6

Grain yield of corn hybrids depending on sowing dates, (average for 2020-2021)

Name hybrid	Yield at 14% humidity, t/ha								
	Early (at a soil temperature of 6-8°C)			Average (at a soil temperature of 8-10°C)			Late (at a soil temperature of 10-12°C)		
	2020	2021	average	2020	2021	average	2020	2021	average
Early ripening									
P 8307	10,6	12,9	11,8	8,9	10,2	9,6	11,3	12,2	11,8
P 8521	9,7	10,0	9,9	8,3	9,5	8,9	8,7	8,9	8,8
P 8271	10,5	11,1	10,8	9,2	10,8	10,0	10,0	10,3	9,2
HIP0.5 t/ha	0,43	0,26	–	0,19	0,29	–	0,22	0,31	–
Mid-morning									
P 8904	13,2	17,0	15,1	10,2	11,1	10,7	12,4	14,3	13,4
P 8666	12,8	16,1	14,5	11,5	13,6	12,6	12,0	13,9	13,0
P 8834	11,9	14,8	13,4	9,9	10,8	10,4	9,7	12,8	11,3
HIP0.5 t/ha	0,21	0,25	–	0,27		–	0,20	0,24	–
Medium ripe									
P 9074	10,9	12,3	11,6	8,2	9,3	8,8	9,6	10,9	10,3
P 9234	13,1	14,7	13,9	10,5	11,2	10,9	11,3	11,5	11,4
P 9610	11,2	12,3	11,8	11,4	12,4	11,9	11,8	12,6	12,2
LSD 0.5 t/ha	0,23	0,27	–	0,25	0,18	–	0,19	0,24	–

the source is formed on the basis of own research results

These tables show that for all maturity groups of corn hybrids there is a dependence of grain yield on the time of sowing. When using later sowing dates, the moisture content of the studied hybrids increases, this is due to the reduction of the period of moisture release.

Thus, the optimally early sowing dates stably ensure the minimum moisture content of the grain, which affects the costs of funds during its drying and allows to significantly reduce the cost of production.

Research has established that the individual productivity of corn plants of various hybrids decreased with the use of later sowing dates. Thus, in particular, when using an early sowing period (at a soil temperature of 6-8°C), the individual productivity ranged from 130,6 g to 229,9 g. The highest individual productivity was in P 8834 – 229,9 g. A decrease in the individual productivity of corn plants taken for study was observed when applying the second and third terms of sowing. So, when sowing in the second season, it ranged from 129,5 to 192,6, and when sowing in the third season - from 117,7 to 181,1 g.

On the basis of two-year observations, it was established that the highest grain yield was formed on variants with mid-early hybrids: P 8904 – 15.1 t/ha, 10,7 and 13,4 t/ha; P 8666 – 14,5 t/ha, 12,6 and 13,0 t/ha, respectively, when sowing in the early, middle and late season. Early maturing corn hybrids were less productive.

The least productive corn hybrid was P 8521 – 9,9 t/ha, 8,9 and 8,8 t/ha, respectively, when sown in the early, middle and late season. When sowing is delayed, there is a significant decrease in the individual productivity of corn hybrids, but this trend was not observed in all studied hybrids. So, in particular, in P 9610, early sowing led to a decrease in productivity. Therefore, this hybrid must be sown later in order to obtain high productivity.

The importance of early-maturing hybrids has recently increased. Although early-ripening hybrids are less productive, they differ from medium-ripening plants in that they have a shorter vegetation period, they make better use of the precipitation that falls in the first half of summer, are characterized by the rapid return of moisture to the grain when ripening, so they can be grown not only in the southern, but also in the northern regions of the country.

Therefore, the realization of the genetic potential of its productivity in the conditions of the right-bank forest-steppe of Ukraine depends on the selection of a corn hybrid of a certain maturity group with the available zoning and sowing dates.

Conclusions. Corn productivity in the right-bank forest-steppe of Ukraine largely depends on the origin and precociousness of the hybrid, as well as the timing of sowing. Sowing dates affect the passage of phenological phases in corn. Late sowing times contribute to the shortening of the growing season and grain ripening period. The vegetation period of corn hybrids at the early sowing period varied between 117-134 days, medium - 115-136 days, and late - 113-132 days.

The highest growth rates at the initial stages of development were in such hybrids as: P 8271, P 8666 and P 9074. These hybrids have higher competitiveness against weeds for life factors. The following hybrids had slow initial growth and development: P 8307 and P 8834. The highest repairability score was established in such corn hybrids as: P8904 and P 9074. The lowest - in hybrids: P 8307, P 8521, P 8666. Resistant to moisture deficit (dry conditions) in the phase of 5-7 leaves, the

following hybrids were found: P 8271, P 8904, P 8307 and P 8666, which did not reduce growth rates during dry conditions.

When sowing in the early season (at a soil temperature of 6-8°C) of corn hybrids, the height of the plants ranged from 232,2 to 289,5 cm, when sowing in the middle season (at a soil temperature of 6-8°C) - from 263,0 to 306,1 cm, and at late sowing times (at a soil temperature of 10-12°C) the height of the plants was in the range of 268,3 – 291,8 cm.

A delay in sowing corn hybrids led to a decrease in yield, but this trend was not followed for all studied hybrids. So, in particular, in hybrid P 9610, early sowing led to a decrease in productivity. Therefore, it must be sown later in order to obtain high productivity.

The studied hybrids were highly resistant to fusarium stem and root rots, blistering soot, rust, and helminthosporiosis, and the number of plants damaged by these diseases ranged from 0 to 5%.

On the basis of two-year observations, it was established that the highest grain yield was formed on variants with mid-early hybrids: P 8904 – 15,1 t/ha, 10,7 and 13,4 t/ha; P 8666 – 14,5 t/ha, 12,6 and 13,0 t/ha, respectively, when sowing in the early, middle and late season.

Thus, the farms of the Vinnytsia region and the right-bank forest-steppe, where genotypes with high FAO can be used, hybrids with different maturing periods are recommended for sowing. This will reduce the risks of gross crop failure caused by the action of adverse weather factors, and will make it possible to optimize the terms of sowing and harvesting the crop.

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АНОТАЦІЯ
ПРОДУКТИВНІСТЬ ГІБРИДІВ КУКУРУДЗИ ЗАЛЕЖНО ВІД ТЕХНОЛОГІЧНИХ ПРИЙОМІВ ВИРОЩУВАННЯ

Основні прийоми вирощування нових гібридів кукурудзи різних груп стиглості в Лісостепу залишається недостатньо вивченою, а також мало досліджень стосовно розробки та адаптації до конкретних ґрунтово-кліматичних умов цілісних технологічних систем, які б ґрунтувались на використанні біологічного потенціалу культури та застосуванні ресурсозбережних заходів; науково обґрунтувати принципи добору гібридів для конкретних підзон Лісостепу і теоретично аргументувати напрямки ресурсозаощадження в сортових технологіях вирощування різних біотипів.

В статті наведено результати досліджень з вивчення впливу строків посіву на зернову продуктивність різних гібридів кукурудзи в умовах правобережного Лісостепу України.

Дослідженнями встановлено, що Строки сівби впливають на проходження фенологічних фаз у кукурудзи. Пізні строки сівби сприяють скороченню вегетаційного періоду та періоду дозрівання зерна. Період вегетації гібридів кукурудзи при ранньому строку сівби коливався у межах 117-134 день, середнього – 115-136 днів, пізнього – 113-132 днів.

Запізнення із строками сівби гібридів кукурудзи призводило до зниження урожайності, але дана тенденція прослідковувалась не для всіх вивчених гібридів. Так, зокрема у гібрида Р 9610 посів у ранні строки призводив до зниження урожайності. Тому його необхідно висівати у більш пізні строки для отримання високої продуктивності. На основі проведених двохрічних спостережень встановлено, що найвищу урожайність зерна сформовано на варіантах із середньоранніми гібридами: Р 8904 – 15,1 т/га, 10,7 та 13,4 т/га; Р 8666 – 14,5 т/га, 12,6 та 13,0 т/га, відповідно при сівбі в ранній, середній та пізній строк.

Від підбору гібриду кукурудзи певної групи стиглості з наявною придатністю до поширення та строків сівби залежить реалізація генетичного потенціалу його продуктивності в умовах правобережного Лісостепу України.

Ключові слова: *кукурудза, гібриди, зерно, строки сівби, група стиглості, технологія вирощування, урожайність.*

Табл. 6. Літ. 15.

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