

Influence of Cultivation Technology on the Growth and Development of Sweet Corn Plants of Hybrid Moreland F1

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ABSTRACT

The results of research on the influence of plant standing density and level of mineral fertilization on growth and development of sweet corn plants of hybrid Moreland F1 on sod-podzolic soils have been presented. The change in influence degree of technological factors on the height of sweet corn plants in different periods of the crop growth and development has been established. It was determined that the longest vegetation period had the crops of sweet corn grown under conditions of full mineral fertilization and maximum plant density of 80.000/ha – 80.3 days, and the shortest one was on the variant with unfertilized background and plant density of 60.000/ha – 73.2 days. Increase of mineral fertilizer dose contributed to better growth of sweet corn than in variants without mineral fertilizers. Increase of plant density up to 80.000/ha led to unnatural stretching of plants (over 190 cm). It was determined that the optimal plant height of the crops was at the density of 60 thousand/ha on the background of nutrition $N_{135}P_{90}K_{125} + N_{60} + N_{30}$. The maximum average daily growth was characterized by sweet corn plants on the background of nutrition $N_{135}P_{90}K_{125} + N_{60} + N_{30}$ with plant density 80.000/ha – 2.93 cm.

Keywords: sweet corn, plant density, mineral fertilizers, vegetation period, agrophytocenosis.

INTRODUCTION

At the time of intensive technologies and hard shortage of food products corn is predicted to occupy honorable place as the plant of the future. Since it has a very high yield potential and significant spurt of breeding progress in this direction, as well as a great market demand for its green mass – as one of the best raw materials for obtaining alternative types of energy and fuel [Vihrachov & Berdin, 2010; Hryhoriv et al., 2020; Mishchenko et al., 2022a]. Although we note that the successes of modern selection have enabled producers to achieve the expected yielding capacity of crops,

capable only when creating optimal conditions for plant development and taking into account relevant features and needs of crops. However, it should be noted that corn differs in many respects from the majority of plants grown and widespread in Ukraine, but, looking at the experience of a large number of agrarian European countries, where corn crops currently occupy very large areas, the further cultivation and use of the plant potential in our country is certainly a promising direction [Pasternak, 2015; Hryhoriv et al., 2022; Radchenko et al., 2022; Tsyuk et al., 2022].

It is generally known that the most important factor in modern technology for growing and

obtaining high yields of corn grain is the use of high-quality hybrid seeds for sowing, which makes it possible to increase productivity per hectare by approximately 50–80%. Scientific branches and production experience prove that modern domestic corn hybrids are able to provide grain yields up to 11–15 t ha⁻¹ in our conditions. However, wide-spreading of hybrids of Ukrainian selection is hindered by low yield of parental forms in hybridization areas and high cost of seed production [Lavrynenko & Kokovikhin, 2007; Nikishenko & Lavrynenko, 2009; Karbivska et al., 2022a].

However, nowadays it should be emphasized that a significant obstacle on the way to obtaining high permanent corn yields is abiotic stresses, the determining factors of which in the conditions of forest-steppe of Ukraine are drought, heat and cold. At the end of the 20th century and during 2000–2019 the share of drought phenomena on the territory of Ukraine, as well as in the whole Europe, increased significantly. Therefore, the issue of combating this negative phenomenon is becoming increasingly relevant [Pashchenko et al., 2009; Honcharenko, 2017; Rieznik et al., 2021; Karpenko et al., 2022; Mishchenko et al., 2022b].

Today, according to UNO, losses from droughts exceed 20% of total losses from natural disasters. Thus, annual losses of corn crop due to drought are estimated at 15%, or 120 million tons of grain. Drought is also often the main reason for big fluctuations in productivity, especially under conditions of insufficiently high level of agricultural technology. Thus, yielding capacity of corn for grain in well-developed countries of North America and Europe is on average 8.6 t ha⁻¹ compared to 3.6 t ha⁻¹ in less developed tropical countries of Asia and Africa [National Agriculture Statistics Service, 2021].

That is why, in order to meet demands of Ukraine population for complete food products, it is important to expand the assortment of cultivated crop plants. In this regard, production of sweet corn, which is one of the most biologically valuable vegetable crops, deserves great attention [Hryhoriv et al., 2021; Tanchyk et al., 2021; Karbivska et al., 2022b].

MATERIAL AND METHODS

Field experiments were laid out and conducted in accordance with current standards and requirements of the research methodology

in agronomy. Agricultural machinery used in the experiments was standard, except for implementation of the factors studied. Experiments were carried out on the basis of dendrological park Druzhba named after Zinovy Pavlyk at Vasyl Stefanyk Precarpathian National University, Ivano-Frankivsk Region, on sod-podzolic surface-glazed soil during 2018–2020.

According to soil research data, the soils of research area moderately contain humus – 2.62%. The soils are acidic – (pH of saline solution 4.1–4.5, hydrolytic acidity is insignificant), sum of absorbed bases is within 11–12 mg–eq. per 100 g of soil, degree of saturation with bases is 87%.

Variety of sweet (su) corn Moreland F1 (originator – created by Swiss selectors from Syngenta company) was chosen for the experiment. It is intended to be sown in all regions of Ukraine, belongs to medium maturity group. Vegetation is 83 days.

Field and laboratory studies were conducted in accordance with generally accepted methods of research in agronomy [Bondarenko & Yakovenko, 2001; Lytvynov, 2011].

Sowing was carried out according to the scheme of experiment. The subject of research included study of the following factors:

Factor A – fertilization background:

- without fertilizers;
- N₉₀P₉₀K₉₀;
- N₁₃₅P₉₀K₁₂₅ + N₆₀ + N₃₀.

Factor B – density of plants:

- 60.000/ha;
- 70.000/ha;
- 80.000/ha.

The experiment was repeated four times. Total experimental area is 50 m², accounting – 10 m². Placement of repetitions – by a continuous method, placement of variants – by the method of randomized split blocks.

Control was the variant without fertilizers. The following mineral fertilizers were used for conducting research: complex – in the form of nitrogen–phosphorus–potassium (16% a.s.); ammonium nitrate (34.4% a.s.). Fertilizers were applied to the plots in spring under cultivation. Fertilization of sweet corn crops was carried out with nitrogen fertilizers according to corresponding variants of experimental scheme in the phase of 3–4 and 6–7 leaves.

Various plant measurements (10 observations or samples per plot unless otherwise specified)

were made during vegetation periods to quantify the effects of plant spacing and population on the growth and phenology. Biometric studies were carried out in main phases of the crop growth and development in four-time repetition [Bondarenko & Yakovenko, 2001].

Obtained data were processed by the methods of mathematical statistics: dispersion, correlation, regression analysis of field experiment data, using computer programs MS Excel 2010 and Agrostat 2013 [Ushkarenko et al., 2014].

In the process of carrying out research we used the following research methods: field – to study interaction of research subject with biotic and abiotic factors; laboratory – analysis of plants and soil in order to study interaction between

plants and environmental conditions; measuring and weighing – to establish the level of crop productivity; mathematical and statistical – to establish reliability of the results.

RESULTS AND DISCUSSION

Meteorological conditions of the Western region of Ukraine are formed under the influence of three main factors, namely: geographical origin, circulation of air masses and subsurface. An important climate-forming factor of this region is Carpathian Mountains, which influence distribution of air currents near the earth’s surface. The western region is a moderately warm and humid area.

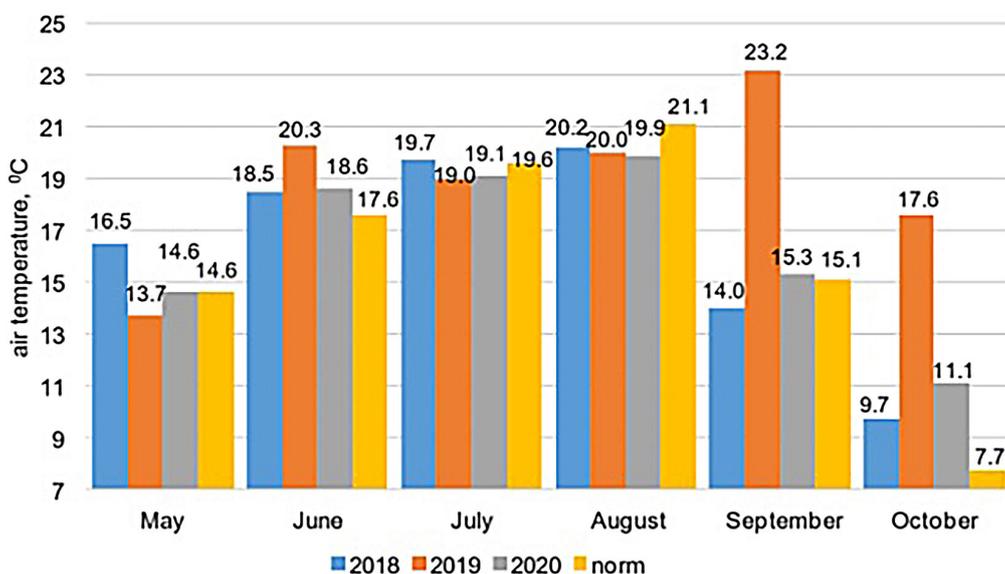


Figure 1. Air temperature during vegetation period of sweet corn, 2018–2020, °C

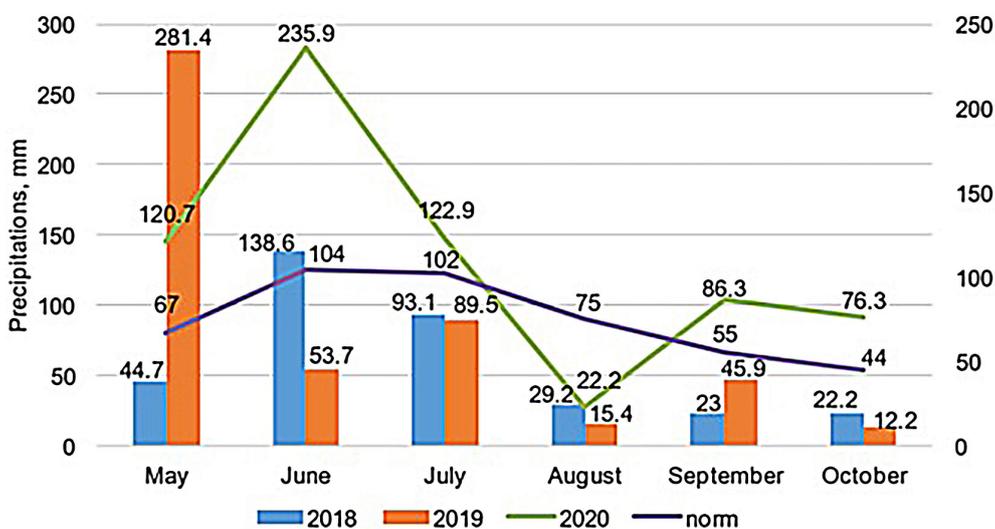


Figure 2. Precipitation amount during vegetation period, 2018–2020, mm

Natural and climatic conditions that have been formed on the territory of the study contribute to development of agriculture, cultivation of main agricultural crops, including sweet corn.

Analysis of hydrothermal conditions that formed during vegetation period of corn in the years of research was carried out according to the data of Ivano–Frankivsk regional weather station (Fig. 1, Fig. 2).

The research showed that during vegetation period of sweet corn in experimental period meteorological conditions of some months differed significantly from the average long-term data both in terms of temperature indices and amount of precipitation.

Analyzing weather conditions, we determined that during 2018–2021 research period meteorological conditions slightly differed from the average long-term indices in terms of precipitation and temperature, but in some months significant differences were noted, which ultimately affected the level of crop productivity.

The study and analysis of influence of cultivation technology elements on the course of growth processes of corn plants make it possible to determine optimal parameters of agrotechnology to ensure rational use and redistribution of production factors (moisture, nutrients, light and heat) in agrophytocenosis in order to obtain the desired productivity.

As it is known, the length of crop's vegetation period is a feature usually determined by genetic characteristics of variety or hybrid. Although, growing technology can affect to a certain extent the speed of plant organism ontogenesis.

The results of our research established that all studied elements of agrotechnology have an effect

on the speed of phenophase and duration of sweet corn vegetation. A tendency to lengthen vegetation period was found with an increase in the dose of mineral fertilizers and plant density (Table 1).

It is worth noting that duration of interphase periods “sowing – seedling”, “seedling – 3–5 leaves”, “shooting – panicle flowering” were minimally influenced by agro-technological factors, and the greatest fluctuations were observed during the periods “3–5 leaves – panicle shooting” and “panicle flowering – beginning of milk-wax ripening of the grain.” The minimum duration of vegetation period was in the variants without fertilizers and density of sweet corn plants 60.000/ha and averaged 73.2 days. The longest period from sowing to technological ripeness was characteristic for the crops grown on a double fertilization background and with a maximum plant density of 80.000/ha. With such agro-technical complex vegetation period of the crop averaged 80.3 days. Thus, agrotechnical factors are able to a certain extent to regulate passing speed of individual phenophases of sweet corn, accelerating or, on the contrary, delaying the time of technical ripeness of crop grain.

Measuring the height of sweet corn plants by main phenophases makes it possible to assess the dynamics of plant growth under different technological growing conditions, peculiarities of growth processes and their relation to agricultural technology. After all, it has been proven that mineral fertilizers are a powerful factor in regulating growth processes, the leading role belongs to nitrogen fertilizers.

A significant dependence of plant height on the dose of mineral fertilizers and plant density was found in the phase of 3–5 leaves of sweet corn.

Table 1. Duration of interphase periods of sweet corn under different nutrition background and plant density, average for 2018–2020, days

Variant	Plant density, pcs/ha	Shoots-3–5 leaves	3–5 leaves–panicle shooting	Panicle shooting–flowering	Panicle flowering–beginning MWR of grain	Sowing–beginning MWR of grain
Control (without fertilizers)	60.000	11.8	25.8	4.1	20.8	73.2
	70.000	11.8	26.1	4.1	21.1	73.8
	80.000	11.8	27.1	4.1	21.4	75.1
N ₉₀ P ₉₀ K ₉₀	60.000	11.8	28.4	4.1	21.4	76.4
	70.000	12.1	29.1	4.1	22.1	78.2
	80.000	12.1	29.4	4.4	22.1	78.8
N ₁₃₅ P ₉₀ K ₁₂₅ + N ₆₀ + N ₃₀	60.000	12.1	29.4	4.1	21.8	78.1
	70.000	12.1	29.8	4.4	21.8	78.8
	80.000	12.4	30.5	4.4	22.5	80.3

Table 2. Height of sweet corn plants in the phase of 3–5 leaves depending on the studied factors, average for 2018–2020, cm

Plant density, pcs/ha (factor B)	Fertilization background (factor A)			Average for factor A
	Control (without fertilizers)	$N_{90}P_{90}K_{90}$	$N_{135}P_{90}K_{125} + N_{60} + N_{30}$	
60.000	22.20	24.90	28.50	22.90
70.000	22.90	26.40	29.50	26.22
80.000	24.30	28.00	30.20	28.87
Average for factor B	24.70	25.38	26.45	

Note: LSD_{05} : factor A – 0.23 cm; factor B – 0.26; complex effect of factors AB – 0.75 cm.

Table 3. Height of sweet corn plants in the panicle shooting phase depending on the studied factors, average for 2018–2020, cm

Plant density, pcs/ha (factor B)	Fertilization background (factor A)			Average for factor A
	Control (without fertilizers)	$N_{90}P_{90}K_{90}$	$N_{135}P_{90}K_{125} + N_{60} + N_{30}$	
60.000	115.50	135.30	145.50	121.85
70.000	120.50	139.20	151.60	135.33
80.000	124.60	142.30	156.40	144.85
Average for factor B	127.70	131.79	136.25	

Note: LSD_{05} : factor A – 0.85 cm; factor B – 0.69; complex effect of factors AB – 2.02 cm.

Plant density per every 10 thousand/ha leads to an increase in the height of crop plants, on average, by 4.3–4.7%, and application of mineral fertilizers in a dose of $N_{135}P_{90}K_{125} + N_{60} + N_{30}$ – by 26.2%, compared to the background without fertilizers (Table 2). While according to the studies of Adesina et al. [2014], who reported that after transplanting sweet corn, physiological changes in the root are reflected on the growth of vegetative mass of the plant. Secondly, plant height decreases with sowing delay, which was also recorded in previous studies [Williams, 2008; Rosa, 2008; Ugur & Moden, 2015], this is due to a shorter period available for absorbing solar radiation, which affects formation of vegetative masses.

It was found that similar dynamics of the index can be observed during the period of panicle

shooting, and the influence of all studied factors was significant. Sweet corn plants were significantly higher on variants with the maximum nutrition background $N_{135}P_{90}K_{125} + N_{60} + N_{30}$ and plant density of 80.000/ha. The minimum height of crop plants is noticed in the variant without fertilization and plant density 60.000/ha.

At the beginning of milk-wax ripeness of grain, sweet corn plants were significantly higher on the variants with triple nutrition background and plant density of crops 80.000/ha. The minimum height of crop plants was recorded on unfertilized plots with plant density 60.000/ha. Fluctuation amplitude of the index by the variants of experiment before harvesting was 57.7 cm. The greatest effect on plant height is obtained by mineral fertilizers, application of which in a dose of $N_{135}P_{90}K_{125} + N_{60} + N_{30}$ increased the index by

Table 4. Height of sweet corn plants at the beginning of milk-wax ripeness, depending on the studied factors, average for 2018–2020, cm

Plant density, pcs/ha (factor B)	Fertilization background (factor A)			Average for factor A
	Control (without fertilizers)	$N_{90}P_{90}K_{90}$	$N_{135}P_{90}K_{125} + N_{60} + N_{30}$	
60.000	144.3	168.8	182.4	152.3
70.000	148.2	175.6	189.5	170.1
80.000	154.9	180.2	197.0	181.3
Average for factor B	159.9	164.9	170.6	

Note: LSD_{05} : factor A – 0.52 cm; factor B – 0.75; complex effect of factors AB – 2.01 cm.

Table 5. Average daily growth of sweet corn plants in the period “3–5 leaves – beginning MWR of grain”, average for 2018–2020, cm

Plant density, pcs/ha (factor B)	Fertilization background (factor A)		
	Control (without fertilizers)	$N_{90}P_{90}K_{90}$	$N_{135}P_{90}K_{125} + N_{60} + N_{30}$
60.000	2.43	2.69	2.81
70.000	2.46	2.72	2.88
80.000	2.51	2.75	2.94

19.2% compared to unfertilized variants. Density of plants from 60.000/ha to 80.000/ha contributed to their extraction by only 10.3% (Table 4).

Index of average daily plant growth is of great interest to scientists as it is an integrative expression of agricultural technology impact on intensity of crop growth during vegetation period. Calculation of this index made it possible to reveal the tendency of sweet corn to accelerated growth in the period from the phase 3–5 leaves to beginning of milk–wax ripeness of grain with application of mineral fertilizers in the maximum dose of $N_{135}P_{90}K_{125} + N_{60} + N_{30}$ and density of crop plants 80.000/ha (Table 5).

The minimum average daily growth of sweet corn plants was noted on unfertilized background of nutrition with plant density 60.000/ha (2.43 cm), while the maximum increase was noted in the crop plants on variants with a triple nutrition background and maximum density of 80.000/ha (2.94 cm). The total amplitude of index fluctuation by the variants of experiment was 0.60 cm, which indicates the possibility of adjusting the growth rates of sweet corn by agrotechnical methods of its cultivation.

It must be said that scientists Tollenaar and Lee [2002] came to the conclusion that productivity of corn depends on specific genetic characteristics of planted hybrid, favorable environmental conditions and application of adequate agricultural techniques. They proved that grain production potential will be affected by interaction between hybrid and growing conditions, and that the same hybrid responds differently to different conditions depending on environmental temperature, sunlight and water availability.

CONCLUSIONS

It has been proven that cultivation technology affects the duration of sweet corn vegetation. It was found that sweet corn plants were most sensitive to fertilization and density of crops in

the phase of 3–5 leaves, however, in the phase of shooting panicle and at the beginning of milk–wax ripeness of crop grain, a slight decrease in effect of mineral fertilizers and density of plants was observed. Improvement of agricultural background significantly improves the course of all physiological processes in a plant organism, which contributes to their more intensive growth.

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