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Харків
НФаУ

У журналі розглянуто проблеми синтезу й аналізу органічних та елементоорганічних сполук, аналогів природних сполук і лікарських субстанцій, наведено результати фізико-хімічних досліджень у вищезазначених напрямах. Також з погляду (біо)органічної, фармацевтичної, аналітичної та фізичної хімії проаналізовано питання з різних аспектів рослинництва, ґрунтознавства й дослідження навколишнього середовища.

Для працівників науково-дослідних установ, вищих навчальних закладів та фахівців хімічного, фармацевтичного, біологічного, медичного і сільськогосподарського профілів.

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Corn: Sowing Parameters

Abstract

Aim. To highlight the results of the research conducted in 2020–2021 aiming at studying the effect of multi-depth and multifraction sowing of the hybrid corn seeds of the DMS Sticker mid-early maturity group on the yield when grown in the conditions of the Northern Steppe of Ukraine and determine the economic efficiency of the approaches.

Materials and methods. Winter wheat was a predecessor crop in the study. Tillage methods and related conditions are described in the article. Herbicides were used to protect against weeds. Sowing was carried out in the third decade of April at a soil temperature of +8–10 °C. The experiment considered 2 factors, namely the depth of sowing seeds and the size of the seed fraction. The results obtained were processed using measurement, mathematical and statistical methods of research, as well as calculation and comparison approaches.

Results and discussion. On average, depending on the factors studied, the height of the plants varied significantly, as a rule, the tallest plants were obtained from large seeds, which had the highest mass of 1000 seeds. Thus, in particular, on average over two years of research, the height of the plants was 250.4 cm when the weight of 1000 seeds was 255 g, and the seeds were wrapped by 4–5 cm; when the weight of 1000 seeds was 300 g, the height was 251.1 cm, while with the weight of 350 g it was 258.3 cm; with the wrapping depth of 7–8 cm the height was 252.1 cm, 255.8 and 268.5 cm, and with the wrapping depth of 10–11 cm it was 257.6 cm, 261.8 and 266.1 cm.

Conclusions. The use of the large seed fraction provided an increase in the yield of the DMS Sticker corn hybrid by 1.09–1.79 t ha^{-1} compared to the use of the small seed fraction and was 8.70 t ha^{-1}. When using the large seed fraction and the wrapping depth of 10–11 cm, the cost of production was 56,550 UAH ha^{-1}. The cost price of 1 ton of production was the lowest and amounted to UAH 2,247.1, the conditional net profit was the highest – 37,000 UAH ha^{-1}, and the level of profitability was 189.3 %.

Keywords: corn; hybrid; seeds; weight of 1000 seeds; depth of wrapping; height of plants; productivity; conditional net profit; cost price; level of profitability

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Кукурудза: параметри сівби

Анотація

Мета. Висвітлити результати наукових досліджень 2020–2021 рр., метою яких було виявити вплив на врожайність різноглибинної та різнофракційної сівби насіння гібриду кукурудзи середньоранньої групи стиглості DMS Sticker за вирощування в умовах Північного Степу України та визначити економічну ефективність застосування такої сівби.

Матеріали та методи. Культурою-попередником у дослідженні була озима пшениця. Способи обробляння ґрунту та супутні умови описано в статті. Для захисту від бур'янів використовували гербіциди. Посів здійснювали в третій декаді квітня за температури ґрунту +8–10 °C. Експеримент враховував 2 фактори, а саме: глибину посіву насіння та розмір фракції насіння. Отримані результати обробляли, використовуючи вимірювальні, математичні і статистичні методи дослідження, а також розрахунковий та порівняльний підходи.

Результати та їх обговорення. Залежно від досліджуваних факторів висота рослин істотно змінювалася: як правило, найвищі рослини були отримані з крупного насіння, що мало найбільшу масу 1000 насінин. Так, зокрема, за маси 1000 насінин 255 г у разі загортання насіння на 4–5 см пересічно за два роки досліджень висота рослин становила 250,4 см, за маси 1000 насінин 300 г – 251,1 см, а у випадку маси 1000 насінин 350 г – 258,3 см; за глибини загортання 7–8 см – 252,1 см, 255,8 і 268,5 см, а за глибини загортання 10–11 см – 257,6 см, 261,8 і 266,1 см.

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Висновки. Використання великої фракції насіння проти використання дрібної фракції забезпечило збільшення врожайності гібрида кукурудзи DMS Sticker на 1,09–1,79 т га$^{-1}$ і становило 8,70 т га$^{-1}$. За використання великої фракції насіння та глибини загортання 10–11 см собівартість продукції становила 56 550 грн га$^{-1}$. Собівартість 1 т продукції була найнижчою і становила 2 247,1 грн, умовно чистий прибуток був найвищим – 37 000 грн га$^{-1}$, а рівень рентабельності – 189,3 %.

Ключові слова: кукурудза; гібрид; насіння; маса 1000 насінин; глибина загортання; висота рослин; урожайність; умовно чистий прибуток; собівартість; рівень рентабельності

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■ Introduction

Corn is one of the most valuable agricultural crops. If all agrotechnical requirements are met, it can form a high yield. For the cultivation of corn, especially with intensive technologies, morphological characteristics of plants, which determine suitability for mechanized cultivation and harvesting, are important [1, 2].

In recent years, corn occupies an increasingly stable position in the world grain market. In this field, the natural and economic conditions of Ukraine allow not only to meet domestic needs, but also to significantly increase its export potential. However, in reality, on the way to creating a stable and favorable environment, including market infrastructure, in the production practice of growing corn, there are still numerous obstacles of an agrotechnological nature [1, 3].

A feature of the current technology for growing high-yielding corn hybrids is the optimization of the fractional composition of the seed material and the determination of the optimal depth of its wrapping. A high-quality seed material is the key to a large harvest. It has been determined [4, 5] that due to high-quality seeds, the increase in the corn grain yield can be 20–80%. At the same time, the use of the large fraction of corn seeds provides a significant increase in the grain yield [6–9].

The depth of seed wrapping is also important since very shallow and deep seed wrapping negatively affect field germination, completeness and uniformity of seedlings, and the intensity of growth of corn plants in the initial growing season. To obtain friendly and full-fledged seedlings, seeds are sown to such a depth that it is provided with a sufficient amount of moisture, air and heat [10]. It is important to correctly choose the parameters of the optimal seeding depth depending on the seed fraction, biological properties of the hybrid, moisture availability of the seeding horizon, mechanical composition of the soil, energy of the starting growth of the hybrid, in order to obtain friendly and leveled seedlings with a high field seed germination [12, 13]. In addition, the deeper the seed is sown, the more the seedlings come into contact with pathogenic microorganisms and pests on their way, so they are more affected by them, especially on soils with a heavy mechanical composition [10, 11].

Both very shallow and deep wrapping of seeds negatively affects field germination, completeness and uniformity of seedlings, the growth intensity of corn plants in the initial growing season. The great depth of seed wrapping contributes to the fact that young seedlings have to spend excessive amounts of plastic substances to overcome the seed layer of the soil, as a result of which they are depleted. In addition, the deeper the seed is sown, the more the seedlings encounter pathogenic microorganisms on their way; therefore, they are more affected by them, especially on soils with a heavy mechanical composition. When the depth of seed wrapping, which has micro- and microtraumas, increases, its germination decreases by 20–21% [11], the temperature conditions for seed germination deteriorate, and therefore, the seedlings may be unfriendly and thinned [12]. At the moment, there is a ridge technology for growing corn, which makes it possible to increase productivity by 15–20% due to early sowing in the ridge. However, this technology did not spread in Ukraine due to insufficient moisture in the upper

soil layer during the entire growing season and its high energy consumption. The depth of corn seed wrapping also depends on the timing of sowing. Thus, in particular, when sowing seeds in early periods, for the purpose of better heat supply, the depth of wrapping is reduced to 3–4 cm [10–12]. In order to protect seeds from mold during early sowing, they should be wrapped shallower (4–6 cm), and later – by 6–8 cm [12]. Sowing corn seeds to a depth of more than 7 cm leads to a decrease in field germination by 5.5%, and grain yield by 3.7–12.8%. The greater the mass of 1,000 grains, the deeper the seed penetration into the soil, especially four-line hybrids [12].

With the optimal depth of sowing, the mold of seeds and seedlings of corn is reduced. An increase in the depth of seed wrapping increases the risk of damage to seedlings by soil pathogens – the causative agents of mold and root rot, as well as powdery mildew diseases and damage by wireworms. Full friendly seedlings can be obtained by sowing seeds at such a depth where they will receive a sufficient amount of moisture, air and heat. When the top layer of the soil dries, the seeds are wrapped deeper so that they lie in the moist soil. With the close occurrence of groundwater, the depth of seed wrapping is reduced to 5–6 cm, and on light soils prone to rapid drying, it can be increased to 10–12 cm [11, 12].

There are data that the best development of corn plants is ensured by a seed wrapping depth of 5 cm. Sowing 1 cm deeper or shallower can reduce the yield by 10–20%. In areas with insufficient moisture, after sowing corn, rolling is recommended; it improves the conditions for seed germination, reduces its moldiness and damage by stem and root rots.

Large seeds give aligned and friendly seedlings since the primary (embryonic) roots and the first leaf are formed, practically, only due to the nutrients of the grain. The strength of the germinal roots and the area of the first leaf in a straight line depend on the size of the grain [2, 5, 12].

The variety of the seed material is associated with the location of the grain in the cob (matricular). The grain on the cobs is formed unevenly, everything starts from the middle of the cob, the size of the grains goes from bottom to top. The highest quality seeds are formed in the middle of the cob, i.e., the size of the seeds goes downward from bottom to top. Grains in the middle part of the corn cob contain more enzymes; these seeds start the germination process faster, especially since the swelling of corn seeds before the germination process requires less water than 40% of the weight of the grain [5, 8, 12].

Fractions of different sizes may receive different degrees of damage during harvesting, depending on the harvesting technology and post-harvest processing. In some cases, large fractions can be damaged to a significant extent, in other cases, small ones can be affected due to which their quality varies in different ways. Mechanical damage and thermal cracking of seeds can reach 75–85% [11, 12].

Coarse and medium fractions of seeds have similar sowing and yield properties, while fine fractions lead to a significant decrease in quality. At the same time, it should be noted that such results are possible when separating seeds according to the "grain width" feature [8]. The highest yield of corn grain is obtained for sowing large and medium fractions, for silage – medium ones, for green fodder – small fractions. These recommendations are given for old 3–4-line hybrids [12].

Usually, in production conditions, the minimum seed weight limit for sowing is rarely lower than 200 grams, and in the case of using seeds of a smaller weight, there is always a dispute about its suitability for forming productive sowing. Seeds of larger fractions are used on more structured soils and lighter in mechanical composition, with poorer moisture-holding capacity and in areas with less moisture availability (the possibility of deeper wrapping and greater need for moisture for germination). When using seeds of siliceous and tooth-shaped forms, it is worth starting sowing with siliceous ones since they need more moisture for swelling and germination.

Summarizing data from literary sources, it should be noted that the insufficient study of the size of the seed fraction and the depth of its wrapping requires further research, which is necessary and relevant.

Corn has enormous potential for record grain yields. But this becomes a reality only if the grain cultivation technology is followed, which corresponds to the biological characteristics of the corn plant. Knowing these requirements, it is possible to reduce or completely remove the negative impact of one or another factor [12].

Our aim was to study the effect of the fraction size and the depth of seed wrapping on the productivity of the DMS Sticker mid-early maize hybrid (FAO 250) during 2020–2021 on ordinary chernozem in the conditions of the northern part of the Pervomaysky district of the Mykolaiv region [13].

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Materials and methods

The predecessor crop in the experiment was winter wheat. After harvesting the predecessor, the field was disked to a depth of 14–16 cm. Plowing was carried out to a depth of 22–25 cm. In the spring, moisture was closed with heavy harrows (BZTS 1) and pre-sowing cultivation (Europak). Protection against weeds included the application of herbicides Harness – 3.0 L ha^{-1} before seedlings and Milagro in the phase of 5–7 leaves – 1.25 L ha^{-1}. Sowing was carried out in the optimal time (the third decade of April) at a soil temperature of +8–10 °C using an updated SUPN-8 seeder with a seeding rate of 50,000 pcs. seeds per hectare.

The scheme of the experiment included two factors. *Factor A* (the depth of sowing seeds): 1. depth – 4–5 cm; 2. depth – 7–8 cm; 3. depth – 10–11 cm. *Factor B* (size of seed fraction): 1. small (weight of 1000 grains) – 255 g; 2. medium (weight of 1000 grains) – 300 g; 3. large (weight of 1000 grains) – 350 g [13].

Repetition for hybrids in experiments was 4 times. Placement of plots was performed using the method of randomized repetitions. To determine the productivity level and morphological characteristics of plants, the measurement method of research was used; to assess the importance and reliability of the research results obtained, mathematical and statistical methods were applied; to obtain the economic assessment of the cultivation of a corn hybrid, we used calculation and comparison approaches [14–17].

Results and discussion

The results obtained in the studies confirmed the opinion that the height of plants could change depending on the conditions of the year and the features of the elements of growing technology. The year 2021 was the most favorable for the manifestation of plant height, while in 2020, due to a decrease in the amount of moisture and increased temperatures, the height of plants decreased somewhat, but this applied to the depth of seed wrapping of 4–5 and 7–8 cm. When wrapping seeds to a depth of 10–11 cm, due to the better moisture availability of this soil layer, even in 2020, some improvement in the growth processes of the DMS Sticker corn hybrid was observed.

The height of the plants varied significantly depending on the size of the seeds, as a rule, the tallest plants were obtained from large seeds, which had the highest mass of 1000 seeds. Thus, in particular, on average over two years of research, the height of the plants was 250.4 cm when the weight of 1000 seeds was 255 g, and the seeds were wrapped by 4–5 cm; when the weight of 1000 seeds was 300 g, the height was 251.1 cm, while with the weight of 350 g it was 258.3 cm; with the wrapping depth of 7–8 cm the height was 252.1 cm, 255.8 and 268.5 cm, and with the wrapping depth of 10–11 cm it was 257.6 cm, 261.8 and 266.1 cm.

The influence of the size of the seed fraction and the depth of their wrapping on the height of cob laying in the corn hybrids was studied. Thus, with an increase in the mass of the seed fraction, the height of cob laying in the DMS Sticker hybrid also increased, with the weight of 1000 seeds of 255 g, the height of cob laying was 87.5 cm, with the weight of 1000 seeds of 300 g it was 88.5 cm, and with the seed weight of 350 g – 89.8 cm at the seed wrapping depth of 4–5 cm. At the seed wrapping depth of 7–8 cm, it was 90.1 cm, 93.3 and 9.5 cm, and at the seed wrapping depth of 10–11 cm – 86.5 cm, 91.7 cm and 93.5 cm, respectively, for small, medium and large fractions. There was also an increase in the height of cob laying with an increase in the depth of seed wrapping. This is explained by a better moisture supply of the lower layers of the soil, especially in the event of spring droughts.

Significant reserves of nutrients in the endosperm of a corn kernel and a large embryo allow it to germinate from a depth of 10 cm or more and maintain viability for a long time in dry soil. The results of the research conducted showed the influence of the size and depth of seed wrapping on the number of rows of grains.

The data obtained confirm that the size of the seed fraction does not significantly affect the number of rows of grains on the cob, it is only necessary to note that when sowing with seeds of medium and large fractions of the DMS Sticker corn hybrid, the number of rows was slightly higher compared to sowing with small seeds. The largest number of rows on the cob was noted in the DMS Sticker corn hybrid for sowing with seeds of the large fraction – 14.8 pcs, and for the medium fraction – 14.4–14.7 pcs, while for sowing with seeds of the small fraction it was the lowest 14.1–14.3 pcs. The use of medium and large seed fractions ensures a slight increase in the number of grain rows in all hybrids. Therefore, it can be noted that this feature is more

Table 1. The grain moisture content of the DMS Sticker corn hybrid depending on the factors studied (average for 2020-2021), %

Seed fraction (Factor A)	Seed wrapping depth (Factor B)		
	4-5 cm	7-8 cm	10-11 cm
Small (255 g)	23.86	24.43	24.45
Medium (300 g)	24.64	24.79	24.82
Large (350 g)	25.05	25.19	25.43

Table 2. The grain yield of the DMS Sticker corn hybrid in the net weight depending on the factors studied (average for 2020-2021), t ha^{-1}

Seed fraction (Factor A)	Seed wrapping depth (Factor B)		
	4-5 cm	7-8 cm	10-11 cm
Small (255 g)	6.91	7.39	7.61
Medium (300 g)	7.53	7.98	8.33
Large (350 g)	8.15	8.44	8.70

genetically determined, and less dependent on agricultural cultivation techniques.

When the depth of seed wrapping changed, the number of rows of grains changed ambiguously. We did not determine a significant relationship between the increase in the depth of seed wrapping and the number of rows of grains in the DMS Sticker corn hybrid although it was present to some extent.

The next feature that determines the level of productivity of corn hybrids is the number of grains in a row. Thus, the number of grains in a row was largely determined by the size of the seed fraction. When using seeds of medium (30.0–31.0 pcs) and large (31.1–31.4 pcs) fractions for sowing the number of grains in a row was significantly higher than when sowing seeds of small fractions (29.4–30.2 pcs). Thus, the use of the medium and large fraction of seeds ensures a significant increase in the number of grains in a row of the corn hybrid studied.

The number of grains in a row changed ambiguously due to changes in the depth of seed wrapping. Thus, in particular, the number of grains in a row, on average over two years, at the seed wrapping depth of 4–5 cm was 28.5–30.3 pcs, at the wrapping depth of 7–8 it was 28.9–32.3 pcs, and at the depth of 10–11 cm it was the highest – 29.2–32.4 pcs depending on the years of research.

Based on the data obtained, it can be stated that the option of sowing to the depth of 10–11 cm provided more stable indicators of the number of grains both in dry (2020) and in wetter (2021) years when they were carried out with the largest seeds.

Depending on the number of rows of grains and the number of grains in the row of the beginning of corn, a different number of grains were formed on one crop plant, and therefore, the plants had different productivity. Thus, depending on the options, each beginning formed an average of 414.5 to 464.7 grains over the years of research. Moreover, their maximum sphericity was formed at the beginning of plants sown to a depth of 10–11 cm with the largest seeds.

In addition to the number of grains at the beginning, an important element of the productivity of a corn crop is the actual number of ears per plant. Thus, in our options, this indicator varied from 1.38 to 1.49 pieces per plant.

Based on the data obtained, it can be stated that the maximum number of buds (1.49 pcs per plant) was formed when sowing the largest seeds (350 g per 1000 pcs) and sowing them to a depth of 10–11 cm. The least variable was seed sowing with an average weight. Regarding the sowing depth, it was identical.

Depending on the number of grains at the beginning and the number of beginnings on the plant, their productivity varied from 170.5 to 218.1 g per plant, and the maximum was for sowing to a depth of 10–11 cm with the largest seeds.

Therefore, the seed fraction and the depth of its wrapping can change the values of the elements of the crop structure in the DMS Sticker corn hybrid.

As a result of the research conducted, on average over two years, the moisture content of the grain when using the fine fraction was 23.86% for the wrapping depth of 4–5 cm, 24.43% for the seed wrapping depth of 7–8 cm, and 24.45% for the wrapping depth 10–11 cm; when using the medium fraction of seeds – 24.64%, 24.79 and 24.82%, while using the large fraction of seeds – 25.05%, 25.19% and 25.43%, respectively (Table 1).

Therefore, the increase in the size of the seed fraction provided an increase in the level of preharvest moisture, which ultimately caused additional costs for grain drying. For changes in the depth of seed wrapping, this dependence was not detected.

As for the yield of grain, it is necessary to note the lowest level of its value, on average over two years of research, for the use of the small fraction of seeds of the DMS Sticker hybrid: 7.67 t ha^{-1} for wrapping depths of 4–5, 8.25 – for 7–8 cm and 8.50 t ha^{-1} for the seed wrapping depth of 10–11 cm (Table 2).

With the use of the medium seed fraction, the yield increased by 0.36–1.1 t ha^{-1}, compared to the fine fraction, and with the use of the large

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seed fraction, the yield was the highest and was 9.16 t ha^{-1} at the wrapping depth of 4–5 cm, 9.50 t ha^{-1} for wrapping depths of 7–8 cm and 9.82 t ha^{-1} for wrapping depths of 10–11 cm.

Due to the excess moisture of the harvested grain and the need for additional drying and bringing it to 14% moisture, the parameters of the grain obtained differed from the threshed grain.

Therefore, the use of the large seed fraction provided an increase in the yield of the DMS Sticker corn hybrid by 1.09–1.79 t ha^{-1} compared to the use of the small seed fraction and was 8.70 t ha^{-1} in the net weight. In addition, it is necessary to note the highest value of productivity (8.15–8.70 t ha^{-1}) of this hybrid when sowing the large fraction of the seed material in all variants of the depth of seed wrapping.

■ Conclusions

Thus, based on the results obtained and their analysis in the conditions of the northern part of the Pervomaysky district of the Mykolaiv region, it has been proposed to use the large fraction of seeds weighing 1000 grains of 350 g for the formation of the grain yield of the DMS Sticker corn hybrid (FAO 250) at the level of 8.70 t ha^{-1} and the depth of its wrapping when sowing is 10–11 cm.

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