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FORMATION OF BIOMETRIC INDICATORS OF MAIZE EAR UNDER THE INFLUENCE OF FOLIAR FEEDING AND WEATHER CONDITIONS

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Topicality. *For high maize yields, the maintenance of sufficient nitrogen levels during key stages of crop growth and development is critical. Split nitrogen application optimises plant nutrition and reduces unproductive losses.* ***Purpose.*** *Study of the influence of foliar feeding of maize with urea or its tank mixtures with sulphur on the formation of biometric indicators of ears short-season maize hybrids in the Western Forest-Steppe of Ukraine.* ***Materials and methods****. Two-factor experiment studied early-ripening maize hybrid DN Aton and mid-early hybrid DN Astra; variants of foliar feeding with urea and highly concentrated liquid sulphur fertiliser Chimic S in stages 5–6 and 8–9 leaves.* ***Results.*** *The research showed that biometric indicators of maize ears were significantly influenced not only by foliar feeding, but also by weather conditions during the growing season during the years under study. On average, the maize ear length under various foliar feeding variants increased by 1.2–4.1 % in the early-ripening hybrid DN Aton and by 1.7–6.8 % in the mid-early DN Astra compared to the control during the years of research. Foliar feeding with urea contributed to an increase in grain weight per ear in the early-ripening hybrid DN Aton by 6.5–18.2 % and in the mid-early DN Astra by 7.0–23.9 %, the 1000-grain weight by 3.1–10.9 % and 3.7–13.0 %, and the grain content of the ear by 6.7–13.9 % and 6.0–20.0 %, respectively. The addition of sulphur in the form of a highly concentrated liquid fertiliser Chemic S to urea resulted in an additional increase in grain weight per ear in the early-ripening hybrid DN Aton by 3.3–4.4 % and in the mid-early DN Astra by 1.3–4.8 %. The 1000-grain weight increased by 2.1–2.2 and 1.9–2.3 %, respectively, and the ear grain content increased by 0.8–3.9 and 1.3–2.4 % compared to the control.* ***Conclusions****. The most effective feeding was double treatment of maize with urea in combination with highly concentrated liquid sulphur fertiliser Chemic S in the 5–6 and 8–9 leaf stages, which increased the ear length of early-ripening hybrid DN Aton by 5.3 %, mid-early hybrid DN Astra – by 10.2%, ear grain content – by 16.0 and 22.9 %, grain weight per ear – by 22.1 and 27.8 %, and 1000-grain weight – by 13.2 and 15.2%, respectively.*

Key words*: maize, hybrid, feeding, urea, sulfur, ear length, grain weight, 1000-grain weight.*

Introduction. Maize (*Zea mays* L.) forms a large amount of biomass, therefore, among grain crops; it requires a higher rate of nutrient availability. During the growing season, maize consumes a large amount of nutrients from the soil. The nutrients can be conditionally divided into the following groups: 6 macroelements, 6 microelements, and 12 additional elements that are part of the chemical composition of the plant. Macroelements play a special role in the formation and functioning of cells and tissues and required by the plant organism in the largest quantities. These include nitrogen, phosphorus, potassium, sulphur, calcium, and magnesium. Thus, different early-ripening maize hybrids consume an average of 24–32 kg of nitrogen, 10–14 kg of phosphorus, 25–35 kg of potassium, 6–10 kg of magnesium, and 6–10 kg of magnesium and calcium, and 3–4 kg of sulphur from the soil and fertilisers to produce 1 tonne of grain with the corresponding amount of stems and leaves [1, 2].

Studies conducted in various soil and climatic zones have shown that of all macroelements, nitrogen, which plants consume from seedling to full grain maturity, has the greatest impact on the growth and development rates of maize hybrids, as well as on yield and quality. However, this consumption is uneven throughout the development stages.

Thus, at the beginning of growth, nitrogen assimilation by maize plants is insignificant (3–5 %). Starting from 6–8 leave stages, nitrogen is intensively absorbed by plants, and its consump-

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tion from the 8-leaf stage to the stage of drying of the flower columns (pistils) on the ears accounts for 85 % of the total amount of nitrogen. Therefore, in order to develop a proper nitrogen nutrition system for maize, the dynamics of nitrogen consumption by plants must be understood [3–5].

The study found that providing plants with nitrogen during key stages of growth and development is important for achieving high maize yields. Splitting the nitrogen application into several doses can optimise plant nutrition and reduce non-productive losses. According to M. I. Dudka, foliar feeding of maize plants in the arid conditions of the Steppe zone is an effective method of fertilisation, which increases the availability of nutrients – macro- and microelements – and stimulates better absorption of nutrients from the soil [6–9].

Among nitrogen fertilisers, urea is the best for foliar feeding because it has high nitrogen content and is easily converted into ammonia in the soil. Urea releases nitrogen slowly, continuously and evenly, which allows the plant to be supplied with this macroelement at all stages of development, including the late stages, which affects the grain quality..

In particular, studies conducted at the Erastivka Research Station of the State Enterprise Institute of Grain Crops of NAAS showed that spraying crops in the 5–6 leaf stage with urea (10 kg/ha) resulted in a 7.7 % increase in leaf area, and in the 8–9 leaf stage (20 kg/ha) – by 12.8 % compared to the control. An increase in plant height and ear insertion height was also noted. Feeding also contributed to an increase in the number of ears per 100 plants and a significant increase in grain yield – by 0.20 t/ha and 0.24 t/ha, respectively, on average across all nutrition backgrounds [10].

In the northern part of the Steppe, on ordinary low-humus chernozems, foliar feeding with urea (15 kg/ha) in the 6–8 leaf stage had almost no effect on plant height and lower ear insertion height. In addition, we found that the leaf area of a single plant and the number of ears per 100 plants also varied insignificantly. Grain yield increased, on average across all nutrition backgrounds, from 7.77 t/ha in the control to 8.09 t/ha with foliar feeding of plants with urea (15 kg/ha) [11].

In the conditions of the Left-Bank Forest-Steppe of Ukraine on typical low-humus chernozems, foliar feeding of maize with urea (15 kg/ha) in the 5–6 leaf stage under different methods of primary tillage contributed to an increase in the plant height of maize hybrids of different maturity groups, 1000-grain weight and yield [12].

On sod-carbonate soils of the Small Polissia region, increasing the application rates of nitrogen fertilisers from N90 to N125-150 for grain maize improved the maize yield attributes in terms of such indicators as grain weight per ear and 1000-grain weight. However, nitrogen fertilisers did not significantly affect the increase in the proportion of grain in the ear weight, which varied between 85.6 and 87.3 %. Grain yield increased by 6.8–23.5 %, while the return on each additional kilogram of nitrogen fertilisers in grain gradually decreased [13].

Sulphur, as well as nitrogen, is a component of plant protein and, therefore, part of the raw material for building new cells and tissues of maize plants. The application of nitrogen and sulphur is mutually complementary in terms of effectiveness, given that a sulphur deficiency blocks nitrogen absorption. The Department of Agronomy at the University of Life Sciences in Poznan conducted two series of field trials to study the effectiveness of different nitrogen fertilisers (N and N + S) in maize crops. It was found that when enriched with sulphur nitrogen fertiliser (ammonium sulphate), maize produces a significantly higher grain yield than when other fertilisers are applied [14].

The study was aimed at investigating the effect of foliar feeding of maize with urea or its tank mixture with sulphur on the formation of biometric indicators of ears in short-season maize hybrids under the conditions of the Western Forest-Steppe of Ukraine.

Materials and Methods. The research was conducted at the Khmelnytskyi State Agricultural Research Station of the Institute of Feed Research and Agriculture of Podillia of NAAS during 2021–2024. The soil of the experimental site is podzolised medium loam, slightly eroded, low humus chernozem on loess-like loam of brownish-pale colour, with a fine-nutty structure. The soil is viscous and sticky in wet conditions. The soil is sufficiently saturated with bases – 39.8–42.0 mg eq. per 100 g, with a hydrolytic acidity of 1.8–2.7 mg eq. per 100 g of soil.

The humus content (according to Tyurin) is 3.2 %. Medium content of nutrients: easily hydrolysable nitrogen – 14.4–16.6, mobile phosphorus – 1.0–12.0, exchangeable potassium – 7.8–8.0 mg per 100 g of soil.

Maize cultivation technology, with the exception of the factors studied, is generally accepted for the Western Forest-Steppe zone of Ukraine. After harvesting the previous crop (soybeans), stubble was ploughed to a depth of 6–8 cm and the main tillage (ploughing) was carried out to a depth of 25–27 cm. Spring tillage began with harrowing, followed by two cultivations: the first to a depth of 10–12 cm, the second (pre-sowing) to the depth of seed incorporation. Mineral fertilisers were applied during pre-sowing cultivation at a rate of $N_{48}P_{48}K_{48}$. The early-ripening hybrid DN Aton and the mid-early DN Astra were sown at the optimal dates for the region – in late April with a planned pre-harvest plant density of 90 and 85 thousand plants/ha, respectively, using SU-12 seeder. Maize plants were fertilised in the 5–6 and 8–9 leaf stages according to the experimental design. Domestic fertilisers were used in the experiments, namely: urea (N – 46 %) and highly concentrated liquid sulphur fertiliser Chemic Sulphur (SO_3 – 200 g/l; N – 100 g/l).

Research methods included field studies to determine the response of maize plants to the factors under examination; morphophysiological studies to obtain biometric parameters of plants; calculation and weighing to establish indicators of plant structure and productivity; and mathematical and statistical studies to determine the reliability of field trial results.

Results and Discussion. Scientific research has shown that the productivity of maize hybrids is ensured by their biological properties, which enable them to respond positively to weather conditions in the growing area and the level of mineral nutrition. The weather conditions during the growing season in the years of research differed not only from the long-term indicators, but also from each other, which undoubtedly affected the growth and development of plants, the formation of indicators of assimilation surface, photosynthetic potential, individual productivity and grain yield. In particular, under conditions of sufficient moisture availability, the period from sowing to seedling emergence in 2021 and 2024 lasted 8–10 days; in 2022 it increased to 14–16 days, while the lack of precipitation and productive moisture in the seedbed layer caused this period to increase to 14–20 days in 2023. Hydrothermal conditions during the periods of maize plant growth and development, ear formation, and grain filling were generally favourable, with sufficient rainfall but uneven distribution and fairly high average daily air temperatures. Grain ripening occurred under various moisture and temperature conditions. The best conditions for maize grain ripening were in 2023, while the worst were in 2022 (Table 1).

The analysis of the ear structure showed that in both maize hybrids, foliar feeding of plants with nitrogen fertilisers (urea) improved biometric indicators and yield attributes, namely, the ear length, the average number of grains per ear, the grain weight per ear and the 1000-grain weight increased.

At the same time, the above indicators also varied over the years of research. In particular, the ear length in early-ripening hybrid DN Aton was 17.2–17.8 cm in 2022, while in 2021 and 2023 it increased to 17.2–19.2 and 18.8–19.3 cm, respectively, and in 2024 it was the smallest – 14.6–15.4 cm. Among plants of the mid-early hybrid DN Astra, the longest ear length was 20.4–22.2 cm in 2021, in 2022 and 2023 ear length decreased to 16.6–19.0 and 17.2–18.7 cm, and in 2024 – to 16.0–17.6 cm, depending on the variant of foliar feeding. Over the years of research, the average ear length in maize plants of early-ripening hybrid DN Aton was 17.0–17.9 cm, and maize plants of mid-early hybrid DN Astra had ear length of 17.6–19.4 cm. Foliar feeding with urea or its tank mixture with sulphur increased the ear length by 1.2–4.1 and 1.7–6.8 %, respectively (Table 2).

As a crop with high individual productivity and the ability to compensate for the insufficient development of some yield attributes with others, as well as narrow limits of variability of individual productivity traits, maize is characterised by an important structural indicator: the average number of grains per ear or grain content.

We found that in plants of the early-ripening hybrid DN Aton, the average number of kernels per ear varied from 504 to 774 over the years of research, and in the mid-early hybrid DN Astra, it varied from 444 to 630, depending on the foliar fertilisation variant. Maize

Table 1. Weather conditions during the growing season for maize, 2021–2024

Year, period	Month						For growing season
	May	June	July	August	September	October	
Average daily air temperature, °C							
2021	15.8	22.0	25.2	20.7	13.8	7.9	17.6
2022	16.2	22.4	22.0	22.1	13.6	11.1	17.9
2023	17.2	20.6	22.4	23.9	19.0	11.8	19.2
2024	17.9	22.9	24.8	23.7	18.4	9.9	19.6
Average for 1960–2020	13.6	18.4	19.3	18.6	13.4	7.4	15.1
Total precipitation, mm							
2021	188.6	58.2	349.2	166.5	71.2	0.7	834.4
2022	55.4	63.1	93.2	153.2	206.8	79.1	650.8
2023	9.9	126.2	295.4	45.4	9.2	74.4	560.5
2024	129.0	124.1	334.7	42.0	129.6	46.8	806.2
Average for 1960–2020	70.1	107.4	129.9	89.8	62.4	46.6	506.2
Hydrothermal coefficient							
2021	3.84	0.88	4.48	2.59	2.72	0.28	2.46
2022	1.10	0.94	1.36	2.24	5.08	2.29	2.17
2023	0.19	2.04	4.25	0.61	0.16	2.00	1.55
2024	2.32	1.80	4.36	0.57	2.35	1.51	2.15
Average for 1960–2020	1.61	1.93	2.16	1.58	1.56	2.03	1.81

Table 2. Biometric indicators of the maize ear and yield attributes, 2021–2024

Foliar feeding (B)	Hybrid (A)	Ear length, cm	Grain content, pcs.	Grain weight per ear, g	1000-grain weight, g
Control (without feeding)	DN Aton	17.0	567	131.0	231.9
	DN Astra	17.6	484	131.5	265.6
Urea, 10 kg/ha in the 5–6 leaf stage	DN Aton	17.2	605	139.5	239.0
	DN Astra	17.9	515	140.8	275.5
Urea, 10 kg/ha in the 5–6 leaf stage + Chemic Sulphur, 1.5 l/ha	DN Aton	17.4	610	144.4	244.0
	DN Astra	18.4	524	143.6	281.7
Urea, 20 kg/ha in the 8–9 leaf stage	DN Aton	17.5	617	147.6	247.4
	DN Astra	18.5	551	154.1	287.2
Urea, 20 kg/ha in the 8–9 leaf stage + Chemic Sulphur, 1.5 l/ha	DN Aton	17.6	641	154.1	252.9
	DN Astra	18.7	558	161.5	293.6
Urea, 10 kg/ha in the 5–6 leaf stage Urea, 20 kg/ha in the 8–9 leaf stage	DN Aton	17.7	646	154.9	257.1
	DN Astra	18.8	581	164.2	300.1
Urea, 10 kg/ha in the 5–6 leaf stage + Chemic Sulphur, 1.5 l/ha Urea, 20 kg/ha in the 8–9 leaf stage + Chemic Sulphur, 1.5 l/ha	DN Aton	17.9	658	160.0	262.6
	DN Astra	19.4	595	169.3	305.9

plants of both hybrids had the highest grain content of ear in 2021, and the lowest in 2024. In the early-ripening hybrid DN Aton, grain content was 640–774 and 532–546 grains, respectively, in the mid-early hybrid DN Astra – 504–630 and 444–588 grains per ear, and 567–658 and 484–595 grains, respectively, on average over the years of research. Foliar feeding with urea contributed to an increase in the grain content of ears by 6.7–13.9 % in the early-ripening hybrid DN Aton and by 6.0–20.0 % in the mid-early hybrid DN Astra. The addition of the highly concentrated liquid sulphur fertiliser Chemic Sulphur to urea increased this indicator by another 0.8–3.9 and 1.3–2.4 %, respectively..

The grain weight per ear is an yield attribute that has the greatest impact on crop yield. According to our calculations, the highest grain weight per ear was recorded in 2023 for the early-ripening hybrid DN Aton (153.2–187.1 g) and the mid-early hybrid DN Astra (143.5–196.1 g). The lowest grain weight was recorded in the early-ripening hybrid DN Aton (106.6–140.0 g) in 2021 and in the mid-early hybrid DN Astra (123.9–164.0 g) in 2024. On average over the years of research, the grain weight per ear was 131.0–160.0 and 131.5–169.3 g for short-season maize hybrids, respectively.

The 1000-grain weight also varied throughout the study period. It was lowest in both maize hybrids in 2021 – 173.2–202.2 g in the early-ripening hybrid DN Aton and 223.1–272.0 g in the mid-early hybrid DN Astra, while the average weight over the years of research was 173.2–202.2 and 223.1–272.0 g, respectively, depending on foliar feeding.

Over the years of research, it was established that foliar feeding of maize plants with urea contributed to an increase in grain weight per ear in the early-ripening hybrid DN Aton by 6.5–18.2 %, in the mid-early hybrid DN Astra – by 7.0–23.9 %, and the 1000-grain weight – by 3.1–10.9 % and 3.7–13.0 %, respectively. The addition of sulphur in the form of the highly concentrated liquid fertiliser Chemic Sulphur to urea further increased the grain weight per ear in the early-ripening hybrid DN Aton by 3.3–4.4 % and in the mid-early hybrid DN Astra by 1.3–4.8 %, as well as the 1000-grain weight increased by 2.1–2.2 % and 1.9–2.3 %, respectively.

Conclusions. Thus, summarising the results of our research, we found that the biometric indicators of maize ears varied under the influence of foliar feeding and weather conditions during the growing season. The application of urea and highly concentrated liquid sulphur fertiliser Chemic Sulphur for foliar feeding of maize contributed to an increase in ear length, grain content, grain weight per ear and 1000-grain weight. Two applications of urea fertiliser with the addition of highly concentrated liquid sulphur fertiliser Chemic Sulphur in the 5–6 and 8–9 leaf stages proved to be the most effective, increasing the ear length of early-ripening hybrid DN Aton by 5.3 %, and in the mid-early hybrid DN Astra – by 10.2 %, grain content of ear – by 16.0 and 22.9 %, grain weight per ear – by 22.1 and 27.8 %, 1000-grain weight – by 13.2 and 15.2 %, respectively.

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Молдован Ж. А., Молдован В. Г. Формування біометричних показників качана кукурудзи під впливом позакореневого підживлення та погодних умов. *Зернові культури. 2025. 9 (1). 121–126.*

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Актуальність. Для досягнення високої врожайності кукурудзи, критично важливо підтримувати достатній рівень азоту упродовж ключових фаз росту та розвитку культури. Дробне внесення азоту при цьому оптимізує живлення рослин і знижує непродуктивні його втрати. **Мета досліджень.** Вивчення впливу позакореневого підживлення кукурудзи карбамідом або його бакових сумішей з сіркою на формування біометричних показників качана гібридами кукурудзи скоростиглих груп в умовах Західного Лісостепу. **Матеріали і методи.** У двофакторному досліді вивчали гібриди куку-рудзи ранньостиглий ДН Атон та середньоранній ДН Астра; варіанти позакореневого підживлення карбамідом і висококонцентрованим рідким сірчаним добривом Хімік Сірка – у фази 5–6 та 8–9 листків. **Результати.** Встановлено, що у роки проведення досліджень на формування біометричних показників качана істотно впливало не лише застосування позакореневого підживлення, але й погодні умови вегетаційного періоду. У середньому за роки досліджень, за різних варіантів позакореневого підживлення, довжина качана збільшувалася у ранньостиглого гібрида ДН Атон на 1,2–4,1 %, у середньораннього ДН Астра – на 1,7–6,8 % порівняно з контролем. Позакореневі підживлення карбамідом сприяли збільшенню маси зерна з одного качана у ранньостиглого гібрида ДН Атон на 6,5–18,2 % та у середньораннього ДН Астра – на 7,0–23,9 %, маси 1000 зерен – на 3,1–10,9 та 3,7–13,0 %, озерненості качана – на 6,7–13,9 та 6,0–20,0 %, відповідно. Додавання сірки у вигляді висококонцентрованого рідкого добрива Хімік Сірка до карбаміду зумовлювало додаткове збільшення маси зерна з одного качана у ранньостиглого гібрида ДН Атон – на 3,3–4,4 %, у середньораннього ДН Астра – на 1,3–4,8 %. Маса 1000 зерен відповідно збільшувалася на 2,1–2,2 та 1,9–2,3 %, а озерненість качана – на 0,8–3,9 та 1,3–2,4 % порівняно з контролем. **Висновки.** Найбільш ефективним є дворазове підживлення кукурудзи карбамідом з додаванням висококонцентрованого рідкого сірчаного добрива Хімік Сірка у фази 5–6 та 8–9 листків, що забезпечило збільшення довжини качана у рослин ранньостиглого гібрида ДН Атон на 5,3 %, у рослин середньораннього ДН Астра – на 10,2 %, озерненості качана – на 16,0 та 22,9 %, маси зерна з 1 качана – на 22,1 та 27,8 %, маси 1000 зерен – на 13,2 та 15,2 % відповідно.

Ключові слова: *кукурудза, гібрид, підживлення, карбамід, сірка, довжина качана, маса зерна, маса 1000 зерен*