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IMPACT OF FIELD PROTECTIVE FOREST BELTS ON CORN PRODUCTIVITY IN CONDITIONS OF CLIMATE CHANGE

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With the presence of highly effective forest shelterbelts, the yield of agricultural crops in adjacent fields can increase by 13% due to the optimization of microclimate parameters: air temperature, humidity, air velocity, soil fertility. Therefore, the tasks we have set are relevant in today's conditions. Considering the effects of climate change, every growing season is extreme; therefore, the potential of field shelterbelts could increase significantly. However, in the present circumstances no studies have been conducted to investigate the limits of the impact of field shelter belts on crop yields. Therefore, our research is highly relevant. The aim of the study is to investigate the actual impact of primary and secondary field shelterbelts on increasing corn yields and to determine the zone of perpendicular spread of their effective influence under conditions of climate change. Investigations were conducted on corn crops at distances of 1 m, 10 m, 100 m, 200 m, 300 m, 400 m, and 500 m perpendicular to the primary and secondary fieldshelter belts. The studies have shown that primary and secondary field shelterbelts increase corn yields up to a distance of 400 m, raising yields by up to 23%. The highest corn yield is observed at a distance of 200 m from the field shelterbelt. At a distance of up to 10 m from the field shelterbelt, grain yield is 38–66% lower compared to that at 200 m. The average corn yield near a windbreak secondary field shelterbelt at a distance of 0–500 m from it is 2.0% lower than that near the main forest strip. Its positive effect extends up to 300 m, with the highest crop productivity observed at a distance of 100 m. The increase of corn crop productivity due to the influence of the secondary shelter belt is 17%, and no sharp decrease in yield is observed near the shelterbelt at a distance of up to 10 m.

Key words: *field shelter belt, species, corn, yield, influence, distance.*

Вітер Н.Г. Вплив полезахисних лісосмуг на продуктивність кукурудзи в умовах зміни клімату

Високоефективні полезахисні лісосмуги, які розташовані на прилеглих до них полях, можуть значно підвищити врожайність сільськогосподарських культур на 13% завдяки оптимізації багатьох параметрів мікроклімату: температури повітря, вологості, швидкості руху повітря, родючості грунту. Тому проведені нами спостереження є актуальними. При врахуванні умов глобальних змін клімату відповідно кожен сільськогосподарський рік є екстремальним, тому потенціал полезахисних лісосмуг може значно зростати. Але в умовах сьогоднішнього часу детальні дослідження вивчення меж впливу полезахисних лісосмуг на врожайність сільськогосподарських культур не проводились. Тому проведені нами дослідження стали актуальнними.

Мета дослідження – дослідити фактичний вплив основних і допоміжних полезахисних лісосмуг на підвищення врожайності кукурудзи,а також на зону перпендикулярного поширення ефективного впливу в умовах зміни клімату. Спостереження проводились за посівами кукурудзи на відстанях 1 м, 10 м, 100 м, 200 м, 300 м, 400 м, 500 м перпендикулярно до основної та допоміжної полезахисних лісосмуг. Досліджено, що основні та допоміжні полезахисні лісосмуги підвищують врожайність посівів кукурудзи до відстані 400 м від підвищенням її урожайності до 23%. Найвища врожайність кукурудзи на відстані 200 м від лісосмуги. На відстані до 10 м від лісосмуги, врожайність зерна менша на 38–66%, у порівнянні з відстанню у 200 м. Середня врожайність кукурудзи біля продувної *допоміжної лісосмуги на відстані 0–500 м від неї на 2,0 нижча, ніж від основної лісосмуги. Її позитивний ефект простягається на відстань до 300 м з найвищою продуктивністю посівів на відстані 100 м. Підвищення продуктивності посівів кукурудзи від впливу допоміжної лісосмуги складає 17% і не спостерігається дуже різкого зниження врожайності біля допоміжної лісосмуги на відстані до 10 м.*

Ключові слова: *полезахисна лісосмуга, види, кукурудза, врожайність, вплив, віддаль.*

The Relevance of the Research Topic. Shelterbelts are an important component of the forest and agricultural landscape, serving as an effective, long-term, and relatively low-cost measure for combating water and wind erosion of soils. Field shelterbelt have a positive impact on the formation of the microclimate of the territories and increase crop yields [1, c. 56].

Scientists have proven that one hectare of field shelterbelts can effectively protect 20–30 hectares of arable land. Based on these data, millions of hectares of arable land in Ukraine are protected by field shelterbelts, which contributes to the efficient use of land and reduces the costs of crop production. In order to optimize the number of field shelterbelts and to prevent reduction of their total area, it is necessary to plant approximately 6,000–7,000 hectares of field shelterbelts annually for their restoration [2, c. 183].

When highly effective field shelterbelts grow, crop yields in adjacent fields increase by approximately 13% due to the optimization of microclimate parameters, water and nutrient regimes of the soil, and a 1% increase in the area of field shelterbelts makes it possible to obtain an additional 5,3 cwt/ha of grain crop yield. In oder to preserve existing or create new field shelterbelts on degraded lands or in areas with poor water conditions, the yield increase can be twice as high. A significant increase in yield will depend on the effectiveness of the current ecological condition of the field shelterbelts [3, c. 229].

Statement of the Problem. Newly established field shelterbelts on agricultural land, when maintained on a permanent basis, represent the only effective and long-term approach to increasing crop yields by improving microclimatic conditions, altering the hydrological regime, and combating soil erosion. Over the past 15–20 years, afforestation efforts in field shelterbelts have decreased again in Ukraine, as these shelterbelts currently lack dedicated owners [4, c. 273].

Field shelterbelts are an important part of the modern agricultural landscape and play a significant role in their functioning, as well as in the development of agroecosystems. Field shelterbelts are unique plantings that differ significantly from other plantings in terms of their location (primary plateau) and structure (narrow strip) [5, c. 85].

Field shelterbelts do not require depreciation, and therefore play a multifunctional role in protecting agricultural lands from adverse natural disasters (droughts, storms, blizzards, water and wind erosion), improving the environment, ensuring crop yields, and increasing soil fertility [6].

Field shelterbelts are classified by structure into primary and secondary belts based on their location according to the prevailing wind directions; they differ not only by location, width, and tree species composition, but also in the methods used to maintain them. The system of primary and secondary field shelterbelts should function as a unified network of forest-reclamation complexes, in which each part complements the others to ensure the ecological protection of the agroecosystem from extreme natural factors. Such features enhance the ecological effect [7, c. 117].

Currently, little is known about the current state of field shelterbelts. The reason for this is that no inventory of field-protective forest belts has been conducted since the mid-1970s. Studies show that Ukraine has 0.43–0.44 million hectares of field shelterbelts. About 13 million hectares of agricultural land are protected by field shelterbelts, which account for only 30% of the total area of agricultural land in Ukraine. When all types of forest belts are taken into account – roadside, farm-adjacent, forests near water bodies, and forests adjacent to fields and steppes – the total area of agricultural landscapes accounts for 40% of the total area. The area of protective forests for agricultural purposes in Ukraine is 1.5%, while the scientifically justified area is 3.0–3.5% [8, c. 42].

Field shelterbelts in agroecosystems improve ecological, agroforestry, and environmental protection factors and ensure the sustainable functioning of the crop production sector of agricultural activity. However, the current agroforestry infrastructure of field-protective plantings in Ukraine is ineffective. This is evidenced by low crop yields during years with adverse climatic conditions. As a result, ecological and economic losses from soil erosion amount to 9 billion UAH per year [9, c. 84].

Considering the conditions of climate change, practically every agricultural year is extreme, so the potential of field shelter belts can increase significantly. However, for today, no studies have been conducted to determine the extent of the impact of field shelter belts on crop yields under conditions of global warming and climate change. Therefore, the tasks we have set are relevant. [10, c. 82].

Research Methodology. Field observations were conducted during 2024–2025 in Vinnytsia District of Vinnytsia region on agricultural lands protected by blown primary and secondary field shelter belts. The soils are medium-loamy podzolized chernozems. Observations were conducted on corn crops at distances of 1 m, 10 m, 100 m, 200 m, 300 m, 400 m, and 500 m perpendicular to the primary and secondary fieldshelter belts. [11, c. 182].

The diameter of the corn ear at the base ranged from 5 to 8 cm, depending on the distance to the field shelter belts. The largest diameter was observed at a distance of 10–300 m, and the smallest at a distance of 1 m. Starting at a distance of 400 m from the field shelter belts, the diameter of the corn ear begins to decrease.

It has been proven that, under conditions of sufficient moisture in Ukraine, the planting density for grain corn should not exceed 75,000 plants per hectare. If the density is further increased from 75,000 to 100,000 plants per hectare, the yield will hardly increase at all, and with further increase it will decrease.

Observations of dynamics in corn plant density at various distances from the main field shelter belts showed that it ranged from 71,400 to 100,000 plants per hectare. The highest plant density was observed at distances of 400 and 500 m from the quantity, and the lowest at a distance of 10 m. However, a plant density of 85,700 plants/ha was predominant. This quantity was recorded at distances of 1, 100, 200, and 300 m from the field shelter belts (Table 1).

The height of the corn plants ranged from 200 to 340 cm. The tallest plants were found at the distance of 400 and 500 m from the field shelter belts, where plant density was the highest. The shortest corn plants were found at the distance of 1 m from the field shelter belts, where the effect of trees competing with corn plants for light was evident. Further away from the the field shelter belts, the height of the corn plants increased.

Research results. At all distances from the the field shelter belts, a single ear was found on each corn plant. However, they varied in length and diameter. The length of the ears ranged from 17 to 23 cm. The longest ear was found at distances of 300 and 400 m from the field shelterbelts, and the shortest at a distance of 1 m. The tendency was observed of increasing ear length from a distance of 1 m to 300–400 m, followed by a decrease in this parameter.

Table 1

Corn crop productivity indicators depending on the distance to the main field shelterbelt, mid-2024–2025

Indicators of productivity	Distance from the field shelterbelt, m						
	1	**10**	**100**	**200**	**300**	**400**	**500**
Plant density, thousand plants/ha	85,7	71,4	85,7	85,7	85,7	100,0	100,0
Plant height, cm	200	270	290	320	330	340	340
Number of ears per plant, pcs.	1	1	1	1	1	1	1
Length of the ear, cm	17	20	22	22	23	23	21
Initial diameter of the ear, cm	5	8	8	8	8	6	7
Weight of a thousand seeds, g	235	236	236	236	235	231	228

The diameter of the corn ear at the base ranged from 5 to 8 cm, depending on the distance to the field shelterbelts. The largest diameter was observed at a distance of 10–300 m, and the smallest at a distance of 1 m. Starting at a distance of 400 m from the field shelterbelts, the diameter of the corn ear begins to decrease.

The weight of a thousand of corn seeds ranged from 228 to 236 g. The highest weight was observed in plants growing 10–200 m from the field shelterbelts, while the lowest was observed at a distance of 500 m. There is a trend of increasing the weight of a thousand corn seeds from a distance of 1 m to 10 m from the field shelterbelts; after that, this measure stabilizes and begins to decrease at a distance of 300 m from the field shelterbelt.

Observations of similar parameters for corn crops in relation to the secondary field shelterbelts showed that plant density ranged from 57.1 to 85.7 thousand plants/ha. The highest plant density was observed at distances of 1–100 m from the field shelterbelts, and the lowest at distances of 200 m and 500 m. The plant density of corn near the main field shelterbelt was 16.3% higher than near the secondary field shelterbelt (Table 2).

Table 2

Corn crop productivity indicators depending on the distance to the auxiliary forest shelterbelt, mid-2024–2025

Indicators of productivity	Distance from the field shelterbelt, m						
	1	**10**	**100**	**200**	**300**	**400**	**500**
Plant density, thousand plants/ha	85,7	85,7	85,7	57,1	71,4	71,4	57,1
Plant height, cm	220	270	320	300	320	280	280
Number of ears per plant, pcs.	1	1	1	1	1	1	1
Length of the ear, cm	16	17	23	23	23	17	19
Initial diameter, cm	6	7	7	7	7	6	7
Weight of a thousand seeds, g	235	236	236	236	235	231	228

The height of the corn plants near the secondary field shelterbelt ranged from 220 to 320 cm. The tallest plants were found at distances of 100 and 300 m, and the shortest at a distance of 1 m. An increase in corn plant height was observed from a distance of 1 m to 100 m, and a decrease in height from a distance of 400 m. Corn plants near the main field shelterbelt were found to be 5% taller than those growing near the the secondary field shelterbelt. In general, the average height of corn plants near the main field shelterbelt was 4.9% greater (Fig. 1).

The number of ears was similar to that of the corn plants growing near the main field shelterbelt – one per plant. The length of the corn ears near the secondary field shelterbelt ranged from 16 to 23 cm. The longest ears were found at distances of 100–300 m, while the shortest were found at a distance of 1 m. There is a trend of increasing corn ear length from 1 m to 100 m from the secondary field shelterbelt, followed by stabilization of this indicator over a distance of 100–300 m and a subsequent decrease in length. It was found that the average length of a single corn plant growing near the main field shelterbelt was 6.1% greater than near the secondary field shelterbelt (Fig. 2).

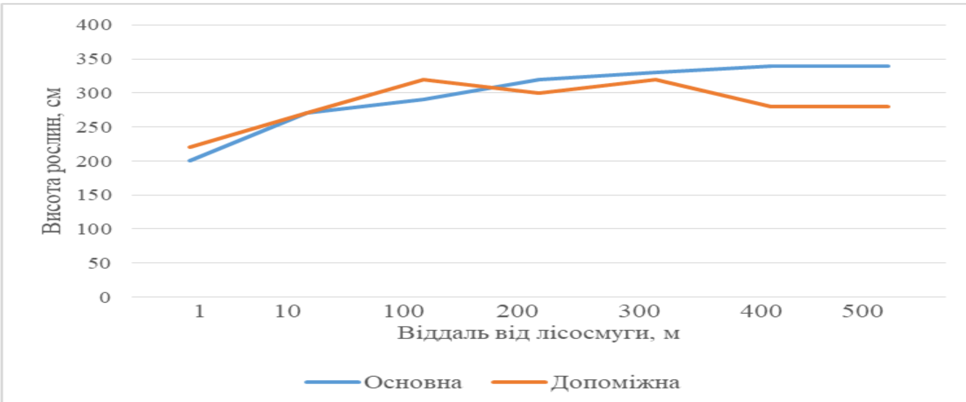

Fig. 1. Dynamics of corn plant height depending on the distance from the main and auxiliary shelterbelt, mid-2024–2025

The diameter of the corn ear was 6–7 cm. The smallest diameter was recorded at distances of 1 and 400 m, while at all the other distances it was 7 cm. The average diameter of the corn ears near the secondary field shelterbelt was 5.4% smaller than near the main one.

The weight of a thousand of corn seeds near the main field shelterbelt ranged from 228 to 236 g. The highest seed weight was observed at distances of 10–200 m, and the lowest at a distance of 400 m. There is a trend of increasing the weight of a thousand of corn seeds from 1 to 10 m, followed by stabilization at a maximum measure over 10–200 m and a subsequent decrease in weight. The weight of a thousand of seeds did not depend on the type of field shelterbelt adjacent to the corn crop.

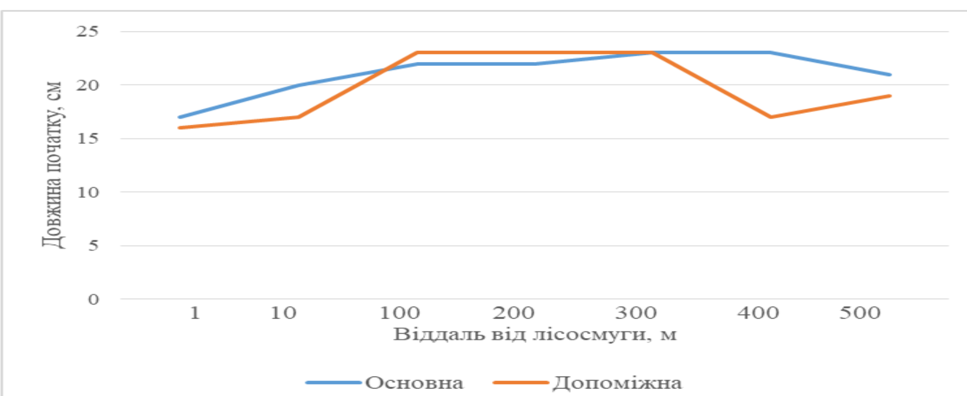

Fig. 2. Dynamics in the length of the ear corn plant depanding on distance from the main and secondary field shelterbelts, 2024–2025

Monitoring of corn yields at various distances from field shelterbelts showed that near the main field shelterbelt, grain yields ranged from 2.37 t/ha at a distance of 1 m to 9.03 t/ha at a distance of 300 m from the main which amounted to 33.5%. A trend of increasing yield was observed from 1 m to 300 m, followed by a decrease from 400 to 500 m. A significant increase in corn seed yield was observed from a distance of 10 m to 100 m from the main field shelterbelt, which amounted to 33.5% , and from 1 m to 10 m – 58.2%. At distances of 100 m and 200 m from the main field shelterbelt, the corn grain yield was the same – 8.53 t/ha. At distances from 200 m to 300 m, it increased by another 5.5%. At distances of 300 m to 400 m from the main field shelterbelt, corn grain yield decreased by 19.2%, and from 400 m to 500 m – by another 2.3% (Fig. 3).

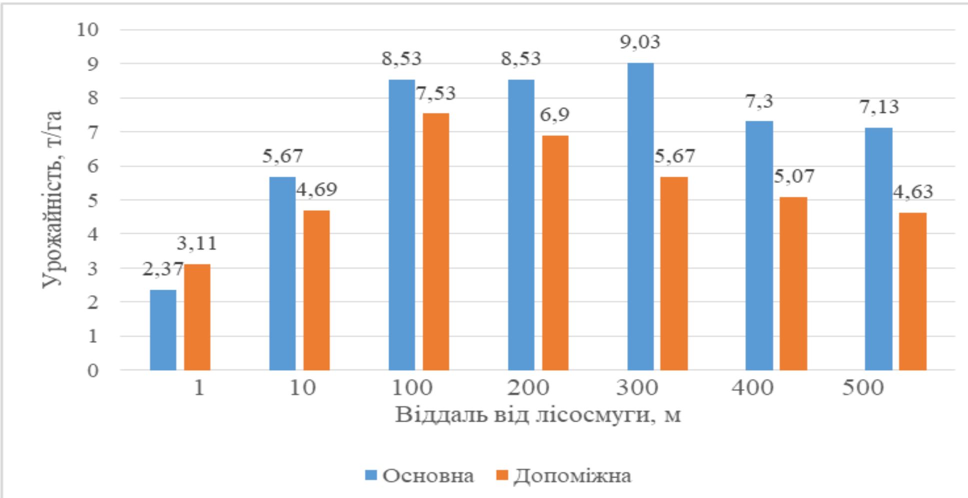

Fig. 3. Dynamics in corn yield depanding in distance from field shelterbelts, t/ha, average for 2024–2025

Near the secondary field shelterbelts, corn grain yield ranged from 3.11 t/ha at a distance of 1 m from the shelterbelt to 7.53 t/ha at a distance of 100 m from the shelterbelt. The average corn yield near the main field shelterbelt was 22.6% higher than near the secondary field shelterbelts. Only at a distance of 1 m from the secondary field shelterbelt the corn yield was 23.8% higher than at this distance from the main field shelterbelt. At distances ranging from 1 m to 10 m from the secondary field shelterbelt, corn grain yield increased by 33.7%; from 10 m to 100 m – by 37.7%; from 100 m to 200 m – decreased by 8.4%; from 200 m to 300 m – it was 17.8% lower; at a distance of 300 m to 400 m – it was 10.6% lower, and at a distance of 400 m to 500 m – it decreased by 8.7%.

A moderate positive correlation was found between corn grain yield and the distance of plants from the main field shelterbelt ($r = 0.4962$) with a coefficient of determination $R^2 = 0.2462$, while no correlation was found with the secondary field shelterbelt. It means, as the distance from the main field shelterbelt increases, corn yield increases, but there is no such trend for secondary field shelterbelt. (Fig. 4).

A strong positive correlation was found between corn grain yield and plant height near the main field shelterbelt ($r = 0.8450$); the length of the ear ($r = 0.9413$); and the diameter of the ear ($r = 0.7582$).

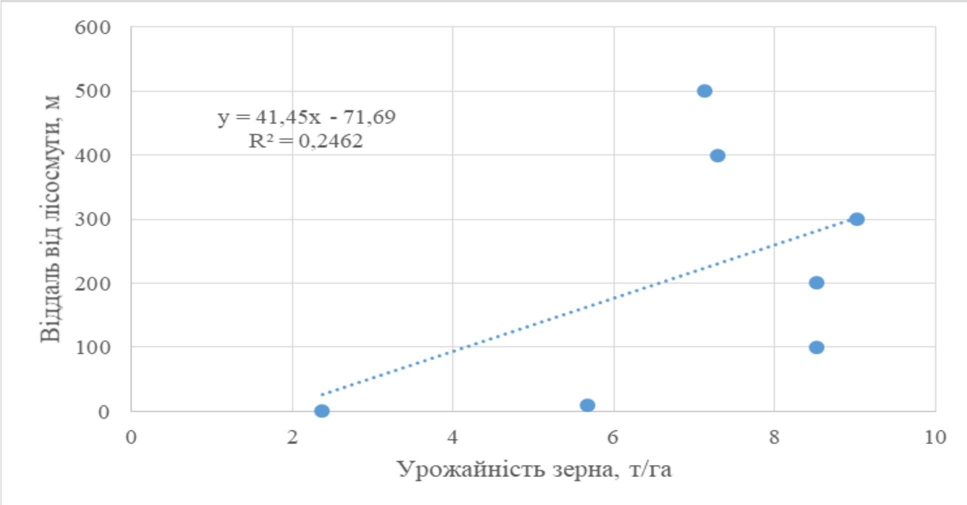

Fig. 4. Correlation-regression dependence and coefficient of determination between corn grain yield and distance from the main field shelterbelt, 2024–2025

A strong positive correlation was established between corn grain yield and plant height near the secondary field shelterbelt r = 0.8785; ear length r = 0.8638; a moderate positive correlation between corn grain yield and the diameter of the ear base r = 0.5879; the weight of 1,000 seeds r = 0.3360.

Conclusions and Future Research Directions. The highest corn grain yield was observed at a distance of 300 m from the main blown field shelterbelts, which was 21.0% higher than at a distance of 500 m. Consistently high corn yields were observed at a distance of 100–300 m from the main blown field shelterbelt. The average corn yield near the primary blown field shelterbelt was 22.6% higher than near the secondary blown field shelterbelt. The highest corn grain yield near the secondary blown field shelterbelt was observed at a distance of 100 m from it, with a subsequent decrease.

It is recommended to grow grain corn within 100–300 m from the main blown field shelterbelts, where consistently high yields are achieved, with maximum yields observed at a distance of 300 m.

It is advisable to plant corn near the secondary blown field shelterbelts at a distance of about 100 m, which ensures the highest yield; however, a gradual decrease in productivity with increasing distance from this zone should be taken into account.

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