

Influence of foliar feeding on the grain productivity of corn hybrids in the conditions of the right-bank forest-steppe of Ukraine

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Ukraine is a large agricultural country with grain production of more than 60 million tons. At that, the percentage of tilled agricultural land reaches 80%, and in some regions even exceeds 90%. The environmental imbalance of agricultural production is becoming more evident with the increasing destructive tendencies in the land use. The problem of soil fertility loss is of particular relevance under present conditions. On the one hand, this problem is caused by the high percentage of tilled agricultural land in the territory of Ukraine and the intensive use of the eroded lands, but, on the other hand, by insufficiently high farming culture and rapid growth of deficiency in organic substance and basic soil nutrients (Kolisnyk, 2019; Tsyhanskyi et al., 2019).

According to the statistical bulletin of Ukraine, the areas where corn was grown in Ukraine in 2015-2017 reached 4.3-4.7 mln ha, and Ukraine occupied the leading position in the world in 2016 in grain production, producing 28.07 mln t, with an average yield in the country of 66.0 t/ha (Kolisnyk, 2019; Kolisnyk, 2016).

Therefore, modern agrotechnologies in agriculture are the important factors in improving crop productivity and preserving soil fertility. Modern technologies being used in the competitive agricultural crop production are the means of functioning of sustainable systems in agriculture. It is possible to improve the efficiency and stability of agriculture only due to the introduction of intensive crop growing technologies. The latest technologies contribute to a more efficient use of the potential of modern varieties and hybrids, and increase yields and their quality by influencing the productive process of plant development. These technologies favour the optimization of production costs with regard to the ecological safety of the environment and maintain the relative agroecosystem balance (Palamarchuk et al., 2010; Kolisnyk, 2007; Butenko et al., 2019).

Long-term experiments indicate that the potential of the new corn hybrids hasn't been used quite enough (Kolisnyk, 2016; Khodanitska, 2020). The realization of its genetic potential will significantly increase the seed production and stimulate the development of the processing industry. Taking into account the biological characteristics of new corn hybrids and the development of new technologies for their growing, there arises the need to optimize the interaction of the hybrid with the available hydrothermal environmental resources and the arranged factors, which will ensure a more complete realization of their potential in the specific region.

Keywords: Grain; Corn; Hybrid; Foliar feeding; Maturity group; Growth and development stage; Crop yield

Introduction

Proceeding from the intensification of agrarian production, the most expedient is the study of the development of model technologies for growing crops under conditions of self-renewable farming systems. These systems are the most appropriate ones for the effective application of the laws of nature and better use of the region's existing bioclimatic resources. They are to ensure the preservation and enhancement of soil fertility, to efficiently use the precipitation and productive moisture storage, and to contribute to the corn grain yields. It is known that the model of a self-renewable farming system has to include a set of organizational and agrotechnical measures being economically and environmentally grounded, with the most active involvement and optimal use of high technologies, biopharmaceuticals of symbiotic associative and protective action and natural growth stimulators. For that reason, the study of the reaction of the new corn hybrids to the arranged cultivation factors under the traditional and alternative farming systems is an extremely urgent issue that needs appropriate justification for the regional conditions.

Materials and Methods

The aim of the study is to explore the effects of foliar application rates and the productivity of the corn hybrids belonging to the groups of different maturity.

The research on the effects of foliar application on a complex of economically valuable traits, including the productivity of corn hybrids of the groups of different maturity, was conducted during 2018-2019.

The field research was carried out in the research field of Vinnytsia National Agrarian University in the village of Ahronomichne, Vinnytsia district, Vinnytsia region (Khodanitska et al., 2019).

The growth, development and formation of plant productivity occur through a complex interaction of soil and climatic factors, the main of which are heat, moisture, light and nutrition. The regularities in the interaction between the soil and a plant are determinant in the theoretical substantiation of the modern systems in agriculture and the resource investment in the crop growing technologies (Khodanitska, 2020; Kolisnyk et al., 2019).

The climatic conditions where the research area is located are quite different. This is due to the specific features of the geographical location and geomorphology of its territory. The climate of the Right-Bank Forest-Steppe of Ukraine is affected by the air masses formed over the Atlantic Ocean, while the climate of the Left-Bank - mainly by those formed over Scandinavia. In general, the climate of the areas characterized by warm summers and moderately cold winters. Continentality is increasing from west to east, which accordingly influences the amount of precipitation and the fluctuation range in daily temperatures (Ivanov et al., 2019).

In general, the climate is characterized by a long but moderately mild and warm winter for the mentioned above location, which is influenced by the Atlantic Ocean. It is mainly defined by cyclone weather with frequent precipitation. Its beginning is represented by thaw periods. In February, the cyclone weather becomes less prevalent. The outbreak of cold air causes severe frosts. The duration and stability of the snow cover varies greatly from year to year. Spring usually begins in the second decade of March: the temperature rises intensively, the snow melts, the soil thaws out. It often happens to be prolonged, characterized by the periods of cold weather and the outbreaks of warm air. Light spring frosts end in late April, but sometimes occur in the second decade of May. The duration of the frost-free period is 165-175 days. Summer is characterized by high and stable temperatures. In July, the average monthly temperature varies from +10°C in the west, to +20°C in the east. The absolute peak temperature reaches +39 - 40°C. The irregularity in weather conditions during the years under investigation allowed us to completely assess the response of the corn hybrids in different maturity groups to different thermal and humidity conditions created in the Right-Bank Forest-Steppe.

Results and Discussion

The analysis of the plant response to the changes in environmental conditions in a certain soil and climatic zone allows us to totally take into a consideration the requirements of corn for growing conditions and to approach the development of agrotechnical techniques that are aimed at highest possible productivity in a more grounded way (Khodanitska, 2020; Karpenko et al., 2019).

The growth and development of plants reflect the essence of the interactive processes of plant organisms with environmental factors, as the realization of the genetic potential, possessed by the plant, is fully revealed only under the influence of environmental conditions. As Academician V.S. Tsykov states, any living process in plants can be described only if it is considered in a particular region being cultivated. Therefore, the study of the processes of growth and development of the corn hybrids in different maturity groups, influenced by the models of growing technologies and the level of their intensification, is an important scientific problem, which needs appropriate justification for the conditions of the region (Khodanitska et al., 2019; Palamarchuk, 2019; Ding, 2014). It is known that the corn hybrids in different maturity groups are ecological biotypes of the crops with different rates of growth and development, variability of morphological signs, duration and intensity of photosynthetic activity, development of the root system and other biological properties. They are defined by the different response to the changes in the environmental (Tsykov, 2013). The Table 1 shows the mean data in 2018-2019. According to these data, we can conclude that the mid-early hybrid Vizyr appeared to be the least susceptible to foliar fertilizers and, compared with the check variant, the application of Reacom-Plus Corn (2l/ha) at the stage of 3-6 leaves increased the duration of the vegetation period by 1 day only which equals 133 days.

Table 1. The duration of the vegetation period of the corn plants, depending on the effects of foliar feeding, days (mean data in 2018-2019).

Hybrid name	Average time of the vegetation period		
	check variant	application of Reacom-Plus Corn at the stage of 3-6 leaves - 2l/ha	application of Reacom-Plus Corn at the stage of 10-12 leaves - 2l/ha
Adway	119	128	129
Vizyr	123	133	139

However, with the application of Reacom-Plus Corn (2l/ha) at the stage of 10-12 leaves, a considerable extension of the vegetation period from 10 to 16 days can be observed, and, accordingly, the maximum increase in the vegetation period by 16 days is observed in Vizyr hybrids.

One of the main factors for increasing the corn seed yield is the introduction of the best district varieties and hybrids with the high-sowing and high-yielding qualities.

The vegetation period affects the productivity of corn hybrids to some extent. As the vegetation period increases, corn grain yield increases as well. That is, there is a direct correlation between the vegetation period and the corn productivity.

In addition to the vegetation period, the grain productivity of the corn hybrids is also affected by other economically valuable traits of plants. These include: height of the plants, number of cobs per stalk, height of the cob attachment, area of the corn husk, number of veins per leaf and others.

The plant height is a secondary feature by which corn productivity can be determined. There is a close interconnection between the height of the plants and the vegetation period. Thus, the hybrids with a longer vegetation period have higher plants. In turn, the hybrids with a longer vegetation period have greater seed productivity. In that way, there is a direct connection between the crop yield and the plant height: the higher the plants, the more productive they are. However, nowadays there are hybrid combinations characterized by a low plant height, but a high grain yield.

The area of the corn husk plays an important role in shaping the quantity and quality of seeds in a cob. The productivity of the cob depends on the functions of the corn husk. It is found out that the larger the area of the corn husk, the higher the seed productivity

of the corn hybrids. In turn, the area of the corn husk, as well as the height of the corn plants, depend largely on the crop cultivation technology.

The number of cobs on the plant is the grading factor. However, it is highly dependent on the plant density, plant feeding area and cultivation techniques.

The height of the cob attachment is also the grading factor. It determines the suitability of plants for mechanized harvesting to a greater extent.

The mean values of morphological parameters (Table 2) demonstrate that the early-ripening Adway hybrid was most responsive to the introduction of foliar feeding at the stage of 10-12 leaves. The height of the plant at the mentioned stage was 40 cm higher than the check variant and made 264 cm.

Table 2. Morphological indicators of corn hybrids depending on the effects of foliar fertilizers (mean data in 2018-2019).

Hybrid name	check variant	Plant height, cm		Height of the cob attachment, cm		
		application of Reacom-Plus Cornat the stage of 3-6 leaves – 2l/ha	application of Reacom-Plus Cornat the stage of 10-12 leaves - 2 /ha	check variant	application of Reacom-Plus Cornat the stage of 3-6 leaves -2 l/ha	application of Reacom-Plus Cornat the stage of 10-12 leaves -2 l/ha
Adway	224	241	264	81	84	94
Vizyr	237	237	258	73	82	86

However, the greatest plant height is observed in the mid-early Adway hybrid when the fertilizer is applied at the same stage and makes 264 cm. The early-ripening Vizir hybrid shows a slight reaction to the application of Reacom-Plus Corn (2l/ha) at the stage of 3-6 leaves. The height of the plants in this case was the same as the check variant and made 237 cm. However, when applying the fertilizer at the stage of 10-12 leaves for the same hybrid, the increase in height by 21 cm is observed.

When characterizing the mean values of the height of the cob attachment to the plant, it is important to note that the application of Reacom-Plus Corn (2l/ha) at the stage of 3-6 leaves doesn't cause any significant difference from the check variant and is 3-9 cm in all hybrids on the average.

The data in Table 3 indicate that the foliar application of Reacom-Plus Corn (2l/ha) at the stage of 3-6 leaves significantly affects the cob structure.

An important indicator in the description of the crop structure is the weight of 1000 seeds. In our studies, this indicator was the highest - at the level of 300 g in the check variant. In the experimental plants the highest indicator was in the Advei hybrid when applying Reacom-Plus Corn (2 l/ha) at the stage of 3-6 leaves. The data were 313 and 373 g respectively - 10 and 22 g more than in the check variants.

Table 3. Indicators of corn yield structure depending on the impact of foliar feeding (mean data in 2018-2019).

Hybrid name	Number of rows of grains			Number of grains in a row			Weight of 1000 seeds, g		
	1*	2	3	1	2	3	1	2	3
Adway	13	18	18	31	32	32	303	313	308
Vizyr	14	14	14	38	38	43	251	273	269

1*-Check variant

2- Application of Reacom-Plus Cornat the stage of 3-6 leaves - 2 l/ha

3- Application of Reacom-Plus Cornat the stage of 10-12 leaves -2 l/ha

Table 3 shows the mean data of the yield structure indices, depending on the impact of foliar fertilizer Reacom-Plus Corn - 2 l/ha in the experimental field. These data show that the application of foliar feeding at the stage of 3-6 and 10-12 leaves differently changed the yield structure indices.

In modern conditions, in order to improve the existing technologies of corn cultivation, it is necessary to identify and optimize the level of complex action and interaction of the main components that affect the yield structure and define its parameters; to determine how single or complex factors affect the performance of such complex system as the crop census.

The main target of the modern corn hybrids at the market is to satisfy to a greater extent the agricultural producer's expectations to get high profit in this crop cultivation. In order to do this, it is necessary to understand what needs and challenges the farmer faces in his job. Some of the challenges are related to the influence of the regulated factors, actually, the cultivation technology. Technological methods of cultivation have an extremely large influence on the realization of the yield potential of the modern corn hybrids (Kolisnyk et al., 2019; Kolisnyk et al., 2020; Didur, 2019).

Raising crop yields is the main goal of most agronomic research. The success in increasing the productivity depends to a large extent on understanding the basic regularities of productive processes and how they relate to the growing conditions. As O.M. Kolisnyk stated, the yield is a function of the coaction of a number of factors, and the loss of at least one of them can reduce to nothing the effect of all others (Palamarchuk et al., 2010; Kolisnyk, 2016; Kolisnyk, 2007).

Table 4. demonstrates the mean data of the efficiency of corn hybrids, which show that the maximum yield increase was obtained by the application of Reacom-Plus Corn (2 l/ha) at the stage of 3-6 leaves in the Vizir hybrids. It made 0.98 t/ha, which was 12.66% more than in the check variants.

Table 4. Efficiency of corn hybrids, depending on the effects of foliar feeding, t/ha (mean data in 2018-2019).

Hybrid name	Cropcapacity			Yield growth to the check variant					
	1	2	3	t/ha			%		
				1	2	3	1	2	3
Adway	8.73	9.23	9.61	-	0.50	0.88	-	5.72	10.08
Vizyr	7.74	8.27	8.72	-	0.53	0.98	-	6.84	12.66

1*-Check variant

2- Application of Reacom-Plus Cornat the stage of 3-6 leaves - 2 l/ha

3- Application of Reacom-Plus Cornat the stage of 10-12 leaves -2 l/ha

It should be noted that the presence of the chelated microelements had rather positive effect on corn plants: they prolonged the vegetation period and improved the quality of seeds.

Conclusion

The influence of growing conditions, which were investigated in 2018-2019, on the course of the phenological stages of plant growth and development, on the dynamics of leaf area growth, photosynthetic potential and the level of dry matter accumulation, is reflected in the individual efficiency of corn hybrids in different maturity groups (Kolisyk et al., 2020; Palamarchuk, 2019; Ryan, 2017). As regards the highest yield, it was obtained by the application of Reacom-Plus Cornat the stage of 10-12 leaves in the mid-early Adway hybrid. It made 9.61 t/ha, which is 0.89 t/ha more than the early-ripening Vizyr hybrid, which had the lowest yield by the application at the stage of 3-6 leaves and accordingly equals 8.72 t/ha.

Consequently, the application of mineral fertilizers Reacom-Plus Corn for foliar feeding has a positive effect on the formation of the yield structure and corn yield. It facilitates its increase, both at the stage of 3-6 leaves and 10-12 leaves, however, in the second case the better results can be observed almost everywhere which is evident from the above mentioned tables.

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