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Evaluation of the Effects of Herbicides on the Weeds and the Productivity of Hybrids Maize

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Abstract. **In the early stages of maize (*Zea mays* L.) development, it is important to limit weeds that compete with maize for nutrients, moisture, light. Weed control has various methods, for example, agrotechnical, chemical. The aim of the study is to evaluate of the Effects of Weeds and Hybrids on the Productivity of Maize grain in Ukraine. The research was conducted in field conditions in 2019-2021 at the Mykolayiv National Agrarian University, which is located in the southern steppe of Ukraine. The results of the study show that weeds significantly *(P<0.05)* reduced the maize grain yield. During the grain harvesting period, the number of weeds in GS 89 decreased to 137 and 121 weeds m^{-2}. In the experiment, the predominance of early summer weeds (more than 66%) over late summer weeds (about 49%) was found. Effective weed reduction requires the use of several agrotechnical elements. Grain yield of maize hybrids increased significantly in areas where herbicides were applied. The corn hybrid 'Gran 6' was more productive. Maize hybrid *Gran 6* is 1.3 times more productive than maize hybrid *Odesskii 385 MB* in all test variants, which was also influenced by the hybrids' biological differences: maize hybrid *Gran 6* has a shorter vegetation period and is taller (on average 209.1 cm) than maize hybrid *Odesskii 385 MB*, which is 198.0 cm tall on average. Moisture consumption differed in vegetation years (2019-2021), the highest was in 2021 (70.6%), when a higher corn grain yield was also established.**

Keywords: herbicides, hybrid, maize, moisture, precipitation, weed control, yield.

I. INTRODUCTION

As the population of the planet increases, it is necessary to increase the amount of food production, i.e. to grow productive food plants, such as maize. In the world, the area of maize and its yield are increasing [1] - [4].

In order to increase the productivity of plants, it is necessary to apply the latest, improved, scientifically based technological elements, such as mineral fertilizers, hybrids, high-quality seed material, etc. [1]- [2], [4] - [9].

Maize (*Zea mays* L., diploid 2n = 20) also name Corn is a grain crop that belongs to the family *Poaceae* [1], [8], [10]. Maize is a no-residue crop that can be used for biogas production after harvesting the grain [11], because it is suitable for biogas production throughout the year [12].

Ukainian researchers A.A. Ivashchenko, S.A. Remenjuk, A.A. Ivashchenko (2018) [13] have pointed out that the problem in Ukraine is crop weediness. The number of unwanted plant seeds and vegetative reproduction organs found in the soil in the 0-30 cm layer ranges from 114 thousand units m^{-2} (in the Steppe area) up to 171 thousand. unit m^{-2} (in the forest steppe). Weed seeds of the *Chenopodioideae* family are the most abundant in the soil - 51.8-62.7%.

If weeds are not limited, maize cannot grow, which can even lead to a complete loss of yield, because, for example, in Latvian conditions, at the beginning of corn growth (in May and June), the air temperature is too low to promote rapid corn growth, whereas it does not slow down the growth of weeds [14]. Crops can be protected from weeds by using appropriate herbicides [15] - [17]. From an environmental protection point of view, it is better to use herbicides after the germination of corn and weeds, when the qualitative and quantitative composition of weeds is visible [14].

The aim of the study is to evaluate of the Effects of Weeds and Hybrids on the Productivity of Maize grain in Ukraine.

II. MATERIALS AND METHODS

Annual crop – maize (Zea mays L.) from *Poaceae* family – was tested in the locations and under the

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conditions described in Table 1. Trials are set up in the southern steppe of Ukraine.

TABLE 1 TRIAL METHODS OF THE MAIZE (2019-2021)

Parameters	Trial	
	Designation/ units	***Results, size, quantity***
Soil type	Black soil of southern Ukraine, heavy loam	
Soil composition	pH	6.8
	OM, % (deep 0-30 cm)	2.9 (Tyrin's method)
	P, mg kg^{-1}	8.5 (DL method)
	K, mg kg^{-1}	18.0 (DL method)
Trial plots [18]	m^2	100
Replication	Number	3
Hybrids	Variety	Odeskii 385 (Одесский 385 MB) (FAO 380) Gran 6 (Гран 6) (FAO 260)
Hydro-thermal coefficient	HTC	0.7-0.8
Agro-chemicals	Herbicide	Maister Pover ® OD, dispersion in oil Laudis ® 30 WG, a water dispersible granule

The agrochemicals were given to the maize in the five leaf phase (GS 15) [19]. In the study, herbicides were used according to the manufacturer's instructions. Herbicide active substances [20, 21]:

- *Maister Pover* ® OD (foramsulfuron – 31.5 g L^{-1}, iodosulfuron-methyl-sodium – 1.0 g L^{-1}, metil-tienkarbazon – 10.0 g L^{-1}, cyprosulfamide (phytoprotecteur) - 15.0 g L^{-1}).
- *Laudis* ® 30 (tembotrione 200.0 g kg^{-1}, isoxadifen 100.0 g kg^{-1}).

Maize grains were harvested at the maturity stage (GS 89), when the kernels are hard and shiny. The yield is determined at a standard humidity of 14%.

The weeds were determined according to the method of the Institute of Grain Farming of the Ukrainian Academy of Sciences by superimposing 0.25 square meters of accounting frames along the largest diagonal, (0.5 m x 0.5 m) at 4 points of each of the two incompatible repetitions.

The weeds' dry matter determination method - quantitative - by weight, which determines the number of weeds (pieces m^{-2}), their dry and wet weight per unit area (g m-2). Weed plants are cut and weigh. Dry weeds indoors or outdoors until the humidity naturally decreases (when plants are bent, they break). Dry until mass doesn't change (air-dry state). Quantitative method (30 days after maize sowing) - determination of the quantitative composition and quantitative-weight method, taking into account the above-ground biomass of weeds in the air-dry state before harvesting (i.e., based on 1 m^2 of field).

The obtained research results were processed using the software and information complex PIK "Agrostat" [22].

III. RESULTS AND DISCUSSION

In the southern steppes of Ukraine, an important factor shaping plant productivity is the provision of moisture. Accumulation of soil moisture in the 0.00-0.05 m soil layer increases plant productivity [23]. The accumulation of moisture reserve in the 0.00-1.00 m soil layer during the germination of corn hybrids was not the same in the research years:

- In 2019 - 127 mm,
- In 2020 - slightly smaller (120 mm),
- In 2021 - 130 mm (optimal).

Precipitation in the form of rain during the growing season of corn hybrids provided plants and soil with 174.6 mm, 266.2 mm and 180.7 mm (2019-2021) (Table 2). From the soil 2019-2021 116.0, 111.0 and 105.0 mm of moisture were used in the years. In general, the total water consumption in 2019 was 290.6 mm or 2906 m^3 ha^{-1}, but in 2021 it reached 3772 m^3 ha^{-1}.

TABLE 2 TOTAL WATER CONSUPTION OF PLANTS IN A MAIZE TRIALS

Year	Moisture spent, m^3 ha^{-1}		
	Precipitation	***Soil***	***In total***
2019	1746	1160	2906
2020	1807	1050	2857
2021	2662	1110	3772
Year	**The humidity used, %**		
	Precipitations	***Soil***	***In total***
2019	60.1	39.9	100
2020	63.2	36.8	100
2021	70.6	29.4	100

Precipitation consumption differed in vegetation years (2019-2021), the highest was in 2021 (71%) (Table 2, Table 3), when a higher corn grain yield was also established (Table 4). In order to obtain an adequate yield, it is important to ensure an adequate amount of moisture during the maize vegetation period, especially during the critical periods of crop growth and development [4], [8], [24]. Water deficit can also cause decreased grain number in ears [12].

TABLE 3 WATER CONSUMPTION COEFFICIENT FOR MAIZE HYBRIDS, $M^3\ HA^{-1}$

Hybrid (Factor A)	Year	Herbicide (Factor B)		
		None (control)	***Maister Pover***	***Laudis***
Odesskii 385 MB (A1)	2019	1446	751	852
	2020	2164	1171	1293
	2021	1182	598	615
	average	1598	840	920
	± compared to controls' average	0	-758	-678
Gran 6 (A2)	2019	1105	563	612
	2020	1721	879	940
	2021	922	479	522
	average	1249	641	691
	± compared to controls' average	0	-608	-558
P_{05}	**Year**	$\mathbf{F_A}$	$\mathbf{F_B}$	$\mathbf{F_{AxB}}$
	2019	0.15	0.20	0.32
	2020	0.01	0.04	0.04
	2021	0.05	0.07	0.11

The indicator of the efficiency of the selected agrotechnical techniques is the yield of the crop. One of the reasons for yield reduction is weed contamination [25]. The results of the study show that weeds significantly ($P<0.05$) reduced the corn grain yield (Table 4). Analyzing (Table 4) the grain yield of maize hybrids, it can be seen that the productivity was affected by the contrasting weather conditions, the degree of weed pollution, the biological characteristics of the hybrids and the characteristics of herbicides.

For the maize hybrid *Odesskii 385 MB*, the grain yield in 2021 was 2.4 times higher than in 2020 (Table 4), and for the corn hybrid *Gran 6* – 2.5 times (control field where no herbicides were used). For the hybrid *Odeskii 385 MB* trials, where the herbicide *Maister Pover* was used, the yield increase in 2021 compared to 2020 was 2.6 times, and where the herbicide *Laudis* was used, the increase was 2.8 times. For hybrid *Gran 6* trials where the herbicide *Maister Pover* was used, the yield increase in 2021 compared to 2020 was 2.4 times, the same increase was observed where the herbicide *Laudis* was used.

TABLE 4 GRAIN YIELD OF HYBRID CORN, $T\ HA^{-1}$

Hybrid (Factor A)	Year	Herbicide (Factor B)		
		None (control)	***Maister Pover***	***Laudis***
Odeskii 385 MB	2019	2.01	3.87	3.41
	2020	1.32	2.44	2.21
	2021	3.19	6.31	6.13
	average	2.17	4.21	3.92
	± compared to controls' average	0.00	+2.04	+1.75
Gran 6	2019	2.63	5.16	4.75
	2020	1.66	3.25	3.04
	2021	4.09	7.87	7.22
	average	2.79	5.43	5.00
	± compared to controls' average	0.00	+2.64	+2.21
P_{05}	**Year**	$\mathbf{F_A}$	$\mathbf{F_B}$	$\mathbf{F_{AxB}}$
	2019	0.13	0.16	0.23
	2020	0.02	0.03	0.04
	2021	0.06	0.07	0.10

Maize hybrid *Gran 6* is 1.3 times more productive than maize hybrid *Odeskii 385 MB* (Table 4) in all test variants. This could be explained by the biological differences of the hybrids, since the maize hybrid *Gran 6* has a shorter vegetation period (Table 1) and is taller (on average 209.1 cm) than the corn hybrid *Odeskii 385 MB*, which is on average 198.0 cm tall. Maize yield and height are influenced by factors such as hybrid and year, as well as the interaction of these two mentioned factors [12]. However, the hybrid effect cannot be attributed only to the genetic differences between the hybrids, as each hybrid had different growth conditions (moisture, temperature, etc.) during the defined development phases, which also affected productivity.

In the experiment (Table 5), the predominance of early summer weeds (more than 66%) over late summer weeds (about 49%) was found. In the corn trials carried out in 2019-2021, weeds characteristic of the south of Ukraine were found:

- Annual weeds - *Chenopodium album* L., *Amaranthus retroflexus* L., *Sinapis arvensis* L., *Setaria glauca* L., *Echinochloa crus-galli* L.
- The most common was *Ambrosia artemisiifolia* L., which is classified as a quarantine weed (or invasive) in Ukraine.
- Perennial weeds – *Convolvulus arvensis* L., *Cirsium arvensis* L., *Sonchus arvensis* L., *Elytrigia repens* L.

In the research conducted in Latvia that *Cirsium arvense* L., *Vicia* spp. and perennial *Sonchus arvensis* L. are common (>40% of fields) in corn crops [26]. In the maize hybrid trials (Table 5), the level of weed invasion depended on the agro-meteorological conditions of the vegetation year, plant development phases and the use of herbicides.

TABLE 5 WEEDNESS OF MAIZE HYBRIDS AR DIFFERENT PHASES OF DEVELOPMENT

Hybrid	**Maize development phase**	**Herbicide, number m^{-2}**		
		None (control)	***Maister Pover***	***Laudis***
Odeskii 385 MB	GS 15	154	17	19
	GS 89	137	19	20
	± compared to controls' GS 89	0	-118	-117
Weed air - dry matter, g m^{-2}	GS 89	436	50	54
Gran 6	GS 15	142	15	16
	GS 89	121	16	18
	± compared to controls' GS 89	0	-105	-103
Weed air - dry matter, g m^{-2}	GS 89	418	47	50

During the maize development phase, 154 and 142 weeds m^{-2} were found in GS 15 control plots (without herbicides), but during the grain harvesting period, the number of weeds in GS 89 decreased to 137 and 121 weeds m^{-2} (Table 5), i.e. by 11% and 15%. The use of herbicides also reduced the number of weeds per m^{-2}: *Maister Pover* - by 87%, *Laudis* - by 85%.

It is important to improve corn cultivation technologies on farms [12]. In the future, the response of the hybrid genotype to different agrotechnical methods and agro-climatic conditions should be studied more.

IV. CONCLUSIONS

The trial years (2019-2021) differed in moisture availability, which affected the productivity of corn hybrids. The best provision of soil moisture and rainfall was in 2021, which also contributed to the increase in maize grain yield compared to 2019 and especially 2020.

Maize hybrid *Gran 6* is 1.3 times more productive than maize hybrid *Odesskii 385 MB* in all test variants, which was also influenced by the hybrids' biological differences: maize hybrid *Gran 6* has a shorter vegetation period and is taller (on average 209.1 cm) than maize hybrid *Odesskii 385 MB*.

Perennial weeds characteristic of the south of Ukraine were found in the corn trials conducted 2019-2021 annual. The level of their invasion depended on the agro-meteorological conditions of the vegetation year, the phases of plant development and the use of herbicides.

The number of weeds in maize fields depends on the phase of development of maize. On control plots (without herbicides), this indicator decreased from the development phase of GS 15 to GS 89 in maize hybrids Odessa 385 MV and Gran 6 by 11 and 15%, respectively. The use of herbicides also reduced the number of weeds per m^{-2}: *Maister Pover* - by 87%, *Laudis* - by 85%.

To increase the productivity of corn crops in the south of Ukraine, the technology model, where is used the *Gran 6* hybrid and sprayed the agrophytocenosis with herbicide *Meister Power*, to reduce the weeds in of the maize fields is more effective.

Effective weed reduction requires the use of several agrotechnical elements.

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