

## EVALUATION OF RESISTANCE OF SELF-POLLINATED MAIZE LINES TO THE PATHOGEN OF COMMON SMUT DURING ARTIFICIAL INFECTION IN BUKOVYNA

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**Topicality.** In agricultural production, the urgent issue of combining maize yield and resistance to various environmental stress factors needs to be addressed. In Bukovyna, the most common disease affecting maize is common smut, caused by the pathogen *Ustilago zae* (Beckm.) Unger. In Bukovyna, the most common maize disease is the pathogen *Ustilago zae* (Beckm.) Unger. Smut affects susceptible maize hybrids the most, infecting 10–25 % of plants. Therefore, the study was conducted in an infectious nursery with artificial infection of maize ears to obtain a more accurate phytopathological assessment of breeding material (self-pollinated lines of *Zea mays* L.) exposed to the common smut pathogen (*Ustilago zae* (Beckm.) Unger). **Purpose.** To select the most resistant self-pollinated maize lines to the common smut pathogen for breeding programmes aimed at developing new hybrids. **Methods.** The research was conducted on the fields of the breeding crop rotation of the Bukovyna State Agricultural Experimental Station of the Institute of Agriculture in the Carpathian Region of NAAS, in accordance with generally accepted methods for field experiments and methodological recommendations on the artificial infection of maize ears with the causative agent of common smut. **Results.** The resistance of 58 self-pollinated lines of the collection nursery to the pathogen of common smut was assessed during 2022–2024. We found 9 (15.5 %) self-pollinated lines with high resistance to the common smut pathogen (infection rate of 0–5.0 %), 16 (27.5 %) resistant lines (infection rate 6.0–25.0 %) and 28 (48.2 %) moderately resistant lines (infection rate 26.0–50.0 %). **Conclusions.** As a result of the assessment, highly resistant samples of self-pollinated lines to common smut infection were selected and included in the breeding programme for the development of new hybrids adapted to the growing conditions in Bukovyna.

**Key words:** selection, maize, line, artificial infection, common smut, infection, group of resistance

**Introduction.** The South-Western Forest-Steppe, in particular Bukovyna, is one of the conventional maize-growing regions of Ukraine.

Modern maize hybrids have high yield potential, which is not fully realized in production due to their insufficient resistance to major diseases.

Losses of maize grain due to the harmful effects of phytopathogens average 9.4 %, and this indicator in Ukraine ranges from 19–25 % and above [5].

In each soil and climate zone, maize is affected by 10–15 disease pathogens and damaged by pests. Pathogens that cause diseases of seedlings, roots, stems, ears, and leaves have a detrimental effect on the crop. The diseases affect the generative and vegetative organs of maize plant, leading to drooping ears, stem breakage, and lod-

ging of the entire plant [6].

Breeding programs are faced with the challenge of combining plant productivity with their resistance to various environmental stress factors, i.e., increasing the adaptive potential of agricultural crops [4].

The fact that maize is increasingly grown as a monoculture contributes to this, as it leads to the accumulation of pathogens in the soil.

In Bukovyna, the most widespread disease affecting maize is common smut, caused by *Ustilago zae* (Beckm.) Unger. The disease causes the most damage to susceptible hybrids, affecting 10–25 % of plants. During the growing season, the fungus can produce 3–5 generations. The number of such repeated cycles depends on weather conditions. High temperatures and

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**Fig. 1. Common smut on maize in the breeding field of Bukovyna State Agricultural Research Station.**

periodic droughts are most favourable conditions for the development of common smut. Uneven rainfall increases the development of the disease, while systematic sufficient moisture, as well as prolonged droughts limits smut.

Maize is most susceptible to the disease during the period from silking stage to grain filling. Damage to plants by pests and mechanical injury during soil tillage also contribute to the spread of common smut [1, 6].

The volume of crop losses is influenced by the number, size, and location of galls on a single plant. Large galls cause losses of about 60 % or more, medium-sized galls cause losses of 25 %, and small galls cause losses of 10 % [7].

The most effective method of controlling this disease is to search for effective sources of resistance that meet the requirements of breeders and producers.

In the process of breeding work, the station conducts selection of resistant source material of maize at all stages of the breeding process, starting with the collection nursery of lines and ending with the nursery for competitive variety testing of hybrids.

The research was aimed at selecting the most resistant self-pollinated maize lines to the

Artificial infection of upper ears of maize

pathogen of common smut (*Ustilago zae* (Beckm.) Unger) and developing new hybrids adapted to the climate conditions of Bukovyna.

**Materials and Methods.** The research was conducted on the fields of the breeding crop rotation at the Bukovyna State Agricultural Research Station of the Institute of Agriculture in the Carpathian Region of NAAS.

The soil in the breeding crop rotation was heavy loamy meadow chernozem. The humus content in the arable layer was 3.5 %, and the content of available forms of nutrients (mobile phosphorus, exchangeable potassium, nitrogen) was average.

Maize seeds were sown on a plot of 4.9 m<sup>2</sup> using the dotted method at the optimal dates for the region. The plant density was 50,000 plants/ha. Standards were sown every 20 samples.

The agricultural technology used for growing maize is generally accepted for the region and is aimed at optimizing plant growth and development. The experiments were conducted in accordance with methodological recommendations [8].

with the causative agent of common smut was carried out according to the method of H. V. Hrysenko and Ye. L. Dudka [9].

For artificial infection with the causative agent of common smut, a spore suspension was prepared from the local population. Artificial treatment was carried out by injecting 2–3 ml of an aqueous spore suspension solution with a concentration of 0.2 % into the ears. One upper ear on 10 plants of each sample was infected. Infection was carried out on the seventh day from the beginning of the appearance of pistils. Registration was carried out 30 days after infection.

The degree of infection of maize ears by common smut was determined as a percentage of the total number of plants recorded, and the following resistance groups were identified: highly resistant plants – infection within 0–5.0 %; resistant – 6–25.0 %; moderately resistant – 26.0–50.0 %; susceptible – 51.0–75.0 %; over 75.0 % – highly susceptible plants.

**Results and Discussion.** Weather conditions during the years of the experiments differed significantly from the long-term average in terms of precipitation and its distribution, as well as temperature regime, which allowed us to differentiate maize samples according to their resistance to common smut.

Thus, the growing season in 2022 was characterized by elevated air temperatures and a deficit of precipitation. The average daily air temperature was 17.8 °C (compared to the long-

term average of 15.4 °C), which is 2.4 °C higher than the long-term average, and the precipitation deficit was 17.9% (Table 1).

In 2023, temperatures were higher than

**Table 1. Air temperature during the maize growing season (2022–2024)**

Month	Average daily air temperature, °C			Long-term average, °C
	2022	2023	2024	
April	9.4	8.2	13.3	8.3
May	17.3	15.8	17.6	14.5
June	21.6	20.1	22.0	17.4
July	22.0	22.3	23.8	19.2
August	21.8	23.1	23.2	18.6
September	14.4	19.3	18.3	14.2
During growing season	17.8	18.1	19.7	15.4

the long-term average, and precipitation was 63.5 mm (14.3 %) lower than the long-term average. The hottest year was 2024, when the difference between the average daily temperature and the long-term average was 4.3 °C, and the precipitation deficit for that year was 3.7%. Over the years of research, precipitation

fell most unevenly during the growing season. For example, April 2023 was characterized by significant waterlogging, with precipitation exceeding the long-term average by two times (Table 2).

According to years of research, May was the driest month, with precipitation 5.0, 6.4, and 3.3 times lower than the long-term average, res-

**Table 2. Precipitation during the maize growing season (2022–2024)**

Month	Precipitation, mm			Long-term average precipitation, mm
	2022	2023	2024	
April	27.5	113.0	72.7	57
May	14.6	11.4	21.9	73
June	118.0	76.9	104.4	89
July	84.2	90.4	82.6	94
August	50.1	60.1	54.3	74
September	70.3	28.7	91.8	57
During growing season	364.7	380.5	427.7	444

pectively. In 2022 and 2024, June was characterized by significant waterlogging. Excessive precipitation was recorded in 2022 (118.0 mm compared to the long-term average of 89.0 mm) and in 2024 (104.4 mm compared to the long-term average of 89.0 mm), where on June 1 and 4, precipitation (67.6 mm) accompanied by squally winds and hail led to partial flooding of crops (Fig. 2).

Low precipitation was observed in August 2022–2024 (32.3 %, 18.8 %, and 26.6 %, respectively) and in September 2023 (49.6 %) compared to the long-term average. The stressful conditions of the 2023 growing season were most favourable for the infection of maize lines with the common smut pathogen.

In 2022–2024, in an infectious nursery, the resistance of maize lines from the collection

nursery, including standard lines F2, 990 zS, and Uch 52 SV, to smut was studied by artificially infecting ears. Depending on the genotype, self-pollinated lines showed varying degrees of resistance to this disease. According to the results of the studies, the lines were divided into 5 different groups according to their resistance, depending on the degree of damage (Table 3).

In 2022, 16.7 % of samples were classified as highly resistant: Uch 1/20, Uch 7/20, Uch 8/20, and the standard line Uch 52 SV. The group of resistant lines included Uch 3/20, Uch 5/20, Uch 10/20, Uch 11/20, Uch 13/20, and Uch 15/20. The largest number of lines studied was classified as moderately resistant (38.9 %), including the standard lines F2 and 990 zS.

In 2023, the largest number of samples stu-



**Fig. 2** Breeding field of Bukovina State Agricultural Research Station after heavy rains with hail.

**Table 3.** Distribution of self-pollinated maize lines into groups of resistance to common smut under artificial infection (2022–2024)

Material	Year	Resistance group (number of infected plants, %)				
		highly resistant (0–5 %)	resistant (6–25%)	moderately resistant (26–50 %)	susceptible (51–75 %)	highly susceptible (> 75 %)
Self-pollinated maize lines of the collection nursery	2022	16.7	33.3	38.9	11.1	0
	2023	10.0	25.0	55.0	5.0	5.0
	2024	20.0	25.0	50.0	5.0	0

died belonged to the moderately resistant group (55.0 %), as well as the F2 and 990 zS standard lines. The resistant group included the lines Uch 1/22, Uch 8/22, Uch 17/22, and Uch 20/22, while the highly resistant group included the lines Uch 15/22 and Uch 16/22.

In 2024, the highly resistant group included the lines Uch 1/22, Uch 5/22, Uch 15/22, and Uch 17/22, while the resistant group included the lines Uch 6/22, Uch 8/22, Uch 20/22, Uch 23/22, and Uch 24/22. The largest number of lines under study, including standard lines, was classified as moderately resistant (50.0 %). Based on the results of the studies, lines from

the susceptible group (51.0–75.0 % infection) and highly susceptible group (>75 % infection) to common smut were excluded from the selection process. Nine self-pollinated lines that are highly resistant to the common smut pathogen, sixteen resistant lines, and twenty eight moderately resistant lines were selected for further breeding process to develop new hybrids adapted to the conditions of Bukovyna.

**Conclusion.** As a result of the research, the lines most resistant to common smut (*Ustilago zae* (Beckm.) Unger) infection were identified, which will be used in the selection of hybrids resistant to this pathogen.

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UDC 633.15:631.52:632

**Томаш Л. В., Микуляк І. С., Лінська М. І., Козак Г. В., Карп Т. Я. Оцінка стійкості самозапилених ліній кукурудзи до збудника пухирчастої сажки при штучному зараженні в умовах Буковини. Зернові культури. 2025. 9 (1). 70–74.**

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**Актуальність.** В аграрному виробництві гостро стоїть питання вирішення проблеми поєднання врожайності і стійкості кукурудзи до різних стресових факторів навколишнього середовища. В умовах Буковини найпоширенішою хворобою кукурудзи є пухирчата сажка збудник – *Ustilago zae* (Beckm.) Unger. Найбільшої шкоди вона завдає при вирощуванні сприйнятливих гібридів, уражаючи 10–25 % рослин. Для оцінки стійкості селекційного матеріалу (самозапилених ліній кукурудзи *Zea mays* L.) до дії збудника пухирчастої сажки (*Ustilago zae* (Beckm.) Unger). Дослідження проводили в інфекційному розсаднику при штучному зараженні качанів. **Мета досліджень.** Відібрати найбільш стійкі до збудника пухирчастої сажки самозапилені лінії кукурудзи, для включення їх у програми схрещування при створенні нових гібридів. **Методи.** Дослідження проводили на полях селекційної сівозміни Буковинської державної сільськогосподарської дослідної станції Інституту сільського господарства Карпатського регіону НААН, згідно із загально визначеними методиками проведення польового дослідження, методичними рекомендаціями щодо штучного зараження качанів кукурудзи збудником пухирчастої сажки. **Результати.** Впродовж 2022–2024 рр. зроблено оцінку стійкості 58 самозапилених ліній колекційного розсадника до збудника пухирчастої сажки. Виділено 9 (15,5 %) високостійких самозапилених ліній (ураження 0–5,0 %), 16 (27,5 %) стійких (ураження 6,0–25,0 %) та 28 (48,2 %) – середньостійких ліній (ураження 26,0–50,0 %). **Висновки.** За результатами оцінки толерантності самозапилених ліній до ураження пухирчастої сажкою виділені високостійкі зразки: які включені в програму селекції нових гібридів адаптованих до умов вирощування на Буковині.

**Ключові слова:** селекція, кукурудза, лінія, штучне зараження, пухирчата сажка, ураженість, група стійкості