UDC 633.15/.17:632.95:631.811.98 https://doi.org/10.31867/2523-4544/0339

EFFICIENCY OF PRE-SOWING TREATMENT OF MAIZE AND SORGHUM SEEDS

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Topicality. *Maize and sorghum seedlings are damaged by a number of phytophages, among which the most dangerous is the Elateridae family. Integrated pest management, along with other steps, includes pre-sowing seed treatment. In the best case scenario, complex formulations that simultaneously control pests and pathogens should be chosen for seed treatment. However, there are practically no such products in the List of Permitted Pesticides. Thus, scientific substantiation of the feasibility of using tank mixtures containing insecticides, fungicides and substances with other physiological effects (immune stimulation, growth regulation, etc.) is required.* ***Purpose.*** *To study the agrotechnical efficiency of pre-sowing seed treatment (encrustation) with formulations of different spectrum of action for controlling click beetles larvae in maize and sorghum crops of the Northern Steppe of Ukraine.* ***Materials and Methods.*** *The research was conducted at the experimental plots of the Plant Protection Laboratory at State Enterprise Institute of Grain Crops NAAS. The pre-sowing seed treatment (incrustation) of the maize hybrid DN Khortytsia and grain sorghum variety Yarona with a tank mixture of formulations including Cruiser 350 FS insecticide, Maxim XL 035 FS fungicide and Vermystym growth regulator was conducted. The following methods were used: laboratory and field methods to determine the damage degree of seedlings, statistical methods to perform analysis of variance of yield data.* ***Results.*** *The best results among the studied formulations and their mixtures were obtained when the tank mixture of insecticidal, fungicidal and growth-regulating action was used for seed treatment, which provided technical efficiency up to 70–75 % and an increase in maize grain yield of 1.90 t/ha and sorghum grain yield of 2.40 t/ha.* ***Conclusions.*** *In the growing season 2019–2021, the highest protective capacity (seedling death rate – 2.3–4.0 %) and technical efficiency of 70–75 % was shown by the mixture of formulations: Cruiser 350 FS + Maxim XL 035 FS + Vermystym in all weather conditions. The synergy of active ingredients contributed to the preservation of 1.90 t/ha of maize grain and 2.40 t/ha of sorghum grain.*

Key words: *maize, sorghum, larvae of click beetles, weather conditions, efficiency of formulations, grain yield*

Introduction. Maize and sorghum seedlings are damaged by cutworms, Oscinella frits, flea beetles, click beetles, blackflies and other phytophages. The most dangerous during this period are the larvae of the click beetles (wireworms). They eat away at the seed embryo and endosperm; damage the underground part of the stem, and as a result, the plant density decreases. The economic injury threshold (EIT) for wireworms is 3–5 insects per m^2 [1–3].

The harmfulness of the larvae of the click beetles depends on a number of factors, including soil, climatic and weather conditions. For example, when the air temperature rises in winter, the number of insects decreases. At the same time, sufficient moisture is critical for the development of eggs of these insects, so drought in May–August and dehydration of the topsoil also have a negative impact on their development [4–6].

According to the Ukrainian Hydrometeorological Centre, the average long-term hydrothermal coefficient (HTC) in the Steppe zone is 0.9, but over the past 15 years this indicator has dropped to 0.78, indicating an increase in the temperature in the region. As a result of the global warming, the area under drought-resistant crops, in particular grain sorghum, is expanding. Sorghum is considered pest-resistant due to its characteristic morphological, physiological and biochemical traits. However, sorghum is injured by the same pests as maize and, as a result, in most cases requires crop protection based on environmental factors, phytophage species, agricultural practices, etc. [7, 8].

Given climate changes, adjustments to the structure of crops, migration of soil biota in the zonal dimension, further improvement of chemical control of wireworms during seed germination and in the early stages of growth and de-

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velopment of grain crops is required.

Materials and Methods. The research was conducted on the experimental field of the State Enterprise Institute of Grain Crops of NAAS of Ukraine (Dnipropetrovsk region) during 2018–2021. Agricultural technology in the experiments was recommended for the Steppe zone, except for the techniques studied. The mid-early maize hybrid DN Khortytsia (FAO 240) and the mid-ripening grain sorghum variety Yarona were grown. Winter wheat was used as a predecessor.

The experimental design included pre-sowing seed incrustation with the insecticide Cruiser 350 FS (thiamethoxam, 350 g/l) belonging to the group of nicotinic acetylcholine receptor antagonists, systemic and contact fungicide Maxim XL 035 FS (fludioxonil, 25 g/l + metalaxyl, 10 g/l) belonging to the phenylpyrrole and phenylamide class, and plant growth regulator Vermystym (an organic and mineral complex). The full experimental design is shown in the Table 1. The research was conducted in accordance with generally accepted methods and recommendations in crop production [9–13].

The soil of the experimental plots is a full-profile medium loamy chernozem on loess with the following content in the arable layer: humus – 3.72 %, total nitrogen – 0.20 %, phosphorus – 0.12 %, potassium – 2.1 %. The soil solution reaction is close to neutral (pH of the aqueous suspension is 6.75).

Results and Discussion. It was found that the effectiveness of pre-sowing treatment of maize and grain sorghum seeds with formulations of different spectrum of action is largely affected by the weather conditions in spring and the duration of the period from sowing to full seedlings of the crop. In 2019, a nearly monthly rainfall of 28 mm fell from 15 to 20 April, which allowed seeds to be embedded in moist soil. Moderate temperature regime and periodic rainfall during May resulted in the timely emergence of full-formed seedlings, contributed to the enhanced growth and development of plants. Therefore, the harmfulness of wireworms was relatively low: 7.8–9.2 % died in the control variants, while in the protected crops this indicator decreased to 4.6–5.6 %.

In contrast, soil moisture deficit was observed in spring 2020, combined with dramatic changes in day and night air temperatures and slow soil warming, led to a significant increase in the duration of the sowing – seedling period. The wireworms carry out vertical migration within local foci, allowing them to better adapt to changes in the hydrothermal regime of the arable soil layer, damage seeds and seedlings even at low pest populations and unfavourable weather conditions. Therefore, the number of lost plants increased to 11.6–17.0 % in the control and to 6.1–8.5 % after pre-sowing inoculation compared to 2019.

In 2019, there was no significant difference in the effectiveness of the products between crops. On average, 7.0 % of maize seedlings and 9.9 % of sorghum seedlings died during the long pre-emergence period in 2020. This difference is explained by the limited genetic potential of small seeds of sorghum, lower germination energy and delayed seedlings emergence by 2–4 days compared to maize.

The assessment of the protective capacity of chemicals allowed us to identify a variant using a three-component mixture of insecticide, fungicide and growth regulator, at which the level of effectiveness was 70–75 %. This pattern was observed on both crops in different weather years.

In 2019, the grain yield of maize was 4.70–7.02 t/ha (Table 1). The high yields were obtained as a result of the meteorological situation during the period from 1 to 10 July (tasseling stage), when 55.8 mm of precipitation fell, which allowed the plants to largely realise their potential. However, sorghum crops were less productive (3.63–5.07 t/ha) due to the lack of agronomically viable precipitation in the period from 8 June to 2 July and from 9 July to 3 August. In contrast, the average yield of maize was 3.75 t/ha and of sorghum was 5.68 t/ha in 2020, which is explained by the peculiarities of water consumption of plants, as well as the amount, nature and timing of precipitation. Favourable year for both maize and sorghum was 2021, primarily associated with rainy weather during the growing season.

Precipitation was 350 mm in the period from May to August, which was 171 % of the long-term average. As a result, yields of maize were 6.41–8.23 t/ha and of sorghum – 4.56–8.09 t/ha, respectively.

A direct correlation between the protective capacity of the formulations and the yield

Table 1. Yield of maize and grain sorghum depending on pre-sowing seed incrustation with different formulations, t/ha

Variant	Maize				Sorghum			
	years				years			
	2019	2020	2021	average	2019	2020	2021	average
Control (no seed treatment)	4.70	2.77	6.41	4.63	3.63	4.25	4.56	4.15
Cruiser 350 FS	6.66	4.07	7.24	5.99	4.47	5.99	6.40	5.62
Maxim XL 035 FS	6.43	3.60	7.35	5.79	3.62	5.74	6.02	5.13
Vermystym	5.53	3.62	7.21	5.45	3.47	5.44	6.18	5.03
Maxim XL 035 FS + Vermystym	6.71	4.11	7.38	6.06	4.49	6.08	7.63	6.07
Cruiser 350 FS + Maxim XL 035 FS + Vermystym	7.02	4.33	8.23	6.53	5.07	6.50	8.09	6.55
LSD_{05}		0.31			1.1	0.31		

Notes*. Application rates for maize: Cruiser 350 FS – 7 l/t, Maxim 035 FS – 1 l/t, Vermystym – 6 l/t; for sorghum – 4, 5 and 6 l/t, respectively.*

of field crops was also established. A high increase in grain yield compared to the control was obtained in the variants with pre-sowing seed incrustation with Cruiser 350 FS insecticide and a mixture of Maxim XL 035 FS fungicide and Vermystym growth regulator (maize – 1.36–1.43 t/ha, sorghum – 1.47–1.92 t/ha). In the case of using Maxim XL 035 FS and the growth regulator Vermystym, the increase in main products decreased to 0.98–1.16 and 0.82–0.88 t/ha, respectively. The highest yields were recorded for the crops with seed treated with a mixture of Cruiser 350 FS + Maxim XL 035 FS + Vermystym. The combination of active ingredients with different spectrum of action contributed to an additional 1.90 t/ha of maize grain and 2.40 t/ha of sorghum grain on average in 2019–2021.

Conclusions. The degree of damage caused to cereal crops by wireworms was determined by the toxicological capacity of formulations for pre-sowing seed incrustation, biological characteristics of plants and weather conditions during the growing season. In favourable hydrothermal conditions for timely seedlings (10–12 days in 2019), the harmfulness of wireworms was insignificant: 7.8–9.2 % of maize and sorghum seedlings died in the control variant, and 4.6–5.6 % in the variants with seed incrustation. Given a pre-emergence period of 20–23 days (2020), this indicator reached 11.6–17.0 and 6.1–8.5 %, respectively. Over the years of research, the average number of dead sorghum plants was 1.4 times higher than that of maize. In terms of plant protection, the best results were obtained when the seed was encrusted with a mixture of an insecticide (Cruiser 350 FS), a fungicide (Maxim XL 035 FS) and a growth regulator (Vermystym). Their effectiveness was 70–75 %.

The years 2019 and 2021 were favourable for high productivity of maize (4.70–7.02 and 6.41–8.23 t/ha, respectively), and 2020 and 2021 were favourable for sorghum (4.25–6.50 t/ha and 4.56–8.09 t/ha). The year 2020 was difficult for maize (soil and atmospheric drought in August) and 2019 was difficult for sorghum (soil water deficit, lack of agronomically valuable precipitation during critical stages of plant growth). The highest average crop yields were recorded in the variants where the seeds were treated with a mixture of formulations (insecticide + fungicide + growth regulator). The synergy of different active ingredients provided an additional 1.90 t/ha of maize grain and 2.40 t/ha of sorghum grain.

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УДК 633.15/.17:632.95:631.811.98

Семенов С. С. Ефективність допосівної обробки насіння кукурудзи та сорго.

Зернові культури. 2024. 8 (2). 251–254.

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Актуальність. Сходам кукурудзи й сорго шкодить ціла низка фітофагів, серед яких найбільш небезпечною вважається родина коваликів (*Elateridae*). Інтегрований захист від них, поряд із іншими заходами, передбачає проведення допосівного протруювання насіння. У довершеному варіанті для обробки зерна слід обирати комплексні препарати, які одночасно діють на шкідників і збудників хвороб. Однак у «Переліку дозволених для застосування пестицидів» такі практично відсутні. Виникає необхідність наукового обґрунтування доцільності використання бакових сумішей у складі інсектицидів, фунгіцидів та речовин, що мають інші фізіологічні ознаки (стимуляція імунітету, ріст регуляція, тощо). **Мета досліджень.** Вивчення агротехнічної ефективності допосівної інкрустації насіння препаратами різного спектру впливу з метою захисту посівів кукурудзи й сорго від личинок коваликів у Північному Степу України. **Матеріали і методи.** Дослідження проводились на експериментальних майданчиках лабораторії захисту рослин ДУ ІЗК НААН України. Була передбачена допосівна інкрустація насіння гібрида кукурудзи ДН Хортиця і сорту сорго зернового Ярона баковою сумішшю препаратів у складі інсектициду Круїзер 350 FS, фунгіциду Максим XL 035 FS та регулятора росту Вермистим. Використовували: лабораторно-польові методи для визначення ступеня пошкодження проростків, статистичний – для виконання дисперсійного аналізу урожайних даних. **Результати.** Встановлено, що серед препаратів які досліджувалися і їх сумішей кращі результати отримали у випадку застосування для протруювання насіння баковою сумішшю препаратами інсектицидної, фунгіцидної і рістрегулюючої дії, яка забезпечила технічну ефективність на рівні 70–75 % і приріст урожайності зерна кукурудзи – 1,90 т/га, зерна сорго – 2,40 т/га. **Висновки.** Незалежно від погодних умов вегетаційного періоду 2019–2021 рр. найвищу захисну спроможність (загибель проростків – 2,3–4,0 %) і технічну ефективність 70–75 % виявила суміш препаратів: Круїзер 350 FS + Максим XL 035 FS + Вермистим. Синергія діючих речовин сприяла збереженню 1,90 т/га зерна кукурудзи і 2,40 т/га зерна сорго.

Ключові слова: *кукурудза, сорго, личинки коваликів, погодні умови, ефективність препаратів, урожайність зерна*