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# EFFICACY OF BIOLOGICAL AND CHEMICAL SEED TREATMENTS FOR SUSTAINABLE MAIZE CROP PROTECTION

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***Abstract***

*This study evaluates the efficacy of maize seed treatments to identify environmentally friendly crop protection solutions and reduce reliance on toxic chemical pesticides. Conventional products (Signal, Redigo Pro) and organic treatments (Bioseed, Biosem, Raiza Mix) were tested during 2024 at ARDS Turda (Transylvanian Plateau) and ARDS Brăila (Romanian Plain). Requiem Prime and Repel Aves, typically used as foliar repellents, were experimentally tested as seed treatments. The experiments were conducted on Turda 344 and Harmonium hybrids, respectively, analyzing seedling emergence dynamics, pest resistance, yield, hectoliter weight, and 1000-kernel weight. At ARDS Turda, Repel Aves (250 ppm) showed the highest emergence and yield increases (20-25%) under drought conditions, while higher concentrations (1000 ppm) caused phytotoxicity. At ARDS Brăila, Requiem Prime (250 ppm), Redigo Pro, and Signal achieved the best results, with high yields and superior quality. Organic treatments like Bioseed and Biosem showed intermediate performance, while untreated seeds had the weakest results. The study highlights biological seed treatments as effective and sustainable alternatives, enhancing yield and resilience to climatic stressors while supporting eco-friendly agriculture.*

***Key words****: biological treatments, climatic conditions, seed treatment, sustainable agriculture, yield.*

## INTRODUCTION

Romania's temperate-continental climate and nutrient-rich soils create favorable conditions for agriculture, making it a vital sector in many parts of the country. Maize stands out as the dominant grain crop, in terms of cultivated area and overall production. Protecting crops against pests and abiotic stress represents a major challenge for farmers, especially in the context of climate change and the need to reduce the use of conventional pesticides. In this context, innovative seed treatments based on diverse active substances are essential to ensure optimal crop development and to reduce losses caused by pathogens and pests.

Given this, testing commercial and experimental products with insecto-fungicidal effects has become a priority. Field experiments began with the evaluation of commercial products with bird-repellent effects, which were initially used for treating crops during vegetation rather than for seed treatment. The main reason for this research direction was to identify a solution to the problem of biologically treated maize seeds, which birds often consume before they have a chance to germinate (Georgescu et al., 2024).

Methyl anthranilate is a natural aromatic compound recognized for its repellent effect against birds and insects (Mason et al., 1989; Avery & Decker, 1994; Avery et al., 1995; Mason & Clark, 1995; Blackwell et al., 2001). According to research conducted by Avery et al. (1998), this substance has the ability to deter birds from consuming seeds, thereby protecting crops during the early stages of development.

Products based on organic substances and plant extracts have gained popularity as a sustainable alternative to conventional pesticides. Terpenes act as natural repellents (Plata-Rueda, 2020). They work by interfering with the olfactory system of insects, disrupting their ability to detect hosts or food sources. The strong aroma of these compounds masks attractive chemical signals or produces a disorienting effect, causing insects to avoid treated areas (Boncan et al., 2020). Tabanca et al. (2013) highlighted that the terpenoid p-Cymene, when used alongside other terpene compounds, demonstrated high efficiency in repelling phytophagous insects such as mosquitoes and grain beetles.

In Romania, most commercial products for treating maize, sunflower, wheat/autumn cereals, and rapeseed seeds against diseases and pests are chemically synthesized. These include: pyrethroid insecticides designed to combat soil pests (e.g., *Agriotes* spp., *Melolontha melolontha, Tanymecus dilatic*ollis, etc.), fungicides for cereal seed treatment targeting pathogens such as *Cochliobolus* sp., *Fusarium* sp., *Septoria* sp., *Tilletia* sp., *Ustilago* sp., etc., insecto-fungicides formulated as concentrated microcapsule suspensions.

Combined fungicides that contain two active substances with different modes of action and activity spectrum.

These products can be either non-systemic or systemic, contact-based, or repellent, with limited assimilation and translocation of the active substance within the plant.

Only a few biological seed treatment products are available on the market, and most are based on plant extracts or mixtures containing neem oil, organic matter, microorganisms, humic acids, and fulvic acids.

The objective of these experiments was to evaluate the efficiency of various seed treatments applied to maize seeds in order to protect crops and optimize their yield under different agro-pedoclimatic conditions.

## MATERIALS AND METHODS

The research was conducted in 2024 at A.R.D.S. Turda and A.R.D.S. Brăila, located in two distinct agricultural regions, each with different soil and climatic conditions. This allowed for a detailed comparative evaluation of the effectiveness of the treatments applied to the maize crop.

At A.R.D.S. Turda, situated in the Transylvanian Plain, the soil is classified as vertic clay-illuvial soil, with a loamy-clay texture, neutral pH, and good to very good phosphorus and potassium availability. The soil has a medium humus content and is prone to rapid compaction under high moisture conditions or the action of heavy machinery.

In this context, the research was conducted under climatic conditions characterized by high temperatures and severe drought. The 2024 agricultural year recorded significant temperature deviations from the multiannual average, and a major rainfall deficit, particularly in June (-48.4 mm below the multiannual average), negatively impacted crop development.

In the Turda experiment, the Turda 344 hybrid was used, with a sowing density of 57,000 plants/ha.

Plant emergence was monitored at three different intervals:

- 10 days after sowing (14.05.2024),
- 24.05.2024, and
- 05.06.2024.

Simultaneously, assessments were conducted on damage caused by pests and diseases, including wireworms (*Agriotes* sp.), crows, cutworms (*Agrotis segetum*), and rotting plants.

The harvested yield was evaluated in kg/ha. The experiments conducted at A.R.D.S. Brăila aimed to achieve the same objectives but under different agro-pedoclimatic conditions. The predominant soil type in this area is a cambic chernozem, characterized by high fertility but prone to rapid moisture loss.

The 2024 climate in this region was marked by extreme temperatures and severe rainfall deficits. Although total precipitation reached 471 mm, slightly above the multiannual average, its uneven distribution required the implementation of special strategies to protect crops from water stress.

In this experiment, the Harmonium hybrid was used, with the same sowing density of 57,000 plants/ha as in the Turda experiment. The treatment variants applied were identical to those used at Turda.

At Brăila, parameters related to plant emergence and pest or disease attacks were not monitored. The evaluation focused exclusively on the following parameters:

- Number of cobs/10 m²;
- Harvest moisture content (U%);
- Hectoliter mass (HM);
- Thousand Grains Weight (TGW, g);

- Grain yield (%) (the ratio of kernel weight to total ear weight, excluding the cob - rachis);
- Production (kg/ha).

***The products used in the applied treatments***. For seed treatment and stimulation of maize crop development, several market-available products with different roles were used: a fungicide based on cypermethrin 300 g/L (Signal 300 ES) applied at 2 L/t, a biostimulant based on plant extracts and beneficial microorganisms (Raiza mix) applied at 2 L/t. To protect roots against diseases and promote soil health, the product Mycoforce was used at 100 g/t, a mixture containing mycorrhizal fungi, *Trichoderma* sp., and *Bacillus* sp.

The experiment also included products based on organic substances and plant extracts. Requiem Prime, with the active substance containing 152.3 g/L of a terpenoid mixture (α-terpinene: 59.7%; p-cymene: 22.4%; d-limonene: 17.9%), and Repel Aves, based on methyl anthranilate (30%), are products intended for plant protection, although they are not approved for seed treatment. The inclusion of these products in the experiment aimed to evaluate their potential repellent effect against birds, as well as their insecticidal and fungicidal properties. These products were applied at doses of 125, 250, 500, and 1000 ppm (µL active substance per kg of seed). Prior to planting, germination tests (25°C/7 days) (Cojanu et al., 2024) were conducted on seeds treated with the experimental products Requiem Prime and Repel Aves at different concentrations. For the experiment conducted at S.C.D.A. Brăila, two additional products designed to support plant development and improve resistance to biotic and abiotic stress conditions were tested: BioSeed (10 L/t), based on plant extracts, plant and fruit oil, and Biosem (10 L/t), which includes a complex of microelements, plant extracts, neem oil, organic matter, microorganisms, *Trichoderma* fungi, humic acids, and fulvic acids. In the experiment at A.R.D.S. Turda, three replications were established for each treatment, while at A.R.D.S. Brăila, four replications were conducted, with each replication covering an area of 10 m².

***Statistical analysis***. The data obtained from the evaluation of plant emergence were subjected to statistical analysis using GraphPad Prism software version 7.05. The Shapiro-Wilk test was used to verify the normality of the data distribution, and the Levene test was employed to assess the homogeneity of variances. Subsequently, to highlight significant differences between treatments and evaluation periods, the ANOVA test was applied. For comparison of differences between treatments, the Tukey test ($p< 0.05$) was used to identify groups of treatments that showed significant differences between them. Values are presented as mean (arithmetic average) ± standard deviation (SD) for each treatment variant, evaluation period, and evaluated parameter.

## RESULTS AND DISCUSSIONS

At A.R.D.S. Turda, plant emergence was monitored at three distinct stages: 10 days after sowing (14.05.2024), on 24.05.2024, and on 05.06.2024 (Table 1). Statistical analysis revealed significant differences between treatments and between evaluation periods. The ANOVA test indicated a p-value < 0.0001, confirming the existence of statistically significant differences between the mean values of emerged plants across the three evaluated periods.

Table 1. The emergence of plants from treated maize seeds (Mean ± SD)

| Variants | 14.05.2024 (Mean± SD) | 24.05.2024 (Mean ± SD) | 05.06.2024 (Mean ± SD) |
|---|---|---|---|
| Control | 42.0 ± 0.0 | 30.3 ± 7.4 | 28.0 ± 3.6 |
| Requiem Prime 125 ppm | 42.0 ± 0.0 | 27.7 ± 5.1 | 30.3 ± 2.1 |
| Requiem Prime 250 ppm | 42.0 ± 0.0 | 27.7 ± 4.9 | 30.7 ± 2.5 |
| Requiem Prime 500 ppm | 42.0 ± 0.0 | 19.7 ± 8.6 | 25.0 ± 1.7 |
| Requiem Prime 1000 ppm | 42.0 ± 0.0 | 29.3 ± 5.0 | 28.7 ± 5.8 |
| Repel Aves 125 ppm | 42.0 ± 0.0 | 27.3 ± 6.1 | 26.0 ± 3.5 |
| Repel Aves 250 ppm | 42.0 ± 0.0 | 32.0 ± 5.1 | 32.7 ± 2.1 |
| Repel Aves 500 ppm | 42.0 ± 0.0 | 27.3 ± 4.4 | 27.3 ± 2.3 |
| Repel Aves 1000 ppm | 42.0 ± 0.0 | **4.3 ± 1.2** | **2.3 ± 1.5** |
| Raiza mix | 42.0 ± 0.0 | 26.7 ± 6.7 | 22.7 ± 5.7 |
| Mycoforce | 42.0 ± 0.0 | 28.0 ± 3.6 | 25.3 ± 3.9 |
| Signal 300 ES | 42.0 ± 0.0 | 29.0 ± 5.0 | 30.0 ± 3.1 |

According to the Tukey test, the applied treatments produced varied results. The variant treated with Repel Aves 250 ppm recorded the highest emergence rates in all evaluation stages, with an average of 42.32 ± 5.1 and 32.7 ± 2.1 emerged plants, respectively. In contrast, the variant treated with Repel Aves 1000 ppm showed a significant decrease in the number of emerged plants, with an average of 4.3 ± 1.2 at the evaluation on 24.05.2024 and only 2.3 ± 1.5 at the final evaluation on 05.06.2024.

Treatments with Raiza mix and Requiem Prime 500 ppm also recorded lower emergence rates compared to other variants, suggesting a possible negative influence on seed germination under the specific conditions of 2024.

The multiple comparison test (Tukey) highlighted significant differences between the results obtained at the evaluation period on 14.05.2024 compared to the subsequent periods. The effectiveness of the treatments was significantly higher in the 14.05.2024 evaluation compared to 24.05.2024 ($p = 0.0044$) and 05.06.2024 ($p = 0.0005$).

This indicates an important influence of the evaluation timing on the results, particularly for treatments that showed superior emergence rates in the first evaluation.

Regarding the rotted plants (Table 2), the Repel Aves 1000 ppm variant recorded the highest values, with a very large number of rotted plants in all replications (37-38 plants), indicating a high susceptibility to rotting and a negative effect of this treatment. The Mycoforce variant showed low values for rotted plants, with 0 to 3 plants affected, suggesting a protective effect against rotting. The multiple comparison Tukey test highlighted significant differences between treatments. The variant treated with Repel Aves 1000 ppm recorded significantly more rotted plants compared to the control ($p < 0.0001$) and compared to the treatments with Mycoforce, Raiza mix, Repel Aves 125 ppm, and Repel Aves 250 ppm ($p < 0.0001$). This result indicates that treatments with Repel Aves 125 ppm and Repel Aves 250 ppm demonstrated superior efficiency in preventing plant rotting.

Regarding the wireworm (*Agriotes* sp.) attacks (Table 2), the infestation was minor, with most variants recording a low number of affected plants (between 1 and 5). However, the variant treated with Repel Aves 250 ppm showed the best effect compared to the other variants, followed by the treatment with the chemical product Signal.

The crow attacks (Table 2) in the Repel Aves 250 ppm variant appeared to be the lowest, indicating that the product is effective in preventing crow attacks, fulfilling its primary purpose and contributing to the success of the crop. Alternative treatments that demonstrated promising effects in this regard include Requiem Prime at 125 ppm and 250 ppm.

The lowest values of cutworm (*Agrotis segetum*) attacks were recorded in the variant treated with Requiem Prime 250 ppm, followed by Repel Aves 250 ppm. Raiza mix and Mycoforce recorded slightly higher values, with up to 5 plants attacked by cutworms, indicating a lower level of protection against this pest.

Table 2. The influence of maize seed treatment (Turda 344 hybrid) on the number of plants attacked by diseases and pests

| Variants | No. of rotten plants (Mean ± SD) | No. of plants attacked by wireworms (*Agriotes* sp.) (Mean ± SD) | No. of plants attacked by crows (Mean ± SD) | No. of plants attacked by turnip moth (*Agrotis segetum*) (Mean ± SD) |
|---|---|---|---|---|
| Control | 5.0 ± 1.0 | 1.67 ± 0.58 | 6.0 ± 2.65 | 1.33 ± 1.53 |
| Requiem Prime 125 ppm | 3.0 ± 1.0 | 2.0 ± 1.0 | 4.33 ± 0.58 | 2.33 ± 0.58 |
| Requiem Prime 250 ppm | 3.0 ± 1.0 | 2.33 ± 0.58 | 4.33 ± 1.15 | 1.67 ± 1.53 |
| Requiem Prime 500 ppm | 5.0 ± 1.0 | 3.67 ± 0.58 | 6.0 ± 1.0 | 2.33 ± 0.58 |
| Requiem Prime 1000 ppm | 3.67 ± 3.06 | 2.33 ± 1.53 | 5.0 ± 1.0 | 2.33 ± 1.15 |
| Repel Aves 125 ppm | 4.33 ± 0.58 | 3.0 ± 1.0 | 5.33 ± 3.06 | 3.67 ± 1.53 |
| Repel Aves 250 ppm | 4.33 ± 3.21 | 1.67 ± 1.53 | 2.33 ± 1.15 | 2.33 ± 1.53 |
| Repel Aves 500 ppm | 4.0 ± 1.0 | 3.33 ± 1.53 | 7.67 ± 1.15 | 2.33 ± 1.15 |
| Repel Aves 1000 ppm | 37.33 ± 0.58 | 1.33 ± 0.58 | 0.33 ± 0.58 | 0.67 ± 1.15 |
| Raiza mix | 2.67 ± 0.58 | 3.0 ± 2.65 | 10.33 ± 3.06 | 3.33 ± 1.53 |
| Mycoforce | 1.33 ± 1.53 | 3.67 ± 1.53 | 8.33 ± 2.52 | 3.33 ± 3.06 |
| Signal 300 ES | 3.33 ± 2.08 | 1.67 ± 1.15 | 4.67 ± 1.53 | 2.33 ± 2.08 |

Regarding maize production, the One-way ANOVA test indicated the presence of significant differences between treatments ($p < 0.0001$). The Tukey multiple comparison test confirmed that the treatment with Repel Aves 1000 ppm recorded a significantly lower yield compared to the control ($p = 0.0094$) and the treatments with Mycoforce, Raiza mix, Repel Aves 125 ppm, and Repel Aves 250 ppm ($p < 0.001$). This result suggests a potential incompatibility of this treatment with the Turda 344 hybrid.

The treatments with Repel Aves 125 ppm and Mycoforce also recorded high average yields, indicating a positive effect on production. The Raiza mix treatment showed good values, although slightly lower than the most effective variants, suggesting a moderate yet consistent efficacy.

These results indicate that the choice of seed treatment can significantly influence the yield of the Turda 344 maize hybrid, with the Repel Aves 250 ppm variant appearing to be the most suitable option for optimizing the yield of this hybrid (Table 3).

Table 3. Production results obtained from the experience with maize seed treatments (Turda 344 hybrid)

| Crt. nb. | Variants | Production (kg/ha) (Mean ± SD) |
|---|---|---|
| 1 | Control | 3858.67 ± 130.86 |
| 2 | Requiem Prime 125 ppm | 4486.0 ± 536.61 |
| 3 | Requiem Prime 250 ppm | 4671.67 ± 893.29 |
| 4 | Requiem Prime 500 ppm | 4766.67 ± 1334.67 |
| 5 | Requiem Prime 1000 ppm | 4126.0 ± 875.65 |
| 6 | Repel Aves 125 ppm | 5336.33 ± 577.62 |
| 7 | Repel Aves 250 ppm | 5798.33 ± 547.26 |
| 8 | Repel Aves 500 ppm | 4822.67 ± 742.03 |
| 9 | Repel Aves 1000 ppm | 1067.0 ± 502.33 |
| 10 | Raiza mix | 5263.0 ± 536.54 |
| 11 | Mycoforce | 4764.33 ± 710.02 |
| 12 | Signal | 4007.67 ± 1249.23 |

At A.R.D.S. Brăila, the application of different treatments to maize seeds (Harmonium hybrid) resulted in significant differences for certain evaluated parameters, while for others, the treatment effects showed no statistically significant variations.

The number of cobs per 10 m² showed similar values across all treatment variants ($p > 0.05$), except for the treatments with Repel Aves 1000 ppm, which differed significantly ($p = 0.03$) from the Raiza mix treatment. Lower values recorded for Biosem (39 ± 5.57) and Raiza (36 ± 4.0) indicate a lower efficacy of these treatments in this regard (Table 4).

Regarding harvest moisture, the differences between treatments were also significant ($p < 0.01$), with the lowest values observed in the treatments with Bioseed and Raiza, confirming the positive impact of these products on reducing harvest moisture. The lowest moisture values were recorded for Bioseed (14.47 ± 0.35), Raiza (14.67 ± 0.47), and Requiem Prime 125 ppm (15.78 ± 0.64), which is favorable for improving storage efficiency and reducing drying costs. Conversely, the higher values recorded for Requiem Prime and Repel Aves (up to 20.75%) may involve additional costs for moisture management.

In contrast, for the parameters hectoliter mass (HM), thousand kernel weight (TGW), and grain yield (%), the statistical analysis results showed no significant differences between treatments ($p > 0.05$). The hectoliter mass values indicated superior grain quality in the variants treated with BioSeed (73 ± 1.13) and Signal (73.17 ± 0.55), suggesting good dry matter accumulation and superior grain quality. The highest TGW was recorded in the variant treated with Bioseed (327.36 ± 7.47), followed by Raiza and Signal (approximately 320 g) (Table 4), indicating optimal grain development. Lower values observed in the treatments with Requiem Prime (approximately 298-303 g) suggest reduced efficacy of these products in enhancing grain size.

Regarding grain yield, the treatments with BioSeed (89.02 ± 0.83) and Biosem (89 ± 0.21) showed the best results (Table 4), demonstrating the strong efficiency of these products in improving productivity. In comparison, the

control variant had a lower yield (88.04 ± 0.73), indicating that most treatments contributed to improving the final yield.
The average maize yields, depending on the applied treatment, ranged from 5,445 kg/ha for the untreated control to 8,848 kg/ha for the Repel Aves 125 ppm treatment. The highest yield levels were recorded for Repel Aves 125 ppm (8,848 kg/ha), Repel Aves 250 ppm (8,423 kg/ha), and Requiem Prime 1000 ppm (8,348 kg/ha). In contrast, the control exhibited the lowest average production. Although statistical tests (ANOVA and Tukey HSD) did not reveal significant differences between treatments, some variants stood out due to high production values combined with low variability among replicates, which gives them practical relevance. In particular, treatments based on Repel Aves 125 ppm and 250 ppm demonstrated an optimal balance between productivity and consistency, suggesting that these products may represent promising technological solutions for increasing maize yield.
The results obtained in this study are supported by previous research that examined the efficacy of methyl anthranilate as a bird repellent and seed treatment for protecting crops. Various studies have highlighted the potential of this compound in preventing bird attacks and improving seed emergence and plant development.
A study conducted by Dolbeer et al. (1991) demonstrated that methyl anthranilate is an effective bird repellent, significantly reducing seed consumption when treated with this compound. Tests performed in controlled environments indicated that birds actively avoided treated seeds, confirming the aversive effect of the substance. Furthermore, research conducted by Avery et al. (1998) emphasized that methyl anthranilate is a promising compound for protecting seeds from birds, particularly in maize and rice crops. The authors noted that this compound acts by triggering an unpleasant sensory reaction, causing birds to avoid treated seeds.
A study by Lacy et al. (2018) compared the efficacy of three chemical substances in protecting maize crops from bird damage. The results showed that methyl anthranilate was among the most effective treatments tested, significantly reducing seed consumption and consequently limiting economic losses. Additionally, Barzen and Ballinger (2018) analysed the application of methyl anthranilate for protecting maize and sunflower crops. In this context, treatments based on methyl anthranilate proved effective in reducing bird attacks, particularly in the early stages of crop development.
Although positive results were evident in numerous experiments, research conducted by Kaiser et al. (2021) indicated that the efficacy of methyl anthranilate decreases under improper application conditions. For instance, in sunflower crops, treatments applied directly to mature plants did not achieve the expected efficacy, as the substance did not sufficiently penetrate the vegetative structures, reducing effective contact with birds.
In this study, the application of Repel Aves 250 ppm, a product based on methyl anthranilate, demonstrated significant efficacy in protecting maize crops from bird attacks and pests. The results align with previously published data, confirming that applying this substance at moderate concentrations (250 ppm) provides effective protection without generating phytotoxic effects.
A study conducted by Drăghici et al. (2012) highlighted the positive effects of the BioSeed 3+ biostimulant on the germination of *Capsicum annuum* seeds. In this study, the application of BioSeed 3+ at the optimal concentration (C1) resulted in a 150% increase in the germination rate three days after sowing and a 92% increase after 10 days, compared to the control group. This effect was attributed to the product's ability to stimulate the rapid formation and development of the root system, contributing to vigorous seedlings. Additionally, the study emphasized that BioSeed significantly reduced the germination period, which has important economic implications by lowering energy costs for greenhouse heating.
Correlating these observations with the results of our experiment, it is evident that the BioSeed product, applied to maize seeds under the challenging climatic conditions of the 2024 agricultural year, also achieved positive results, contributing to improved plant vigor and higher yields.
Studies conducted on crops such as barley and beans highlight different behaviors of the

Biosem product, underscoring the importance of biological and agroclimatic factors in its efficacy. In barley crops, Biosem demonstrated high efficiency in combating foliar diseases when applied to seeds (Popescu and Ivan, 2024), while in bean crops, Biosem had limited efficacy against fungal diseases but showed beneficial effects in supporting plant vigor during the early growth stages (Podea et al., 2024).

Table 4. Production results for maize crop, in order to determine the quality indices under the conditions of applying seed treatments (Harmonium hybrid)

| Variants_ | Number of cobs /10 m$^2$ (Mean ± SD) | U%_ (Mean ± SD) | HM (Mean ± SD) | TKW (Mean ± SD) | Grain yeld (%) (Mean ± SD) | Production (kg/ha) (Mean ± SD) |
|---|---|---|---|---|---|---|
| Control | 44.5 ± 5.07 | 17.12 ± 1.82 | 72.4 ± 1.37 | 288.09 ± 34.34 | 88.04 ± 0.73 | 5445±864 |
| Repel Aves 125 ppm | 65.0 ± 6.38 | 17.18 ± 1.64 | 72.15 ± 0.88 | 307.01 ± 23.95 | 88.69 ± 0.29 | 8848±720 |
| Repel Aves 250 ppm | 60.67 ± 10.69 | 19.5 ± 2.15 | 71.37 ± 1.8 | 328.53 ± 37.94 | 88.38 ± 0.87 | 8423±611 |
| Repel Aves 500 ppm | 51.25 ± 18.77 | 18.77 ± 2.17 | 71.03 ± 2.24 | 345.57 ± 45.34 | 88.13 ± 1.61 | 7685±2440 |
| Repel Aves 1000 ppm | 67.0 ± 4.24 | 18.38 ± 1.22 | 72.0 ± 0.45 | 315.21 ± 31.41 | 84.8 ± 6.67 | 7763±2962 |
| Requiem Prime 125 ppm | 62.75 ± 7.23 | 15.78 ± 0.64 | 72.5 ± 0.79 | 279.4 ± 25.37 | 84.2 ± 7.15 | 7350±2152 |
| Requiem Prime 250 ppm | 62.5 ± 4.95 | 20.75 ± 0.78 | 70.15 ± 1.77 | 321.11 ± 39.44 | 86.66 ± 1.34 | 6930±2046 |
| Requiem Prime 500 ppm | 45.5 ± 22.22 | 16.95 ± 1.77 | 71.78 ± 0.62 | 286.14 ± 14.38 | 88.6 ± 0.47 | 6395 ± 2975 |
| Requiem Prime 1000 ppm | 62.75 ± 9.6 | 16.82 ± 0.95 | 72.3 ± 0.86 | 303.97 ± 32.47 | 87.4 ± 3.67 | 8348±2089 |
| Bioseed | 52.0 ± 4.58 | 14.47 ± 0.35 | 73.0 ± 1.13 | 327.36 ± 7.47 | 89.02 ± 0.83 | 6870±725 |
| Biosem | 39.0 ± 5.57 | 15.0 ± 0.96 | 72.5 ± 0.44 | 323.11 ± 12.11 | 89.0 ± 0.21 | 5807±501 |
| Raiza mix | 36.0 ± 4.0 | 14.67 ± 0.47 | 71.77 ± 0.31 | 322.25 ± 31.7 | 88.82 ± 0.27 | 6033±591 |
| Signal | 39.67 ± 14.43 | 15.27 ± 0.92 | 73.17 ± 0.55 | 320.78 ± 8.77 | 88.56 ± 0.69 | 6493±2473 |

## CONCLUSIONS

Based on the results obtained from the experiments conducted at A.R.D.S. Turda and A.R.D.S. Brăila, significant differences were observed between the treatments applied to maize seeds. The efficiency of the treatments varied depending on the location and hybrid, emphasizing the importance of adapting plant protection products to specific agroclimatic conditions and the genetic characteristics of each hybrid.

The product Repel Aves, based on methyl anthranilate (30%), demonstrated its effectiveness in protecting maize crops against crow attacks, confirming the primary purpose of the treatment - its repellent effect. This result is particularly valuable in regions where birds can cause significant losses in the early stages of vegetation. In addition, the application of Repel Aves at a concentration of 250 ppm contributed to uniform and vigorous plant emergence, suggesting a possible indirect beneficial effect on seed vigor or reduced losses in the early growth phase.

In contrast, treatments with Repel Aves (1000 ppm) showed a pronounced negative effect, with inferior results across most evaluated parameters, suggesting potential phytotoxicity or incompatibility, especially with the Turda 344 hybrid.

Treatments with Mycoforce and Raiza mix demonstrated moderate beneficial effects, showing increased efficiency in reducing plant rotting and contributing to achieving competitive yields.

The results confirm that biological treatments applied to maize seeds can serve as effective and sustainable alternatives for crop protection, promoting higher yields and reducing the negative environmental impact. Notably, the Repel Aves 250 ppm concentration proved to be the most promising option for optimizing production and protecting against pests while offering an eco-friendly solution for modern agriculture.

However, given the variability of environmental factors and potential differences between hybrids, further testing on larger areas and under diverse agroclimatic conditions is necessary to confirm the stability and efficiency of these products across different cropping scenarios.

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