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RESEARCH ON THE EFFECTIVENESS OF SOME FUNGICIDES IN COMBATING CROWN RUST OF OATS

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Abstract

Oats (Avena sativa L.) currently rank sixth in world cereal production after corn, rice, wheat, barley and sorghum. In 2021, the area cultivated with oats in Romania was 87000 ha, and the average production was 2413.8 kg/ha. The importance of oats is given by its many uses in animal husbandry, human nutrition, beer production, in the cosmetic and pharmaceutical industry, etc. In the present work they are presented the symptoms that manifested the infection with the fungus Puccinia coronata (Corda); the morphological characters of the uredospores, the spores that ensure the propagation (spread) of the disease in culture, and of the teliospores, the resistance spores through which the disease spreads over time (transmission), from one year to another; the effectiveness of tested fungicides whose active substances contain: prothioconazole 53 g/l + spiroxamine 224 g/l + tebuconazole 148 g/l; 100 g/l mefentrifluconazole+300 g/l metrafenone. The research focused on the Ovidiu variety and was carried out under natural infection conditions, during the vegetation period of 2021 in Mircea Vodă commune, Brăila county. The effectiveness of the fungicide treatments applied to the oat crop was reflected in a production increase between 265 and 365 kg/ha.

Key words*: oats, crown rust, fungicides, efficacy.*

INTRODUCTION

Plant diseases caused by infectious pathogens can seriously affect agricultural crops when climatic conditions are favorable for the emergence and development of biotic factors (Lipianu et al., 2023; Zală et al., 2023).

Initially, information about plant pathogens and the diseases they cause was addressed in the discipline of botany, but with the establishment of plant pathology as a discipline in higher education institutions, studies on this category of stressors experienced a wide development (Tronsmo et al., 2020).

Plant diseases can cause losses, in important food crops, of 13-22% of production and, for this reason, they represent one of the biggest threats to the sustainable development of society (Oerke, 2006).

Over time, farmers have focused on different approaches to promote healthy plant growth and development.

Chemical control, represented by the application of fungicides during the vegetation period, with the aim of stopping the appearance, development and transmission of pathogens and exerting an immunity inducer on the host plant, is one of the most economical and common methods of disease control plants from all control strategies.

Currently, fungicides are widely applied, thanks to their affordable price and effectiveness. However, they must be properly applied in order not to cause environmental problems due to their negative effects on soil and water quality, biodiversity and animal and human health (Burdon et al., 2020).

Climate change in Europe (average temperatures tend to increase, occurrence of late spring frosts, prolonged drought in summer, intensification of wind speeds) has a direct impact on plant pathogens in that they may survive to a greater extent high over the winter and thus produce infections of earlier crops and at higher altitudes, a fact that will be reflected in the decrease of productions, despite the application of chemical treatments (Bebber et al., 2013; Chaloner et al., 2021; Newton et al., 2011; Paraschivu et al., 2021).

The role of phytosanitary treatments, along with the other measures of an integrated management of diseases of different

agricultural crops (therefore also of oats) is to preserve their health and to ensure the achievement of potential productions while minimizing production losses (He et al., 2016).
In this context, the purpose of the research carried out in the experimental field was to combat crown rust of oats, by applying the phytosanitary treatment with the fungicides Falcon® Pro (prothioconazole 53 g/l + spiroxamine 224 g/l + tebuconazole 148 g/l) and Revystar® Flex (100 g/l mefentri-fluconazole+300 g/l metrafenone) at the optimal time, respecting the dose recommended by the manufacturers and without having a negative impact on the environment.
Foliar and ear diseases are among the most important limiting factors of cereal production in Central and Eastern Europe, including oats (Paraschivu et al., 2023; Cotuna et al., 2022).
The genus *Puccinia*, as the first recognized genus from the category of rusts, was mentioned by the botanist Micheli (1729), in an illustration of it in honor of another botanist, Tommaso Puccini (Arthur, 1928).
The genus *Puccinia* contains the largest number of species, approx. 4000, which causes rusts (Kirk et al., 2008).
Puccinia coronata Corda (1837) is a macrocyclic, heteroecious fungus with pycnial and aecial stages on the *Rhamnus cathartica* L.
Puccinia coronata Corda is a fungal pathogen that causes crown rust in oats. Worldwide there are over 290 races of *Puccinia coronata* Corda. Uredinial and telial stages of *Puccinia coronata* Corda also occur on other cultivated or wild poaceae species: rye, barley. *Elymus repens*, *E. tranchycaulus*, *Pascopyrum smithii*, *Hordeum jubatum*, *Elytrigia* spp. and *Leymus* spp. etc. (Dixon and Michel, 1964).
The uredinia of *Puccinia coronata* Corda occur on leaves, sheaths and panicles of oats in the form of pustules oblong, up to 5 mm long, and contain masses of orange-yellow spores exposed by rupture of the leaf epidermis.
Telia are mostly linear, black to dark brown, non-powdery, since they are covered by the host epidermis (Docea and Severin, 1990).
Puccinia coronata Corda is one of the most widespread and damaging oat pathogens. Crown rust affects the leaves, sheaths and panicles of oats. The disease can cause oat grain yield to decrease by 15-18%, as well as 1000-grain weight by 8-20%. At the same time, the percentage of hulls was increased by 12-24% (Šebesta, 1971).
There are studies in which the application of a treatment with a fungicide based on triadimefon, at the appearance of the first rust pustules, favored an increase in production by 10-15% (Haegermark, 1981).
Oat crown rust is widespread in all oat growing areas except very arid areas. Crown rust is more common in areas where dew often forms and temperatures are 15-20°C at night and 20-25°C during the day in the oat growing season. Infected oat plants are more sensitive to drought conditions (Simons, 1985).

MATERIALS AND METHODS

To run this experiment, application dose approved in Romania for Revystar® + 0.25 l/ha Flexity® is 0.75 l/ha. Revystar® Flex is recommended to be applied as a first treatment. The recommended time of application is from the elongation of the stem until the appearance of the standard leaf: BBCH 30-37 (Lancashire et al., 1991. Revystar® Flex is composed of Revystar® fungicide and Flexity® fungicide. The different characteristics and modes of action of the two products create a unique synergism that ensures very good control over pathogens (https://www.agro.basf.ro/ro/produse/overview/Fungicide/Revystar-Flex.html).
It is recommended to apply 1-2 terrestrial foliar treatments, preventive or curative, with the Falcon® Pro fungicide, at a minimum interval of 14 days between treatments. The application interval is between the phenophase of the beginning of straw elongation and the phenophase of the beginning of flowering (BBCH 30-61). The recommended application dose is 0.6 l/ha against the complex of foliar diseases. The solution volume was 400 l/ha. (https://www.cropscience.bayer.ro/Products/Fungicide/Falcon-Pro).
Field experiments were conducted in 2021 to evaluate fungicides efficacy Revystar® Flex and Falcon® Pro against *Puccinia coronata* fungus and impact on yields of spring oat Ovidiu variety.
Ovidiu is a spring oat variety created at the Lovrin Agricultural Research and Development Station, approved in 2019.

The Ovidiu spring oat variety is characterized by a high and stable production capacity of approx. 5000 kg/ha (https://scdalovrin.com/soiuri-hibrizi/).

The research was carried out in the oats experimental fields from Mircea Vodă commune, commune located in the central-western part of Brăila county, on the right bank of the Buzău river, at 45°7′40″ latitude and 27°22′37″ longitude, in natural conditions during the vegetation period of 2021 (https://ro.wikipedia.org/wiki/Comuna_Mircea_Vodă,_Brăila).

The soil is chernozem type, favorable for growing oats.

In addition to biotic factors, abiotic factors (temperature, precipitation, atmospheric humidity, wind speed, etc.) contribute to serious yield losses in cereals year after year (Ul Haq, et Ijaz, 2020; Cotuna et al., 2022; Paraschivu et al., 2022).

Oats are a plant of temperate climates (https://universityagro.ru/en/horticulture/oats/).

Climate is one of the dynamic components of the environment, which greatly influences the appearance of diseases (Bălașu et al., 2015).

The main climatic parameters (average temperatures and amount of precipitation) recorded during the oat vegetation period, which influence the emergence and development of *Puccinia coronata* fungus, can be found in Figure 1.

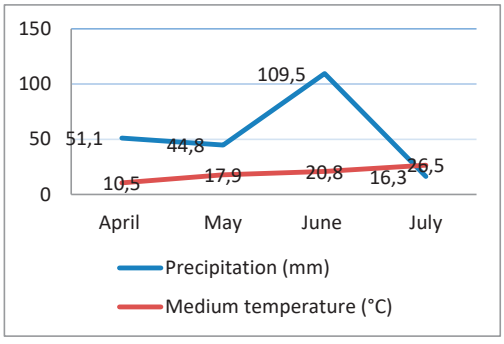

Figure 1. Average temperatures and amount of precipitation recorded in the months of April-July, Mircea Vodă commune (Brăila), 2021; Source: Meteoblue.com

The experience regarding the influence of fungicides in combating *Puccinia coronata* fungus was of a monofactorial type, with 4 variants: V1 - control variant (not treated with fungicide); V2 - treatment with Revystar® Flex; V3-treatment with Falcon® Pro; V4-treatment with both fungicides, first with Revystar® Flex, and second, after 14 days, with Falcon® Pro.

The experiment was arranged in a randomized block design, with 4 repetitions for each varianat. The harvestable surface of the plot was 50 m^2 (Săulescu and Săulescu, 1967).

Visual observation is the fastest method to identify crown rust based on symptoms shown by infected oats plants.

The value of oat crown rust attack is represented in terms of frequency (F%), intensity (I%) and degree of attack (AD%).

Attack degree was calculated using the formula (Chester, 1950):

$$AD\ (\%) = \frac{F\ (\%)\ x\ I\ (\%)}{100}$$

The efficacy of treatments with fungicides applied under field conditions in the experimental variants against the fungus *Puccinia coronata* was calculated with the Abbott formula (1925):

$$E\ (\%) = \frac{AD\ control - AD\ treated}{AD\ control} x\ 100$$

The statistical interpretation of the experimental results was carried out by analysis of variance (Fisher, 1926).

Agrophytotechnical measures from land preparation to harvesting were the same in all variants.

To highlight the role of fungicides application, it was weeded in the variants and two insecticide treatments were applied, so that weeds and pests do not influence the productions.

The microscopic preparation was visualized under the Zeiss Primo Star microscope, and to determine the dimensions of the uredospores and teliospores we used the Zen software.

RESULTS AND DISCUSSIONS

The appearance of symptoms of the disease

The first pustules with uredospores, typical of crown rust attack, appeared on oat leaves in the last decade of May, and the first pustules with

teleutospores appeared approximately one month later (Figure 2).

Figure 2. Typical symptoms of oat crown rust: above) yellow-orange, powdery uredinia; bottom) appearance of telia brown-black, covered by epidermis
Source: original (Popa A.).

Presentation of the morphological characters of the pathogen

Uredospores are spherical or oval, 20-29 x 16-24 µm, unicellular, yellowish, echinulate (Figure 3).

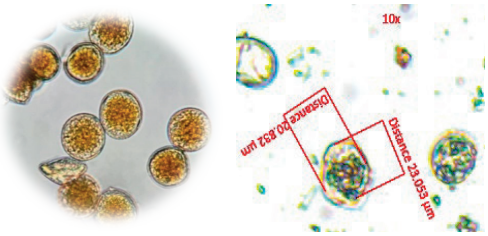

Figure 3. Uredospores of *Puccinia coronata*
Source: original (Popa A.)

Teliospores are two-celled, each cell being provided with a germination pore, reddish, short pedunculate, elongated, 35-56 x 11-20 µm, provided at the top of the apical cell with conical extensions, which give a crown appearance (Figure 4).

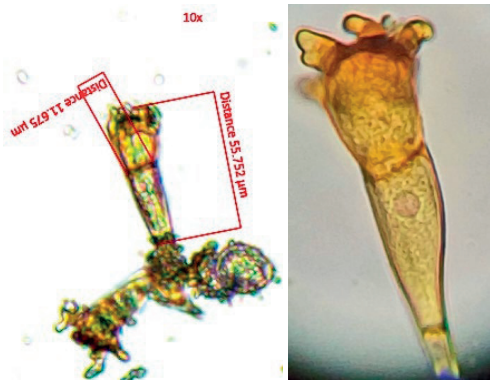

Figure 4. Teliospores of *Puccinia coronata*
Source: original (Popa A.)

The influence of fungicides in the control of crown rust in oats

The first treatment, in the variants with a single treatment, was applied at the appearance of the standard leaf.

The second treatment was applied in the phenophase at the beginning of flowering: the first visible anthers.

The observations were made two weeks after the application of the treatment.

The frequency of crown rust attack decreased from 94.25% in the control variant, to 5.75% in the variant with two treatments applied successively, respectively with Revystar® Flex and then with Falcon® Pro (Figure 5).

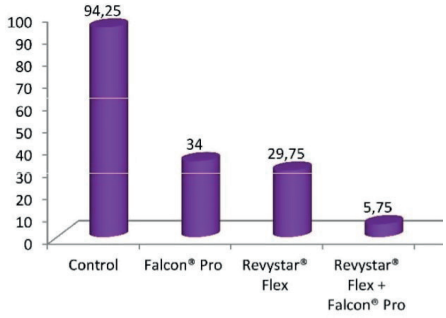

Figure 5. Frequency of crown rust attack (%)

The intensity of the crown rust attack decreased from 24.0% in the control variant, to 3.7% in the variant with two treatments applied successively, respectively with Revystar® Flex and then with Falcon® Pro (Figure 6).

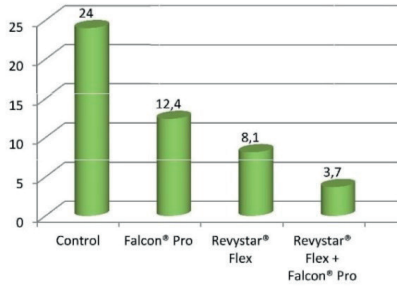

Figure 6. Intensity of crown rust attack (%)

The efficacy of the fungicides was performed based on the degree of attack calculated as a result of scoring the frequency and intensity of crown rust attack (Table 1).

The effectiveness for preventing and combating the attack of crown rust on oats, in the variants with a single treatment, varied from 81.4% (in the variant with Falcon® Pro) to 89.4% (in the variant with Revystar® Flex). In the variants with two treatments, the effectiveness of the application of these two fungicides was 99.1%.

Table 1. Efficacy of applied fungicides against *Puccinia coronata* fungus

Variant	Frequency (%)	Intensity (%)	Attack degree (%)	Efficacy (%)
Control	94.25	24.0	22.62	-
Falcon® Pro	34.0	12.4	4.2	81.4
Revystar® Flex	29.75	8.1	2.4	89.4
Revystar® Flex +– Falcon® Pro	5.75	3.7	0.2	99.1

In the variants in which one treatment with Falcon® Pro and Revystar® Flex fungicides were applied, compared to the untreated control variant, distinctly significant production increases of 2.65 q/ha and 2.88 q/ha were recorded, respectively ha, and in the variant with two treatments a very significant statistical increase of 3.65 q/ha was recorded (Table2).

Table 2. Ovidiu oat variety production, following fungicides application in 2021

Variant	Productions		Difference q/ha	Significance
	q/ha	%		
Control	45.1	100	-	-
Falcon® Pro	47.75	105.87	2.65	**
Revystar® Flex	47.98	106.38	2.88	**
Revystar® Flex + Falcon® Pro	48.75	108.09	3.65	***
DL 5%(*)=1.6 q/ha; DL 1%(**)= 2.6 q/ha;DL 0.1%(***)= 3.1 q/ha.				

CONCLUSIONS

It is very important to consult the fungicides label for the most up-to-date products information.

It is of particular importance to respect the recommended dose of fungicides application, as well as the time of application, which contributes to avoiding pollution of the environment and production, with positive effects on the health of the final consumer, animals or people.

Fungicides phytosanitary treatment represent an important part of oat production.

Effective oat crop monitoring will help farmers make the right decisions about when to apply fungicides and the number of treatments/vegetation period.

The presence of *Puccina coronata* fungus represents a risk situation in oat culture.

The frequency and intensity of the attack of crown rust negatively influenced the yield of oat crops.

Symptoms of oat crown rust were manifested only on its leaves.

Protecting against *Puccina coronata* fungus in oat field is critical to avoid production losses.

The application of fungicides favored the increase of oat production.

Thus, compared to the control variant, we recorded distinctly significant increases in production by 265-288 kg/ha in the variants in which we applied only one treatment and a very significant increase, of 365 kg/ha, in the variant with two treatments.

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