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Efficacy of Zorvec™ Encantia® fungicide for the potato late blight control: Russian experience

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SUMMARY

Efficiency of the Zorvec™ Encantia® (oxathiapiprolin + famoxadone) fungicide against potato late blight has been evaluated under epiphytotic conditions comparing to the standard Ridomil Gold MC (mancoceb + mefenoxam) fungicide. Field trials demonstrated the best protection was provided by Zorvec Encantia: the corresponding AUDPC value was equal to 90, while that for Ridomil Gold MC and untreated control reached 232 and 3244 (LSD_{95} = 67.8). Biological efficiency of the tested and standard fungicides was 97 and 93%, respectively. Potato yield for the compared variants reached 8.6, 31.4, and 33.4 t/ha for the untreated control, Ridomil Gold MC, and Zorvec Encantia, respectively. Thus, application of Zorvec Encantia provided the maximum yield increase (24.8 t/ha), while that for Ridomil Gold was 22.8 t/ha. The quality of harvested tubers assessed after a one-month storage showed that both Zorvec Encantia and Ridomil Gold MC treatments significantly reduced the tuber blight level (25.5 and 25.1%, respectively) and increased the marketable fraction of potatoes by 50 and 48%, respectively.

KEYWORDS

Phytophthora infestans, potato, late blight, oxathiapiprolin-based fungicides

INTRODUCTION

Fungi and oomycetes are the most economically important microbial pathogens of agricultural plants including such important crop as potato. Damage caused by this group of pathogens can reach 70-80% of the total global economic losses associated with microbial diseases of agricultural plants (Moore *et al.*, 2011). For potato, the most harmful pathogen from this group is *Phytophthora infestans* (Mont.) De Bary; yield and storage losses associated with this oomycete may reach up to 70–100% in the absence of any protective measures (Haverkort *et al.*, 2009). Application of fungicides still remains to be the most adopted late blight control method worldwide. The ability of the pathogen to develop resistance to the actively used fungicides necessitates the search for novel compounds able to control the late blight development via new biochemical targets.

Oxathiapiprolin (OXPT) is a novel fungicide discovered by DuPont and the first member of a new class of piperidinyl-thiazole-isoxazoline fungicides. The new fungicide showed a high activity towards a range of plant pathogenic oomycetes including different *Phytophthora* species, such as *P. capsici* (Ji and Csinos, 2015), *P. infestans* (Cohen *et al.*, 2018a), *P. citrophthora*, *P. syringae*, *P. nicotianae*, and *P. hibernalis* (Gray *et al.*, 2018). It acts at multiple stages of the pathogen's life cycle inhibiting zoospore release and zoospore and sporangia germination, blocking mycelial growth within the host plant before visible lesions occur, and preventing lesion expansion and spore production (Cohen *et al.*, 2018b). OXPT targets an oxysterol binding protein (OSBP), a member of the OSBP-related proteins family of lipid transfer proteins (Pasteris *et al.*, 2016). Lipid-binding proteins are involved in many cellular processes related with oxysterol, including signaling, vesicular trafficking, lipid metabolism, and non-vesicular sterol transport (Weber-Boyvat *et al.*, 2013); however, the exact function of OSBP in *Phytophthora* and other oomycetes still remains unknown (Miao *et al.*, 2018).

Due to a unique site of action in oomycete pathogens, OXPT did not show any cross-resistance to other fungicides. At the same time, since the compound is a single-site inhibitor, the corresponding resistance risk is assumed to be medium to high (Cohen *et al.*, 2018b). Therefore, some OXPT-based fungicides have been developed, which represent mixtures with chlorothalonil (Orondis-Opti), mandipropamid (Orondis-Ultra), mefenoxam (Orondis-Gold), or famoxadone (Zorvec-Encantia). Until recent time, only a few studies have been conducted to evaluate the efficacy of such mixtures against foliar oomycete plant pathogens; in the case of late blight, the only published study was arranged on tomato plants and included combinations of OXPT with chlorothalonil, azoxystrobin, mandipropamid, and mefenoxam (Cohen *et al.*, 2018a). At the same time, characterizing and comparing features of fungicides is critical for understanding how to use them for effective late blight disease management.

The objective of the present study was a comparative field evaluation of the efficiency of Zorvec Encantia (oxathiapiprolin + famoxadone) and Ridomil Gold MC (mancozeb + mefenoxam) fungicides against potato late blight under epiphytotic conditions in Central Russia.

MATERIALS AND METHODS

Field trial arrangement

A small-plot field trial was arranged in 2017 on the experimental potato field of the All-Russian Research Institute of Phytopathology (Moscow region). The area of each experimental plot was 42 m^2; the plots were randomly distributed across the field. Each variant was tested in four replications.

Land and field treatment

Potato (cv. Arizona) was planted on May 30 (late planting because of excess soil moisture) and harvested on September 15. The land treatment included under-winter ploughing, disking, deep ground treatment, pre-planting furrow formation, hilling, application of mineral and organic fertilizers; and a pre-emergence treatment with herbicides. During a vegetation season, the whole field was once treated with a prosulfocarb-based herbicide (2 L/ha, 18.07.2019) and thiamethoxam-based Aktara insecticide (0.06 kg/hectare).

Experimental scheme of treatment

For all experimental variants excepting the untreated control, the number of fungicide treatments was 6. The dates of fungicide treatments were Jul 11, Jul 20, Jul 31, Aug 08, Aug 16, Aug 23.

The experimental scheme included the following variants:

A) Untreated control: no fungicidal treatments.
B) Treated control: (1) Tanos, 0.6 kg/ha, (2-3) Ridomil Gold MC, 2.5 kg/ha, (4) Tanos, 0.6 kg/ha, (5-6) Shirlan, 0.4 L/ha.
C) Zorvec Encantia: (1) Tanos, 0.6 kg/ha, (2-3) Zorvec Encantia, 0.5 L/ha, (4) Tanos, 0.6 kg/ha, (5-6) Shirlan, 0.4 L/ha.

Evaluation of the disease development and crop capacity

Field observations were carried out on Jul 11, Jul 25, Aug 2, Aug 16, Aug 23, Aug 30, Sep 08, and Sep 15. The level of the early and late blight development was assessed according to the British Mycological Society scale (James, 1972). Based on the obtained data, the AUDPC values were calculated for all experimental variants according to Shaner and Finney (1977). The crop capacity (t/ha) was determined right after a manual harvesting of plots. Tuber quality assessment including the level of tuber infection and % of marketable tubers was carried out after a one-month storage of harvested potato according to Kuznetsova (2007).

Statistical analysis

The statistical treatment of the obtained data was carried out by ANOVA at the 95% confidence level.

RESULTS

A high late blight susceptibility of the cultivar used and the weather conditions of 2017 (Table 1) provided the early development of the late blight. During June and first two decades of July, air temperature was lower than average annual values, and the amount of precipitation was significant. Under such conditions, the first disease manifestations on the untreated control were observed on July 10. The further disease development was epiphytotic: in August the level of plant affection exceeded 60%, and in the beginning of the third decade plants were completely killed (Figure 1). In relation to the early blight, single leaf lesions were observed only at the end of the vegetation season (September 8), so no significant influence on the yield was registered. Under such conditions, the best protection was provided by the scheme included Zorvec Encantia. A comparison of the calculated AUDPC values showed that this variant of protection provided the maximum efficiency in the late blight control (Figure 2); the biological efficiency of this scheme and the protected control variant was 97.2 and 92.8%, respectively.

Table 1. *Weather data for the vegetation period of 2017 (Moscow region, All-Russian Research Institute of Phytopathology)*

Basic parameters	May	June	Jul	Aug
Average temperature in 2017, ºC	10.4	13.9	17.2	18.0
Average annual temperature, ºC	12.3	16.0	17.4	15.9
Relative humidity in 2017 %	61	71	74	72
Average annual relative humidity, %	68	72	67	72
Average rainfall in 2017, mm	51.0	115.1	137.6	9.6
Average annual rainfall, mm	48.7	71.5	83.1	71.3

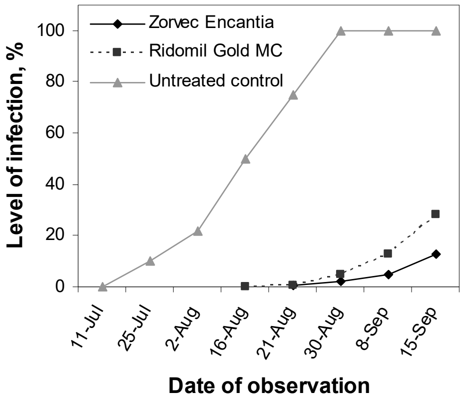

Figure 1. *Dynamics of the late blight development in the compared variants of treatment. The first disease manifestation in the untreated control was observed in the first decade of July*

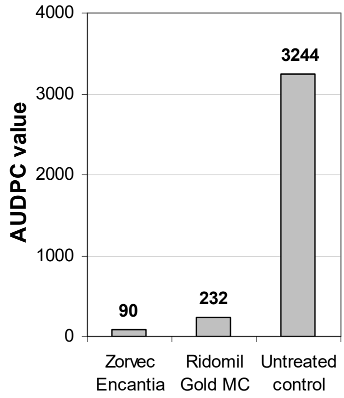

Figure 2. *AUDPC values calculated for the compared variants of treatment ($LSD_{0.95}$ = 67.8)*

The crop capacity corresponded to the late blight development dynamics in the compared variants. In the case of untreated control, it was 8.6 t/ha, whereas the treated control and Zorvec Encantia provided 31.4 and 33.4 t/ha, respectively (Figs. 3, 4). Thus, application of Zorvec Encantia fungicide provided the maximum yield increase (+24.8 t/ha) as compared to the untreated control that exceeded the same value for treated control (+22.8 t/ha). The quality of collected potatoes was evaluated after one-month storage. The level of tuber infection in both Zorvec Encantia and treated control variants was significantly lower (by 25.5 and 25.1%, respectively) than in the untreated control (Figure 5). The marketable fraction of potato in the above-mentioned protected variants was higher than in the untreated control by 50 and 48%, respectively (Figure 4).

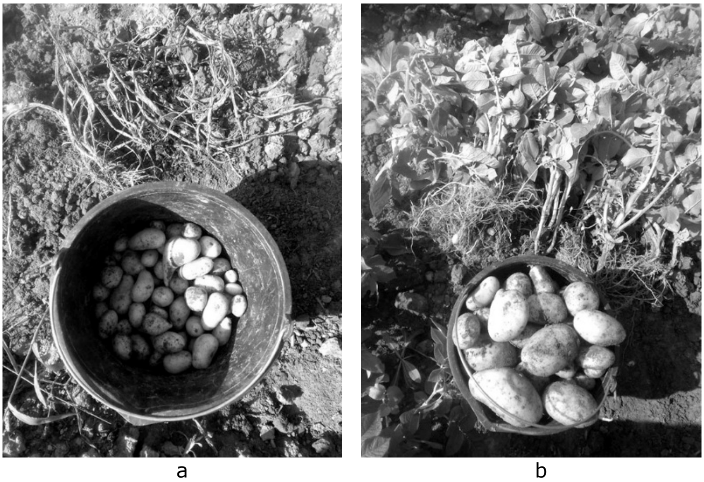

***Figure 3**. Potato yield and plant appearance (cv. Arizona) in (a) untreated (control) and (b) Zorvec Encantia-based variants of treatment. Each variant included five plants (ARRIP experimental field, Moscow region, September 2017)*

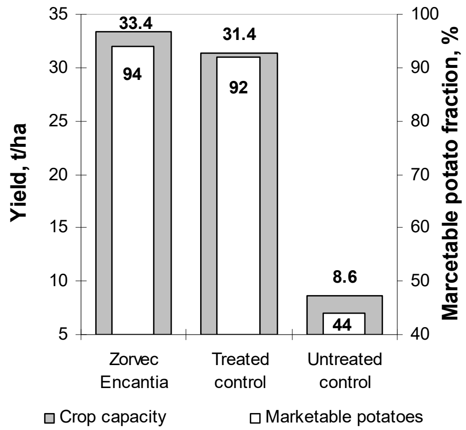

***Figure 4.** The total yield ($LSD_{0.95}$ = 5.45) and marketable fraction of potatoes ($LSD_{0.95}$ = 1.5) of the compared variants*

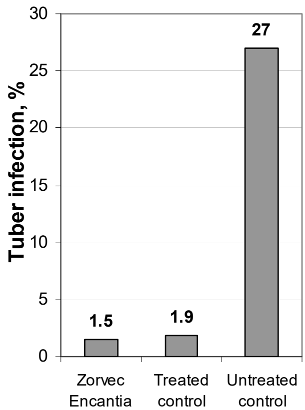

***Figure 5.** The level of tuber infection (%) in the compared variants of treatment ($LSD_{0.95}$ = 2.2)*

CONCLUSION

Both studied schemes of treatment showed high efficiency under epiphytotic conditions. Their use made it possible to extend the vegetation period and, therefore, increase potato yield and improve its quality and marketable fraction of tubers. At the same time, scheme, which included Zorvec Encantia, provided the maximum increase in the yield (+24.8 t/ha) and marketable fraction (+50%) due to its advantage over Ridomil Gold MC (+22.8 t/ha and +48%, respectively) in relation to the suppression of the late blight development.

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