

The occurrence and harmfulness *Fusarium* genus in the onion cultivation (*Allium cepa* L.)

Onion (*Allium cepa* L.) is an important vegetable crop in Poland with over 0.5 million tons produced each year. This makes Poland one of the leading onion producers in Europe. Onion is susceptible to many diseases leading to the deterioration of yield quality and quantity. This vegetable is attacked by some soil-borne pathogens such as *Fusarium* spp. One of the most dangerous onion diseases is Fusarium basal rot, which is caused mainly by *F. oxysporum*. This disease causes serious losses wherever onions are grown.

The main aim of this study was to determine the role of *Fusarium* spp. in onion cultivation. This goal was attained through characterizing the isolates of *Fusarium* collected from different fields in the wielkopolskie and kujawsko-pomorskie provinces, studying their pathogenicity and sensitivity to chemical and biological substances commonly used in plant protection against fungal diseases.

Fungal isolates to study were obtained from the roots of onion bulbs from 22 onion-growing areas and then, grown on PDA medium. The isolates were identified to species based on the morphological characters of the obtained cultures. To confirm preliminary identification a SCAR PCR (Sequence Characterized Amplified Region) analysis and partial DNA sequencing of the TEF (Translation Elongation Factor) gene were conducted. This resulted in the classification of 194 isolates as *Fusarium* spp. Obtained isolates were identified as 10 different species: *F. oxysporum*, *F. redolens*, *F. avenaceum*, *F. equiseti*, *F. tricinctum*, *F. graminearum*, *F. solani*, *F. acuminatum*, *F. culmorum* and *F. proliferatum*. The most frequent species was *F. oxysporum* (about 80% of the isolates). Genetic variability and mating types were studied for all isolates. The URP-PCR analysis showed a significant intra- and interspecific diversity among isolates from onion. Two dendrograms generated on the basis of the molecular fingerprintings. In both trees, the majority of the *F. oxysporum* isolates were clustered in the same clusters. Other groups included a mix of different isolates representing all the identified species. Based on the analysis of mating type genes, isolates were divided into two groups. One comprised 45.4% of the isolates representing the MAT-1 type (with the ALPHA domain), while the other – 54.1% of the isolates characterized as the MAT-2 type (HMG domain). The pathogenicity of *Fusarium* to onion was also investigated. For this purpose, three experiments were carried out: in the field – at the “Marcelin” experimental station in 2017 and 2018, with seedlings – in the plant growth chamber, and a laboratory study – on onion leaves. *Fusarium* isolates for analyses were obtained from onions and wheat. Two

experiments were performed in the field. In the first one, the effect of inoculation of 13 onion cultivars with two *F. oxysporum* isolates: Fo1 (from onion) and Fo2 (from wheat) was tested. In the second one, the effect of inoculation by *F. avenaceum*, *F. culmorum*, *F. graminearum* and *F. poae* isolates on the health status of onion cv. Wolska was compared. Inoculation was carried out during seed sowing. The percentage of plant mortality was considered to be a measure of the effectiveness of inoculation. The mortality was the highest (in both years of the experiment) for onions inoculated with Fo1 (*F. oxysporum* from onion), amounting to 73.0% in 2017 and 50.3% in 2018. Pathogenicity in the seedling test was determined by the effect of *Fusarium* isolates on seedling emergency. Three experiments were carried out. In the first one, the same isolates were used as in the field experiments and it was confirmed that isolate Fo1 had the highest effect on the inoculated plants (47.5% seed emergency), while the Fp (*F. poae*) isolate had the lowest impact. In the other experiments seeds were inoculated with onion isolates obtained in the first stage of study. The experiments differed in temperature. Significantly lower emergence was observed in most cases in combinations with the higher temperature. *Fusarium avenaceum* species turned out to be the most pathogenic species in both temperature variants of the experiment. In contrast, *F. solani*, *F. redolens* and *F. oxysporum* had a slightly lesser impact on plants. In the experiment, in which the pathogenicity of isolates on onion leaves was determined, it was shown that the Fg isolate (*F. graminearum*) had the greatest significant effect on plant tissue, while the Fo2 isolate (*F. oxysporum* from wheat) the least. Four fungicides (thiophanate-methyl, difenoconazole, azoxystrobin and thiuram) and 5 fungus species of the *Trichoderma* genus (*T. aureoviride*, *T. citrinoviride*, *T. hamatum*, *T. harzianum*, *T. longipilis*) were evaluated for their efficacy against the *Fusarium* species. The effectiveness of fungicides was expressed as percentage inhibition of colony growth calculated on the basis of the control colonies (colonies without fungicides treatment). Thiophanate-methyl (75.8% inhibition) was the most effective fungicide. The lowest effective treatment was that with thiuram (22.8%). The most sensitive species to the used active substances was *F. oxysporum* (62.1%), while the least sensitive – *F. tricinctum* (18.4%). Tests with biocontrol agents showed an antagonism between the *Fusarium* isolates and the *Trichoderma* species. It was found that all species of the genus *Trichoderma* reduced growth of the tested isolates at a similar and high level (> 70%). The highest individual biotic effect (IBE) index was generated by *T. citrinoviride* and *T. harzianum* isolates, especially against *F. equiseti* and *F. oxysporum*. However, the highest growth inhibition was recorded for isolates sub-cultured with *T. aureoviride* and *T. hamatum*. Among the *Fusarium* isolates, *F. graminearum* showed the weakest growth.

This research shows the common presence of *Fusarium* fungi in onion cultivation. Moreover, studies point to a high genetic variability and differences in the pathogenicity of *Fusarium* isolates depending on the species, climatic conditions and origin. The results of the research indicate a great potential for the use of natural antagonists – fungi of the genus *Trichoderma* – in the protection against *Fusarium* diseases of onion.

Keywords: *Fusarium* spp., *Fusarium oxysporum*, *Allium cepa*, onion, basal rot of onion, pathogenicity, chemical control, biological control, genetic diversity, mating types.