Crop Protection 110 (2018) 14–20

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

The effect of crop rotation and fungicide seed treatment on take-all in winter cereals in Lithuania

Jūratė Ramanauskienė*, Roma Semaškienė, Akvilė Jonavičienė, Antanas Ronis

Department of Plant Pathology and Protection, Institute of Agriculture, Lithuanian Research Centre for Agriculture and Forestry, Akademija, LT-58344, Kėdainiai distr., Lithuania

ARTICLE INFO

Keywords:
Fluquinconazole
Real-time PCR
Silthiofam
Soil inoculum
Yield

ABSTRACT

Agricultural production is increasingly based on monoculture farming in Lithuania, which inevitably exacerbates the problems caused by a rising incidence of soil borne diseases. Take-all (*Gaeumannomyces graminis*), formerly a minor disease, has become common causing substantial damage to winter wheat and winter barley. The aim of the present study was to analyze the influence of different rotation sequences on take-all occurrence and to investigate disease control options with seed treatment fungicides fluquinconazole and silthiofam during the 2014–2015 growing seasons. The total amount of *Gaeumannomyces graminis* var. *tritici* (*Ggt*) and *G. graminis* var. *avenae* (*Gga*) DNA in the roots of winter wheat seedlings grown in the soil collected from different rotations was measured. Significantly higher DNA concentrations of *Ggt/Gga* were detected in the roots of seedlings grown in the soil of winter barley monoculture, compared to the winter wheat monoculture. Comparable amount of *Ggt/Gga* DNA in winter wheat seedlings was determined in the soil of winter wheat monoculture and winter wheat after oil seed rape (OSR) in both seasons, while in the second winter wheat it was considerably lower. Higher take-all incidence and disease index were established in winter barley than in winter wheat monoculture. Nevertheless in the rotation with one-year OSR, take-all incidence and disease index were significantly reduced compared to the monoculture and second winter wheat. The highest grain yield of winter wheat in both years was achieved in the rotation with OSR. The tested seed treatment fungicides fluquinconazole and silthiofam resulted in a significant reduction in take-all occurrence and a slight increase in grain yield. The findings of this study demonstrate that the OSR was the most valuable tool for management of take-all in wheat.

1. Introduction

Take-all, caused by the fungus *Gaeumannomyces graminis* var. *tritici* (*Ggt*) and, to a lesser extent, *G. graminis* var. *avenae* (*Gga*) is one of the most damaging root diseases of winter wheat (Hornby et al., 1998; Cook, 2003). This pathogen can also affect roots of rye, triticale and barley. Cereal species differ in their sensitivity to take-all. Usually, the effect of the disease on yield is greatest for wheat and barley; while rye is more resistant to take-all (Gutteridge et al., 2003; Bithell et al., 2011). The pathogen survives parasitically in the roots during the growing season and saprophytically on plant debris after crop harvesting (Freeman and Ward, 2004). Primary infection of roots occurs by growth of the fungus from fragments to nearby roots (Brown and Hornby, 1971). During the cropping season, primary infection of seedlings roots is caused by infected residues and secondary infection from infected roots (Brassett and Gilligan, 1988; Bailey and Gilligan, 1999). Hyphae penetrate through the roots, causing symptoms of nutrient deficiency, and progress upward into the bases of stems. Symptoms of the disease are manifested as black lesions on the roots. Symptoms on above-ground parts of the infected plant include stunting, premature death and white heads (Cook, 2003; Guilleroux and Osbourn, 2004). Under certain conditions the *Gaeumannomyces graminis* can produce ascospores, which spread by rain and wind. Spores infect cereals and survive in the soil on plant debris. Usually sexual reproduction of this pathogen is considered as not important under field conditions (Murray et al., 2013; Campbell and Benson, 2011).

Take-all disease of cereals is a complex and variable biological system. Existence of the pathogens depends on the biology of the fungus, interactions with the higher plant and soil and root micro-flora (Gilligan et al., 1994). Influence on grain yield and grain quality components depends on timing of the disease (Shoeny et al., 2001). Take-all can affect yield and quality of the grain as a result of decreased grain-filling caused by premature ripening (Gutteridge et al., 2003; Bithell et al., 2011). Breeding varieties with resistance to take-all is the most promising way to protect cereals, but no effective resistance has been identified so far (Gutteridge et al., 2003; Yang et al., 2011). The

* Corresponding author.
E-mail address: jurate.ramanauskiene@lammc.lt (J. Ramanauskienė).

https://doi.org/10.1016/j.cropro.2018.03.011
Received 22 September 2017; Received in revised form 21 March 2018; Accepted 22 March 2018

most important cultural practice used to control take-all is crop rotation. Other cultural practices that influence take-all severity include sowing date, tillage practices, application of fertilizers, and grass weed control (Freeman and Ward, 2004). For inoculum of *G. graminis* var. *tritici* the major factors which influenced disease development on plants is cropping history, pre-crop infection and the amount of inoculum decay (Hornby, 1998). Usually, depending on weather and soil conditions, disease severity is higher in the second wheat or barley crop after break crops, while lower in the first (Cromey et al., 2006). Different break crops differ in their capacity to maintain the take-all fungus through the break year and allow the disease to increase to damaging proportions in the following crops. According to Hornby et al. (1998), second crop of wheat after oilseed rape (OSR) are often at greater risk take-all damage than second crop of wheat after other break crops. The soil may become suppressive to take-all in the case of long-term wheat monoculture (Hornby, 1979; Weller et al., 2002). Through repeated cropping of cereals, disease severity often increases to a peak over 2–4 years, after which take-all decline (TAD) takes place naturally and low symptom levels are then recorded as long as monoculture continues (Cook, 2003). This decline may result from effects on the pathogen, the host or the balance of antagonistic microflora in the soil (Bateman et al., 1997; Rengel, 1997; Hornby, 1983). General soil suppression increases with increasing microbial biomass in the soil (Weller et al., 2002).

Effective take-all control is slow to implement because the disease occurs in patches and epidemics can progress at different rates in different parts of the same field (Asher and Shipton, 1981; Freeman and Ward, 2004). Seed-treatment fungicides have the potential to decrease the losses caused by take-all. In the past, chemical control of take-all in wheat has been ineffective (Jenkyn and Prew, 1973; Prew and McIntosh, 1975). Since the end of the last century, two fungicides with different modes of action, fluquinconazole (trade name Jockey) and silthiofam (trade name Latitude) have become available for use as seed-treatments for controlling take-all (Löchel et al., 1998; Beale et al., 1998; Shoeny and Lucas, 1999).

The aim of the present study was to analyze the influence of different rotation sequences on take-all severity in Lithuania and to investigate two disease control options, fluquinconazole and silthiofam.

2. Materials and methods

2.1. Crop rotations experiment

The study was carried out at the Institute of Agriculture, Lithuanian Research Centre for Agriculture and Forestry during the 2013/2014 and 2014/2015 cropping seasons. The influence of different rotation sequences on take-all severity was investigated using four field trials: winter wheat (grown as a monoculture since 2005); winter barley (grown as a monoculture since 2004) (barley monoculture field was poor-drained, which led to long-term waterlogging); winter wheat after a one-year break crop (OSR); second winter wheat (winter wheat after winter wheat) (Table 1). Before the experiment (since 2011) spring barley was grown in winter barley monoculture field. In winter wheat rotations was a loam texture of soil and in winter barley was a loam sandy. Planting rate for winter wheat was 450 seeds m^2 and that of winter barley, 420 seeds m^2. Non-treated seeds and conventional plant protection practices were used in this experiment (Table 2). Six plots (5 × 5 m) in each field were marked for disease assessment.

2.2. Disease assessment in field experiments

Assessments of the severity of disease were done in crop rotations experiment for estimation of disease levels in different rotations and in field trial to study the effects of seed-treatment fungicides fluquinconazole and silthiofam. Ten 20-cm rows were dug from each plot along two parallel zigzags transects at growth stage (GS) 75 (Zadoks et al., 1974). The roots of 100 plants were washed and the percentage of take-all affected root area assessed. Assessment was based on a scale of 0–4: 0 (a) = no disease; 1 (b) = slight take-all (1–10% of root system affected); 2 (c) = slight take-all (11–30% of root system affected); 3 (d) = moderate take-all (31–60% of root system affected); 4 (e) = severe take-all (61–100% of root system affected) (Bithell et al., 2012). The number of plants in each category was used to derive a take-all index (TAI):

$$TAI = (0a + 10b + 30c + 60d + 100e) / T$$

where a, b, c, d and e represent the respective number of plants in each of the five infection categories, and T is the total number of assessed plants (a + b + c + d + e). The incidence of take-all was calculated as the percentage of infected plants in each sample.

Table 1
Rotation details of field experiments, from 2013 to 2015.

Rotation	2013/2014			
	2011	2012	2013	2014
WW[a] monoculture	Since 2005			
B[b] monoculture	Since 2004 (since 2011 winter barley)			
WW after OSR[3]	Winter wheat	Winter wheat	Oilseed rape	Winter wheat
Second WW	Winter wheat	Potato	Winter wheat	Winter wheat
	2014/2015			
	2012	2013	2014	2015
WW monoculture	Since 2005			
B monoculture	Since 2004 (since 2011 winter barley)			
WW after OSR	Winter wheat	Winter wheat	Oilseed rape	Winter wheat
Second WW	Winter wheat	Oilseed rape	Winter wheat	Winter wheat

[a] Winter wheat.
[b] Barley.
[3] Oilseed rape.

2.3. Inoculum in soil

Level of inoculum of *Gaeumannomyces graminis* var. *tritici* and *G. graminis* var. *avenae* in soil was estimated in four different crop rotations: winter wheat monoculture, winter barley monoculture, winter wheat after OSR and second winter wheat. Prior to sowing, soil samples were collected for the determination of take-all infectivity. Soil cores (5.5 cm diameter × 10 cm deep) were randomly collected from five locations of each marked plot (Gutteridge and Hornby, 2003). Each core was inverted into 7.5 cm diameter and 11-cm height plastic cups containing drainage holes, in which 1 cm of coarse sand had been previously overlaid. Ten non-treated grains of winter wheat cv. 'Kovas DS' were placed on the soil surface and covered with clay beads. After watering, all cups were placed in a controlled growth chamber at 12 °C in a 16 h day and 8 h night regime. During the growing period, a twice-weekly watering regime was implemented. After 6 weeks, the plants were lifted. The roots were washed and used for DNA extraction of *Gaeumannomyces graminis* var. *tritici* and *G. graminis* var. *avenae*.

2.4. DNA extraction

DNA extraction from roots was carried out on composite samples, comprising five samples from the same rotation field cups. Samples were homogenized in liquid nitrogen. DNA was extracted from 0.1 g of homogenized sample in two replicates using a commercial Genomic DNA purification kit (Thermo Fisher Scientific Baltics, Lithuania). Plant