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Short communication

Control of *Stagonospora nodorum* and *Septoria tritici* in wheat by pre-treatment with *Drechslera teres*, a non-host pathogen

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Abstract

A field study is described which explored the possibility of controlling *Stagonospora nodorum* and *Septoria tritici* on wheat using a barley pathogen, *Drechslera teres*. Pre-treatment of wheat cv. Hussar flag leaves with *D. teres* resulted in a significant reduction in disease caused by *S. nodorum* and *S. tritici*, resulting in a significant increase in grain yield. When cv. Brigadier leaves were treated with *D. teres* prior to inoculation with *S. nodorum* there was an initial increase in disease expression whilst *D. teres* had no effect on symptoms produced by *S. tritici* on cv. Brigadier. There was significantly less disease on leaves of cvs. Hussar and Brigadier pre-treated with *D. teres* prior to inoculation with an equal mixture of *S. nodorum* and *S. tritici* compared to plants pre-treated with water. It is concluded that *D. teres* and other non-host pathogens show potential as biological control agents for *S. nodorum* and *S. tritici*.

Interest in the biological control of plant diseases has increased in recent years. Although there have been several reports of biological control involving biotrophs (Ouchi et al., 1974, 1976; Cho and Smedegaard-Petersen, 1986), there are few reports of biological control involving necrotrophic pathogens. There have been a number of reports of control of *S. tritici* using *Pseudomonas* spp. (Levy et al., 1989; Flaishman et al., 1996). Jørgensen et al. (1996) described the control of *Drechslera teres* using *Stagonospora nodorum* from wheat, and Blakeman et al. (1986) reported that non-pathogens of barley, *Drechslera catenaria* and *Drechslera siccans*, suppressed *D. teres* in barley. Pre-treatment of leaves with *Phoma medicaginis* and germination fluids of *Bipolaris maydis* and *S. nodorum* reduced subsequent infection by *S. nodorum* (Jørgensen and Smedegaard-Petersen, 1994). It has also been reported that the majority of the fungi associated with *S. nodorum* in the field inhibited its growth on Potato Glucose Agar (Blaszkowski, 1995). This suggests that the use of non-host pathogens, especially fungi, as biological control agents may have potential for crop protection. However, the possibility that pre-treatment with one organism may result in an increase in plant susceptibility to a second organism must also be considered. The aim of the work presented in this paper was to examine the effect of a non-pathogen of wheat, *Drechslera teres* (Sacc.) Shoemaker, cause of barley net blotch disease, on subsequent infection by two of the most important pathogens of wheat, namely *Septoria tritici* Roberge in Desmaz. (teleomorph: *Mycosphaerella graminicola* (Fückel) J. Schröt. in Cohn), cause of septoria tritici blotch, and *Stagonospora nodorum* (Berk.) Castellani & EG Germano (teleomorph: *Phaeosphaeria nodorum* (E. Müller) Hedjaroude), cause of stagonospora nodorum blotch. Although *D. teres* is regarded as non-pathogenic on wheat under field conditions, small necrotic spots were observed on wheat inoculated with *D. teres* under controlled environment conditions (Nolan and Cooke, unpublished data).

Winter wheat cvs Brigadier and Hussar were sown in outdoor microplots (27 cm diam.; 1.16 g of seed per microplot), surrounded by 1 m^2 guard rows of winter oats in a randomised block design with 5 replicates per treatment. Inoculum of *S. nodorum* and *S. tritici* was produced on Czapek-Dox V8 agar, incubated at 15–20 °C with a light cycle of 16 h near-ultraviolet light/8 h darkness (Cooke and Jones, 1970). *D. teres* was produced on potato dextrose agar incubated using the same conditions. At growth stage 49 (Zadoks et al., 1974) plants of both cultivars were inoculated with 60 ml *D. teres* at a concentration of 10^6 spores ml^{-1}. Five days later, plants in each microplot were challenged with 50 ml of *S. nodorum* (10^6 spores ml^{-1}), or 50 ml of *S. tritici* (10^6 spores ml^{-1}), or 50 ml of an equal mixture of both pathogens (10^6 spores ml^{-1}). Plants also received *D. teres* alone, to determine if the organism caused symptoms on wheat; other plants received water prior to being challenged with the pathogens (control plants). After both inoculations, the microplots were enclosed within large clear polythene bags to encourage infection by the pathogens. Percentage disease (necrosis) severity was assessed for the top (flag) leaves on ten tillers per replicate on four occasions, 10, 16, 23 and 29 days post-inoculation (d.p.i.) with *S. nodorum*/*S. tritici*. The effects of treatments on 1000 grain weight (TGW) yield were also determined. Data were analysed using analysis of variance and the means separated using Fisher's protected Least Significant Difference test.

Plants inoculated with *D. teres* alone produced no symptoms in the field. There was a significant reduction in disease caused by *S. nodorum*, *S. tritici* and a mixture of the two pathogens when cv. Hussar was pre-treated with *D. teres* prior to inoculation with the pathogens ($P < 0.01$) (Figure 1). *D. teres* also significantly reduced disease caused by a mixture of the two pathogens on cv. Brigadier at all assessments ($P < 0.01$); however, there was a significant increase in disease initially when cv. Brigadier was pre-treated with *D. teres* prior to inoculation with *S. nodorum* ($P < 0.01$) (Figure 2). *D. teres* had no effect on symptom expression by *S. tritici* on cv. Brigadier. There was a significant increase in TGW yield of cv. Hussar when plants were pre-treated with *D. teres* prior to inoculation with the wheat pathogens ($P < 0.01$) (Figure 3a); however, *D. teres* had no effect on the grain yield of cv. Brigadier (Figure 3b).

These results highlight the importance of the cultivar factor when examining pathogen interactions. Cultivar Hussar is more resistant to *S. nodorum* under field conditions than cv. Brigadier, and this may explain why *D. teres* appeared to pre-dispose cv. Brigadier to infection by *S. nodorum*. *S. nodorum* normally develops only a limited surface mycelium and penetrates the host

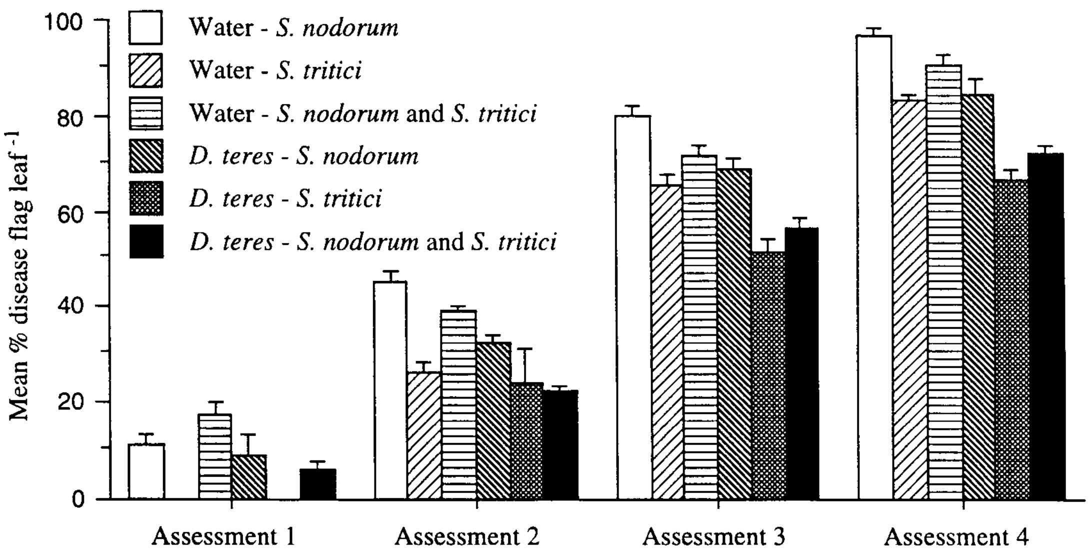

Figure 1. Mean % disease at the first (10 d.p.i.), second (16 d.p.i.), third (23 d.p.i.) and fourth (29 d.p.i.) assessments (± standard error) on cv. Hussar flag leaves pre-treated with *D. teres* or water and challenged with *S. nodorum* and *S. tritici*.

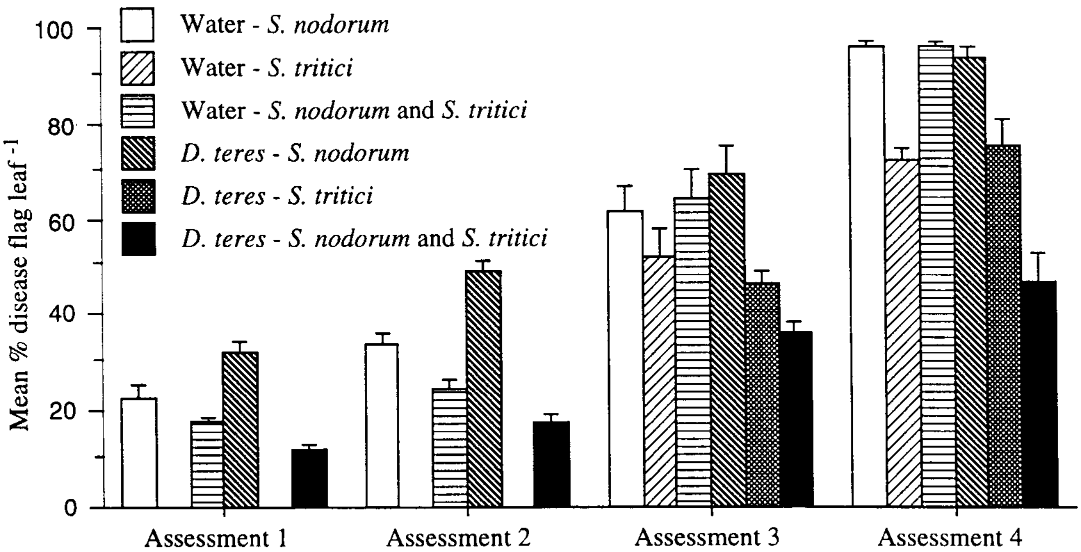

Figure 2. Mean % disease at the first (10 d.p.i.), second (16 d.p.i.), third (23 d.p.i.) and fourth (29 d.p.i.) assessments (± standard error) on cv. Brigadier flag leaves pre-treated with *D. teres* or water and challenged with *S. nodorum* and *S. tritici*.

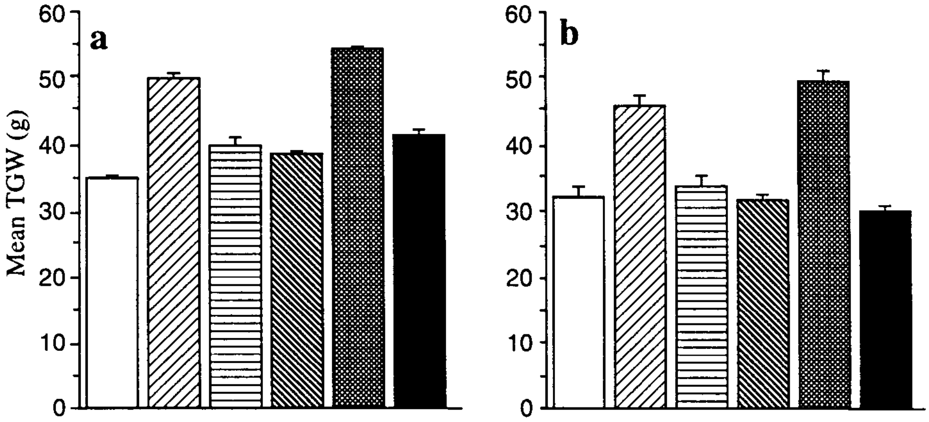

Figure 3. Mean TGW (± standard error) for (a) cv. Hussar and (b) cv. Brigadier pre-treated with *D. teres* or water and challenged with *S. nodorum* and *S. tritici*.

in a relatively short time. It was noted by Dickinson and Skidmore (1976) that the period during which *S. nodorum* must compete with other phylloplane fungi was limited and that only *Botrytis* (which is not normally present in the cereal phylloplane) showed significant antagonism towards *S. nodorum*. *S. tritici*, however, produces more surface mycelium and shows longer incubation and latent periods than *S. nodorum*; therefore *S. tritici* may be more sensitive to the presence of other microorganisms, particularly on more susceptible cultivars. The suppressive ability of *D. teres* was greater when both wheat pathogens were present together, and this response appears to be less cultivar specific, being similar in both cultivars used in this study. An organism which controls both wheat pathogens simultaneously obviously has much greater potential as a biocontrol agent. It is possible that as *S. nodorum* and *S. tritici* often occur on the same wheat leaf together under field conditions, one pathogen may either pre-dispose the wheat plant to infection by the second pathogen, or induce a resistance response to the second pathogen; the effect of such an interaction on disease expression would be further confounded if one wheat cultivar was more susceptible to the presence of *D. teres* than the other and if *D. teres* differentially affected the pathogen mixture. These hypotheses were not tested in the present work but could offer interesting prospects for future research. Although the data presented here were from one field experiment only, the degree of control of *S. nodorum* and *S. tritici* achieved, despite the variable environmental conditions in the field, suggests that *D. teres* will control these pathogens under field conditions. However, further research using a greater number of wheat cultivars and inducer and challenger organisms is needed.

Several mechanisms may be responsible for the suppression of disease observed here, including competition for infection sites, pH changes (Diem, 1969), mechanical obstruction, antibiosis (Porter, 1924), nutrient competition or nutrient impoverishment (Blakeman and Brodie, 1977; Fokkema, 1973) and induced or enhanced resistance of the plant. Despite the fact that the specific mechanism(s) operating in the *D. teres–S. nodorum* and *D. teres–S. tritici* interactions described here were not determined, the barley pathogen *D. teres* shows interesting potential as a biocontrol agent for *S. nodorum* and *S. tritici*, especially when both pathogens are present together on wheat leaves.

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