THE INFLUENCE OF TILLAGE, CROP ROTATION AND RESIDUE MANAGEMENT ON TAN SPOT (*DRECHSLERA TRITICI REPENTIS*. DIED. SHOEMAKER) IN WINTER WHEAT

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Abstract. *Tan spot caused by the necrothrophic pathogen Drechslera tritici repentis (Died.) Shoemaker becomes an important disease of winter wheat worldwide under a changing global climate and new resource conserving technologies. Beside the positive impact of minimum tillage and no-tillage systems on the soil physical and chemical properties as well as soil erosion reduction, soil moisture conservation, productivity of labor and machinery, energy conservation, environmental benefits (reduced Greenhouse gas emissions) and increased crop yields, practicing minimum tillage and no-tillage systems with residues have a major impact on the risk of Drechslera tritici repentis in wheat comparatively with conventional tillage system without residues, due to the pathogen`s ability to survive in the previous year`s crop residues especially if those crops are bread wheat, durum wheat or triticale. Under both minimum and no-tillage systems with residues the onset of tan spot epidemic occurs earlier than under conventional tillage and higher levels of disease severity are recorded during grain filling stage. Thus, an adequate management of crop residues is required because they are an important source of inoculum for Tan spot and it is also important to introduce additional control measures beside chemical ones, biological control and host resistance as a part of an integrated disease management. Considerable reduction in disease severity has been observed on those plots where it is practiced crop rotation in all tillage systems. Thus, lower percent of area with leaf tan spots have been assessed in wheat after non cereal crops than in continuous monoculture demonstrating the benefits of alternative crops preceding wheat for both minimum and no-tillage systems with residues. Even crop rotation and an efficient residue management are effective tools for reducing tan spot in winter wheat, farmers should not rely on few management practices to minimize tan spot risk, but rather to develop a sustainable long-term strategy for disease management to protect their crops and conserve natural resources.*

Key words: *Drechslera tritici repentis, management, residue, tillage, wheat, tan spot*

INTRODUCTION

Tan Spot produced by *Drechslera tritici repentis* (Died.) Shoemaker (telemorph *Pyrenophora tritici repentis* (Died.) Drechs.) is one of the most devastating and widespread necrotrophic pathogen of wheat (*Triticum aestivum* L.) mainly in the coolest zone of the warmer areas. The disease was first described in 1823 (HOSFORD, 1982) and since then it has become a potentially destructive disease of wheat worldwide (DIEDICKE, 1902; DRECHSLER, 1923; NISIKADO, 1928; ANDREWS AND KLOMPARENS, 1952; SHAW AND VALDER 1953; DUFF, 1954; MISRA AND SINGH, 1972; HOSFORD, 1971; DUBIN AND GINKEL, 1991; LINHARES AND DA LUZ, 1994; FERNANDEZ ET AL.1994; DUVEILLER ET AL., 1998; LAUGHMAN ET AL., 1998; ALI AND FRANCL, 2001; ALI ET AL., 1999, 2001; SAROVA, ET AL., 2003; MEHTA ET AL., 2004; LAMARI ET AL., 2005; MARAITE ET AL., 2006; RONIS AND SEMAŠKIENÉ, 2006; TODOROVA,

2006; MORENO ET AL., 2008; PARASCHIVU ET AL., 2010; GAMBA ET AL., 2012; COTUNA ET AL., 2013). Tan Spot of wheat is also an economically important disease causing average yield losses of 5-10% but also under favorable conditions for pathogen`s development have been reported yield losses from 20% to 70% (MISRA AND SINGH, 1972; REES AT AL., 1988; SHABEER AND BOCKUS, 1988; LAMARI AND BERNIER, 1989 a, b;).The fungus can infect wheat kernel and leaves causing red smudge and black point (FERNANDEZ et al., 1994) and tan spot, respectively. Tan spot can affect wheat quality reducing kernel weight (SHABEER AND BOCKUS, 1988; SCHILDER AND BERGSTROM, 1990), number of grains per head (SCHILDER AND BERGSTROM, 1990), total biomass (KREMAR AND HOFFMANN, 1992) and producing the antraquinone mycotoxins emodin, catenarin and islandicin (BOURAS et al., 2009). The fungus toxins (host - selective toxins – HST`s) which are produced in the interaction between host and pathogen are responsible for subversion of host resistance mechanisms leading to disease symptoms on susceptible wheat cultivars (FARIS et al., 2003).

Eight races of *Pyrenophora tritici-repentis* have been identified to date based on their ability to cause necrosis and/or chlorosis on a set of wheat differential hosts. Race 1 of *Pyrenophora tritici -repentis* is predominant worldwide and produces both Ptr ToxA and Ptr ToxC (CIUFFETTI AND TUORI, 1999; ADHIKARI ET AL., 2008; EFFERTZ ET AL., 2002; STRELKOV AND LAMARI, 2003). According with the results regarding specific interactions between wheat cultivars and individual isolates of *P. tritici - repentis* Lamari and Bernier (1989a) suggested the presence of four pathotypes as follow: pathotype 1 = tan necrosis or extensive chlorosis ($nec^{+}chl^{+}$), pathotype 2 = only tan necrosis ($nec^{+}chl^{-}$), pathotype 3 = only extensive cholorosis ($nec^{-}chl^{+}$) and pathotype 4 = avirulent ($nec^{-}chl^{-}$). Ptr ToxA induces necrosis and Ptr ToxB induces chlorosis in susceptible cultivars, while Ptr ToxC produces chlorosis but in different cultivars than Ptr ToxB does (Ciuffeti et al., 1998; Effertz at al., 2002; Martinez et al., 2001, 2004; Strelkov et al., 1999, 2006). These three host - selective toxins (HST`s) interact with the products of the dominant genes Tsn 1, Tsn 2 and Tsc 1, respectively. Ali et al. (2010) suggested the presence of a new races of *P. tritici - repentis* that potentially produce new toxic components (Ptr ToxD). The attack of the necrotrophic pathogen *Drechslera tritici - repentis* has been increased significantly especially under a changing global climate and conservation agriculture (CA – reduced tillage combined with retention of crop residues on the soil surface, at least 30%, and crop rotation), making it imperative to develop new strategies to control it. Despite its multiple benefits such as soil erosion reduction, soil moisture conservation, productivity of labor and machinery, energy conservation, environmental benefits (reduced Greenhouse gas emissions) and increased crop yields conservation agriculture with wheat monoculture has resulted in frequent onset of tan spot epidemics worldwide (BOCKUS AND SHROYER, 1998). In order to reduce the risk of tan spot epidemics and pesticides use it is important to adopt adequate integrated disease management which combines chemical, biological, cultural, genetic controls (BOCKUS ET AL., 1992; PERRELLO ET AL., 2003, 2006, 2008; ANNONE, 2005, 2006; SIMON ET AL., 2011). Agronomic practices such as tillage, crop rotation and residue management all play important roles in determining the risk of tan spot, by influencing the type, amount and location of the inoculums. The goal of this paper is to identify agronomic practices, such as tillage, crop rotation and residue management options that might be associated with the development of Tan spot in wheat and how can be used these practices to reduce the incidence and severity of this disease.

THE PATHOGEN, DISEASE CYCLE AND ENVIRONMENTAL CONDITIONS FOR THE DEVELOPMENT OF TAN SPOT

Pyrenophora tritici - repentis (Died.) Dresch. is the pathogen responsible for tan spot of wheat. It is a facultative parasite fungus of Phylum *Ascomycota* and its anamorph corresponds to *Drechslera tritici - repentis* (Died). Shoemaker. It was first time isolated from *Agropyron repens* and determined as *Pleospora trichostoma* by Diecke. In 1928 was isolated from wheat Nisikado, who called *Helminthosporium tritici - repentis* (*Drechslera tritici - repentis*) (HOSFORD, 1982). The fungus propagates asexually by conidia and sexually by ascospores. Conidiophores arising singly or in groups of 2 - 3, emerging through stomata or between epidermal cells, simple, erect, straight or flexuous, with a swollen base, mid-pale to brown, smooth, usually up to 250 µ and give rise to conidia that are subhyaline, cylindrical, solitary, straight or slightly curved, rounded at the apex, the basal segment distinctly and characteristically conical or shape of a snake`s head, thin-walled with 1 - 9 pseudosepta and multinucleate (ELLIS AND WALLER, 1976). Pseudothecia of *Pyrenophora tritici - repentis* are dark brown, spherical to subspherical, smooth, from 400 to 500 µ of diameter. The asci measure usually from 170 to 251 µ by 43 to 50 µ. The ascospores are brown, three - septate transversely, multinucleate and range from oval to globose, measuring usually 47 - 65 µ of length and 20 - 26 µ of wide. The ascospores are biseriate and uniseriate in the middle towards the apex respectively (ELLIS AND WALLER, 1976).

Previous research indicated that ascospores infected mainly the lower leaves (leaf three and below) and conidia the upper leaves (Wright and Sutton, 1990). The favorable conditions for *Pyrenophora tritici - repentis* dispersal and infection are among 10^{o} to 30^{o} C and moisture among 6 hs to 48 hs (HOSFORD et al., 1987; Sah 1994). Maturation of pseudothecia and ascospores occurs from 5-20^{o}C but optimal temperature range from 15 - 18^{o}C (Wright and Sutton, 1990), while conidia are produced at temperatures between 10 - 25^{o}C, the optimum is 12^{o}C (LUZ AND BERGSTROM, 1986). However, temperature (DA LUZ AND BERGSTROM, 1986; HOSFORD ET AL., 1987; SUMMERELL AND BURGESS, 1988), moisture (PLATT AND MORRALL, 1980; RAYMOND ET AL., 1985; SUMMERELL AND BURGESS, 1988), light (KHAN, 1971), plant age or leaf position (REES AND PLATZ, 1983; RAYMOND ET AL., 1985; COX AND HOSFORD, 1987; SHABER AND BOCKUS, 1988; HOSFORD ET AL., 1990), host genotype and virulence of the isolate are reported to contribute to the amount of inoculums and disease severity (REES AND PLATZ, 1983; LAMARI AND BERNIER, 1989). Tan spot epidemics has been associated with the infected straw of wheat which is considerate the main source of inoculums by many authors (WATKINS, J. E., ODVODY, G. N., BOOSALIS, M. G. AND PARTRIDGE, J. E., 1978; REESE AND PLATZ, 1980; REES ET AL., 1982; SUTTON, J. C. AND VYN, T. J., 1990; WRIGHT, K. H. AND SUTTTON, J. C., 1990). The seeds and collateral hosts are also considered principal sources of inoculums. Despite that some authors consider that conidia may play a primary role in the initiation of tan spot epidemics (KRUPINSKI, 1992), ascospores are generally thought to be the source of primary inoculum (REES AND PLATZ, 1983; RAYMOND ET AL. 1985; SUTTON AND VYN, 1990), followed by repeated cycles of conidial production on diseased leaf tissue (REES AND PLATZ, 1980; WRIGHT AND SUTTON, 1990; SCHILDER AND BERGSTROM, 1992).

INCIDENCE OF TAN SPOT IN DIFFERENT TILLAGE SYSTEMS, CROP ROTATION AND RESIDUE MANAGEMENT

Conservation agriculture (CA) which consists of reduced tillage combined with retention of crop residues above the soil (30%) and adequate crop rotation is becoming more popular and more widely used. Leaving large amounts of residue on the soil surface is a more desirable farming practice, helping to reduce soil erosion, conserves energy and increases soil moisture and yields (LIMONE-ORTEGA ET AL., 2000; GOVAERTS et al., 2005). Retaining more crop residue on the soil surface and practicing no - tillage system result in different impact on the pathogens comparatively with conventional tillage system without residues. Tillage systems affect the soil physical and chemical properties as well as diseases development. Some disease increase in importance, while other decrease. Therefore, the interaction of tillage system and Tan spot infection is a matter of particular interest. Crop residues in reduced tillage or no-tillage plots can provide an important source of tan spot inoculum. *Pyrenophora tritici - repentis* produces the sexual stage on field stubble being able to survive saprophytically between cropping seasons in infested residue on or above the soil surface. On infested residues the pathogen produces ascospores, which is considered primary inoculum while conidia are produced on lesioned tissue and are disseminated by wind causing multiple secondary infections. ADEE AND PFENDER (1989) showed that the tan spot severity was related to the amount of primary inoculum. However, conservation tillage practices which involves minimum tillage and no-tillage and residues retained top on the soil for erosion control, may increase the severity of tan spot and high tan spot levels occurs during grain filling (GEBHART ET AL., 1977; MEHTA AND GAUDENCIO, 1991). ANNONE AND KOHLI (1996) reported high tan spot levels (50 - 60%) on wheat grown under minimum and zero tillage, compared to situations where residues were partially or totally buried (20%). Practically, reduced tillage with residues creates a refuge for *Pyrenophora tritici - repentis* and therefore for these agricultural practices requires additional control for pathogens.

Reduced tillage and lack of crop rotation have favored tan spot spread in many wheat growing areas. Under reduced tillage the onset of tan spot epidemic occurs earlier than under conventional tillage (MEHTA AND GAUDENCIO, 1991). Practices for suppressing initial inoculums, especially rotation of wheat with non-host crops (oilseeds, pulses and forages) and plowing infested residues that have remained on or above the soil surface have long been recommended for managing tan spot (DUCZEK ET AL., 1999; SMITH AND YOUNG, 2000). It is highly recommended that reduced tillage be completed with crop rotation. This practice controls many diseases and allows as much of the crop residue as possible to be retained on the soil surface. Crop rotation takes advantage of the fact that plant pathogens important on one crop may not cause disease problems on another crop and on the mean time allows time for the decomposition of residue on which pathogens carryover. DUCZEK ET AL. (1999) indicated that a minimum 2 years between wheat crops is required to prevent *Septoria* Leaf Spot, but 1 year between wheat crops may be sufficient to control Tan spot. Lesion numbers were reduced about 30% overall and percentage necrosis was reduced about 60% overall when wheat followed canola, barley, crambe and flax compared with wheat grown after wheat (KRUPINSKI et al., 2002, 2007). However, the optimal adaptation to reduced tillage systems with residues includes also a change in the crop rotation in order to control pathogens and to increase yields.

CONCLUSIONS

Integrated tan spot management is principally focused on tillage system, crop rotation and crop residues, as principal source of inoculum and on limiting number of successive conidia cycles. Even the incidence and severity of tan spot increases under conservation agriculture system, this seems to be more profitable than conventional agricultural practices. Breeding of new resistant wheat cultivars beside crop rotation and adequate residue management will provide an effective, economical and environmentally control in tan spot. Crop rotation and an efficient residue management are effective tools for reducing tan spot in winter wheat in all tillage systems, but farmers should not rely on few management practices to minimize tan spot risk, but rather to develop a sustainable long - term strategy for disease management to protect their crops and conserve natural resources.

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