Will Climatic Changes Enhance the Risk of *Tilletia indica* in Europe?

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Abstract: The losses caused by *T. indica* consist mainly in losses of export markets, in costs of quarantine precautions, control and treatment of the infected grain. These reasons were satisfactory for implementation of plant quarantine precautions against *T. indica* in the countries of the European Union. However, all the known records of *T. indica* from the field fall to regions of arid or semiarid climate with mild to cold winter and a hot summer, altogether with a small amount of rainfall. At present, the important requirement of critical amount of the viable nongerminated teliospores at the time period suitable for infection and suitable weather conditions at the same period (namely before wheat flowering) is not accomplished in Europe. Conditions necessary for the establishment of *T. indica* in Europe are discussed.

Keywords: *Tilletia indica*; Karnal bunt; wheat; environmental factors; quarantine pest

When we consider the danger of new pathogens we are mostly concerned about pathogens from warmer climatic zones due to the increasing average temperatures in Europe. One of those pathogens is *Tilletia indica*, an object of plant quarantine in the EU. Till now all the known occurrences of this pathogen fall to regions of arid and semiarid climate with hot summers, mild to cold winters and altogether with a small amount of rain. All locations where *T. indica* has established are situated on or close to latitudes 30° North and 30° South (Jones 2007a).

Teliospores of *T. indica* germinate on or near soil surface and produce promycelia upon which primary sporidia develop. Primary sporidia give rise to secondary sporidia. This is supported by humidity often provided by rainfall. Sporidia are dispersed to the wheat flowers by air currents or rain splash. Wheat florets are infected by germ tubes from germinating sporidia through stomata. Hyphae then grow to the base of the floret and invade the periderm of the nascent kernel (Fuentes-Davilla 1996).

As mentioned above, unlike common bunt and dwarf bunt with infection occurring from the contaminated seed or soil in very early stages of wheat development, the infection with *T. indica* occurs in the stage of wheat anthesis. Therefore not all the spikes of the plant neither the whole spike are attacked. The infection of a kernel is usually only partial. There were losses not higher than 0.3–0.5% of the overall harvest in the region of *T. indica* occurrence in India in the years of the utmost epidemic incidence, even though in some samples approximately 89% of the kernels were infected. However, substantial losses caused by *T. indica* consist mainly of losses of export markets (both as a seed and as a food), in costs of quarantine precautions, control and treatment of the infected grain (Jones 2007b).

As *Tilletia indica* is a quarantine organism, wheat imported to Europe has to originate from

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areas where *T. indica* has never been proved or where the disease symptoms were not observed on the wheat in the field. During harvest and before dispatch, the representative samples have to be sampled and the absence of smut fungus *T. indica* must be proven.

Why has not *T. indica* occurred in Europe till this time? This pathogen was described already in 1931 in Botanical Station Karnal, India. However, till 1981, when USA interdicted the import of wheat from the regions of occurrence of *T. indica,* wheat trade did not take the risk of distribution of *T. indica* into consideration. At the present time *T. indica* occurs aside from India and Pakistan only in the northwest Mexico, and in the southern California, Arizona and Texas in the United States. The disease has also been recorded in southern Nepal, Iraq, and southern Iran. Also wheat from Afghanistan, Lebanon, Syria and Turkey has been found contaminated with teliospores of *T. indica* though the pathogen has never been reported from the fields in these countries. Incidence of *T. indica* in these countries remain unclear (Jones 2007a). Arid to semiarid climate suits *T. indica* for preservation of viable spores until the time period convenient for infection. The dark, thick-walled teliospores are well adjusted to the hot and dry climate. At the time before wheat flowering *T. indica* demands rainfall for teliospores germination and transfer of sporidia to the ear. In comparison with the regions, where *T. indica* occurs presently, the precipitations in Europe are distributed more uniformly, they are less evaporated, moisture is available for a longer time period. These conditions support microbial antagonism and teliospores degradation. Also interactions of moisture and cold periods could influence the spore viability. Cooler conditions and more frequent rainfalls probably trigger "suicidal" germination of teliospores at the time not suitable for infection. The requirement of critical amount of the viable nongerminated teliospores at the time period before flowering is thus not accomplished.

On the basis of up to now experience and knowledge on harmfulness of this smut fungus the contemporary state of legislation could seem not to be reasoned enough. However the risk of potential spreading in Europe especially due to climatic changes should not be underestimated. The nature can provide us all kinds of amazements (e.g. mutants of the pathogen adopted to our conditions). The target of research, plant quarantine and commercial organisations would be to find in contemporary legislation such a solution, that will not enhance the risk of transfer and eventual distribution of a new disease in Europe. On the other side this should not inhibit to a great extent the free trade with wheat, particularly when the restrictions involve the less developed countries.

For the future assessment of the risk of *T. indica* following data should be mainly considered:

***1. Survival of* T. indica *teliospores during the whole year and their germination at the critical period for infection of wheat*.** Overwintering of *T. indica* teliospores in soil was studied at three sites in Europe (Norway, UK, Italy). At each site experiments were set up in three consecutive years at 5, 10, and 20 cm depth. *T. indica* teliospores germinated in all experimental variants at least three years though viability was decreasing with the time of deposition in soil (Inman *et al.* 2008). Thus overwintering of teliospores has not been

Figure 1. Typical partial infection of wheat kernels with smut fungus *Tilletia indica*

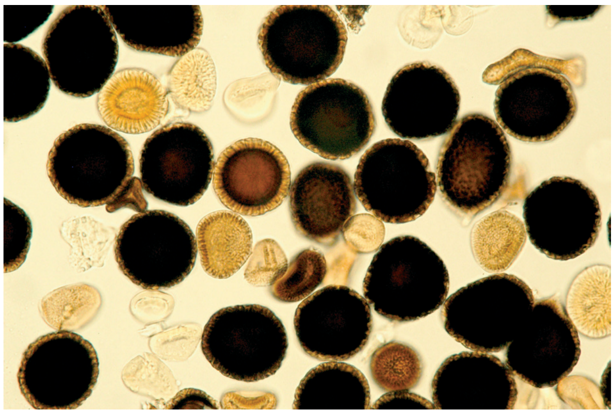

Figure 2. Thick, dark-walled teliospores of *Tilletia indica*

the limiting factor for bunt incidence in Europe. Therefore a Pest Risk Analysis (PRA) concluded that the pathogen had the potential of establishing in the UK and many other European countries (Sansford 2004).

2. Critical climatic and soil factors for the coincidence of teliospores germination with the suitable stage of wheat development. Goates and Jackson (1996) indicated 35 days around anthesis of wheat in the USA as critical for infection. Many methods for the forecast of *T. indica* incidence have been elaborated, (e.g. Humid Thermal Index – HTI) however they are mostly valid only for specific local conditions.

3. Presence of critical amount of inoculum able to germinate at the critical period for infection. Though the amount of teliospores after overwintering may be satisfactory for infection, the inoculum may be substantially reduced by premature germination and does not reach the critical amount at the critical period for infection. Factors affecting teliospores dormancy obviously play an important role (Jones 2009). Though teliospores of *T. indica* have been very likely already several times introduced to various European countries (e.g. with seed samples from CIMMYT Mexico where *T. indica* occurs) their amount was obviously unsatisfactory to cause the disease under given conditions.

Example of *T. indica*, a pathogen typical for warmer climatic zones, shows pitfalls in presumption of the risk of pathogens from warmer zones for zones where increase of average temperature is expected merely on the base of increased average temperature and decrease of precipitations without respecting timing of warm and rainy periods.

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