2.4 The history of wheat rust

2.4.1 History of stem rust

The fungal ancestors of stem rust have infected grasses for millions of years and wheat crops for as long as they have been grown.[2] According to Jim Peterson, professor of wheat breeding and genetics at Oregon State University, "Stem rust destroyed more than 20% of U.S. wheat crops several times between 1917 and 1935, and losses reached 9% twice in the 1950s," with the last U.S. outbreak in 1962 destroying 5.2% of the crop.[2]

While *Ug99* wasn't discovered until 1999, stem rust has been an ongoing problem dating back to Aristotle's time (384-322 B.C).[4] An early ancient practice by the Romans was one where they would sacrifice red animals such as foxes, dogs, and cows to Robigo or Robigus, the rust god. They would perform this ritual in the spring during a festival known as the Robigalia in hopes of the wheat crop being spared from the destruction caused by the rust.[4] Weather records from that time have been observed and it has been speculated that the fall of the Roman Empire was due to a string of rainy seasons in which the rust would have been more harsh, resulting in reduced wheat harvests.[4] Laws banning barberry were established in 1660 in Rouen, France. This was due to the fact that European farmers noticed a correlation between barberry and stem rust epidemics in wheat.[4] The law banned the planting of barberry near wheat fields and was the first of its kind before the parasitic nature of stem rust was discovered in the 1700s.[4]

Two Italian scientists Fontana and Tozzetti first explained the stem rust fungus in wheat in 1767.[4] Thirty years later it received its name, Puccinia graminis, by Persoon and in 1854 brothers Louis René and Charles Tulasne discovered the characteristic five-spore stage that is known to some stem rust species.[4] The brothers were also able to make a connection between the red (urediniospore) and black (teliospore) spores as different stages within the same organism, but the rest of the stages remained unknown.[4]

Anton de Bary later conducted experiments to observe the beliefs of the European farmers regarding the relationship between the rust and barberry plants and after successful attempts to connect the basidiospores of the basidia stage to barberry, he also identified that the aeciospores in the aecia stage reinfect the wheat host.[4] Upon de Bary's discovery of all five spore stages and their need for barberry as a host, John Craigie, a Canadian pathologist, identified the function of the spermogonium in 1927.[4]

Due to the useful nature of both barberry and wheat plants, they were eventually brought to the Northern America by European colonists.[4] Barberry was used for many things like making wine and jams from the berries to tool handles from the wood.[4] Ultimately, as they did in Europe, the colonists began to notice a relationship between barberry and stem rust epidemics in wheat.[4] Laws were enacted in many New England colonies, but as the farmers moved west, the problem with the stem rust moved with them and began to spread to many areas, creating a devastating epidemic in 1916.[4] It wasn't until two years later in 1918 that the United States created a program to remove barberry. The program was one that was supported by state and federal entities and was prompted by the looming fear of food supplies during the war.[4] The "war against barberries" was waged and called upon the help of citizens through radio and newspaper advertisements, pamphlets, and fair booths asking for help from all in the attempt to rid the barberry bushes of their existence.[4] Later, in 1975-

1980, the program was reestablished back to state jurisdiction.[4] Once this happened, a federal quarantine was established against the sale of stem rust susceptible barberry in those states that were part of the program.[4] A barberry testing program was created to ensure that only the species of barberry and other variations of plants that are immune to stem rust will be grown in the quarantine area.[4]

2.4.2 Nomenclatural history of yellow (stripe) rust and wheat leaf rust

Although Gadd first described stripe rust of wheat in 1777, it was not until 1896 that Eriksson and Henning (1896) showed that stripe rust resulted from a separate pathogen, which they named P. glumarum. In 1953, Hylander et al. (1953) revived the name *P. striiformis*.[1g]

What is the appropriate name for Wheat Leaf Rust?

Fungal names are important. These are keys to all information behind them. Then, appropriate name can lead users to right information. In case of plant pathogenic fungi using appropriate name is more important because of practical reasons. There are several examples among rust fungi which one species called with different names during different eras. However, one of the most interesting ones is the name for *Puccinia* species causing Wheat Leaf Rust (WLR). This species have been called by at least six different names since 1882, when G. Winter (1882) described the *Puccinia rubigo-vera*.[1b] For long time WLR interpreted as a specialized form of *P. rubigo-vera*. Later, Eriksoon and Henning (1894) put it under the *P. dispersa* f.sp. *tritici*. In 1899 and after some experiments Eriksson concluded that the rust should be considered as a separate authentic species. For this reason he described *P. triticina*. This name was used by Gaeumann (1959)[2b] in his comprehensive book about rust fungi of middle Europe. Mains (1933) was among the first scientists who use a species name with broad species concept for WLR.[3b] He considered *P. rubigo-vera* as current name and put 32 binomials as synonym of that species. The next important article about naming WLR published by Cummins and Caldwell (1956). They considered the same broad species concept and also discussed the validity of *P. rubigo-vera* which was based on an uerdinial stage basionym. Finally, they introduced P. recondita as oldest valid name for WLR and also other grasses. Their idea and publication followed by Wilson & Henderson (1966) in another comprehensive rust flora viz. British Rust Flora. Wilson and Henderson (1966)[4b] also used a broad species concept for *P. recondita* and divided this broad species to 11 different formae speciales. The accepted name for WLR in their flora was *P. recondita* f.sp. *tritici*.

Cummins (1971) in his rust monograph for Poaceae introduced an ultra-broad species concept for *P. recondita* and listed 52 binomials as its synonyms.[5b] Such a concept found a great attention among mycologists and plant pathologists around the world and that's the reason we still can see *P. recondita* as an appropriate name for WLR is some publications. There was another stream opposite to broad morphologically based concept among uredinologists. In case of graminicolous rust fungi this stream started by Urban (1969) who introduced *P. perplexans* var. *triticina* as an appropriate name for WLR.[6b] To Urban's understanding, a taxonomic name should reflect both morphology and ecology of the species. Savile (1984) was also among the uredinologist believing to narrow species concept and considered *P. triticina* as an authentic taxonomic name for WLR.[7b] Urban's research continued and he put many morphological, ecological and also field experiences together. Finally he considered WLR as a part of Puccinia persistens species with aecial stage on

Ranunculaceae members, totally different from *P. recondita* which produce its aecial stage on Boraginacec family members. His final name for this rust was *P. persistens* subsp. *triticina*.[8b] Interestingly, recent molecular and also morphological studies proved Urban's taxonomy for WLR.[9b] It seems after more than a century and introducing several names, we have an appropriate name for WLR.