Fighting the Orange Invader: *Puccinia coronata f. sp. avenae* in the World's Oat Fields

Pragati Sharma[1*], Isha Saini[2], Tanisha Gupta[3], Dr. Ajit Kaur[2], Dr. Urmila Gupta Phutela[2]

[1]Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana

[2] Department of Microbiology, Punjab Agricultural University, Ludhiana

[3]Department of Plant Pathology, Punjab Agricultural University, Ludhiana

Corresponding Author: sharmapragati747@gmail.com

Oats is an important fodder as well as grain crop, grown in winter and used as a winter cover crop for both as a food for livestock and humans and as a raw material of industrial use. Oats like other major crop plants suffers from many diseases, some of these diseases are very specific to particular oat varieties and some of them have a wide host range. Every stage of plant's growth and development is affected, either causing harm to a specific stage of growth or a specific plant component or organ, or may harm a plant more broadly.

Most of the Oat-attacking pathogens have a close association with the plant. Therefore, occurrence of the disease due to the pathogen is more likely to develop in those places where crop grows well. However, other infections produce less serious or occasional illnesses because they are less strong in certain environments or less suited to the species.

Numerous diseases result in either significant direct harm, often in the form of decreased fodder output, or indirect harm, which compromises the product's quality. Crown and stem rusts are one of the major diseases that cause severe direct damage. Unfortunately, because infection affects grain yield, kernel weight, and groat percentage, the worldwide occurrence *of Puccinia coronata f.sp. avenae* (Pca) inhibits oat production and lowers the grain's economic value (Doehlert et al., 2001; Holland and Munkvold, 2001; Humphreys and Mather, 1996). Additionally, oat plants lodge and straw output is weakened by crown rust infection (Endo and Boewe, 1958).

Historical Aspect

In the late 1800s, historical accounts of Pca-induced oat crop damage first surfaced. Shortly before the disease was discovered in the United States (Thaxter, 1890), crop failures due to crown rust infection were initially documented in Europe (Cornu, 1880) and in the Baltics (Sivers, 1887). Since then, oat production has been impacted by oat crown rust outbreaks, which have led to yield losses of 10% to 40% (Behnken et al., 2009; Martinelli et al., 1994; Simons, 1970). Epidemics of crown rust have sporadically struck many parts of the world throughout the 20th century. In South America (Gassner, 1916), Portugal (D'Oliveira, 1942), Australia (Waterhouse, 1952), Israel (Wahl and Schreiter, 1953), southeastern Europe (Kostic, 1959), and the United States (Sherf, 1954), severe harm caused by this virus has been documented. Brazil and Uruguay have seen crown rust epidemics nearly every year since the 1990s (Leonard and Martinelli, 2005; Wahl and Schreiter, 1953). According to recent reports, Pca poses a significant risk to the production of oats in Canada (Chong et al., 2008) and Tunisia (Hammami et al., 2010).

Life Cycle

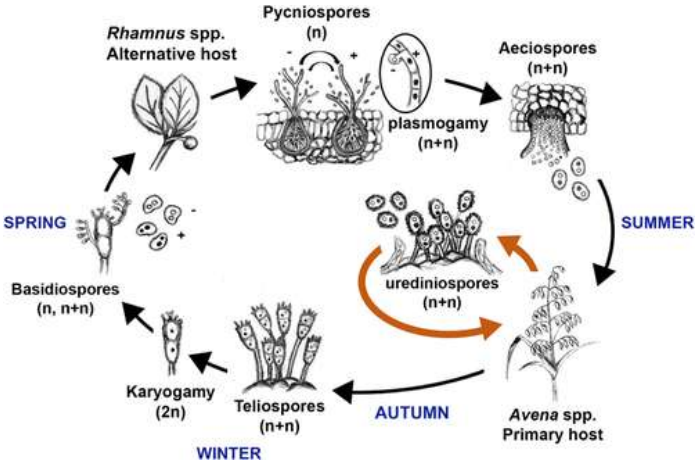

Fig 1: Life cycle of *Puccinia coronata*

Source: Drawing by M. Figueroa

In both domestic and wild oat species, the asexual phase of the cycle (orange arrows) is finished over the summer as several rounds of infection. The sexual phase starts with the differentiation of teliospores to endure cold winter temperatures in late summer. In order to create basidiospores in the spring, teliospores go through karyogamy and complete one meiotic event. Before germinating and infecting buckthorn (Rhamnus species), basidiospores likely go through mitosis and carry either the (–) or (1) mating

type. The fungus in buckthorn produces pycniospores, which allow plasmogamy when they come into touch with neighboring hyphae of the opposite mating type. The asexual cycle is then restarted by aeciospores infecting the oat.

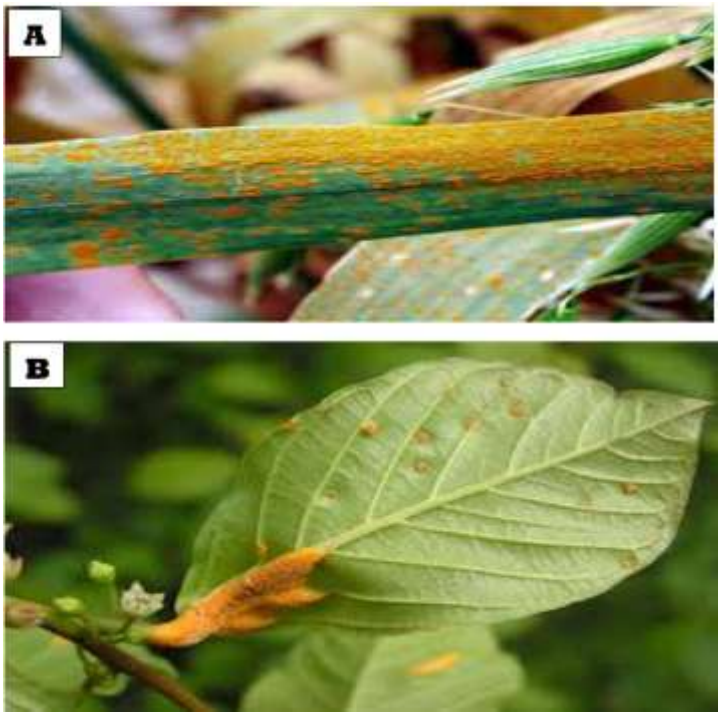

Fig 2: 'A' shows the pustules of uredia on the leaf surface and Figure 'B' shows pathogen symptom on Buckthorn

Symptoms

Orange-yellow spherical to rectangular *uredinia* (pustules) with freshly generated *uredinio* spores are the result of infection of sensitive oat types. Pustules can range in size and exceed 5 mm in length. Although sporadic symptoms can appear in the oat leaf sheaths and/or floral structures, including awns, the infection mostly affects the leaf surfaces. In resistant oat variants, symptoms can range from tiny pustules to flecks, usually accompanied by necrosis and/or chlorotic halos. Rhamnus species leaves are mostly home to the pycnial and aecial phases, while petioles, immature stems, and floral structures can also infrequently exhibit symptoms. Aecial structures can vary in size, sometimes exceeding 5 mm in diameter, and exhibit a distinctive hypertrophy. Aecia develop on the leaf's abaxial surface (top and bottom), whereas pycnia are found on the adaxial surface (top).

Disease Management Approaches: Using biocontrol agents, eliminating the alternate host, creating resistant cultivars, and using fungicide are management strategies to stop crown rust outbreaks (Hoffman et al., 2006; McCallum et al., 2007; Simons, 1970).

Choice of variety

The best way to overcome the likelihood and severity of rust infection is through genetic resistance. Selecting cultivars with resistance profiles appropriate for local rust risk and prevalent pathotypes is crucial since rust populations contain pathotypes with different levels of pathogenicity.

Fungicides

Fungicides can be used as a foliar application on crops or as a seed treatment or in-furrow fertilizer application during planting to combat rust. Early in the disease outbreak, before vulnerable cultivars experience serious infection, fungicides should be used to combat rusts. The top three leaves, including the flag leaf, should be protected by fungicide sprays; the best period to protect the upper canopy is when the flag leaf emerges. Oat rusts have quick life cycles, therefore even in vulnerable cultivars with moderate rust severity, fungicide may be needed to prevent the disease from developing quickly.

Green bridge management

Wild oats, which frequently appear along fence lines or roadsides well before crops and serve as a source of rust inoculum during the cropping season, serve as a green bridge for leaf rust of oats. The carry-over of inoculum between seasons can be decreased by green bridge management, which includes grazing or using herbicide to get rid of volunteer and wild oats before planting.

Crop observation

Crop surveillance is crucial to maximizing the response to any disease outbreak, especially in vulnerable cultivars. Growers can be alerted to the existence of rust inoculum in the area by monitoring wild oat numbers.

References

Behnken, L.M., Breitenbach, F.R. and Miller, R.P. (2009) Impact of Foliar Fungi-cide to Control Crown Rust in Oats in 2009.

Browning, J.A. 1973. Oats: Continental Control Program. *In* R.R. Nelson (ed). *Breeding plants for disease resistance*, pp. 155 - 180. Pennsylvania, USA, Pennsylvania State University Press.

Chong, J., Gruenke, J., Dueck, R., Mayert, W. and Woods, S. (2008) Virulence ofoat crown rust [Puccinia coronata f. sp. avenae] in Canada during 2002–2006. Can. J. Plant Pathol. 30, 115–123.

Cornu, M.M. (1880) Notes sur quelques parasites des plantes vivantes: generationsalternantes; pezizes a sclerotes. Bull. Soc. Bot. Fr. 27, 209–210.

D'Oliveira, B. (1942) A estacao agronomica e os problemas nacionais de fitopatolo-gia. Rev. Agron. 30, 414–438.

Doehlert, D.C., McMullen, M.S. and Hammond, J.J. (2001) Genotypic and environmental effects on grain yield and quality of oat grown in North Dakota. CropSci. 41, 1066–1072.

Endo, R.M. and Boewe, G. (1958) Losses caused by crown rust of oats in 1956 and1957. Plant Dis. Rep. 42, 1126–1128

Gassner, G. (1916) Die geteriedroste und ihr aufreten im subtropischedn ostlichensudamerika. Zentralbl. Bakteriol. Parassitenkd. Infekt. Hyg. Abt. 2, 305–381

Hammami, I., Allagui, M.B., Chakroun, M. and EL-Gazzeh, M. (2010) Naturalpopulation of oat crown rust in Tunisia. Phytopathol. Mediterr. 49, 35–41

Harder, D.E. & Haber, S. 1992. Oat diseases and pathologic techniques. *In* H.G. Marshall and M.E. Sorrells (eds). *Oat science and technology,* pp. 307 - 402. [Agronomy Monograph, No. 33]. Madison, WI, USA: Crop Science Society of America.

Hoffman, D.L., Chong, J., Jackson, E.W. and Obert, D.E. (2006) Characterizationand mapping of a crown rust resistance gene complex (Pc58) in TAM O-301. CropSci. 46, 2630–2635.

Humphreys, D.G. and Mather, D.E. (1996) Heritability of b-glucan, groat percent-age, and crown rust resistance in two oat crosses. Euphytica, 91, 359–364.

Kostic, B. (1959) The cereal rusts in the south-eastern part of Yugoslavia in 1958 and1959. Robigo, 9, 8–12

Leonard, K.J. and Martinelli, J.A. (2005) Virulence of oat crown rust in Brazil andUruguay. Plant Dis. 89, 802–808

Martinelli, J.A., Federizzi, L.C. and Bennedetti, A.C. (1994) Effect of oat cultivarsmixtures and seed treatments on the restriction of leaf rust disease progress.Summa Phytopathol. 20, 113–115

McCallum, B.D., Fetch, T. and Chong, J. (2007) Cereal rust control in Canada.Aust. J. Agric. Res. 58, 639–647.

Sherf, A.F. (1954) The 1953 crown and stem rust epidemic of oats in Iowa. Proc.Iowa Acad. Sci. 61, 161–169

Simons, M.D. (1970) Crown Rust of Oats and Grasses Monograph. Worcester, MA:APS at The Hefferman Press, Inc

Simons, M.D. (1970) Crown Rust of Oats and Grasses Monograph. Worcester, MA:APS at The Hefferman Press, Inc.

Simons, M.D. 1985. Crown rust. *In* A.P. Roelfs and W.R. Bushnell (eds). *The cereal rusts: diseases, distribution, epidemiology and control,* pp. 132 - 172. New York, NY, USA: Academic Press.

Sivers, M.N. (1887) Ein probeanbau verschiedener hafersorten. Balt. Wochenschr. Landwirt. Sch. Gewerbefl. Handel. Dorpat. 39, 390–391

Thaxter, R. (1890) Report of Mycologist, Fourteenth Annual Report. New Haven, CT:Connecticut Agricultural Experiment Station.

Wahl, I. and Schreiter, S. (1953) A highly virulent physiological race of crown ruston oats in Israel. Bull. Isr. Res. Counc. 3, 256–257.

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Waterhouse, P.M. (1952) Australian rust studies. IX. Physiologic rust determinationsand surveys of cereal rusts. Proc. Linn. Soc. New South Wales. 77, 209–258.

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