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Original Research Article

RUST FUNGI ON SOME POACEOUS WEEDS OF WHEAT CROPS IN PAKISTAN

NAJAM-UL-SEHAR AFSHAN* & ABDUL REHMAN NIAZI

**Centre for undergraduate studies, Department of Botany, University of the Punjab, quaid-e-azam campus, Lahore, 54590, Pakistan*

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ABSTRACT

The article enlists common poaceous weeds found in wheat crop sand their specific parasitic rust fungi. In this study, four (04) plant taxa of Poaceae infected with rust fungi are collected from different wheat crops grown in different areas of Pakistan. The rust fungi are isolated, characterized and identified. All these host plants are known weeds of wheat crop in Pakistan. This work would help to identify and enlist the potential rust fungi on weeds of wheat crop that could be utilized to control these noxious weeds in future.

1. Introduction

Agriculture is the backbone of Pakistan, employing 50% of the total labor force at national level and contributing 25% to GDP and 85% to export earnings. Wheat, rice, cotton and sugarcane are the major crops occupying more than 21 million hectares land in irrigated and rainfed areas. Wheat has a unique position among the cultivated crops. Firstly, it is grown on a larger area as compared to other crops. Secondly, it provides more carbohydrates and proteins in the world diet than any other crop. Thirdly, the world wheat trade exceeds all other crops combined. At the national level in Pakistan, during 2004-05, the area under wheat cultivation was 8.358 million hectares with a production of 21.612 million tons [1]. Its cultivation is economical and it gives good yields of grain with excellent storage properties. It contains 13% protein and is a staple food in Pakistan [2].

Weed interference is one of the important constraints, contributing towards low yield of wheat in Pakistan because insects and diseases are not a significant problem in wheat. About 75% population is residing in rural areas. Being Agriculturists, it is our responsibility to produce the food with such increased rate that could fulfill the food requirements of the bulging population. Vertical improvement is the only way because of having enough room to get the maximum yield from the existing cultivars of wheat as horizontal improvement is impossible. Different farmers reported wheat yield losses due to weeds differently. About 44% farmers reported 20-30% yield losses in wheat, 30% of the farmers reported 31-40% and 17% farmers reported 41-50% wheat yield losses [3]. The critical weed competition period in wheat is 30 to 60 days after sowing. After 60 days of sowing there is no economic benefit to eradicate weeds from wheat crop. The growth of most of the crops involves a constant battle with the weeds in addition to insect pests and diseases. Weeds not only reduce the crop yield, but also deteriorate the quality of the produce thereby, reducing its market value. Therefore, the eradication of weeds from the crop fields is essential for obtaining maximum returns. The various methods for eradication of weeds are Hoeing and Weeding, Tillage, Bar Harrowing, Crop Rotation, Chemical Control & Biological Control [2]. Hence weed control is very important for increasing our crop production. Despite the extensive use of herbicides, biological control methods for weeds are most efficient and economical. Biological control of noxious weeds is the deliberate use of natural enemies to reduce the density of a

Corresponding Author: NAJAM-UL-SEHAR AFSHAN, Department Centre for undergraduate studies, Department of Botany, University of Punjab, quaid-e-azam campus, Lahore, Pakistan. **Telephone No:** 03464654707 **E-Mail:** pakrust@gmail.com, mushroomniazi@gmail.com

particular weed to a tolerable level. The objective of biological weed control is not eradication but simply the reduction of weed population to an economically low level [4, 5]. Several rust fungi have been used as biological control agents against certain noxious weeds. The plant rust fungi are virulent, highly host specific, are typically wind dispersed, may infect directly through the host epidermis or through stomata and do not require wounds. Therefore, members of this group of fungi are particularly well suited as biocontrol agents [6]. Watson [5] lists 17 species of rusts which have been introduced to non-native locations to control noxious weeds, mainly in Australia but also in the United States and Canada. Some native species of rusts have been used to control weeds and varying degrees of success have been achieved. Boneseed rust, *Endophyllum osteospermi* is highly promising as a biocontrol agent for boneseed (*Chrysanthemoides monilifera* subsp. *monilifera*) because it reduces growth and reproduction of the plants, deforming infected branches into 'witches' brooms' [7]. But, before their use as biological control agents, it is important to identify and characterize specific rust fungi of a particular weed in any crop. This paper aims to identify and characterize some important and noteworthy rust fungi on poaceous weeds of wheat crop in Pakistan. In future, we can utilize this information to introduce these rusts as biological control agents for weeds that are a permanent hazard for our wheat crops.

2. Materials and Methods

Rust infected plants were collected from different wheat crops in Pakistan. Freehand sections of infected tissue and spores were mounted in lactophenol and gently heated to boiling. The preparations were observed under a NIKON YS 100 microscope and photographed with a digipro-Labomed. Drawings of spores and paraphyses were made using a Camera Lucida (Ernst Leitz Wetzlar, Germany). Spore dimensions were taken by an ocular micrometer. At least 25 spores were measured for each spore stage. The rusted specimens have been deposited in the herbarium of the Botany Department, at the University of the Punjab, Lahore (LAH).

3. Result and Discussion

Sr. No.	Weeds of Poaceae	Rust fungi
1	*Bromus japonicus* Thunb.	*Puccinia graminis* var. *stakmanii* A. L. Guyot, Massenot & Saccas ex Z. Urb.
2	*Cynodon dactylon* (L.) Pers.	*Puccinia cynodontis* Delacr. ex Desm.
3	*Cyperus rotundus*	*Puccinia conclusa* Thüm.
4	*Lolium* sp.	*Puccinia coronata* var. *coronata* Corda, *Puccinia striiformoides* M. Abbasi, Hedjar. & M. Scholler
5	*Phalaris minor* Retz.	*Puccinia coronata* var. *gibberosa* (Lagerh.) Jørst.

Table1: Poaceous weeds and their rust fungi

3.1 *Description of species*

I. ***Puccinia conclusa*** Thuem., Journal Sci. math. phys. nat. Lisboa, 1 Ser. 6(no. 24): 237 (1878)= *Puccinia romagnoliana* Maire & Sacc., Ann. Mycol. 1: 220 (1903).

Spermogonia and aecia unknown. Uredinia hypophyllous, brown, 0.2–0.3 × 0.09–0.1 mm. Urediniospores globose to subglobose or obovoid, brown, 18–21 × 21–28 µm, echinulate, wall 1.5–3 µm thick; germ pores 2, equatorial; pedicel hyaline, short. Telia hypophyllous, covered by epidermis, black, 0.2 × 0.1 mm, with brown paraphyses. Teliospores ellipsoid to clavate or oblong, pale brown, slightly constricted at septa, base attenuated, 13–21 × 44–60 µm; apex rounded or conical, 4–8 µm thick; wall 1–2 µm thick, smooth; pedicel pale brown, short, up to 40 µm long.

MATERIAL EXAMINED**: PAKISTAN**, **PUNJAB**, Lahore, at 217 m a. s. l., on *Cyperus rotundus* L., with II + III stages, 25th May, 2009, NSA # 01; Gujrat, on *Cyperus rotundus* L., with II + III stages, 12th April, 2011, NSA # 01A.

COMMENTS: *Puccinia conclusa* has previously been reported on *Cyprus difformis*, *C. iria* L. and *C. rotundus* from Chuharkana (Sheikhupura), Karachi, Lahore and Khanspur [8–14].

II. ***Puccinia coronata* var. *coronata*** Corda, *Icon. fung.* (Prague) 1: 6 (1837)

Spermogonia and aecia unknown. Uredinia amphigenous, mostly on adaxial leaf surface, yellowish brown to cinnamon brown, 0.07–0.09 × 0.1–0.3 mm; with few colorless to light brown, cylindrical to clavate paraphyses, less common, apex 12–13 µm wide while 7–9 µm thick below, up to 50 µm long. Urediniospores globose-subglobose or ellipsoid, (15–) 17–21 × (17–) 19–28 µm; germ pores 5–9, scattered, obscure; wall 1.3–2 µm thick, echinulate, golden brown to cinnamon brown. Pedicel minute, deciduous, 4–8 × 10–12 µm. Telia amphigenous or on abaxial surface, long covered by the epidermis, or only tardily exposed, blackish brown, with a few brown stromatic paraphyses, sori scarcely loculate, sori 0.06–0.08 × 0.09–0.2 mm. Teliospores , clavate to ellipsoid or oblong, 10–16 (–20) × 35– (47–) 56 (–62) µm (excluding digitations), digitations 2– several, 5–12 µm long, wall up to 2 µm thick at sides, smooth, chestnut brown, paler basally, about 2–4 (–6) µm thick apically excluding digitations. Pedicel short, yellowish brown to brown, 6–7 × 9–15 µm.

MATERIAL EXAMINED**: PAKISTAN, KHAIBER PAKHTUNKHAWAH** (KPK), Khanspur-Ayubia, at 2575 m a. s. l., on *Lolium* sp., with II + III stages, 12th June, 2011, NSA # 06.

Puccinia coronata var. *coronata* has been reported on *Lolium persicum* from Quetta [15–16]; on *Agrostis* sp. from Swat, Kaghan valley, Peshawar valley, Karachi and Faisalabad [17–18, 10–12], and on *Festuca* sp. from Swat [19].

Puccinia coronata var. *gibberosa* (Lagerh.) Jørst., (1949) [1948]

Spermogonia and aecia unknown. Uredinia amphigenous, brown, 0.2–0.4 × 0.09–0.2 mm. Urediniospores globose-subglobose or ovoid, 20–24 × 21–29 µm; germ pores 2–6, scattered, obscure; wall 1.5–2 µm thick, verrucose, pale yellow to nearly colorless; pedicel minute, deciduous. Paraphyses capitate to clavate, cap 12–13 µm wide while 7–9 µm thick below, up to 50 µm long. Telia amphigenous, long covered by the epidermis, or only tardily exposed, blackish brown, sori 0.3–0.5 × 0.09–0.1 mm. Teliospores golden to brown, 14–24 × 35–59 µm, wall up to 2 µm thick at sides while about 2–5 µm thick apically excluding digitations, apex coronate with digitations, 3–7 µm long. Pedicel short, yellowish brown to brown.

MATERIAL EXAMINED**: PAKISTAN**, **PUNJAB**, Lahore, at 217 m a. s. l., on *Phalaris minor* Retz., with II, III stages, 15th April, 2010, NSA # 02.

Puccinia coronata var. *gibberosa* has been reported as a new record for Pakistan with *Phalaris minor* as a new host for *P. coronata* species complex from Pakistan [8]. It is a new record for Lahore.

III. ***Puccinia cynodontis*** Delacr. ex Desm., *Plantes Crypt. de France* 2: no. 655 (1859) = *Aecidium plantaginis* Ces., *Erb. critt. Ital.*, Ser. 1: no. 247 (1859)

Spermogonia and aecia unknown. Uredinia amphigenous, mostly on abaxial surface, subepidermal, yellowish brown to cinnamon brown, 0.09–0.1 × 0.1–2.0 mm. Urediniospores globose to subglobose, 19–27 (–30) × (21–) 23–33 µm (mean 25.04 × 27.98 µm); wall 2–3 µm thick, pale brown to cinnamon brown, finely verrucose; germ pores 2–3, equatorial, pedicel hyaline, short. Telia mostly abaxial, sometimes amphigenous, early exposed, dark brown to blackish brown, 0.2–0.4 × 0.2–0.6 mm. Teliospores clavate to ellipsoid, 18–28 × (28–) 37–45 (–58) µm (mean 23.30 × 43.26 µm); wall 2–3 µm thick, chestnut brown to golden brown, smooth; apex mostly acuminate, 6–10 µm thick; germ pores obscure; pedicel hyaline to light brown, thin walled, 10–12 × 60–70 µm .

MATERIAL EXAMINED: **PAKISTAN**, **PUNJAB**, Lahore, at 217 m a. s. l., on *Cynodon dactylon* (L.) Pers., with II and III stages, 13th August, 2010. NSA # L03.

Puccinia cynodontis has been reported on *Cynodon dactylon* from Tandojam, Karachi, Faisalabad and Quetta [20, 10–11, 12–13, 21, 15–16]. It is a new record for Lahore.

IV. ***Puccinia graminis* var. *stakmanii*** A. L. Guyot, Massenot & Saccas ex Z. Urb., *Česká Mykol.* 21: 14 (1967)

Spermogonia and aecia not seen. Uredinia intermixed with telia, dark blackish brown, amphigenous. Urediniospores 14–23 × 20–36µm, ovoid to ellipsoid or subglobose, wall 2–3µm thick at side, up to 6µm at apex, brown to chestnut brown, echinulate, the echinula are about half the diameter on the spore equator, germ pores 3–4, equatorial. Pedicel brown, 6–7 × 50µm. Telia amphigenous, black, 0.09–0.14 × 0.06–0.3mm. Teliospores oblong to ellipsoid, constricted at the septum, attenuated below, chestnut brown, 16–24 × 30–52µm; germ pore 1 in each cell, wall up to 3µm thick at side; apex conical, 4–9µm thick. Pedicel light brown, persistent, 6-8 × 86µm.

MATERIAL EXAMINED: **PAKISTAN**, **KHAIBER PAKHTUNKHAWAH** (KPK), Khanspur-Ayubia, at 2575m, on *Bromus japonicus* Thunb. 30th April, 2010, NSA # 08.

The black stem rust, *P. graminis* Pers., is a common heteroecious species with species of *Berberidaceae* as aecial hosts and members of the *Poaceae* as telial hosts. Cummins [22] lists 77 host genera of *Poaceae* (primarily in subfamily *Pooideae* but also a few in the subfamily *Panicoideae*) containing species that harbor *P. graminis*. *Puccinia graminis* and *P. graminis* subsp. *graminicola* Z. Urb. and *P. graminis* var. *stakmanii* have previously been recorded on *Triticum aestivum* L. and *Bromus japonicus* from Swat state, Miana; on *Agropyron semicostatum* Nees. from Miana; on *Agrostis munroana* Aitch. & Hemsl. from Kaghan valley; on *Hordeum vulgare* L. from Faisalabad; on *Cynodon dactylon* Pers. from Quetta and on *Bromus japonicus* from Khanspur [23, 10–11].

V. ***Puccinia striiformoides*** M. Abbasi, Hedjar. & M. Scholler, in Abbasi, Hedjaroude, Scholler & Goodwin, *Rostaniha* 5(2): 75 (2005) = *Puccinia striiformis* var. *dactylidis* Manners, *Trans. Br. mycol. Soc.* 43: 65 (1960)

Spermogonia and aecia unknown. Uredinia mostly on the adaxial surface, yellow to yellowish brown, 0.05–0.06 × 0.2–0.3 mm. Urediniospores globose–subglobose or ovoid, hyaline to light yellow, echinulate, 16–21 × 19–24 µm; wall 1.5–2 µm thick; germ pores up to 8, scattered, obscure. Paraphyses intermixed, abundant, hyaline, cylindric to clavate, 3–5µm thick and up to 50 µm long. Telia amphigenous or mostly abaxial, black, striate, covered by the epidermis, loculate, 0.09–0.15 × 0.03–0.04 mm, surrounded by a few paraphyses. Teliospores mostly two–celled but one–celled teliospores are also common. Two–celled teliospores are mostly oblong-clavate or often ellipsoid, 13–24 × 29–49 µm, light golden to clear chestnut brown, often paler basally, smooth; germ pore 1 per cell, obscure; wall 1.5–2 µm thick at the sides, 3–6 µm thick apically, apex truncate, pointed or obliquely conical, not or slightly constricted at septa, base attenuated; pedicel short, up to 8 µm long, but mostly less than 7 µm. One-celled teliospores 15–20 × 17–30 µm, clavate to ellipsoid or often angular, light golden to clear chestnut brown, smooth; wall thickness up to 1.5–2 µm, apex truncate, pointed or obliquely conical, up to 3–6 µm thick; pedicel very short. Paraphyses clavate, few, chestnut brown, 5–5.5 µm wide and up to 47 µm long.

MATERIAL EXAMINED**: PAKISTAN, KHAIBER PAKHTUNKHAWAH** (KPK), Khanspur-Ayubia, at 2575 m a. s. l., on *Lolium perenne* L., with II + III stages, 20th September, 2006. NSA # 05.

Puccinia striiformoides has been reported as a new record from Pakistan with *L. perenne* as a new host for this rust [23].

Conflict of interest statement

We declare that we have no conflict of interest.

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