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Effect of age of host on development of stripe rust of barley

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Abstract
Stripe rust of barley caused by *Puccinia striiformis* f. sp. *hordei* (Psh), is an important disease in barley growing regions of India and worldwide. The effect of plant age on the development of stripe rust in barley was studied on susceptible cultivar RD2035 under artificial disease inoculation condition in cage house. For identifying plant age susceptible to stripe rust, five staggered sowing at 10 days interval during 2016-17 and 2017-18**.** Maximum stripe rust severity was observed in the plants ageing 25 DAS with PDS 80.57. However, plant age of 65 DAS exhibited minimum PDS 11.27. The present finding showed that the per cent rust severity decreased with increased plant age. The youngest plant groups showed more vulnerability to rust infection with highest percent rust severity, minimum incubation period and latent period as compare to older one.

Keywords: barley, stripe rust, plant age, susceptible, *Puccinia striiformis, Hordeum vulgare*

Introduction
Barley (*Hordeum vulagere* L.) is one of the most important fourth cereals crop of the world after rice, wheat and maize and source of food for large population of cool and semi-arid areas of the world, where wheat and other cereals are less adapted. In India used as variety of purposes including animal feed, human food and in industry for malting and brewing (Selvakumar *et al*., 2015; Singh *et al*., 2019) [11, 15]. This crop is considered as poor man's crop in India because of its low input requirement and better adaptability in the harsh environments (Verma *et al*., 2012) [18]. In India, barley is grown about 0.609 million hectares area with 1.818 million tonnes production and a productivity of 29.9 q/ha (Anonymous, 2020-21). Barley suffers from several diseases responsible for heavy reduction in yield and grain quality. Out of them, stripe rust caused by *Puccinia striiformis* f. sp. *hordei*, (Psh) is the major constraint in South Asia, East Africa, and Central and North America affecting both quantity and quality of barley produced (Luthra and Chopra, 1990; Roelfs and Huerta-Espino, 1994) [11, 13]. The change in host-plant resistance as a function of developmental stage at the time of infection has been given several names: ontogenic resistance, developmental resistance, mature-seedling resistance, adult-seedling resistance, adult-plant resistance and, occasionally, age-related resistance (Kus *et al*., 2002; Whalen, 2005) [10, 19]. In general, incubation period increases and severity decreases with plant age (Kendrick & Walker, 1948) [8]. The present findings are in agreement with Agrios (2005) [1], who reported that plant age is important in disease infection and young plants are more susceptible. Therefore, under epidemic conditions and non availability of resistant varieties, cultural practices is the only option in reducing rust severity as a component in integrated management of the disease (Kanwar *et al*., 2021) [7]. Age-related resistance can have implications for disease management strategies.

Materials and Method
Stripe rust inoculum
Every season, in the first fortnight of November the fresh and pure inoculum of *Puccinia striiformis* f. sp. *hordei* (PSH) was obtained from ICAR-IIWBR Regional Station, Flowerdale, Shimla (H.P.) to carry out the experiments. The inoculums was consisting of viable uredospores of four predominating pathotypes *viz*., 57 (0S0), 24 (0S-1), M (1S0) and G (4S0) prevailing in the major barley growing areas of the country.

Maintenance and multiplication of pathotypes

All these four pathotypes of *Puccinia striiformis* f. sp. *hordei* (PSH) were maintained and multiplied on the seedlings of highly susceptible barley cultivar BL-2. The seedlings were inoculated with uredospores of individual pathotype separately in cage house at two leaf stage (10-20 Zadoks scale) using syringe technique. The pots of inoculated seedlings were incubated in moist cloth chamber for 48 hrs to provide artificial humid environment for promote rust infection. The inoculum in the form of uredospores was collected after 13-14 days of inoculations on butter paper by gently tapping the infected leaves. The butter paper containing uredospores were put in the air tight glass vials and kept in refrigerator. Thus, the inoculum multiplied this way was utilized during investigations.

Effect of plant age on the development of stripe rust

The effect of plant age on the development of stripe rust of barley was studied on susceptible cultivar RD 2035 under artificial disease inoculation condition in cage house. A pot experiment was laid out in completely randomized design (CRD) with four replications. Barley plants were raised in 25 cm earthen pots. The barley seedlings were artificial inoculated with a mixture of four predominating races M, 57, 24 & G of *Puccinia striiformis* f. sp. *hordei* by using syringe technique at 25, 35, 45, 55 & 65 days old plants and kept under moist cloth chamber to providing optimum humidity to develop the disease and irrigated regularly to maintained the humidity throughout the disease development period. The date of rust appearance was recorded in terms of incubation period, latent period and per cent disease severity using (0-9) scale given by Peterson *et al*., (1948) [12].

Results and Discussion

In addition to pathogen propagule dispersal, disease spread requires successful infection of host tissue. In plant disease epidemiology, susceptibility of host tissue is often assumed to be constant. This assumption ignores changes in host phenology due to developmental stage. Younger plants had significantly greater disease severity than older plants, (Farber and Mundat, 2016) [5]. Age of the host at the time of inoculation is an important factor, affecting its susceptibility to a disease. In order to know the most vulnerable stage of the host, the barley plants of different ages were inoculated by the pathogen. Significant differences in disease severity were observed with different age of plants. Data presented in table showed that the age of plant greatly influenced the development of stripe rust. The per cent rust severity was decreased with increase of plant age. The youngest plant group of 25 days old seedlings was found more vulnerable to rust infection with highest per cent rust severity (80.57), minimum incubation period (10 days) and latent period (12 days). Similar results have been reported by de Vallavielle-Pope *et al.* (2000) [16] that the rate of epidemic development is largely influenced by the length of latent period, which determines the number of potential infection cycles that can be completed during a growing season. Likewise, Changes in host response to a pathogen over time, expressed as plant age, leaf age and leaf position, have been reported for several pathogens (Whalen, 2005; Develey-Riviere & Galiana, 2007) [19, 4]. While, the eldest plant group of 65 days old were showed maximum incubation and latent period of 25 and 32 days respectively with minimum per cent rust severity (11.27) followed by 55 days old group of plants showed 12 days incubation and 19 days latent period with 21.17 per cent rust severity, 45 days old plants showed 10 days incubation and 17 days latent period with 40.87 per cent disease severity and 35 days old group plants with 11 days incubation and 14 days latent period with 65.17 per cent disease severity. The difference in per cent disease severity of plants inoculated at 25 to 65 days was statistically significant from each other. Effects of leaf age on disease development have been described in several studies. However, similar results were obtained in some cases, mature leaves were more resistant to infection (Kus *et al*., 2002; Kurt & Tok, 2006) [10, 9] whereas in others, younger leaves were less susceptible (Heilbronn & Harrison, 1989; Bouhassan *et al*., 2004) [6, 3]. The per cent rust severity decreased with increased in plant age. Van Manen and Xu, (2003) [17] also reported that latent period also vary with the level of host susceptibility and host growth stages, therefore it is important to study the pathogen and host dynamics in plant disease epidemiology.

Table 1: Effect of different plant age on the development of stripe rust in barley

S. No.	Plant age (days)	Incubation period (days)	Latent period (days)	Per cent disease severity
1	25	10	12	80.57 (63.85)
2.	35	11	14	65.17 (53.83)
3.	45	10	17	40.87 (39.74)
4.	55	12	19	21.17 (27.39)
5.	65	25	32	11.27 (19.62)
			S.Em.±	0.61
			C.D. at 5%	1.94

*Mean of four replications Figures in parentheses are arcsine √ per cent angular transformed values

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