Assessment of some Indian wheat genotypes and breeding lines for adult plant resistance (APR) against stripe rust

Rubby Sandhu, Bikram Singh, Tuhina Dey and MK Pandey

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Abstract
Stripe or yellow rust of wheat caused by *Puccinia striiformis* west end *f. sp. tritici* is a devastating foliar disease and is considered of immense importance in cool and humid wheat growing parts of the world. A total of 41 wheat genotypes collected from different institutes of India were evaluated for Adult Plant Resistance to stripe rust. The field studies revealed fifteen genotypes viz.: PBW 750, PBW 752, PBW 779, PBW 790, JAUW 672, WH 1184, HI 1619, 13th HTWT 719, 25th HRWSN 2105, 47th IBWSN 1185, 32nd SAWSN 3011, HD 3086, 22nd SAWYT 316, PBW 763 and PBW 801 exhibiting resistant reaction with Average Coefficient of Infection (ACI) ranging from 0.45 to 2.

Keywords: Adult plant resistance, *Puccinia striiformis*, wheat, stripe rust, coefficient of infection (CI)

Introduction
The spectrum of biotic and abiotic stresses affecting wheat crop is increasingly becoming unpredictable and there is an alarming need for the preparedness towards overcoming these stresses. Stripe or yellow rust of wheat caused by *Puccinia striiformis* is devastating foliar disease and is considered of immense importance in almost all the wheat growing parts of the world (Khan *et al.*, 2012; Singh *et al.*, 2014) [1, 2]. In India, yellow rust severely affects wheat production in North-Western plain zone as well as Northern hills zone due to the favourable environment for rust pathogens (Saharan *et al.*, 2010) [6]. Wheat yield losses caused by *P. striiformis f. sp. tritici* ranges from 10–70% in different wheat producing areas depending upon the susceptibility of cultivars, time of the initial infection, rate of disease development and duration of the disease (Dedryver *et al.* 2009) [3]. Year after year, the susceptible wheat cultivars suffer from stripe rust (*Puccinia striiformis* Westend *f. sp. Tritici*) disease, which increases inoculum build up posing major threat to wheat cultivation of India. Although, remarkable progress has been made in breeding for stripe rust resistant varieties in India, the subsequent evolution of pathogen races at much greater pace has challenged this breeding programme (Khan *et al.*, 2009; Singh *et al.*, 2011) [4, 5] and stripe rust continues to pose a threat for wheat cultivation worldwide (Sareen *et al.*, 2012) [7]. Breeding for resistance is the most effective and efficient control strategy, as it does not add input cost of farmers and is environmentally safe (Yang and Liu, 2004) [11]. To date, 80 yellow rust resistance (Yr) genes have been permanently named in wheat, including the recently mapped *Yr79* (Feng *et al.*, 2018) [18] and *Yr80* (Nsabiyera *et al.*, 2018) [9], and 67 stripe rust resistance genes have been temporarily designated, including all-stage resistance (also termed seedling resistance) and adult-plant resistance (APR) (Wang and Chen, 2017) [18]. Although these *Yr* genes have been identified in diverse wheat accessions, the race specificity of seedling resistance genes limits their efficacy against pathotypes (Kankwatsa *et al.*, 2017). In contrast, APR is generally considered to be durable, but APR genes represent a minority of known resistance genes (Kankwatsa *et al.*, 2017; Yuan *et al.*, 2018) [4]. Therefore, enhancing the resistance of adult plants to cope with evolving races of PST is the preferred strategy for resistance breeding.

Material and Method
A total of 41 wheat genotypes collected from different sources were used for screening under field conditions for stripe rust resistance. The mixture of bread wheat cultivar Agra local,
PBW 343 and Kharchia which showed consistent susceptibility to stripe rust over years under screening tests, were used as susceptible check. The experiment was conducted following randomized complete block design for the field evaluation. Recommended agronomic practices were followed to raise a healthy crop. The artificial rust epidemic was created by repeated spray of inoculations using soap water solutions of mixture of races on experimental materials. The spray inoculations were done in evening on alternate days during mid January. Data pertaining to morpho-physiological and disease reactions was newly recorded as per standard procedures. Details about the origin/pedigree of these genotypes are provided in Table 1.

**Table 1:** List of wheat germplasm lines and breeding lines used for the study

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<td>ND643/2<em>WBLL1/4/WHEAR/KUKUNA/3/C801/3/BATAVIA/2</em>WBLL1</td>
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<td>38</td>
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<td>CCSHAU, Hissar</td>
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<td>41</td>
<td>Agra local</td>
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<td>-</td>
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**Morpho-physiological studies on stripe rust severity**

All the selected genotypes were scored for stripe rust reaction in the field at the Experimental Farm of Division of Plant Breeding and Genetics located at the Main Campus, Chatha. All agricultural practices recommended for the wheat crop were followed. The artificial rust epidemic was created by repeated spray inoculations using soap water solutions of mixture of races on experimental materials. The spray inoculations were done in evening on alternate days during mid-January. The stripe rust severity was recorded as percent of the rust infection on the wheat plants according to the modified Cobb’s scale (Peterson et al., 1948) [12] and the field response scale referred to the infection type (McIntosh and Arts, 1995; Roelf et al., 1992) [12]. The data on disease severity and host reaction was combined to calculate the coefficient of infection (CI) by multiplying the severity value of 0.2, 0.4, 0.8, 1.0 for host response ratings R, MR, MS, S, respectively, (Pathan and Park., 2006) [13].
Results and Discussion
Screening of germplasm against stripe rust under field condition
The data on average coefficient of infection (ACI) recorded during *rabi* 2017-2018 and 2018-2019 was used for phenotypic screening of test genotypes. The yellow rust severity and average coefficient of infection (ACI) of 41 genotypes is presented in the Table 3.

Out of 41 genotypes, 11 genotypes viz; JAUW 649, JAUW 665, JAUW 666, JAUW 667, JAUW 670, JAUW 671 and JAUW 674 were found susceptible accounting for 29.82% of total genotypes with Average Coefficient of Infection (ACI) ranging from 21 to 35. While, 2 genotypes viz; HD 2967 and check variety Agra local showed highly susceptible reactions with Average Coefficient of Infection (ACI) 50 and 85.36 respectively, over two successive years. Four genotypes viz; 22nd SAWYT 323, JAUW 673 and MP 1318 were found moderately resistant accounting for 9.76% of total genotypes with Average Coefficient of Infection (ACI) ranging from 4.76 to 5.78. Nine genotypes viz; JAUW 584, JAUW 654, WH 1080, PBW 723, WH 1142, IBWSN 1080, 35th ESWYT 113, RAJ 3765 and WH 1124 were found moderately susceptible accounting for 21.95% of total genotypes with Average Coefficient of Infection (ACI) ranging from 8.30 to 14.01. Fifteen genotypes viz; PBW 750, PBW 752, PBW 779, PBW 780, JAUW 672, WH 1184, HI 1619, 13th HTWYT 719, 25th HRWSN 2105, 47th IBWSN 1185, 32nd SAWSN 3011, HD3086, 22nd SAWYT 316, PBW 763 and PBW 801 were identified as potential donors for stripe rust resistance accounting for 36.58% of total genotypes with Average Coefficient of Infection (ACI) ranging from 0 to 3. The percentage of disease severity is also illustrated using bar chart in Figure 1.

Table 3: Morphological screening of Forty one wheat genotypes against stripe rust

<table>
<thead>
<tr>
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“~33~

Table 2: Host response to stripe rust in field

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<td>Resistant</td>
<td>Visible chlorosis/necrosis, no uredia are present</td>
<td>R</td>
<td>0.2</td>
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<tr>
<td>Moderately Resistant</td>
<td>Small uredia surrounded by chlorotic or necrotic areas</td>
<td>MR</td>
<td>0.4</td>
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<tr>
<td>Moderately Susceptible</td>
<td>Medium sized uredia with no necrotic margins but possibly some distinct chlorosis</td>
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<tr>
<td>Susceptible</td>
<td>Large uredia and little or no chlorosis present</td>
<td>S</td>
<td>1.0</td>
</tr>
</tbody>
</table>

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These 15 promising genotypes identified in the present characterization study might be useful as parental lines for diversifying Pst resistance sources in wheat breeding. However, there is further need of involving larger number of genotypes to have better picture of germplasm structure to exploit for crop improvement programmes. Saini et al. (2002) [17] screened 20 Indian and 61 exotic wheat cultivars, 8 near-isogenic lines and 2 leaf rust-susceptible wheat cultivars (Agra Local and Morocco) against stripe rust artificially inoculated with the pathogen in experiments conducted at Ludhiana, Punjab and Bajaura, Himachal Pradesh, India. Zeng et al. (2014) [14] also screened a set of wheat germplasm lines for subsequent molecular validation of stripe rust resistance genes Yr5, Yr9, Yr10, Yr15, Yr17, Yr18 and Yr26. The terminal disease severity (TDS) was recorded at adult plant stage following standard procedures and scales developed by McNeal et al. (1971) [16] and Peterson et al. (1948) [12]. This was in accordance to the procedures followed for screening of germplasm lines in the present study.

**Conclusion**

The promising genotypes identified in the present characterization study exhibited effective adult plant resistance. These cultivars should be improved/developed further by accumulating 4-5 minor genes to achieve near-immunity prior to deployment as a control strategy for managing the yellow rust problem. However, further studies for the development of diagnostic molecular markers to assess the adult plant resistance (APR) gene are still needed for genotypic characterization and field evaluations in the current era. Wheat lines, selected on the basis of resistance could be used in a hybridization program to develop new rust resistant cultivars.
References