Field Crops Research 214 (2017) 291–300

Contents lists available at ScienceDirect

Field Crops Research

journal homepage: www.elsevier.com/locate/fcr

Pooling together spot blotch resistance, high yield with earliness in wheat for eastern Gangetic Plains of South Asia

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ARTICLE INFO

Keywords:
Wheat
Spot blotch
AUDPC
Eastern Gangetic Plains
GGE biplot

ABSTRACT

This study was done with an objective to attempt to pool together in wheat, the three most important traits (spot blotch resistance, high yield and earliness) for warm humid Eastern Gangetic plains (EGP) of South Asia. A Recombinant Inbred Line (RIL) population, developed from two contrasting parents (YS#58 × YS#24) for spot blotch resistance, was tested in seven environments falling under three locations of EGP. Most of the components of variation for three traits were highly significant for each environment as well as in pooled analysis. In general, phenotypic correlation for Area Under Disease Progress Curve (AUDPC) among centers was high and positive. Out of 214 genotypes (211 RILs along with their parents YS#24, YS#58 and Sonalika, check for spot blotch susceptibility and earliness) tested, 15 RILs showed better resistance than the resistant parent. Measured over seven environments, six lines were significantly superior to best check for spot blotch resistance while two for grain yield, four for earliness and two for 1000-grain weight. However, only one line (#94) was found significantly superior for all four traits compared to the best check. Genotype × Environment (G × E) interaction was significant but Genotype × Year (G × Y) was non-significant which indicated the importance of locations for spot blotch. To support this fact, lines superior in one location did not perform well in the other. For resistance, line #174 performed most consistently over 7 environments. Although there was negative correlation between AUDPC and days to heading, low AUDPC was observed in two early maturing RILs (#94 and #1). The study demonstrated that through appropriate crossing and evaluation, it is possible to pool together spot blotch resistance in to high yield back ground of wheat with early maturity.

1. Introduction

Wheat (*Triticum aestivum* L.) is a major staple crop of South Asia, especially in the thickly populated Indo-Gangetic plains and on an average meets 20% calorie requirement of people in this part of the world (Joshi et al., 2011). Out of around 40 million hectare area under wheat cultivation in south Asia, 25% fall under EGP but contribute only 16% to the total wheat production. Being densely populated, demand of wheat in EGP can only be met if annual production is increased by 1.5–2% (Chatrath et al., 2007; Joshi et al., 2011). High humidity in the EGP of South Asia and makes it distinct from most other wheat growing warmer locations in the world (Joshi et al., 2007a) and characterized as Mega Environment 5A (ME5A) (Braun et al., 1992). Hot humid weather conditions of EGP often provoke spot blotch disease and leads to significant crop losses (Joshi et al., 2007a). This disease in combination with warmer temperature at post anthesis stage results in further yield losses due to shriveled grains (Hays et al., 2007). Lobell et al. (2008) reported 3–17% wheat yield loss for each degree rise in temperature at reproductive stage of wheat. Therefore, spot blotch and terminal heat stresses are considered the two most important constraints to wheat production in the EGP of South Asia (Joshi et al., 2007a). Despite the soils of EGP being very fertile, average wheat productivity here is around 40% lower than the North Western Gangetic Plains (NWPZ) of India (Anonymous, 2016). Crop losses in the Indian subcontinent due to spot blotch have been estimated to be in the range 15–25% (Dubin and van Ginkel, 1991), but level of loss in individual fields can be much higher. It has been reported that on an average spot blotch causes a yield loss of 17.50% in the Indian subcontinent (Saari, 1998).

Spot blotch is also reported to spread towards north-western part of South Asia due to global warming and erratic rains in winter (Shamim

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http://dx.doi.org/10.1016/j.fcr.2017.08.027
Received 19 April 2017; Received in revised form 7 August 2017; Accepted 27 August 2017

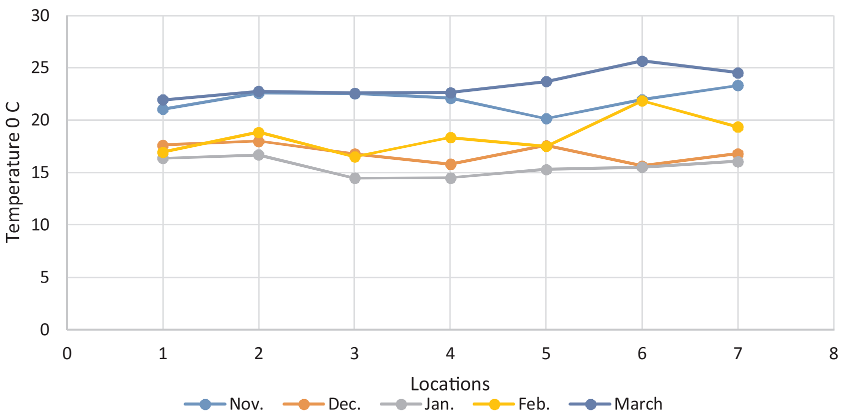

Fig. 1. Monthly mean temperature during wheat crop cycle at all the 7 environments. 1: UBKV 2013-14, 2: UBKV 2014-15, 3: BISA 2013-14, 4: BISA 2014-15, 5: BHU 2013-14, 6: BHU 2014-15, 7: BHU 2015-16.

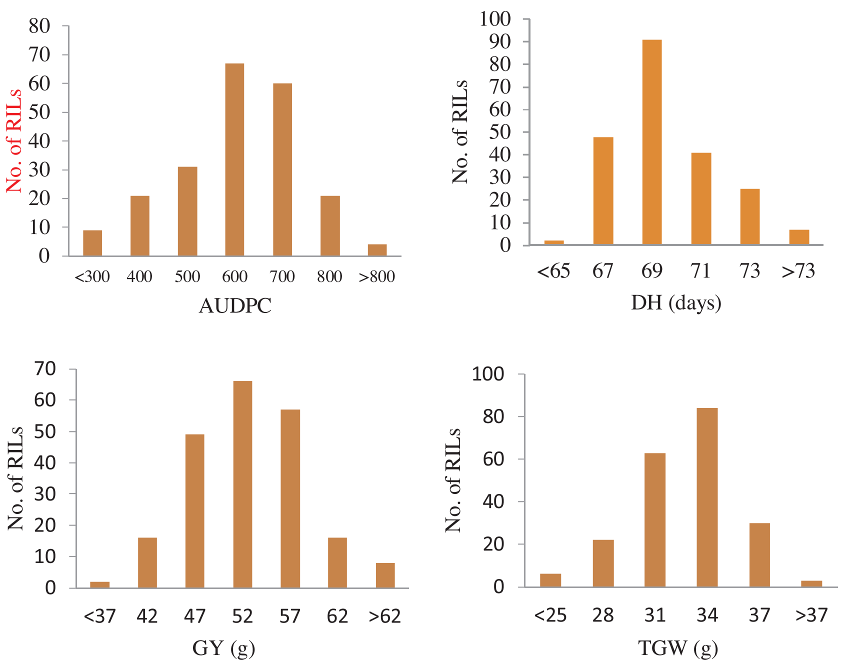

Fig. 2. Frequency distribution of AUDPC, DH, GY and TGW in the RIL population derived from the YS#24 × YS#58 in wheat, tested across 7 environments in India. AUDPC = Area under disease progress curve, DH = Days to heading, GY = Grain yield, TGW = Thousand grain weight.

Table 1
Geographical distribution of three test centers of India used to screen the recombinant inbred lines.

Test centers	State	Latitude	Longitude	Altitude (m)	Mean annual rainfall (mm)
BHU, Varanasi	Uttar Pradesh	25°18′N	83°03′E	75.50	1000
BISA, Samastipur	Bihar	25°57′N	85°40′E	52.00	1200
UBKV, Coochbehar	West Bengal	26°19′N	89°27′E	37.00	2914

et al., 2010). A positive association between spot blotch and heat stress is also reported (Rosyara et al., 2010). High yielding wheat lines of EGP possess spot blotch resistance but their level is not fully satisfactory during the epidemic year (Joshi et al., 2007b,c; Singh et al., 2015). In such a situation, an integrated approach, with host resistance as a major component, is suggested as best option for managing the disease (Joshi and Chand, 2002). For a region like EGP, best wheat variety could be one that carries early maturity, high yield along with resistance to spot blotch disease. However, not long ago a negative association between early maturity and spot blotch susceptibility was reported by many researchers (Dubin et al., 1998; Shrestha et al., 1998). However, Joshi et al. (2002) using segregating generations of the cross ‘Late Resistant’ × ‘Early Susceptible’ for spot blotch reported independent segregation of earliness and spot blotch such that it was possible to develop early maturing wheat lines having good resistance to spot blotch. Such lines yield well as they have an escape mechanism under late sown conditions fraught with high temperature (Joshi et al., 2007a). Moreover, the stability of sources of resistance should also be checked in time and space, requiring multi-location and multi-year experiments (Pande et al., 2013). Genotype and genotype by environment (GGE) biplot analysis has been widely used in recent years to determine the stability of disease resistance through multi-location trials in order to identify stable resistant genotypes (Sharma et al., 2012).

In view of the continued threat of spot blotch disease and increasing heat stress to the wheat crop, there is an urgent need to identify and develop genetically improved germplasm incorporating earliness and tolerance to spot blotch for EGP of South Asia. Therefore, the primary goal of this experiment was to identify the possibility of pooling the three traits resistance, high yield and earliness in wheat for EGP of South Asia.