Characterization of Barley Entries for Spot Blotch Resistance

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ABSTRACT

Barley (Hordeum vulgare L.) belonging to Gramineae family is an important cereal in the countries which have arid and semi-arid type. Among the different diseases occurring on barley, spot blotch or foliar blight caused by Bipolaris sorokiniana (Sacc.) Shoemaker is more damaging than other diseases, causing major reduction in quality and grain yield of barley crop. This disease can be managed by repeated fungicide applications, however, deployment of resistant varieties still remains on the top priority. Out of the 262 barley entries screened for two consecutive years under artificial epiphytotic conditions, five entries consisting of four germplasm lines viz., BL-1309, BL-1313, BL-1532, BL-1562 and one variety PL-891 were resistant towards the disease whereas thirty-three entries and two hundred and eighteen entries exhibited moderately resistant and moderately susceptible reaction respectively. Disease score of more than 78 was recorded in six entries namely, BL-1500, BL-1540, BL-1542, BL-1576, BL-1652 and PL-426 (susceptible check), exhibiting susceptible reaction towards disease. Thus, the barley entries which are resistant to spot blotch disease under artificial inoculated conditions during two years of testing under field conditions can be utilized as donors by breeders to incorporate spot blotch resistance in good yielding cultivars, which are prior found to be susceptible to the disease.

Keywords
Barley, Spot blotch, Bipolaris sorokiniana, screening

Introduction

Barley (Hordeum vulgare L.) is an important cereal of Gramineae family which is serving as the major portion of diet of the people and feed for animals. In the world, barley is cultivated on an area of nearly 50 million hectares with annual production of more than 140 million tons (Mt) (Tricase et al., 2018). It is a dominant crop in the countries which have arid and semi-arid type of climate, which thus favours development and yield of the crop. In the world, following wheat, maize and rice crop, barley occupies the fourth position as important cereal based crop belonging to graminaceous family (Taner et al., 2004). In Punjab, barley covers an area of 7.7 thousand hac with production of 30,000 tonnes and average yield of 38.80 quintals/hectare (Anonymous 2019). Due to damaging effect of different diseases, pests and poor crop management practices, the
average yield of barley in India is reported to be comparatively lower than several other countries. Among the different diseases occurring on barley, spot blotch or foliar blight caused by *Bipolaris sorokiniana* (Sacc.) Shoemaker (teleomorph: *Cochliobolus sativus*) is more damaging than other diseases, causing major reduction in grain quality and yield of this crop (Nutter *et al*., 1985; Arabi and Jawahar 2003). Yield losses of 25-45% in barley crop have been reported in Kazakhstan and 41% in Russia due to this pathogen (Iftikhar *et al*., 2009). Although spot blotch is generally associated with warm conditions, but a survey of barley diseases conducted in higher altitudes of Trans Himalayan - Ladakh region of Indiaby Vaish *et al*., (2011) estimated yield losses of 6% to 53% due to *B. sorokiniana* causing spot blotch of barley.

The infection of this disease at seedling stage starts as small brownish black spots on leaf sheaths and which thus progresses from lower to upper plant parts during crop development (Kutcher *et al*., 1994). Higher level of resistance in different barley germplasm lines is difficult to achieve owing to the genetic changes in the pathogen population, influence of the environment on disease development and the quantitative nature of resistance (Wilcoxson *et al*., 1990). The spot blotch disease frequently hinders the commercial production of barley in the north-eastern states of India. Due to the changing agronomic practices and the quick replacement of local varieties with high-yielding cultivars have thus led to the appearance of this disease in the north-western regions of the country as well where it was earlier found to be insignificant (Bala and Kaur 2008). Foliar fungicide treatments can be used to control the spot blotch on barley, however, considering the environmental issues, deployment of resistant cultivars still remains on the top priority and thus offers the most economically and environmentally safe means of disease control (Singh *et al*., 2017). Thus, the aim of the present study was to evaluate different barley accessions/germplasm lines and released popular varieties for two successive years under artificial inoculated conditions so as to identify resistance sources against spot blotch disease which could serve as donors in breeding for resistance programmes.

**Materials and Methods**

The material under study consisted of two hundred and sixty-two entries including released varieties and advanced breeding lines procured from Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana and Indian Institute of Wheat and Barley Research (IIWBR), Karnal. In order to find new resistance sources among these barley entries against *Bipolaris sorokiniana*, field experiments were conducted for two successive cropping seasons i.e. 2017-18 and 2018-19. Each entry was sown as paired rows of one meter length with 20 cm distance between rows along with susceptible check i.e. PL 426 which was repeated after every 10 entries.

Mass inoculum of the pathogen was prepared in the laboratory by inoculating pure culture of the pathogen i.e. *Bipolaris sorokiniana* on autoclaved sorghum seeds in separate flask, which were then kept in incubator at 25±2°C. After the full growth of the pathogen on the substrate, spores were harvested in distilled water which act as conidial suspension. All these barley entries were spray inoculated at maximum tillering stage with conidial suspension having spore concentration of 10^6 conidia/ml during evening hours for ensuring successful infection (Chaurasia *et al*., 1999). After 12 days of inoculation, the characteristic brown coloured spots developed on leaves which further coalesce to form a large necrotic area thus producing the
characteristic symptom of spot blotch disease. Disease assessment was done by recording the disease severity on leaves at three different crop growth stages viz. flowering, milk and hard dough stage by employing the standard double digit scale (00-99) given by Saari and Prescott (1975).

The left and right side of the double digit indicate the per cent disease severity score of blight on flag leaf (F) and flag-1 leaf (F-1) respectively. Since these two leaves remain green at milk stage and contribute most to the grain filling process, hence reduction of grain yield is directly related to disease severity in these two leaves (Singh et al., 2005). The area under disease progress curve (AUDPC) was also calculated for each entry from the disease score recorded at weekly intervals at different growth stages by the formula given by Roelfs et al., (1992) and all the entries were categorized based on their AUDPC values and terminal disease severity by using described scale ranging from highly resistant to susceptible (Table 1) (Van der Plank, 1968; Duveiller et al., 1998).

\[
\text{AUDPC} = \sum_{i=1}^{a} \left\{ \frac{(Y_i + Y_{i+1})}{2} \times (t_{i+1} - t_i) \right\}
\]

Where,

- Yi = disease score at time ti and,
- Xi and X_{i+1} are disease severity on i and i+1 date, respectively
- ti is the no. of days between i and i+1
- n is the number of observations recorded.

**Results and Discussion**

The most important measure to counteract the attack of pathogen for longer durations is use of resistant cultivars. The results obtained from the evaluation of two hundred and sixty-two barley entries evaluated for two consecutive years against *B. sorokiniana* under artificial inoculated conditions, revealed that all the entries showed almost similar reaction towards the disease during both the years of testing (Table 2). None of the cultivar or germplasm line exhibited highly resistant reaction.

Five entries consisting of four germplasm lines viz., BL-1309, BL-1313, BL-1532, BL-1562 and one variety PL-891 were resistant towards the disease having disease score of less than 35, whereas disease score between 36 to 57 was observed in 33 entries, thus exhibiting moderately resistant reaction. Disease score of more than 69 was recorded in six entries namely, BL-1500, BL-1540, BL-1542, BL-1576, BL-1652 and PL-426 (susceptible check), exhibiting susceptible reaction towards disease, while in rest of the entries, disease score was recorded between 58-69, thus exhibiting moderately susceptible reaction (Table 3).

In context with the present findings, Verma et al., (2013) had also carried out multilocation evaluation of 5458 barley germplasm accessions for resistance to spot blotch under artificial inoculated conditions for four cropping seasons at four different locations and reported that out of these accessions, only 28 accessions were found to be resistant towards spot blotch disease. Similarly, eighty five barley germplasm accessions were screened under artificial inoculated conditions against leaf blight disease by Jain et al., (2014) and out of which 68 entries were found to be resistant while rest of the entries exhibited moderately resistant to susceptible reaction towards disease. Singh et al., (2018) also evaluated 62 wheat genotypes under natural epiphytotic conditions against *Bipolaris sorokiniana*, among which eight genotypes having disease severity between 34.26 to 35.0 per cent were observed as resistant.
Table 1 Categorization of disease reaction based on severity score of spot blotch disease

| Sr. No. | Disease Reaction          | Range of values (DD)* |
|---------|---------------------------|-----------------------|
| 1       | Immune                    | 00-01                 |
| 2       | Resistant (R)             | 12-24                 |
| 3       | Moderately Resistant (MR) | 34-46                 |
| 4       | Moderately Susceptible (MS) | 56-68               |
| 5       | Susceptible (S)           | 78-89                 |
| 6       | Highly Susceptible (HS)   | 99                    |

*First and second value respectively, represents percent blighted area on the flag leaf and flag-1 leaves. Values 1,2,3,4,5,6,7,8, and 9, respectively correspond to 10,20,30,40,50,60,70,80 and 90 percent blighted area.

Table 2 Reaction of different barley entries against *B. sorokiniana* during two consecutive years of testing (2017-18 and 2018-19)

| Germplasm lines/ Varieties | Foliar blight score (dd)* | AUDPC** | DR** | Foliar blight score (dd)* | AUDPC | DR** |
|----------------------------|---------------------------|---------|------|---------------------------|-------|------|
|                            | F  | D  | HD |       | F  | D  | HD |       |
| BL 1301                    | 23 | 35 | 58 | 372.5 | 22 | 34 | 58 | 365.0 | MS  |
| BL 1309                    | 11 | 12 | 23 | 145.0 | 12 | 14 | 24 | 160.0 | R   |
| BL 1313                    | 1  | 11 | 23 | 115.0 | 11 | 12 | 23 | 145.0 | R   |
| BL 1314                    | 12 | 24 | 35 | 237.5 | 12 | 24 | 35 | 237.5 | MR  |
| BL 1319                    | 13 | 35 | 58 | 362.5 | 13 | 37 | 58 | 365.0 | MS  |
| BL 1322                    | 13 | 36 | 58 | 365.0 | 12 | 25 | 58 | 297.5 | MS  |
| BL 1325                    | 12 | 26 | 46 | 275.0 | 12 | 26 | 47 | 277.5 | MR  |
| BL 1335                    | 24 | 36 | 59 | 387.5 | 24 | 35 | 58 | 380.0 | MS  |
| BL 1338                    | 25 | 36 | 58 | 387.5 | 25 | 36 | 58 | 387.5 | MS  |
| BL 1340                    | 22 | 34 | 58 | 365.0 | 22 | 35 | 58 | 367.5 | MS  |
| BL 1363                    | 24 | 37 | 58 | 390.0 | 24 | 37 | 58 | 390.0 | MS  |
| BL 1367                    | 25 | 47 | 69 | 470.0 | 25 | 46 | 68 | 462.5 | MS  |
| BL 1368                    | 22 | 34 | 58 | 365.0 | 22 | 35 | 58 | 367.5 | MS  |
| BL 1669                    | 24 | 45 | 58 | 425.0 | 24 | 36 | 58 | 377.5 | MS  |
| BL 1375                    | 24 | 45 | 58 | 430.0 | 24 | 45 | 58 | 430.0 | MS  |
| BL 1378                    | 22 | 45 | 59 | 422.5 | 22 | 45 | 58 | 422.5 | MS  |
| BL 1390                    | 25 | 45 | 65 | 450.0 | 25 | 45 | 65 | 450.0 | MS  |
| BL 1397                    | 23 | 34 | 45 | 340.0 | 13 | 34 | 45 | 315.0 | MR  |
| BL 1400                    | 13 | 25 | 37 | 250.0 | 12 | 25 | 37 | 222.5 | MR  |
| BL 1403                    | 23 | 44 | 58 | 417.5 | 23 | 44 | 56 | 417.5 | MS  |
| BL 1404                    | 24 | 46 | 58 | 435.0 | 24 | 46 | 58 | 432.5 | MS  |
| BL 1411                    | 25 | 47 | 59 | 445.0 | 25 | 47 | 58 | 442.5 | MS  |
| BL 1413                    | 12 | 34 | 58 | 364.0 | 12 | 34 | 58 | 342.5 | MS  |
| BL 1416                    | 12 | 25 | 47 | 272.5 | 12 | 24 | 47 | 267.5 | MR  |
| BL 1420                    | 13 | 37 | 59 | 365.0 | 13 | 37 | 58 | 362.5 | MS  |
| BL 1421                    | 23 | 37 | 58 | 387.5 | 23 | 36 | 58 | 382.5 | MS  |
| BL 1429                    | 24 | 45 | 58 | 435.0 | 24 | 45 | 58 | 425.0 | MS  |
| BL 1430                    | 13 | 36 | 58 | 365.0 | 13 | 36 | 58 | 357.5 | MS  |
| BL 1440                    | 22 | 35 | 58 | 370.0 | 22 | 35 | 58 | 372.5 | MS  |
| BL 1443                    | 22 | 35 | 58 | 362.5 | 23 | 37 | 58 | 365.0 | MS  |
| BL 1451                    | 23 | 45 | 58 | 425.0 | 23 | 46 | 58 | 430.0 | MS  |
| BL 1470                    | 13 | 37 | 58 | 364.5 | 13 | 36 | 58 | 362.5 | MS  |
| BL 1473                    | 13 | 35 | 58 | 367.5 | 13 | 35 | 58 | 372.5 | MS  |
| BL 1475                    | 34 | 46 | 67 | 482.5 | 34 | 46 | 67 | 482.5 | MS  |
| BL 1500                    | 25 | 46 | 79 | 490.0 | S  | 25 | 46 | 78 | 487.5 | S   |
| BL 1501                    | 25 | 45 | 67 | 455.0 | MS  | 25 | 45 | 67 | 455.0 | MS  |
| BL 1502 | 33 | 45 | 59 | 455.0 | MS | 33 | 45 | 58 | 452.5 | MS |
|---|---|---|---|---|---|---|---|---|---|---|
| BL 1503 | 22 | 34 | 58 | 365.0 | MS | 22 | 34 | 58 | 370.0 | MS |
| BL 1504 | 12 | 24 | 36 | 240.0 | MR | 12 | 24 | 35 | 237.5 | MR |
| BL 1505 | 24 | 36 | 58 | 382.5 | MS | 24 | 36 | 58 | 382.5 | MS |
| BL 1506 | 23 | 44 | 58 | 420.0 | MS | 23 | 44 | 58 | 422.5 | MS |
| BL 1507 | 13 | 36 | 58 | 357.5 | MS | 13 | 36 | 58 | 365.0 | MS |
| BL 1508 | 22 | 45 | 67 | 447.5 | MS | 22 | 45 | 67 | 447.5 | MS |
| BL 1509 | 24 | 37 | 58 | 390.0 | MS | 24 | 37 | 58 | 390.0 | MS |
| BL 1510 | 34 | 46 | 58 | 460.0 | MS | 34 | 46 | 59 | 457.5 | MS |
| BL 1511 | 22 | 34 | 58 | 367.5 | MS | 22 | 34 | 58 | 370.0 | MS |
| BL 1512 | 24 | 46 | 58 | 435.0 | MS | 24 | 46 | 58 | 432.5 | MS |
| BL 1513 | 32 | 44 | 58 | 440.0 | MS | 32 | 44 | 58 | 440.0 | MS |
| BL 1514 | 13 | 36 | 58 | 357.5 | MS | 13 | 36 | 58 | 357.5 | MS |
| BL 1515 | 22 | 35 | 58 | 370.0 | MS | 22 | 34 | 58 | 365.0 | MS |
| BL 1516 | 13 | 24 | 48 | 272.5 | MR | 13 | 24 | 46 | 267.5 | MR |
| BL 1517 | 13 | 24 | 47 | 280.0 | MR | 13 | 24 | 47 | 280.0 | MR |
| BL 1518 | 23 | 34 | 46 | 342.5 | MR | 23 | 34 | 46 | 342.5 | MR |
| BL 1519 | 22 | 35 | 58 | 375.0 | MS | 22 | 35 | 58 | 370.0 | MS |
| BL 1520 | 22 | 34 | 45 | 337.5 | MR | 22 | 34 | 46 | 340.0 | MR |
| BL 1521 | 33 | 45 | 58 | 452.5 | MS | 33 | 45 | 58 | 452.5 | MS |
| BL 1522 | 13 | 34 | 65 | 365.0 | MS | 13 | 34 | 58 | 364.5 | MS |
| BL 1523 | 12 | 34 | 58 | 410.0 | MS | 12 | 46 | 58 | 410.0 | MS |
| BL 1524 | 12 | 35 | 58 | 365.0 | MS | 12 | 36 | 58 | 365.0 | MS |
| BL 1525 | 13 | 34 | 68 | 372.5 | MS | 13 | 34 | 67 | 370.0 | MS |
| BL 1526 | 23 | 36 | 58 | 380.0 | MS | 23 | 34 | 58 | 370.0 | MS |
| BL 1527 | 13 | 25 | 37 | 250.0 | MR | 13 | 24 | 37 | 245.0 | MR |
| BL 1528 | 22 | 44 | 58 | 420.0 | MS | 22 | 36 | 58 | 380.0 | MS |
| BL 1529 | 12 | 34 | 58 | 362.5 | MS | 12 | 34 | 58 | 364.5 | MS |
| BL 1530 | 23 | 35 | 67 | 400.0 | MS | 23 | 35 | 67 | 400.0 | MS |
| BL 1531 | 13 | 44 | 59 | 395.0 | MS | 13 | 34 | 58 | 365.0 | MS |
| BL 1532 | 11 | 23 | 24 | 202.5 | R | 1 | 23 | 24 | 177.5 | R |
| BL 1533 | 23 | 36 | 58 | 382.5 | MS | 23 | 36 | 58 | 380.0 | MS |
| BL 1534 | 25 | 37 | 67 | 415.0 | MS | 25 | 37 | 68 | 417.5 | MS |
| BL 1535 | 24 | 46 | 68 | 460.0 | MS | 24 | 46 | 67 | 457.5 | MS |
| BL 1536 | 23 | 45 | 58 | 425.0 | MS | 23 | 45 | 58 | 425.0 | MS |
| BL 1537 | 22 | 34 | 58 | 370.0 | MS | 22 | 34 | 58 | 370.0 | MS |
| BL 1538 | 13 | 34 | 67 | 370.0 | MS | 12 | 34 | 67 | 367.5 | MS |
| BL 1539 | 22 | 45 | 58 | 425.0 | MS | 22 | 35 | 58 | 375.0 | MS |
| BL 1540 | 25 | 57 | 79 | 545.0 | S | 25 | 57 | 79 | 545.0 | S |
| BL 1541 | 22 | 56 | 67 | 502.5 | MS | 22 | 56 | 68 | 505.0 | MS |
| BL 1542 | 34 | 56 | 78 | 560.0 | S | 34 | 56 | 78 | 560.0 | S |
| BL 1543 | 23 | 35 | 67 | 400.0 | MS | 23 | 35 | 67 | 400.0 | MS |
| BL 1544 | 11 | 36 | 58 | 365.0 | MS | 11 | 24 | 58 | 290.0 | MS |
| BL 1545 | 22 | 34 | 58 | 370.0 | MS | 12 | 34 | 58 | 365.0 | MS |
| BL 1546 | 25 | 47 | 69 | 470.0 | MS | 25 | 47 | 68 | 467.5 | MS |
| BL 1547 | 22 | 34 | 58 | 362.5 | MS | 22 | 34 | 58 | 365.0 | MS |
| BL 1548 | 24 | 45 | 58 | 427.5 | MS | 13 | 34 | 58 | 362.0 | MS |
| BL 1549 | 13 | 23 | 46 | 262.5 | MR | 13 | 24 | 46 | 267.5 | MR |
| BL 1550 | 14 | 35 | 67 | 377.5 | MS | 13 | 35 | 67 | 375.0 | MS |
| BL 1551 | 12 | 35 | 58 | 365.0 | MS | 12 | 35 | 58 | 367.5 | MS |
| BL 1552 | 22 | 34 | 58 | 367.5 | MS | 11 | 33 | 58 | 362.5 | MS |
| BL 1553 | 23 | 45 | 67 | 450.0 | MS | 23 | 45 | 67 | 450.0 | MS |
| BL 1554 | 13 | 37 | 59 | 365.0 | MS | 23 | 35 | 59 | 370.0 | MS |
| BL 1555 | 23 | 37 | 58 | 387.5 | MS | 23 | 35 | 58 | 377.5 | MS |
| BL 1556 | 24 | 45 | 58 | 425.0 | MS | 24 | 35 | 58 | 375.0 | MS |
| BL 1557 | 12 | 23 | 46 | 260.0 | MR | 12 | 23 | 46 | 260.0 | MR |
| BL 1558 | 12 | 25 | 45 | 267.5 | MR | 12 | 25 | 45 | 267.5 | MR |
| BL   | 13 | 35 | 58 | 363.0 | MS | 12 | 35 | 58 | 367.5 | MS |
|------|----|----|----|-------|----|----|----|----|-------|----|
| BL   | 13 | 35 | 58 | 367.5 | MS | 13 | 35 | 58 | 363.0 | MS |
| BL   | 23 | 44 | 67 | 445.0 | MS | 23 | 44 | 67 | 445.0 | MS |
| BL   | 11 | 12 | 23 | 145.0 | R  | 1  | 12 | 23 | 120.0 | R  |
| BL   | 23 | 36 | 58 | 380.0 | MS | 23 | 36 | 58 | 380.0 | MS |
| BL   | 13 | 36 | 58 | 357.5 | MS | 13 | 36 | 58 | 365.0 | MS |
| BL   | 23 | 34 | 46 | 342.5 | MR | 23 | 34 | 46 | 342.5 | MR |
| BL   | 24 | 38 | 58 | 395.0 | MS | 24 | 36 | 58 | 385.0 | MS |
| BL   | 22 | 33 | 58 | 362.0 | MS | 22 | 34 | 58 | 365.0 | MS |
| BL   | 24 | 46 | 58 | 435.0 | MS | 24 | 46 | 58 | 435.0 | MS |
| BL   | 32 | 44 | 58 | 440.0 | MS | 32 | 44 | 59 | 440.0 | MS |
| BL   | 13 | 35 | 58 | 362.5 | MS | 13 | 35 | 58 | 352.5 | MS |
| BL   | 23 | 35 | 58 | 375.0 | MS | 23 | 35 | 57 | 375.0 | MS |
| BL   | 22 | 37 | 58 | 367.5 | MS | 13 | 24 | 57 | 295.0 | MS |
| BL   | 24 | 35 | 67 | 402.5 | MS | 24 | 35 | 67 | 402.5 | MS |
| BL   | 23 | 45 | 68 | 452.5 | MS | 23 | 45 | 68 | 452.5 | MS |
| BL   | 22 | 43 | 58 | 410.0 | MS | 22 | 35 | 58 | 370.0 | MS |
| BL   | 25 | 57 | 79 | 545.0 | S  | 25 | 57 | 79 | 545.0 | S  |
| BL   | 34 | 46 | 67 | 482.5 | MS | 34 | 46 | 67 | 482.5 | MS |
| BL   | 13 | 34 | 58 | 365.0 | MS | 13 | 34 | 58 | 347.5 | MS |
| BL   | 13 | 35 | 58 | 367.5 | MS | 13 | 35 | 58 | 363.0 | MS |
| BL   | 13 | 37 | 59 | 365.0 | MS | 13 | 37 | 59 | 365.0 | MS |
| BL   | 23 | 34 | 58 | 372.5 | MS | 23 | 37 | 58 | 377.5 | MS |
| BL   | 22 | 35 | 58 | 365.0 | MS | 22 | 24 | 58 | 367.5 | MS |
| BL   | 22 | 245 | 58 | 362.5 | MS | 22 | 35 | 58 | 362.5 | MS |
| BL   | 13 | 36 | 67 | 380.0 | MS | 13 | 36 | 67 | 380.0 | MS |
| BL   | 12 | 24 | 46 | 265.0 | MR | 12 | 24 | 46 | 265.0 | MR |
| BL   | 24 | 35 | 58 | 380.0 | MS | 24 | 36 | 58 | 385.0 | MS |
| BL   | 23 | 36 | 59 | 368.0 | MS | 23 | 36 | 58 | 365.0 | MS |
| BL   | 25 | 37 | 58 | 392.5 | MS | 25 | 37 | 58 | 392.5 | MS |
| BL   | 23 | 35 | 57 | 375.0 | MS | 23 | 35 | 58 | 375.0 | MS |
| BL   | 24 | 36 | 47 | 357.5 | MR | 24 | 36 | 47 | 357.5 | MR |
| BL   | 23 | 36 | 58 | 382.5 | MS | 23 | 35 | 58 | 377.5 | MS |
| BL   | 25 | 36 | 58 | 387.5 | MS | 25 | 36 | 58 | 387.5 | MS |
| BL   | 22 | 35 | 67 | 397.5 | MS | 11 | 35 | 67 | 370.0 | MS |
| BL   | 33 | 44 | 67 | 470.0 | MS | 23 | 44 | 67 | 445.0 | MS |
| BL   | 25 | 46 | 68 | 462.5 | MS | 25 | 46 | 68 | 462.5 | MS |
| BL   | 22 | 34 | 58 | 370.0 | MS | 22 | 34 | 58 | 370.0 | MS |
| BL   | 23 | 24 | 36 | 267.5 | MR | 23 | 24 | 35 | 265.0 | MR |
| BL   | 22 | 34 | 58 | 372.5 | MS | 22 | 34 | 58 | 365.0 | MS |
| BL   | 24 | 45 | 58 | 427.5 | MS | 24 | 45 | 58 | 427.5 | MS |
| BL   | 24 | 46 | 58 | 435.0 | MS | 24 | 46 | 58 | 435.0 | MS |
| BL   | 22 | 45 | 59 | 422.5 | MS | 13 | 45 | 58 | 395.0 | MS |
| BL   | 25 | 45 | 66 | 452.5 | MS | 25 | 46 | 66 | 457.5 | MS |
| BL   | 23 | 44 | 58 | 417.5 | MS | 23 | 45 | 58 | 422.5 | MS |
| BL   | 24 | 46 | 58 | 435.0 | MS | 24 | 46 | 58 | 435.0 | MS |
| BL   | 25 | 47 | 58 | 442.5 | MS | 25 | 47 | 58 | 440.0 | MS |
| BL   | 13 | 37 | 58 | 362.5 | MS | 13 | 37 | 58 | 365.0 | MS |
| BL   | 23 | 37 | 59 | 390.0 | MS | 23 | 37 | 59 | 390.0 | MS |
| BL   | 24 | 45 | 59 | 427.5 | MS | 24 | 46 | 58 | 432.5 | MS |
| BL   | 13 | 36 | 58 | 365.0 | MS | 13 | 36 | 58 | 365.0 | MS |
| BL   | 13 | 37 | 59 | 367.5 | MS | 13 | 35 | 58 | 370.0 | MS |
| BL   | 23 | 35 | 58 | 377.5 | MS | 23 | 35 | 58 | 377.5 | MS |
| BL   | 34 | 46 | 67 | 482.5 | MS | 34 | 46 | 67 | 482.5 | MS |
| BL   | 25 | 45 | 67 | 302.5 | MS | 25 | 45 | 58 | 377.5 | MS |
| BL   | 25 | 45 | 67 | 455.0 | MS | 25 | 45 | 67 | 455.0 | MS |
| BL   | 33 | 45 | 59 | 455.0 | MS | 33 | 45 | 58 | 452.5 | MS |
| BL | 24 | 45 | 58 | 427.5 | MS | 24 | 45 | 58 | 427.5 | MS |
|----|----|----|----|-------|----|----|----|----|-------|----|
| BL 1617 | 23 | 45 | 58 | 427.5 | MS | 23 | 45 | 58 | 427.5 | MS |
| BL 1619 | 13 | 58 | 427.5 | MS | 13 | 58 | 427.5 | MS |
| BL 1620 | 22 | 45 | 58 | 427.5 | MS | 22 | 45 | 58 | 427.5 | MS |
| BL 1621 | 24 | 46 | 58 | 427.5 | MS | 24 | 46 | 58 | 427.5 | MS |
| BL 1622 | 22 | 45 | 58 | 427.5 | MS | 22 | 45 | 58 | 427.5 | MS |
| BL 1623 | 24 | 46 | 58 | 427.5 | MS | 24 | 46 | 58 | 427.5 | MS |
| BL 1624 | 32 | 44 | 58 | 427.5 | MS | 32 | 44 | 58 | 427.5 | MS |
| BL 1625 | 13 | 45 | 58 | 427.5 | MS | 13 | 45 | 58 | 427.5 | MS |
| BL 1626 | 23 | 45 | 58 | 427.5 | MS | 23 | 45 | 58 | 427.5 | MS |
| BL 1627 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1628 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1629 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1630 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1631 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1632 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1633 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1634 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1635 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1636 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1637 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1638 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1639 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1640 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1641 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1642 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1643 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1644 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1645 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1646 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1647 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1648 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1649 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1650 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1651 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1652 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1653 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1654 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1655 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1656 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1657 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1658 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1659 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1660 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1661 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1662 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1663 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1664 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1665 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1666 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1667 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1668 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1669 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1670 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1671 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |
| BL 1672 | 25 | 45 | 58 | 427.5 | MS | 25 | 45 | 58 | 427.5 | MS |

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| Variety | Flowering | Dough | Hard Dough | Disease Reaction |
|---------|-----------|-------|------------|-----------------|
| BL 1673 | 22        | 36    | 58         | 380.0 MS 22 36 59 377.5 MS |
| BL 1674 | 23        | 35    | 58         | 375.0 MS 23 35 58 375.0 MS |
| IBYT-18-4 | 24 | 35    | 58         | 375.0 MS 24 35 58 375.0 MS |
| IBYT-18-5 | 13 | 36    | 58         | 370.0 MS 13 36 59 365.0 MS |
| IBYT-18-6 | 25 | 37    | 58         | 392.5 MS 25 37 58 392.5 MS |
| IBYT-18-8 | 23 | 35    | 59         | 375.0 MS 23 35 58 377.5 MS |
| IBYT-18-9 | 24 | 36    | 48         | 360.0 MR 24 36 48 360.0 MR |
| IBYT-18-12 | 24 | 36    | 59         | 387.5 MS 24 36 58 365.0 MS |
| IBYT-18-16 | 25 | 36    | 58         | 387.5 MS 25 36 57 385.0 MS |
| IBYT-18-18 | 24 | 37    | 59         | 387.5 MS 24 37 68 415.0 MS |
| IBYT-18-21 | 22 | 36    | 58         | 380.0 MS 22 36 58 380.0 MS |
| INBYT-HI-18-3 | 33 | 44    | 67         | 470.0 MS 33 45 67 475.0 MS |
| INBYT-HI-18-9 | 24 | 37    | 58         | 390.0 MS 23 37 58 387.5 MS |
| INBYT-HI-18-11 | 13 | 26    | 47         | 280.0 MR 13 26 47 280.0 MR |
| INBYT-HI-18-13 | 25 | 47    | 69         | 470.0 MS 25 47 69 470.0 MS |
| INBYT-HI-18-18 | 22 | 35    | 58         | 362.5 MS 12 36 59 364.0 MS |
| INBYT-HI-18-22 | 24 | 45    | 58         | 427.5 MS 24 45 58 427.5 MS |
| 5thGSBYT-18-3 | 24 | 46    | 58         | 435.0 MS 24 46 58 435.0 MS |
| 5thGSBYT-18-4 | 24 | 45    | 59         | 422.5 MS 22 46 59 427.5 MS |
| 5thGSBYT-18-6 | 25 | 45    | 65         | 450.0 MS 25 45 65 450.0 MS |
| 5thGSBYT18-7 | 23 | 44    | 59         | 417.5 MS 23 46 59 425.0 MS |
| 5thGSBYT-18-15 | 24 | 46    | 58         | 435.0 MS 24 46 58 435.0 MS |
| 5thGSBYT-18-16 | 25 | 47    | 59         | 445.0 MS 25 47 59 445.0 MS |
| 5thGSBYT-18-19 | 23 | 36    | 47         | 355.0 MR 13 36 47 330.0 MR |
| 5thGSBYT-18-21 | 13 | 37    | 59         | 365.0 MS 13 36 59 365.0 MS |
| 5thGSBYT-18-22 | 23 | 37    | 58         | 387.5 MS 23 37 58 387.5 MS |
| IBON-18-46 | 24 | 45    | 58         | 427.5 MS 23 45 58 425.0 MS |
| IBON-18-47 | 12 | 23    | 45         | 257.5 MR 12 23 46 260.0 MR |
| IBON-18-59 | 13 | 36    | 57         | 365.0 MS 13 36 58 365.0 MS |
| IBON-18-60 | 12 | 25    | 45         | 267.5 MR 12 24 45 262.5 MR |
| IBON-18-82 | 23 | 36    | 58         | 377.5 MS 13 36 58 368.5 MS |
| IBON-18-97 | 34 | 46    | 67         | 482.5 MS 34 46 67 482.5 MS |
| IBON-18-100 | 12 | 26    | 46         | 275.0 MR 12 25 46 270.0 MR |
| IBON-18-108 | 25 | 46    | 67         | 460.0 MS 25 46 68 462.5 MS |
| INBON-HI-18-7 | 33 | 45    | 59         | 455.0 MS 33 45 58 452.5 MS |
| INBON-HI-18-11 | 24 | 36    | 58         | 382.5 MS 13 36 58 365.0 MS |
| INBON-HI-18-26 | 23 | 45    | 68         | 452.5 MS 23 45 67 450.0 MS |
| INBON-HI-18-48 | 13 | 36    | 58         | 367.5 MS 13 36 58 367.5 MS |
| INBON-HI-18-49 | 22 | 45    | 67         | 447.5 MS 22 45 67 447.5 MS |
| INBON-HI-18-55 | 24 | 37    | 58         | 390.0 MS 24 36 59 382.5 MS |
| 5thGSBON-18-65 | 34 | 46    | 68         | 485.0 MS 34 46 68 485.0 MS |
| 5thGSBON-18-79 | 22 | 34    | 58         | 367.5 MS 22 34 58 367.5 MS |
| 5thGSBON-18-84 | 24 | 46    | 68         | 460.0 MS 14 46 68 435.0 MS |
| 5thGSBON-18-94 | 32 | 44    | 58         | 440.0 MS 32 44 58 442.5 MS |
| 5thGSBON-18-104 | 13 | 37    | 59         | 365.0 MS 13 37 58 362.5 MS |
| DWRUB 52 | 23 | 35    | 47         | 350.0 MR 23 35 47 350.0 MR |
| DWRB-92 | 34 | 46    | 58         | 460.0 MS 34 46 58 460.0 MS |
| DWRB-123 | 23 | 36    | 46         | 352.5 MR 23 36 47 355.0 MR |
| PL-807 | 24 | 36    | 47         | 357.5 MR 24 35 47 352.5 MR |
| PL-891 | 1 | 12    | 13         | 95.0 R 1 12 23 120.0 R |
| BH 902 | 15 | 26    | 37         | 260.0 MR 15 26 37 260.0 MR |
| BH 946 | 13 | 25    | 36         | 247.5 MR 13 25 36 247.5 MR |
| RD 2849 | 26 | 37    | 38         | 345.0 MR 26 37 38 345.0 MR |
| RD 2917 | 13 | 25    | 38         | 252.5 MR 13 25 37 250.0 MR |
| PL-426 | 56 | 78    | 89         | 752.5 S 46 78 89 727.5 S |

*F- Flowering, D- Dough, HD- Hard Dough stage; ** DS- Disease Reaction*
**Table 3** Categorization of barley entries based on their disease reaction during two cropping seasons (2017-18 and 2018-19)

| Range of value (DD)* | Disease reaction | Range of AUDPC | Barley entries | Total no. of entries |
|---------------------|-----------------|----------------|----------------|----------------------|
| 00-13               | Highly resistant| 0.00           | -NIL-          | 0                    |
| 14-35               | Resistant       | 1-180          | BL-1309, BL-1313, BL-1532, BL-1562 and PL-891 | 5                    |
| 36-57               | Moderately Resistant | 181-360 | BL-1314, BL-1325, BL-1397, BL-1400, BL-1416, BL-1504, BL-1516, BL-1517, BL-1518, BL-1520, BL-1527,BL-1549, BL-1557, BL-1558, BL-1565, BL-1585, BL-1590, BL-1597, BL-1658, BL-1666, IBYT-18-9, INBYT-HI-18-11, 5thGSBYT-18-19, IBON-18-47, IBON-18-60, IBON-18-100, DWRUB-52, DWRB-123, PL-807, BH-902, BH-946, RD-2849, RD-2917 | 33 |
| 58-69               | Moderately Susceptible | 361-500 | BL-1301, BL-1319, BL-1322, BL-1335, BL-1338, BL-1340, BL-1363, BL-1367, BL-1368, BL-1369, BL-1375, BL-1378, BL-1390, BL-1403, BL-1404, BL-1411, BL-1413, BL-1420, BL-1421, BL-1429, BL-1430, BL-1440, BL-1443, BL-1451, BL-1470, BL-1473, BL-1475, bl-1500, BL-1501, BL-1502, BL-1503, BL-1505, BL-1506, BL-1507, BL-1508, BL-1509, BL-1510, BL-1511, BL-1512, BL-1513, BL-1514, BL-1515, BL-1519, BL-1521, BL-1522, BL-1523, BL-1524, BL-1525, BL-1526, BL-1528, BL-1529, BL-1530, BL-1531, BL-1533, BL-1534, BL-1535, BL-1536, BL-1537, BL-1538, BL-1539, BL-1541, BL-1543, BL-1544, BL-1545, BL-1546, BL-1547, BL-1548, BL-1550, BL-1551, BL-1552, BL-1553, BL-1554, BL-1555, BL-1556, BL-1559, BL-1560, BL-1561, BL-1563, BL-1564, BL-1566, BL-1567, BL-1568, BL-1569, BL-1570, BL-1571, BL-1572, BL-1573, BL-1574, BL-1575, BL-1577, BL-1578, BL-1579, BL-1580, BL-1581, BL-1582, BL-1583, BL-1584, BL-1586, BL-1587, BL-1588, BL-1589, BL-1591, BL-1592, BL-1593, BL-1594, BL-1595, BL-1596, BL-1598, BL-1600, BL-1601, BL-1602, BL-1603, BL-1604, BL-1605, BL-1606, BL-1607, BL-1608, BL-1609, BL-1610, BL-1611, BL-1612, BL-1613, BL-1614, BL-1616, BL-1617, BL-1618, BL-1619, BL-1620, BL-1621, BL-1622, BL-1623, BL-1624, BL-1625, BL-1626, BL-1627, BL-1628, BL-1629, BL-1630, BL-1631, BL-1632, BL-1633, BL-1634, BL-1635, BL-1636, BL-1637, BL-1638, BL-1639, BL-1640, BL-1641, BL-1642, BL-1643, BL-1644, BL-1645, BL-1646, BL-1647, BL-1648, BL-1649, BL-1650, BL-1651, BL-1653, BL-1654, BL-1655, BL-1656, BL-1657, BL-1659, BL-1660, BL-1661, BL-1662, BL-1663, BL-1664, BL-1665, BL-1667, BL-1668, BL-1669, BL-1670, BL-1671, BL-1672, BL-1673, BL-1674, DWRB-92, IBYT-18-4, IBYT-18-5, IBYT-18-6, IBYT-18-8, IBYT-18-12, IBYT-18-16, IBYT-18-18, IBYT-18-21, INBYT-HI-18-3, INBYT-HI-18-9, INBYT-HI-18-13, INBYT-HI-18-18, INBYT-HI-18-22, 5thGSBYT-18-3, 5thGSBYT-18-4, 5thGSBYT-18-6, 5thGSBYT-18-7, 5thGSBYT-18-15, 5thGSBYT-18-16, 5thGSBYT-18-21, 5thGSBYT-18-22, IBON-18-46, IBON-18-59, IBON-18-82, IBON-18-97, IBON-18-108, INBON-HI-18-7, INBON-HI-18-11, INBON-HI-18-26, INBON-HI-18-48, INBON-HI-18-49, INBON-HI-18-55, 5thGSBON-18-65, 5thGSBON-18-79, 5thGSBON-18-84, 5thGSBON-18-94, 5thGSBON-18-104 | 218 |
| >69                 | Susceptible     | 500 and above  | BL-1500, BL-1540, BL-1542, BL-1576, BL-1652, PL-426 | 6                    |

*First and second value represents percent blighted area on the flag leaf and flag-1 leaves respectively. Values 1,2,3,4,5,6,7,8, and 9 correspond to 10,20,30,40,50,60,70,80 and 90 percent blighted area respectively.*
Bipolaris sorokiniana is also known to cause foliar blight or spot blotch disease in wheat crop as well. Screening of two hundred wheat germplasm accessions against this pathogen by Latwal et al., (2016) has revealed that on the basis of their AUDPC values over two years of testing, four accessions were found to be highly resistant whereas sixty eight exhibited resistant reaction towards disease. Similarly, screening of 126 barley genotypes against B. sorokiniana in inner tarai region of Nepal was also carried out by Subedi et al., (2020) and among these genotypes resistance was observed in eight genotypes while, thirty two genotypes exhibited moderately resistant reaction.

Therefore, in the present findings, the barley entries resistant to spot blotch disease in their field testing for two successive seasons under artificial inoculated conditions were able to keep the disease intensity on the plant to very low level and thus can act as useful source in incorporating spot blotch resistance in high yielding cultivars of barley which are prior found to be susceptible to the disease.

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