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Screening of Mustard Varieties and Lines against Clubroot and Alternaria Leaf Spot Diseases

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Abstract

The experiment was conducted to find out the resistant varieties/lines against clubroot and Alternaria leaf spot diseases of mustard at the Plant Pathology Division, RARS Jamalpur, Bangladesh during the Rabi season of 2024-2025 with sixty-two (62) varieties and lines of Mustard collected from Oilseed Research Centre (ORC) and Plant Genetic Resources Centre (PGRC), Joydebpur, Gazipur-1701, Bangladesh. To screen for clubroot and Alternaria leaf spot diseases and to evaluate yield and yield-contributing characteristics, sixty-two mustard varieties and lines have been studied. Twenty-one varieties and lines among them exhibited 1.05 to 12.48% clubroot infected plants. Based on the disease severity scale, out of 62 varieties and lines, 41 had no clubbing, 10 had a few minor clubs, 9 had moderate clubbing, and 2 had severe clubbing. According to these results, the defense mechanisms of sixty-two mustard varieties and lines against clubroot disease vary in severity. Seed yield per hectare ranged from 455.60 kg to 2972 kg. The highest seed yield per hectare (2972 kg) was noted in Mustard BD-9955, followed by Mustard BD-9352 (2733 kg), Daulat (2670 kg), Mustard BD-9345 (2328 kg), Mustard BD-9340 (2106 kg), and the lowest in Mustard BD-9956 (455.60 kg). Additionally, a screening for Mustard Alternaria leaf spot was performed. Alternaria leaf spot disease severity ranged from 0.00 to 6.67% among 62 mustard varieties and lines.

Keywords: Mustard Varieties and Lines, Clubroot and Alternaria Leaf Spot, disease incidence (%), disease severity (%), disease severity status, seed yield (kg/ha).

INTRODUCTION

The soilborne obligatory biotrophic pathogen *Plasmodiophora brassicae* (Woronin) is the cause of clubroot disease, a significant crucifer disease. It is currently documented from every continent in the world and is especially common in temperate climates under a variety of soil environmental stress conditions. Plants die completely in a short period of time due to gradually irreversible wilting, yellowing of the leaves, and root galling (club formation) on the primary and secondary roots of Brassica hosts [1]. This disease has been growing alarmingly on rape and mustard since the early 1980s, when widespread cultivation of these crops began in Bangladesh, particularly in areas with acidic soil. Clubroot disease is currently the main and only obstacle to the production of mustard and rape, especially in places with acidic soil where crop loss can reach 100%. In endemic areas, farmers have to stop growing mustard and rape. The pathogen population's virulence and aggressiveness patterns vary greatly both within and between clubroot-infested fields in Bangladesh's various agroclimatic zones. The application of soil ameliorating agents, such as liming to increase soil

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pH, calcium cyanamide, pesticide and nitrogenous fertilizer, different types of soil amendments, such as boron and molybdenum, and cultural practices, such as soil solarization and composting in sick soil, are the conventional methods used to manage the disease. It was discovered that these management techniques weren't always successful. Therefore, it is essential to create resistant cultivars. In Bangladesh, resistant Brassica varieties are extremely rare. Finding Brassica germplasm that is resistant to Bangladeshi *P. brassicae* pathotypes for cultivation was therefore the goal of this work. In Bangladesh, mustard is the main oilseed crop. In Bangladesh, clubroot disease—*caused by Plasmodiophora brassicae*—is a new and deadly mustard disease. In extreme circumstances, it might result in an annual loss of 50–100%. The best way to prevent mustard clubroot disease may be to use resistant cultivars.

The disease known as Alternaria leaf spot is characterized by the development of spots on the diseased leaves, stems, and siliquae as the infected plants mature. As a grey or black lesion appears on the infected leaves and siliquae, this disease may decrease the ability for photosynthesis and promote immature ripening. In addition to infecting the leaves, the infection causes the seeds' size, color, oil content, and germination ability to degrade [2]. Furthermore, *A. brassicae* and *A. brassicicola* are seed-borne diseases that can directly infect developing seeds in siliquae, causing significant damage to seedlings, primarily in nursery beds [3]. In yellow sarson and mustard, Alternaria leaf spot or leaf blight disease can result in yield losses of up to 46–47% and 35–38%, respectively [4, 5]. However, Alternaria leaf spot is thought to be the most devastating and common fungal disease of Brassica because there is no resistant species against *A. brassicae*/*A. brassicicola* in the Brassicaceae family [6]. Due to the expansion of mustard-rapeseed cultivation and the present Brassica cultivars' lack of resistance, infection by pathogens like *Alternaria spp.* has become a significant barrier to mustard-rapeseed production globally, including in Bangladesh. Since Alternaria leaf spots are becoming more and more important in the production of oil, resistant cultivars must be created in order to prevent this disease, increase seed yield, and improve sustainable crop production without the use of hazardous chemicals. The first stage in any disease resistance breeding program, however, is to rapidly screen all the germplasm that is available, including local races, improved varieties, and exotic genetic stocks, using conventional methods under controlled conditions in a greenhouse or through field testing. Furthermore, resistance breeding is a promising approach for long-term disease control because fungicides are unable to successfully control *A. brassicae*/*A. brassicicola* in the field. Interestingly, no comprehensive research on resistance screening for Alternaria leaf spot/black leaf spot of mustard-rapeseed has been conducted in Bangladesh. In light of these conditions, the current work was carried out to screen genotypes of mustard-rapeseed resistance to *A. brassicicola* using techniques developed in Bangladesh and to develop an effective method of inoculating mustard-rapeseed with *A. brassicicola*. The purpose of the anticipated experiment was to identify mustard lines and varieties that are resistant to Alternaria leaf spot and clubroot.

MATERIALS AND METHODS

The experiment was conducted at the Plant Pathology Division, RARS Jamalpur, during the Rabi season of 2024-2025 through sixty-two (62) varieties and lines of Mustard collected from Oilseed Research Centre (ORC) and Plant Genetic Resources Centre (PGRC), Joydebpur, Gazipur-1701, Bangladesh. The collected varieties and lines were screened against clubroot disease and Alternaria leaf spot diseases of mustard under natural field conditions. It was set up with three replications in a randomized complete block design (RCBD). The plot size was 2.0 m by 0.90 m. On November 24, 2024, seeds were sowed continuously in rows that were 30 cm apart. After a few days of germination, the seedlings were spaced five centimeters apart and trimmed. Fertilizers from urea, TSP, MOP, gypsum, zinc sulphate, and boric acid were applied at 120:80:60:40:4:1 kg/ha of N:P:K:S: Zn and Boron. During the final stage of land preparation, half of the urea and all other fertilizers were applied. During the early stages of flowering, the remaining urea was applied. To increase the crop frequently, all intercultural activities were completed on schedule. Days to flowering, days to maturity, plant height, number of siliquae per plant, length of siliqua, 1000-seed weight, seed yield per plot, seed yield per hectare, total number of plants per plot, and the incidence and severity of Alternaria leaf spot and

clubroot diseases of mustard (percentage of infected plants, disease severity, and disease status) were all recorded. Disease severity scale of clubroot (0-3 scale): 0 = No clubbing, 1 = a few small clubs, 2 = moderate clubbing, 3 = severe clubbing was used in this study. Alternaria leaf spot disease of Mustard was scored on 0-8 scale developed by Horsefall and Barratt (1945) [7]. The scale was described as 0 = leaves free from leaf spot, 1 = 0.1 to 3% leaf area blotched, 2 = 3.1 to 6% leaf area blotched; 3 = 6.1 to 12% leaf area blotched, 4 = 12.1 to 25% leaf area blotched, 5= 25.1 to 50% leaf area blotched, 6 = 50.1 to 75% leaf area blotched, 7 = 75.1 to 87% leaf area blotched and 8 = 87.1 to 100% leaf area blotched. The data were analyzed statistically using open-source programme 'R' [8].

RESULTS AND DISCUSSION

Sixty-two varieties and lines of Mustard were evaluated to screen against clubroot and Alternaria leaf spot diseases and for seed yield and yield contributing characters. The performances of different varieties and lines are stated in Table 1, 2 and 3. Significant differences were observed for total no. of plants per plot, infected plants (%), and disease severity, disease status of sixty-two varieties and lines of Mustard that were studied in this experiment (Table 1). The total number of plants per plot varied from 35 to 114. The highest total number of plants (114) in Daulat and lowest in Mustard BD-9322 (35). Clubroot disease screening status observed in sixty-two varieties and lines of Mustard that were used in this study. Among those, twenty-one varieties & lines showed 1.05 to 12.48% infected plants where the line Mustard BD-9351 had the highest and line Mustard BD-9347 had the lowest. The forty-one varieties & lines had no infection of club root disease. Among 62 varieties and lines, according to disease severity scale, no clubbing was found in 41 varieties and lines, 10 varieties and lines showed a few small clubs, 9 varieties and lines demonstrated moderate clubbing and severe clubbing were observed in two lines. These findings indicate that sixty-two varieties and lines of Mustard have different levels of defense mechanism against club root disease. Huang *et al.* (2008) reported in the field in Chengdu, Sichuan, China, the resistance of seventy novel oilseed materials to *Plasmodiophora brassicae* was assessed in a natural setting. Seventy novel oilseed materials were categorized into five kinds based on the severity of the disease: extremely resistant, moderately resistant, resistant-susceptible, moderately susceptible, and highly susceptible. The extremely vulnerable material was represented by lines 40 and 24, which had a high incidence index of more than 50. Line 70, on the other hand, belonged to the highly resistant material and may be utilized for more research on resistance breeding because of its low incidence index of just 2.67 [9]. According to Chattopadhyay and Bagchi (1989) [10], the disease incidence varied from 30% for Indian mustard (*Brassica juncea* L.) to 70% for yellow sarson (*Brassica rapa* L. var. *trilocularis* (Roxb.) Kitam). All of the native popular cultivars of brassica oilseeds and vegetables cultivated in the Darjeeling Hills and plains of north and southwest Bengal state are extremely susceptible, with the exception of foreign germplasm of *B. napus*, *B. nigra*, and *B. carinata* [10,11].

Table 1. Data on total number of plants per plot, infected plants, disease severity and disease status of Sixty-two varieties and lines of Mustard

Genotypes name	Total no. of plants/plot	Infected plants (%)	Disease severity	Disease status
BARI Sarisha-6	59.67 j-u	0.00 (0.00) m	0.00 d	No clubbing
BARI Sarisha-7	56.67 l-v	0.00 (0.00) m	0.00 d	No clubbing
BARI Sarisha-8	66.00 f-p	2.46 (1.54) h-k	1.00 c	A few small clubs
BARI Sarisha-9	74.33 e-j	0.00 (0.00) m	0.00 d	No clubbing
BARI Sarisha-10	68.00 f-n	0.00 (0.00) m	0.00 d	No clubbing
BARI Sarisha-11	74.00 e-j	0.00 (0.00) m	0.00 d	No clubbing
BARI Sarisha-12	68.67 f-n	0.00 (0.00) m	0.00 d	No clubbing
BARI Sarisha-13	62.00 h-s	3.89 (1.48) h-k	2.00 b	Moderate clubbing
BARI Sarisha-14	67.00 f-o	0.00 (0.00) m	0.00 d	No clubbing
BARI Sarisha-15	80.67 c-f	0.00 (0.00) m	0.00 d	No clubbing
BARI Sarisha-16	69.67 f-m	1.47 (1.21) kl	0.33 cd	A Few small clubs

Genotypes name	Total no. of plants/plot	Infected plants (%)	Disease severity	Disease status
BARI Sarisha-17	77.67 d-h	0.00 (0.00) m	0.00 d	No clubbing
BARI Sarisha-18	79.00 c-g	4.45 (2.10) efg	1.00 c	A few small clubs
BARI Sarisha-19	76.00 d-i	0.00 (0.00) m	0.00 d	No clubbing
BARI Sarisha-20	76.00 d-i	0.00 (0.00) m	0.00 d	No clubbing
S. Din-2	76.67 d-i	0.00 (0.00) m	0.00 d	No clubbing
Tori-7	77.67 d-h	0.00 (0.00) m	0.00 d	No clubbing
Kallaynia	77.33 d-h	0.00 (0.00) m	0.00 d	No clubbing
Jumka	88.50 b-e	0.00 (0.00) m	0.00 d	No clubbing
SS-75	71.00 f-l	0.00 (0.00) m	0.00 d	No clubbing
Daulat	114.00 a	0.00 (0.00) m	0.00 d	No clubbing
Rai-5	90.00 bcd	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9318	38.00 xy	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9319	45.00 u-y	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9320	44.00 u-y	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9321	50.00 q-y	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9322	35.00 y	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9326	66.00 f-p	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9327	55.00 m-w	7.30 (2.70) cd	2.00 b	Moderate clubbing
Mustard BD-9328	93.00 bc	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9331	62.00 h-s	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9332	64.00 g-q	3.11 (1.76) ghi	3.00 a	Severe clubbing
Mustard BD-9333	55.00 m-w	5.48 (2.33) de	3.00 a	Severe clubbing
Mustard BD-9334	53.00 n-x	5.65 (2.37) de	2.00 b	moderate clubbing
Mustard BD-9335	42.00 v-y	2.35 (1.50) h-k	2.00 b	moderate clubbing
Mustard BD-9336	62.00 h-s	3.21 (1.79) gh	1.00 c	A few small clubs
Mustard BD-9337	58.00 k-u	1.74 (1.29) jkl	1.00 c	A few small clubs
Mustard BD-9338	55.00 m-w	3.66 (1.90) fgh	1.00 c	A few small clubs
Mustard BD-9340	56.00 l-v	5.35 (2.31) def	1.00 c	A few small clubs
Mustard BD-9341	63.00 h-r	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9342	56.00 l-v	1.890 (1.31) i-l	1.00 c	A few small clubs
Mustard BD-9343	48.00 r-y	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9344	52.00 o-x	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9345	71.00 f-l	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9346	73.00 f-k	2.47 (1.65) g-k	2.00 b	Moderate clubbing
Mustard BD-9347	95.00 b	1.05 (1.00) l	2.00 b	Moderate clubbing
Mustard BD-9348	67.00 f-o	3.00 (1.72) g-j	2.00 b	Moderate clubbing
Mustard BD-9349	46.00 t-y	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9350	52.00 o-x	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9351	40.00 wxy	12.48 (3.53) a	2.00 b	Moderate clubbing
Mustard BD-9352	50.00 q-y	8.01 (2.83) bc	2.00 b	Moderate clubbing
Mustard BD-9353	56.00 l-v	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9954	50.00 q-y	9.99 (3.16) ab	1.00 c	A few small clubs
Mustard BD-9955	51.00 p-x	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9956	58.00 k-u	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9957	57.00 l-v	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9864	53.00 n-x	0.00 (0.00) m	0.00 d	No clubbing

Genotypes name	Total no. of plants/plot	Infected plants (%)	Disease severity	Disease status
Mustard BD-9866	55.00 m-w	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9867	47.00 s-y	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-9868	66.00 f-p	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-10105	68.00 f-n	0.00 (0.00) m	0.00 d	No clubbing
Mustard BD-10106	61.33 i-t	3.25 (1.80) gh	1.00 c	A few small clubs
Level of significance	**	**	**	-
CV (%)	2.34	6.67	6.08	-

** Significant at 5% level (p≤0.05), ** Significant at 1% level (p≤0.01), NS: Not significant (p≥0.05). The same letter in the same column does not differ statistically at the 5% level. Square root-transformed values are shown by values in parenthesis. Disease severity (0-3 scale): 0 = No clubbing, 1 = a few small clubs, 2 = moderate clubbing, 3 = severe clubbing.*

Data on days to flowering, days to maturity and plant characteristics of sixty-two varieties and lines of Mustard are presented in Table 2. Days to flowering varied from 27.44 to 45.33 days. The highest days to flowering are required in BARI Sarisha-9 (45.33 days) as compared to the lowest in Tori-7 (27.33 days). Days to maturity ranged 73.67 to110 days. BARI Sarisha-14 and BARI Sarisha-14 required least days to maturity (73.67 days). On the other hand, 110 days required to maturity in Mustard BD-9957. Plant height varied 91.23 to 209.60 cm. The tallest plant (209.60 cm) observed in Mustard BD-9321 and the shortest plant (91.23 cm) observed in Mustard BD-9957. Primary branches/plant varied 4.83 to 14.43 whereas Mustard BD-9332 had the maximum and Mustard BD-9327 minimum. Secondary branches per plant ranged 0 to 14.40. Mustard BD-9326 had no secondary branches and Mustard BD-9867 possessed the highest secondary branches per plant.

Table 2. Data on days to flowering, days to maturity and plant characteristics of sixty-two varieties and lines of Mustard

Genotypes name	Days to flowering	Days to maturity	Plant height (cm)	Primary branches/plant	Secondary branches/plant
BARI Sarisha-6	43.33 cde	81.67 v	146.40 g-k	6.73 s-v	0.27 rs
BARI Sarisha-7	43.67 cd	89.67 r	148.40 g-j	9.67 f-i	1.93 l-q
BARI Sarisha-8	45.00 ab	77.00 x	153.90 e-h	8.93 ijk	2.27 k-o
BARI Sarisha-9	45.33 a	74.33 z	129.30 m-r	7.73 m-q	6.13 e
BARI Sarisha-10	43.33 cde	95.67 mn	163.10 de	6.40 uvw	4.13 f-i
BARI Sarisha-11	43.00 c-f	104.00 f	157.10 efg	5.13 yz	4.00 f-j
BARI Sarisha-12	44.00 bc	74.67 yz	124.10 q-u	7.00 q-u	0.40 qrs
BARI Sarisha-13	44.00 bc	95.00 n	146.30 g-k	8.53 j-m	3.67 f-k
BARI Sarisha-14	36.67 l	73.67 z	104.10 z	7.67 n-r	0.00 s
BARI Sarisha-15	35.00 mn	73.67 z	132.40 l-q	7.93 l-p	1.33 m-s
BARI Sarisha-16	42.67 def	82.00 uv	153.10 e-h	8.67 jkl	0.73 o-s
BARI Sarisha-17	42.00 fg	82.67 u	156.40 efg	6.20 u-x	2.00 l-q
BARI Sarisha-18	42.33 ef	98.00 kl	149.90 f-i	4.93 z	2.27 k-o
BARI Sarisha-19	43.00 c-f	85.33 t	162.50 de	10.07 efg	3.07 g-l
BARI Sarisha-20	43.33 cde	87.00 s	96.73 z	6.99 q-u	0.60 p-s
S. Din-2	38.33 j	85.00 t	143.50 h-l	8.00 l-p	7.73 cd
Tori-7	27.33 q	75.33 y	102.70 z	8.27 k-o	8.13 cd
Kallaynia	35.33 m	85.00 t	107.30 yz	6.07 vwx	7.60 d
Jumka	42.00 fg	92.00 p	116.20 t-y	5.20 yz	2.30 k-o
SS-75	38.00 jk	87.03 s	146.40 g-k	6.23 u-x	2.23 k-o
Daulat	29.00 p	79.03 w	148.60 g-j	5.23 yz	3.23 g-l
Rai-5	35.00 mn	95.03 mn	160.60 ef	9.83 fgh	4.03 f-i
Mustard BD-9318	37.00 kl	98.03 l	177.40 c	8.43 j-n	1.03 n-s

Genotypes name	Days to flowering	Days to maturity	Plant height (cm)	Primary branches/plant	Secondary branches/plant
Mustard BD-9319	38.00 jk	99.03 jk	187.60 b	9.63 f-i	3.43 g-l
Mustard BD-9320	40.00 hi	100.00 ij	171.60 cd	7.83 m-q	3.43 g-l
Mustard BD-9321	39.00 ij	95.03 n	209.60 a	10.63 de	2.43 j-n
Mustard BD-9322	38.00 jk	99.03 jk	195.80 b	12.83 b	3.43 g-l
Mustard BD-9326	42.00 fg	102.00 h	115.40 t-z	7.03 q-u	0.00 s
Mustard BD-9327	41.00 gh	100.00 j	128.00 n-s	4.83 z	0.83 o-s
Mustard BD-9328	35.00 mn	95.03 n	142.60 h-l	10.43 def	3.43 g-l
Mustard BD-9331	39.00 ij	100.00 ij	140.20 i-m	12.43 b	2.63 i-n
Mustard BD-9332	36.00 lm	98.03 kl	113.20 u-z	14.43 a	5.03 ef
Mustard BD-9333	43.00 c-f	97.03 l	126.40 o-t	7.03 q-u	0.43 p-s
Mustard BD-9334	41.00 gh	103.00 g	112.20 v-z	9.23 hij	3.03 h-l
Mustard BD-9335	39.00 ij	99.03 jk	108.40 xyz	11.43 c	3.03 h-l
Mustard BD-9336	44.00 c	105.00 e	117.40 s-y	7.43 o-s	4.23 fgh
Mustard BD-9337	39.00 j	100.00 j	138.00 j-n	10.03 efg	0.43 p-s
Mustard BD-9338	33.00 o	91.03 q	131.20 m-r	8.43 k-n	1.83 l-r
Mustard BD-9340	35.00 mn	96.03 m	111.00 v-z	6.83 r-v	2.23 k-o
Mustard BD-9341	37.00 kl	100.00 j	126.60 n-t	5.83 wxy	2.03 l-p
Mustard BD-9342	39.00 j	101.00 i	110.00 w-z	7.83 m-q	1.23 m-s
Mustard BD-9343	42.00 fg	106.00 d	119.60 r-x	7.63 n-r	8.03 cd
Mustard BD-9344	41.00 gh	107.00 c	109.60 w-z	6.23 u-x	7.83 cd
Mustard BD-9345	37.00 kl	98.03 kl	135.60 k-p	7.23 p-t	8.43 cd
Mustard BD-9346	37.00 kl	98.03 l	102.80	6.83 r-v	9.23 c
Mustard BD-9347	36.00 lm	97.03 l	103.60 z	5.83 wxy	5.03 ef
Mustard BD-9348	38.97 ij	100.00 j	121.00 q-w	7.43 o-s	10.83 b
Mustard BD-9349	37.97 jk	93.03 o	155.20 efg	5.43 xyz	4.63 fg
Mustard BD-9350	34.97 mn	96.03 m	191.00 b	10.83 cd	3.23 g-l
Mustard BD-9351	37.97 jk	101.00 i	120.20 r-w	9.63 ghi	0.43 p-s
Mustard BD-9352	33.97 n	98.03 kl	128.40 n-s	6.43 t-w	0.63 p-s
Mustard BD-9353	36.97 kl	96.03 m	157.60 efg	5.23 yz	1.23 n-s
Mustard BD-9954	37.97 jk	97.03 l	126.20 o-t	7.63 n-r	2.83 h-m
Mustard BD-9955	38.97 ij	104.00 f	146.20 g-k	8.43 k-n	2.63 h-n
Mustard BD-9956	41.97 fg	107.00 c	122.20 q-v	7.63 n-r	2.03 l-p
Mustard BD-9957	44.97 ab	110.00 a	91.23 z	7.23 p-t	7.83 cd
Mustard BD-9864	38.97 ij	98.03 kl	126.00 p-t	8.43 k-n	0.00 s
Mustard BD-9866	37.97 jk	99.03 jk	111.00 v-z	7.43 p-s	0.60 p-s
Mustard BD-9867	35.97 lm	93.03 o	96.03 z	5.63 w-z	14.40 a
Mustard BD-9868	38.97 ij	100.00 ij	136.60 k-p	5.83 wxy	9.20 c
Mustard BD-10105	41.97 fg	102.00 h	137.60 j-o	9.63 ghi	0.80 o-s
Mustard BD-10106	42.97 c-f	109.00 b	113.00 u-z	5.83 wxy	0.60 p-s
Level of significance	**	**	**	**	**
CV (%)	1.48	2.57	4.41	5.48	3.58

** Significant at 5% level (p≤0.05), ** Significant at 1% level (p≤0.01), NS: Not significant (p≥0.05). The same letter in the same column does not differ statistically at the 5% level.*

Data on seed yield and yield contributing characteristics of sixty-two varieties and lines of Mustard are stated in Table 3. The number of siliquae per plant varied 84.80 to 549.60. BARI Sarisha-14 had

the lowest (84.80) number of siliquae per plant. On the other hand, Mustard BD-9318 and Mustard BD-9322 got the highest number of siliquae per plant. The length of siliqua ranged 3.53 to 9.13 cm. The longest siliqua (9.13 cm) found in Mustard BD-9346 and the shortest siliqua (3.53 cm) in 9353. Thousand-seed weight varied 0.97 to 4.17 g. BARI Sarisha-16 attained the highest 1000-seed weight (4.17 g) and Mustard BD-9956 and Mustard BD-9957 gained the lowest 1000-seed weight. Seed yield per plant varied 82.00 to 535.00 g. The highest seed yield per plant (535.00 g) noted in Mustard BD-9955 followed by Mustard BD-9352 (492.00 g), Daulat (480.70 g), Mustard BD-9345 (419.00 g), Mustard BD-9340 (379.00 g) and the lowest in Mustard BD-9956 (82.00 g). Seed yield per hectare ranged 455.60 kg to 2972 kg. The highest seed yield per hectare (2972 kg) noted in Mustard BD-9955 followed by Mustard BD-9352 (2733 kg), Daulat (2670 kg), Mustard BD-9345 (2328 kg), Mustard BD-9340 (2106 kg) and the lowest in Mustard BD-9956 (455.60 kg).

Table 3. Data on seed yield and yield contributing characteristics of sixty-two varieties and lines of Mustard

Genotypes name	No. of siliqua/plant	Length of siliqua (cm)	1000-seed weight (g)	Seed yield/ plot (g)	Seed yield (kg/ha)
BARI Sarisha-6	242.50 j-m	6.55 f-i	3.22 ijk	286.70 i-m	1593.00 i-m
BARI Sarisha-7	242.10 j-m	6.62 fgh	3.47 e-i	218.30 q-v	1213.00 q-v
BARI Sarisha-8	240.30 j-m	8.40 b	3.50 e-h	233.00 o-s	1294.00 o-s
BARI Sarisha-9	291.50 ghi	5.17 n-q	3.05 kl	284.30 i-m	1580.00 i-m
BARI Sarisha-10	243.40 j-m	5.24 m-q	2.87 lm	245.70 m-r	1365.00 m-r
BARI Sarisha-11	238.40 j-m	4.70 q-t	3.07 kl	297.00 h-l	1650.00 h-l
BARI Sarisha-12	201.30 m-s	4.09 tuv	3.13 jk	267.30 k-p	1485.00 k-p
BARI Sarisha-13	253.30 i-l	5.96 h-m	3.71 cde	231.00 p-t	1283.00 p-t
BARI Sarisha-14	84.80 z	4.79 p-t	3.69 de	252.30 l-r	1402.00 l m-r
BARI Sarisha-15	120.70 xyz	5.60 l-o	3.63 def	173.30 v-z	963.00 v-z
BARI Sarisha-16	261.60 h-k	4.40 r-u	4.17 a	245.70 m-r	1365.00 m-r
BARI Sarisha-17	225.50 j-o	5.65 k-o	3.60 def	212.00 q-w	1178.00 q-w
BARI Sarisha-18	158.10 t-x	5.02 o-r	3.63 def	324.00 e-i	1800.00 e-i
BARI Sarisha-19	301.40 fgh	4.64 q-t	3.70 cde	226.30 p-u	1257.00 p-u
BARI Sarisha-20	91.73 z	5.64 k-o	3.53 efg	187.70 t-z	1043.00 t-z
S. Din-2	298.60 fgh	6.25 g-l	3.67 de	350.70 d-g	1948.00 d-g
Tori-7	333.10 c-f	6.43 g-j	2.57 no	270.70 k-p	1504.00 k-p
Kallaynia	263.70 h-k	4.80 p-t	3.67 de	270.30 k-p	1502.00 k-p
Jumka	90.70 z	5.73 j-o	3.95 abc	282.00 i-n	1567.00 i-n
SS-75	167.00 r-w	5.59 l-o	3.87 bcd	320.00 f-j	1778.00 f-j
Daulat	231.20 j-n	4.11 tuv	2.87 lm	480.70 b	2670.00 b
Rai-5	345.40 b-e	3.81 uv	3.37 f-j	363.00 def	2017.00 def
Mustard BD-9318	549.60 a	3.73 uv	1.97 rst	365.00 de	2028.00 de
Mustard BD-9319	372.60 b	3.73 uv	2.67 mn	355.00 d-g	1972.00 d-g
Mustard BD-9320	291.20 ghi	3.73 uv	2.17 pqr	178.00 v-z	988.90 v-z
Mustard BD-9321	354.20 bcd	3.79 uv	2.37 op	324.00 e-i	1800.00 e-i
Mustard BD-9322	549.60 a	3.81 uv	2.57 no	285.00 i-m	1583.00 i-m
Mustard BD-9326	171.80 q-v	6.53 f-i	3.97 ab	272.00 k-p	1511.00 k-p
Mustard BD-9327	191.60 n-t	5.59 l-o	2.57 no	278.00 j-o	1544.00 j-o
Mustard BD-9328	223.40 j-o	8.23 b	2.57 no	144.00 z	800.00 z
Mustard BD-9331	367.00 bc	3.79 uv	2.77 mn	207.00 r-x	1150.00 r-x
Mustard BD-9332	297.20 fgh	6.89 efg	2.57 no	258.00 l-q	1433.00 l-q
Mustard BD-9333	235.60 j-m	7.33 cde	2.67 mn	232.00 o-t	1289.00 o-t

Genotypes name	No. of siliqua/plant	Length of siliqua (cm)	1000-seed weight (g)	Seed yield/ plot (g)	Seed yield (kg/ha)
Mustard BD-9334	221.00 k-o	6.35 g-k	2.57 no	312.00 g-k	1733.00 g-k
Mustard BD-9335	321.00 d-g	6.99 efg	1.87 stu	185.00 u-z	1028.00 u-z
Mustard BD-9336	290.80 ghi	6.31 g-l	3.57 ef	218.00 q-v	1211.00 q-v
Mustard BD-9337	232.20 j-n	7.97 bc	3.27 h-k	338.00 d-h	1878.00 d-h
Mustard BD-9338	179.60 p-u	6.93 efg	3.57 ef	282.00 i-n	1567.00 i-n
Mustard BD-9340	122.40 xyz	6.43 g-j	2.27 pq	379.00 d	2106.00 d
Mustard BD-9341	212.80 l-q	6.55 f-i	3.37 f-j	298.00 h-l	1656.00 h-l
Mustard BD-9342	188.40 o-t	6.61 fgh	2.57 no	145.00 z	805.60 z
Mustard BD-9343	165.00 r-w	5.67 k-o	1.77 tu	247.00 m-r	1372.00 m-r
Mustard BD-9344	159.80 s-x	6.37 g-k	1.77 tu	349.00 d-g	1939.00 d-g
Mustard BD-9345	213.00 l-q	5.63 kl-o	1.27 w	419.00 c	2328.00 c
Mustard BD-9346	128.00 w-z	9.13 a	1.97 rst	154.00 yz	855.60 yz
Mustard BD-9347	159.80 s-x	7.83 bcd	1.87 stu	235.00 o-s	1306.00 o-s
Mustard BD-9348	204.00 m-r	7.53 cde	1.67 uv	115.00 z	638.90 z
Mustard BD-9349	176.20 p-u	4.37 r-u	1.47 vw	506.00 ab	2811.00 ab
Mustard BD-9350	228.40 j-o	4.23 s-v	1.97 rst	357.00 def	1983.00 def
Mustard BD-9351	309.20 efg	4.85 p-s	1.87 stu	171.00 w-z	950.00 w-z
Mustard BD-9352	151.20 t-y	7.19 def	1.47 vw	158.00 yz	877.80 yz
Mustard BD-9353	221.80 j-o	3.53 v	1.27 w	492.00 b	2733.00 b
Mustard BD-9954	216.20 l-p	5.71 j-o	3.27 ghijk	177.00 v-z	983.30 v-z
Mustard BD-9955	264.00 hij	3.91 uv	1.27 w	535.00 a	2972.00 a
Mustard BD-9956	298.80 fgh	5.43 m-p	0.97 x	82.00 z	455.60 z
Mustard BD-9957	164.20 r-w	4.63 q-t	0.97 x	288.00 i-m	1600.00 i-m
Mustard BD-9864	89.83 z	5.07 o-r	2.07 qrs	237.00 n-s	1317.00 n-s
Mustard BD-9866	132.20 v-y	5.83 i-n	1.47 vw	319.30 f-j	1774.00 f-j
Mustard BD-9867	112.00 yz	4.37 r-u	2.67 mn	166.00 xyz	922.20 xyz
Mustard BD-9868	142.80 u-y	5.70 j-o	1.27 w	193.00 s-y	1072.00 s-y
Mustard BD-10105	308.00 efg	5.97 h-m	2.67 mn	196.00 s-y	1089.00 s-y
Mustard BD-10106	114.60 yz	7.19 def	2.57 no	245.00 m-r	1361.00 m-r
Level of significance	**	**	**	**	**
CV (%)	9.43	6.69	5.38	8.67	8.67

** Significant at 5% level (p≤0.05), ** Significant at 1% level (p≤0.01), NS: Not significant (p≥0.05). The same letter in the same column does not differ statistically at the 5% level.*

Disease severity of Alternaria leaf spot of Mustard was presented in Figure 1. Among 62 varieties and lines of Mustard, disease severity of Alternaria leaf spot varied 0.00 to 6.67%. Alternaria leaf spot disease of Mustard was scored on 0-8 scale developed by Horsefall and Barratt (1945) [7]. The scale was described as 0 = leaves free from leaf spot, 1 = 0.1 to 3% leaf area blotched, 2 = 3.1 to 6% leaf area blotched; 3 = 6.1 to 12% leaf area blotched, 4 = 12.1 to 25% leaf area blotched, 5= 25.1 to 50% leaf area blotched, 6 = 50.1 to 75% leaf area blotched, 7 = 75.1 to 87% leaf area blotched and 8 = 87.1 to 100% leaf area blotched. There were no infection or disease symptoms in 29 varieties and lines of Mustard. Twenty-five varieties and lines of Mustard demonstrated 0.1 to 3.0% disease symptoms. The disease symptoms of Alternaria leaf spot 3.1 to 6.0% were observed in 7 varieties and lines of Mustard. Only one variety showed 6.1 to 12% disease symptoms of Alternaria leaf spot. Among 31 mustard-rapeseed types, Humauan *et al.* (2013) [12] identified one to be resistant to Alternaria leaf spot disease, 12 to be moderately resistant, 17 to be fairly sensitive, and the remaining 1 to be susceptible. Hossain *et al.* (2018) described that all of the 27 mustard-rapeseed cultivars from Bangladesh showed a sensitive

response to *A. brassicicola*, with the exception of BINA Sharisha-8, which exhibited borderline resistance [13].

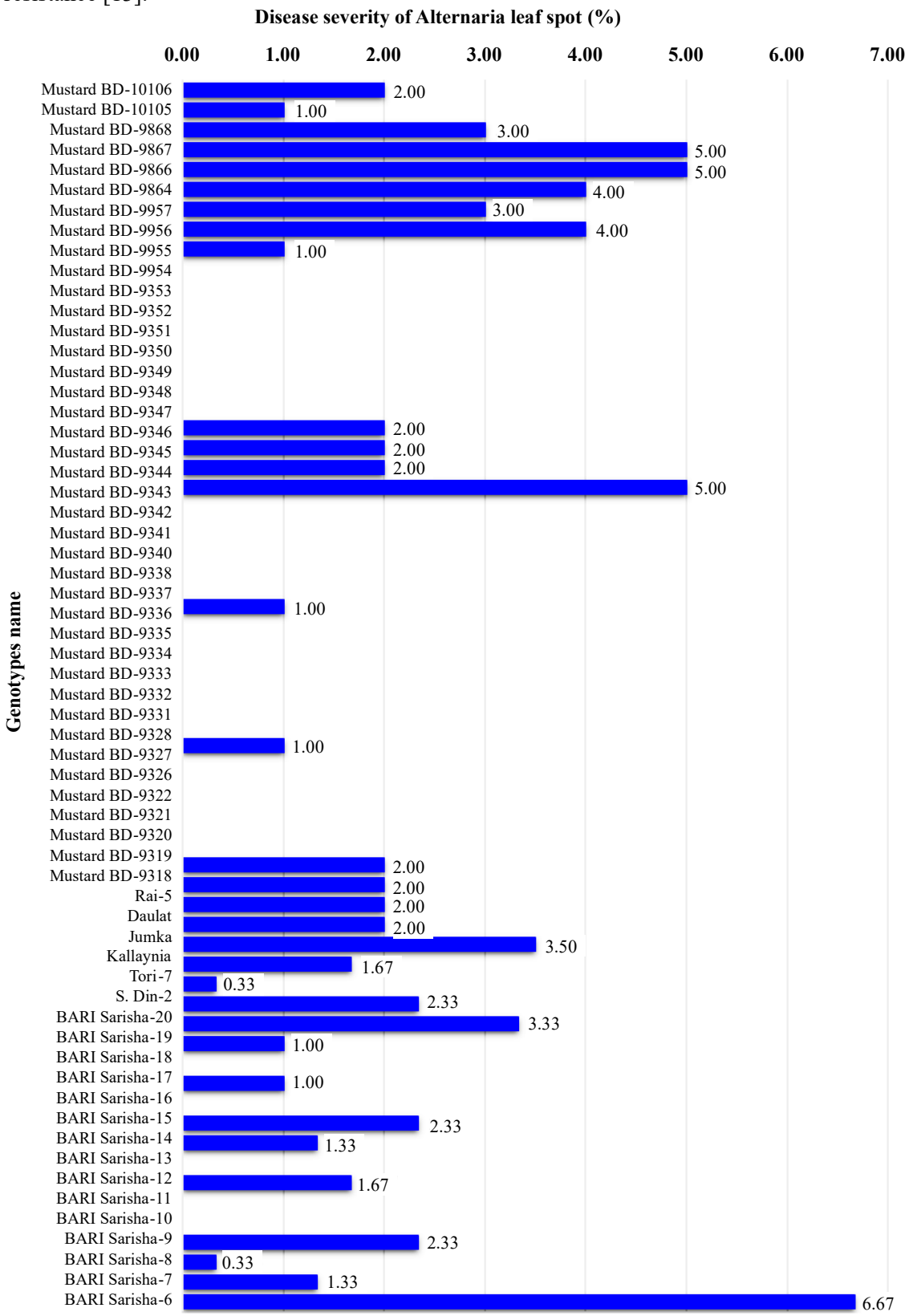

Figure 1. Disease severity of Alternaria leaf spot (%) of different Mustard varieties and lines.

CONCLUSION

Sixty-two varieties and lines of Mustard were evaluated to screen against clubroot and Alternaria leaf spots diseases and for yield and yield contributing characters. Among those, twenty-one varieties & lines showed 1.05 to 12.48% clubroot infected plants. Among 62 varieties and lines, according to disease severity scale, no clubbing was found in 41 varieties and lines, 10 varieties and lines showed a few small clubs, 9 varieties and lines demonstrated moderate clubbing and severe clubbing were observed in two lines. These findings indicate that sixty-two varieties and lines of Mustard have different levels of defense mechanism against clubroot disease. Seed yield per hectare ranged 455.60 kg to 2972 kg. The highest seed yield per hectare (2972 kg) noted in Mustard BD-9955 followed by Mustard BD-9352 (2733 kg), Daulat (2670 kg), Mustard BD-9345 (2328 kg), Mustard BD-9340 (2106 kg) and the lowest in Mustard BD-9956 (455.60 kg). Furthermore, the screening of Alternaria leaf spot of Mustard was also performed. Among 62 varieties and lines of Mustard, disease severity of Alternaria leaf spots varied 0.00 to 6.67%.

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