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Selection of Blast Resistant Lines from Diverse Germplasm Set of Foxtail Millet

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ABSTRACT: The growth and productivity of foxtail millet is affected by many diseases. Among those disease, foxtail millet blast, (*Pyricularia setaria*) which is also known as leaf spot is responsible for the economic loss up to 40% during congenial weather conditions, and it can be well managed through host plant resistance. The present research work has been carried out to assess blast resistant genotypes of foxtail millet under field conditions, a total ninety-three genotypes where evaluated in three replications at breeding farm, Rajmata Vijayaraje Scindia Agricultural University, Gwalior, Madhya Pradesh, India during Kharif 2020-21 and 2021-22. A wide variation in response to blast where seen, as their PDI varied significantly, none of the entries was found highly susceptible, twenty three genotypes where found highly resistant, as their blast severity PDI was recorded less 11.11%. The maximum PDI range 55.55% to 77.77 % was noted in foxtail- 946, 969, 983, 1000, 1354, 1603. The resistant genotypes identified in the present research may be used further to develop improved genotypes against blast, which can help to boost production and productivity of foxtail millet.

Keywords: Foxtail millet blast, *Pyricularia setaria,* PDI, resistant, susceptible.

INTRODUCTION

Foxtail millet (*Setaria italica* (L.) Beauv.) is an important small millet crop which has been cultivated from ages all over the world. It is believed to be originated in North China, and it was domesticated more than 8,700 years ago (Pan *et al.,* 2018). It is mainly cultivated in Asia, Europe, North America, Australia and North Africa for grain and forage (Austin, 2006). It ranks second in the total world's production among all millet, generally millets are considered as an excellent source of energy and essential nutrient, and so it serves as the food source for millions of people across the globe, the grain is popularly used for livestock and poultry feed. Millets are good source of poultry feed during the dry period of the year (Makwana *et al*., 2021). In India, Andhra Pradesh (4,79,000 ha), Karnataka (2,32,000 ha) and Tamilnadu (20,000 ha) are the major foxtail millet growing states contributing about 90 per cent of the total area under cultivation. Minor millets are remarkable crop as compared to cereals in many ways, like beneficial components such as dietary fibre, micro and macro nutrients and bioactive components.

The crop is affected by many diseases, major being blast (*Pyricularia setaria*), rust (*Uromyces setaria*), brown leaf spot (*Drechslera setaria*), downy mildew (*Sclerospora graminicola*) and smut (*Ustilago crameri*). Among all the disease blast and rust are the most destructive air borne diseases. Blast which is also known as leaf spot is responsible for the economic loss up to 40% during congenial weather conditions (Nagaraja *et al*., 2007). Its fungi can cause infection in all the plant parts of foxtail millet in different growing stages, resulting in seedling blast, leaf blast, stem blast, and panicle blast, among which panicle blast is the most harmful for grain yield. The appearance of blast disease is as grayish, water-soaked lesions on foliage that become large and necrotic, resulting in ample chlorosis and premature drying of young and old leaves (Wilson and Gates 1989). Although, there are various traditional approaches for disease control, using blast resistant cultivar is one of the most effective managements of disease that is environment friendly choice for disease control (Tiwari *et al.,* 2018, Bhawar *et al.,* 2020, Mandloi *et al.,* 2022, Verma *et al.,* 2021, Pramanik *et al.,* 2019 Upadhyay *et al.,* 2020; Pramanik *et al.,* 2021). Therefore, the present study was undertaken to evaluate different genotypes of foxtail millet to identify resistant against blast disease by means of disease indexing under field conditions.

MATERIAL AND METHODS

A total of 93 genotypes originated from different countries were used in this study. The field experiment was conducted at the breeding farm, Rajmata Vijayaraje Scindia Agricultural University, Gwalior, Madhya Pradesh, India during Kharif 2020-21 and 2021-22. The experimental field has been laid down and monitored in randomized block design (RBD) in three meter row length with spacing of 30cm from row-to row and 10cm from-plant-to-plant. Observations were recorded at panicle emergence stage for leaf blast symptoms on leaves. The divergent reactions to blast disease (Table 1) *viz.,* susceptible, tolerant and resistant for blast diseases was assessed by using 1-9 rating scale (Proceedings of 27th Annual Group Meeting of AICRP on Small Millets, 2016).

Table 1: Standard Evaluation System (SES) scale for blast.

Score	Description	Reaction
1.	Small brown specks of pinhead size without sporulating centre.	R
2.	Small roundish to slightly elongated, necrotic grey spots, about 1-2 mm in diameter with a distinct brown margin and lesions are mostly found on the lower leaves.	MR
3.	Lesion type is the same as in scale 2, but significant numbers of lesions are on the upper leaves	MR
4.	Typical sporulating blast lesions, 3 mm or longer, infecting less than 2% o the leaf area.	MS
5.	Typical blast lesions infection 2-10% of the leaf area	MS
6.	Blast lesions infecting 11-25% leaf area	S
7.	Blast lesions infecting 26-50% leaf area	S
8.	Blast lesions infecting 51-75% leaf area	HS
9.	More than 75% leaf area affected HS	HS

Percent disease index (PDI) was worked out by using the formula given by Wheeler (1969).

Percent Disease Index (PDI) =

$$\frac{\text{Sum of individual disease rating}}{\text{No. of leaves assessed} \times \text{maximum grade}} \times 100$$

RESULT AND DISCUSSION

In the present investigation total 93 germplasm originated from different part of the world where evaluated against blast and the data are summarized in the Table 2. Among all the genotypes under study none of the genotypes where found to be highly susceptible, 23 genotypes where resulted under highly resistant category, as their PDI was less than 11.11%, while 44 genotypes fall under resistant category as their PDI range was more than 11.11% to 33.33% followed by 18 genotypes falling under moderately resistant category, PDI ranging from more than 33.33% to 55.55%, and 8 genotypes where showing susceptible reaction of more than 55.55% to 77.77%. During *kharif* 2020-21, twenty five genotypes namely Foxtail-49, 96, 132, 160, 200, 237, 267, 295, 362, 364, 663, 717, 774, 784, 838, 936, 1013, 1037, 1137, 1162, 1665, 1725, 1859, 1892, where found highly resistant (<11.11%). 45 genotypes whose PDI is more than 11.11-33.33% found resistant are Foxtail -16, 31, 108, 144, 179, 195, 254, 302, 388, 480, 507, 525, 710, 745, 751, 795, 796, 846, 869, 956, 985, 1026, 1177, 1306, 1354, 1377, 1400, 1406, 1606, 1623, 1629, 1654, 1674, 1736, 1745, 1762, 1780, 1805, 1808, 1820, 1846, 1851, Check MM-7, Check SIA-3156. Seventeen genotypes where found moderately resistant are Foxtail-156, 201, 289, 398, 750, 758, 874, 1251, 151, 1600, 1605, 1636, 1680, 1687, 1704, 1773, 1806 as their PDI more than 33.33% to 55.55% and six genotypes - Foxtail- 946, 969, 983, 1000, 1071, 1136, 1603 observed as susceptible PDI range is above 55.55% to 77.77%.

In Kharif 2021-2022, seventeen genotypes- Foxtail-49, 96, 132, 200, 237, 267, 295, 364, 717, 383, 1027, 1013, 1037, 1162, 1665, 1725, Check SIA-3156 whose PDI was more than <11.11%, found to be highly resistant. Fifty genotypes whose PDI range is 11.11-33.33 was found resistant are Foxtail- 16, 31, 108, 144, 160, 179, 195, 254, 302, 362, 388, 480, 507, 523, 663, 710, 745, 751, 758, 774, 784, 795, 796, 846, 869, 985, 1026, 1137, 1177, 1306, 1377, 1400, 1406, 1606, 1623, 1629, 1664, 1674, 1745, 1762, 1780, 1805, 1808, 1820, 1846, 1851, 1859, 1881, 1892, Check MM-7 and nineteen genotypes was found moderately resistant are Foxtail-156, 201, 289, 398, 750, 874, 936, 956, 1251, 1354, 1600, 1605, 1636, 1680, 1687, 1704, 1736, 1773, 1806 as their PDI was in the range of 33.33-55.55 while eight genotypes where found susceptible PDI range fall in 55.55-77.77 whereas none of the genotypes found highly susceptible.

The pooled analysis of two year data (Table 2) resulted that none of the genotypes where found to highly susceptible, twenty three genotypes where analyzed as highly resistant(<11.11%), Foxtail-49, 96, 132, 160, 200, 237, 267, 295, 362, 364, 663, 717, 774, 784, 838, 936, 1013, 1037, 1137, 1162, 1665, 1725, Check SIA - 3156. Forty-four genotypes where found to be resistant- Foxtail- 16, 31, 108, 144, 179, 195, 254, 302, 388, 480, 507, 525, 710, 745, 751, 795, 796, 846, 869, 985, 1026, 1136, 1177, 1306, 1377, 1400, 1406, 1606, 1623, 1629, 1664, 1674, 1736, 1745, 1762, 1780, 1805, 1808, 1820, 1846, 1851, 1859, 1892, Check MM-7 followed by eighteen genotypes found moderately resistant are Foxtail- 156, 201, 289, 398, 750, 758, 874, 956, 1251, 1511, 1600, 1605, 1636, 1680, 1687, 1704, 1773, 1806 as their PDI range is 33.33-55.55 while eight genotypes Foxtail- 946, 969, 983, 1000, 1071, 1136, 1354, 1603 whose PDI range 55.55-77.7 is found to be susceptible. Pathogenic variation of *M. grisea* causing blast is well adapted for the populations of rice, pearl millet, finger millet and various weed hosts reported by Nakayama *et al.* (2005); Sharma *et al.* (2013). To test genotypes disease severity was documented at the hard-dough for blast was assessed using 1-9 rating scale developed for foxtail millet disease during Proceedings of 27^{th} Annual Group Meeting of AICRP on Small Millets, 2016 described by Rajesh *et al.* (2019). Likewise Rajesh and Nirmalakumari (2020) by standard evaluation system (SES) scale for blast of foxtail millet assessed blast disease using 1 to 9 disease rating scale (Proceedings of 27^{th} Annual Group Meeting of AICRP on Small Millets, 2017) and results SiA 3212 to be maximum grade of disease severity and in DHFTN2-5-3, DHFT 77-3 and PPSS-7 found minimum grade of disease severity. Sharma *et al.* (2014) evaluated 155 accessions, during 2009 and 2010, 21, and resulted twenty eight accessions resistant.

Table 2: Evaluation of promising foxtail millet hybrids and varieties against blast during kharif 2020-21 and 2021-22.

Sr. No.	Entries	2020-21	2021-22	Mean
1.	FOXTAIL- 16	14.81(22.64)	18.52(25.49)	16.67(24.09)
2.	FOXTAIL- 31	11.11(19.47)	14.81(22.64)	12.96(21.1)
3.	FOXTAIL- 49	3.70(11.1)	0.00(0)	1.85(7.82)
4.	FOXTAIL- 96	3.70(11.1)	3.70(11.1)	3.70(11.1)
5.	FOXTAIL- 108	11.11(19.47)	11.11(19.47)	11.11(19.47)
6.	FOXTAIL- 132	3.70(11.1)	7.41(15.79)	5.56(13.63)
7.	FOXTAIL- 144	25.92(30.61)	18.52(25.49)	22.22(28.12)
8.	FOXTAIL- 156	33.33(35.26)	40.74(39.66)	37.03(37.48)
9.	FOXTAIL- 160	7.41(15.79)	11.11(19.47)	9.26(17.71)
10.	FOXTAIL- 179	11.11(19.47)	14.81(22.64)	12.96(21.1)
11.	FOXTAIL- 195	18.52(25.49)	22.22(28.12)	20.37(26.83)
12.	FOXTAIL- 200	3.70(11.1)	0.00(0)	1.85(7.82)
13.	FOXTAIL- 201	40.74(39.66)	48.14(43.94)	44.44(41.81)
14.	FOXTAIL- 237	0.00(0)	0.00(0)	0.00(0)
15.	FOXTAIL- 254	25.92(30.61)	22.22(28.12)	24.07(29.38)
16.	FOXTAIL- 267	0.00(0)	0.00(0)	0.00(0)
17.	FOXTAIL- 289	44.44(41.81)	40.74(39.66)	42.59(40.74)
18.	FOXTAIL- 295	7.41(15.79)	3.70(11.1)	5.56(13.63)
19.	FOXTAIL- 302	11.11(19.47)	14.81(22.64)	12.96(21.1)
20.	FOXTAIL- 362	7.41(15.79)	11.11(19.47)	9.26(17.71)
21.	FOXTAIL- 364	3.70(11.1)	7.41(15.79)	5.56(13.63)
22.	FOXTAIL- 388	14.81(22.64)	14.81(22.64)	14.81(22.64)
23.	FOXTAIL- 398	33.33(35.26)	40.74(39.66)	37.03(37.48)
24.	FOXTAIL-480	18.52(25.49)	14.81(22.64)	16.67(24.09)
25.	FOXTAIL-507	18.52(25.49)	25.92(30.61)	22.22(28.12)
26.	FOXTAIL- 525	25.92(30.61)	29.63(32.98)	27.78(31.8)
27.	FOXTAIL- 663	7.41(15.79)	11.11(19.47)	9.26(17.71)
28.	FOXTAIL- 710	14.81(22.64)	18.52(25.49)	16.67(24.09)
29.	FOXTAIL- 717	0.00(0)	0.00(0)	0.00(0)
30.	FOXTAIL- 745	11.11(19.47)	14.81(22.64)	12.96(21.1)
31.	FOXTAIL-750	37.03(37.48)	48.14(43.94)	42.59(40.74)
32.	FOXTAIL- 751	11.11(19.47)	14.81(22.64)	12.96(21.1)
33.	FOXTAIL- 758	33.33(35.26)	40.74(39.66)	37.03(37.48)
34.	FOXTAIL- 774	7.41(15.79)	11.11(19.47)	9.26(17.71)
35.	FOXTAIL- 784	7.41(15.79)	11.11(19.47)	9.26(17.71)
36.	FOXTAIL- 795	25.92(30.61)	29.63(32.98)	27.78(31.8)
37.	FOXTAIL- 796	14.81(22.64)	18.52(25.49)	16.67(24.09)
38.	FOXTAIL- 838	3.70(11.1)	0.00(0)	1.85(7.82)
39.	FOXTAIL- 846	14.81(22.64)	18.52(25.49)	16.67(24.09)

40.	FOXTAIL- 869	18.52(25.49)	22.22(28.12)	20.37(26.83)
41.	FOXTAIL- 874	33.33(35.26)	37.03(37.48)	35.18(36.38)
42.	FOXTAIL- 936	7.41(15.79)	11.11(19.47)	9.26(17.71)
43.	FOXTAIL- 946	62.96(52.51)	70.36(57.02)	66.66(54.73)
44.	FOXTAIL- 956	29.63(32.98)	37.03(37.48)	33.33(35.26)
45.	FOXTAIL- 969	55.55(48.19)	59.25(50.33)	57.40(49.26)
46.	FOXTAIL- 983	59.25(50.33)	62.96(52.51)	61.11(51.42)
47.	FOXTAIL- 985	18.52(25.49)	25.92(30.61)	22.22(28.12)
48.	FOXTAIL- 1000	59.25(50.33)	66.66(54.73)	62.96(52.51)
49.	FOXTAIL- 1013	3.70(11.1)	7.41(15.79)	5.56(13.63)
50.	FOXTAIL- 1026	18.52(25.49)	18.52(25.49)	18.52(25.49)
51.	FOXTAIL- 1037	0.00(0)	0.00(0)	0.00(0)
52.	FOXTAIL- 1071	55.55(48.19)	59.25(50.33)	57.40(49.26)
53.	FOXTAIL- 1136	59.25(50.33)	62.96(52.51)	61.11(51.42)
54.	FOXTAIL- 1137	3.70(11.1)	11.11(19.47)	7.41(15.79)
55.	FOXTAIL- 1162	3.70(11.1)	3.70(11.1)	3.70(11.1)
56.	FOXTAIL- 1177	18.52(25.49)	22.22(28.12)	20.37(26.83)
57.	FOXTAIL- 1251	37.03(37.48)	37.03(37.48)	37.03(37.48)
58.	FOXTAIL- 1306	18.52(25.49)	22.22(28.12)	20.37(26.83)
59.	FOXTAIL- 1354	29.63(32.98)	37.03(37.48)	33.33(35.26)
60.	FOXTAIL- 1377	22.22(28.12)	29.63(32.98)	25.92(30.61)
61.	FOXTAIL- 1400	14.81(22.64)	18.52(25.49)	16.67(24.09)
62.	FOXTAIL- 1406	14.81(22.64)	18.52(25.49)	16.67(24.09)
63.	FOXTAIL- 1511	48.14(43.94)	51.85(46.06)	50.00(45)
64.	FOXTAIL- 1600	37.03(37.48)	40.74(39.66)	38.89(38.58)
65.	FOXTAIL- 1603	55.55(48.19)	59.25(50.33)	57.40(49.26)
66.	FOXTAIL- 1605	44.44(41.81)	44.44(41.81)	44.44(41.81)
67.	FOXTAIL- 1606	18.52(25.49)	14.81(22.64)	16.67(24.09)
68.	FOXTAIL- 1623	18.52(25.49)	22.22(28.12)	20.37(26.83)
69.	FOXTAIL- 1629	11.11(19.47)	14.81(22.64)	12.96(21.1)
70.	FOXTAIL- 1636	37.03(37.48)	40.74(39.66)	38.89(38.58)
71.	FOXTAIL- 1664	18.52(25.49)	14.81(22.64)	16.67(24.09)
72.	FOXTAIL- 1665	7.41(15.79)	7.41(15.79)	7.41(15.79)
73.	FOXTAIL- 1674	25.92(30.61)	29.63(32.98)	27.78(31.8)
74.	FOXTAIL- 1680	44.44(41.81)	48.14(43.94)	46.29(42.87)
75.	FOXTAIL- 1687	44.44(41.81)	48.14(43.94)	46.29(42.87)
76.	FOXTAIL- 1704	48.14(43.94)	51.85(46.06)	50.00(45)
77.	FOXTAIL- 1725	0.00(0)	0.00(0)	0.00(0)
78.	FOXTAIL- 1736	29.63(32.98)	33.33(35.26)	31.48(34.13)
79.	FOXTAIL- 1745	18.52(25.49)	18.52(25.49)	18.52(25.49)
80.	FOXTAIL-1762	25.92(30.61)	25.92(30.61)	25.92(30.61)
81.	FOXTAIL- 1773	37.03(37.48)	40.74(39.66)	38.89(38.58)
82.	FOXTAIL- 1780	29.63(32.98)	29.63(32.98)	29.63(32.98)
83.	FOXTAIL- 1805	22.22(28.12)	25.92(30.61)	24.07(29.38)
84.	FOXTAIL- 1806	40.74(39.66)	44.44(41.81)	42.59(40.74)
85.	FOXTAIL- 1808	14.81(22.64)	22.22(28.12)	18.52(25.49)
86.	FOXTAIL- 1820	18.52(25.49)	18.52(25.49)	18.52(25.49)
87.	FOXTAIL- 1846	11.11(19.47)	14.81(22.64)	12.96(21.1)
88.	FOXTAIL-1851	22.22(28.12)	25.92(30.61)	24.07(29.38)
89.	FOXTAIL-1859	7.41(15.79)	14.81(22.64)	11.11(19.47)
90.	FOXTAIL-1881	7.41(15.79)	14.81(22.64)	11.11(19.47)
91.	FOXTAIL-1892	14.81(22.64)	18.52(25.49)	16.67(24.09)
92.	Check MM-7	14.81(22.64)	18.52(25.49)	16.67(24.09)
93.	Check SIA-3156	11.11(19.47)	7.41(15.79)	9.26(17.71)
S.Em		0.394	0.358	0.298
CD 0.05		1.106	1.005	0.836

Table 3: Reaction of foxtail millet genotypes against blast disease severity (%).

Sr. No.	Category	No. of entries	Name of entries
1.	Highly Resistant (<11.11%)	23	Foxtail- 49, 96, 132, 160, 200, 237, 267, 295, 362, 364, 663, 717, 774, 784, 838, 936, 1013, 1037, 1137, 1162, 1665, 1725, Check SIA -3156.
2.	Resistant (11.11-33.33%)	44	Foxtail- 16, 31, 108, 144, 179, 195, 254, 302, 388, 480, 507, 525, 710, 745, 751, 795, 796, 846, 869, 985, 1026, 1177, 1306, 1377, 1400, 1406, 1606, 1623, 1629, 1664, 1674, 1736, 1745, 1762, 1780, 1805, 1808, 1820, 1846, 1851, 1859, 1892, 1881, Check MM-7.
3.	Moderately Resistant (33.33-5.55%)	18	Foxtail- 156, 201, 289, 398, 750, 758, 874, 956, 1251, 1511, 1600, 1605, 1636, 1680, 1687, 1704, 1773, 1806.
4.	Susceptible (55.55-77.77%)	08	Foxtail- 946, 969, 983, 1000, 1354, 1603, 1136,1071
5.	Highly Susceptible (>77.77%)	00	--

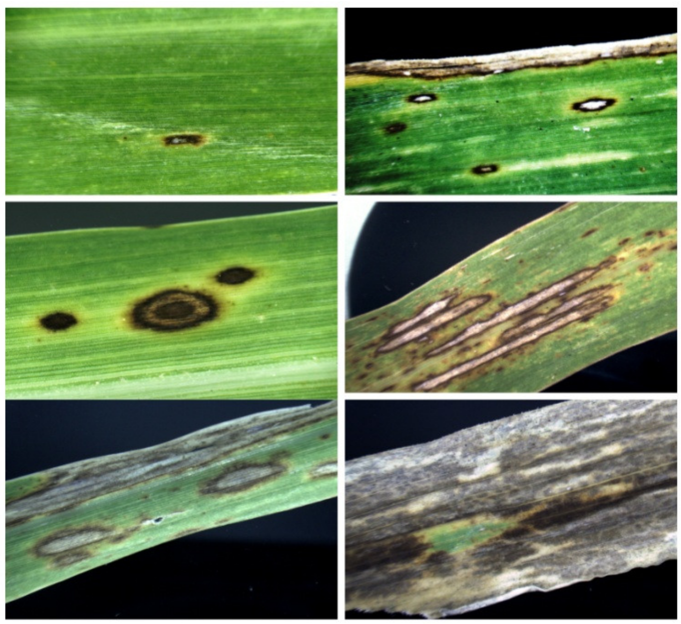

Fig. 1. Pattern of sporulating lesions of blast observed on leaf of foxtail millet.

CONCLUSION

From the present investigation it is concluded that twenty three genotypes where analyzed as highly resistant *viz.,* foxtail-49, 96, 132, 160, 200, 237, 267, 295, 362, 364, 663, 717, 774, 784, 838, 936, 1013, 1037, 1137, 1162, 1665, 1725, Check SIA-3156.

FUTURE SCOPE

Resistant genotypes identified in the present research may be used further to develop improved genotypes against blast, which can help to boost production and productivity of foxtail millet**.**

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Conflict of Interest. None.

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