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Hybridization and identification of resistant sources for major diseases in pearl millet (*Pennisetum glaucum* (L.) R. Br)

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Abstract

The utilization of resistant varieties is a classical approach to prevent the catastrophic losses caused by pearl millet blast and rust with reduction in the cost of production and increased yield. Therefore, a study was conducted during the *kharif* 2023 at Regional Agricultural Research Station, Vijayapura to identify resistance sources against blast and rust disease in pearl millet crop. Fifty hybrids, twenty seven parents along with three checks were screened against blast and rust diseases under field condition. None of the genotypes examined were immune. The hybrids viz., ICMA 94555 X VJP Fe & Zn-1, ICMA 94555 X VJP Fe & Zn-3, ICMA 94555 X VJP Fe & Zn-19, ICMA 94555 X VJP Fe & Zn-24 and ICMA 98222 X VJP Fe & Zn-9 were showed resistance for both rust and blast diseases.

Keywords: Pearl millet, rust, blast

Introduction

Pearl millet is a diploid ($2n = 2x = 14$) in nature stands out as an exceptionally drought resistant, warm season millet crop that primarily serves as a staple food source for millions of the people in the world and provides fodder for animals and poultry feed. It's nutritionally excellence and fundamental role in the sustenance of numerous populations residing in challenging environments characterized by unpredictable rainfall patterns and impoverished soils. It is the most suitable and efficient choice crop for arid and semiarid conditions due to its exceptional ability to make efficient use of soil moisture and its higher tolerance to heat in comparison to sorghum and maize. It also possesses unique genetic predisposition to withstand environmental stress and produce appreciable yield when cultivated on marginal soils. Its cultivation typically takes place in soil marked by diminished fertility receiving an annual rainfall ranging from 150 to 750 mm.

The year 2023 has been declared as the "International Year of Millets" by the FAO, Committee on Agriculture (COAG) forum. Micronutrient malnutrition is increasingly being recognised as a serious public health problem affecting more than half of the population worldwide, with preschool children and women in developing countries being the most vulnerable (Anon., 2004). Improving essential nutrient content in staple food crops through biofortification breeding can overcome the micronutrient malnutrition problem. The most widespread of these are dietary deficiencies in iron (Fe), zinc (Zn) and vitamin A. Iron deficiency is the principal cause of anemia, this impairs children physical growth and mental development, while due to Zn deficiency children have stunted growth. Pharmaceutical supplementations, industrial food fortification, agricultural approaches to dietary diversification and biofortification have been suggested to address these problems.

The crop production and productivity is adversely affected by a number of abiotic stresses (drought and heat) and biotic stresses such as diseases (downy mildew [*Sclerospora graminicola*], blast [*Pyricularia grisea*; teleomorph: *Magnaporthe grisea*], rust [*Puccinia substriata* var. *indica*], ergot [*Claviceps fusiformis*] and smut [*Moesziomyces penicillariae*]). Breeding for downy mildew resistance has always been the top priority in the pearl millet breeding programs in India owing to economic importance of the disease (Rai *et al.* 2014) [8]. However, during recent years, blast, also known as leaf spot, has gained equal importance due to its widespread occurrence in

India. In fact, the disease has attained an alarming status requiring concerted efforts to breed for resistance to blast (Sharma *et al.* 2018) [9]. Rust, a foliar disease reduces seed yield in hybrid seed production plots and adversely affects biomass and quality of forage and grain yields in pearl millet cultivars. Use of host plant resistance is the most feasible and economical means of managing these diseases as the crop is mainly cultivated by resource-poor farmers. Hence, in present investigation an attempt was made to identify blast and rust resistant potential hybrids.

Materials and Methods

A total of 50 hybrids, 27 parents and three checks were screened for blast and rust disease reaction during *kharif* 2023 at Regional Agricultural Research Station, Vijayapura. Each entry was

planted in two rows of 3 m length with a spacing of 45 cm × 15 cm. During the complete crop period, standard package of practices of Zone 3 of Karnataka were followed.

Observations on disease incidence

The blast and rust disease severity was recorded at the time of maturity using 0-9 scale as per the method suggested by Mayee and Datar (1986) [5] by randomly selecting five plants in each genotype. In each entry, severity was recorded by considering lower leaves, middle leaves and top leaves of pearl millet genotypes at maturity stages and based on the disease reaction, genotypes were categorized into immune, resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible as mentioned below.

Scale	Description	Disease Response
0	No lesions on leaf	Immune (I)
1	Few scattered pin head sized lesions on leaf, covering less than 1 per cent area of leaf	Resistant (R)
3	Lesions up to 5 mm in diameter, spindle shaped dark coloured with a lighter centre, covering 1-10 per cent area of leaf	Moderately Resistant (MR)
5	Typical blast lesions scattered throughout the leaf blade, coalescing and covering 11-20 per cent of leaf area	Moderately Susceptible (MS)
7	Typical blast lesions, up to 1 cm in diameter, scattered throughout the leaf blade, coalescing to give blasted appearance to plant and lesions covering 21- 50 per cent of leaf area.	Susceptible (S)
9	Typical blast lesions, more than 1 cm in diameter scattered throughout the leaf blade, coalescing to give blasted appearance to plant and lesions covering more than 50 per cent of leaf area	Highly Susceptible (HS)

Scale for scoring pearl millet rust disease severity

Scale	Description	Category
0	No symptoms on the leaf	Immune (I)
1	Small, dark brown, powdery pustules covering 1 per cent of leaf area	Resistant (R)
3	Typical rust pustules covering 1 to 10 per cent of the leaf area	Moderately resistant (MR)
5	Typical rust pustules covering 11 to 25 per cent of the leaf area	Moderately susceptible (MS)
7	Typical rust pustules covering 26 to 50 per cent of the leaf area	Susceptible (S)
9	Rust pustules covering 51 per cent or more of the leaf area and withering of leaf	Highly susceptible (HS)

Scale for scoring pearl millet blast disease severity

Genotypes and checks were later grouped into different categories based on their reaction to blast and rust disease under unprotected conditions.

Results and Discussion

The degree of disease severity in parents, hybrids and checks regarding blast reaction was recorded using a Scale ranging from 0 to 9 at the crop maturity stage (Mayee and Datar, 1986) [5].

The data in present study revealed that out of the 80 genotypes analyzed, not a single one registered immunity. Among these, 21 genotypes (comprising 6 testers, 14 hybrids and 1 check) exhibited resistance to blast, while 50 genotypes (including 2 lines, 15 testers, 31 hybrids and 2 checks) displayed a moderate level of resistance. In contrast, 9 genotypes (4 testers and 5 hybrids) demonstrated a moderate susceptible reaction. None of the genotypes were categorized as susceptible and highly susceptible to blast (Table 1).

In the past, researchers from both India and other countries have made efforts to identify the factors behind resistance to the pearl millet blast pathogen. Comparable outcomes were documented in studies conducted by Sharma *et al.* (2009) [11], Nagaraja (2013) [6], Lubadde (2014) [4], Sharma *et al.* (2020) [10], Athoni *et al.* (2022) [2], Parihar *et al.* (2022) [7] and Kumara *et al.*, 2023 [3].

Using a 0-9 scale, the disease severity in the parents, hybrids and checks for rust reaction were recorded at the maturity stage (Mayee and Datar, 1986) [5].

Out of the eighty genotypes that were evaluated, the data showed that none were found immune. Nineteen genotypes including 2

lines, 6 testers and 11 hybrids showed resistant reaction for rust and fifty three genotypes (including 16 testers, 34 hybrids and 3 checks) were reflected to be moderately resistance. A fairly susceptible reaction was shown by 8 genotypes (3 testers and 5 hybrids). Additionally, none of the genotypes was discovered to be either vulnerable or very susceptible to rust disease (Table 2). In the past, several researchers from India and across the world have tried to identify the reasons behind resistance to the pathogen that causes pearl millet rust. Nagaraja (2013) [6], Lubadde (2014) [4], Sharma *et al.* (2020) [10], Athoni *et al.* (2022) [2] and Kumara *et al.* 2023 [3] noted similar outcomes from thesis study.

The hybrids viz., ICMA 94555 X VJP Fe & Zn-1, ICMA 94555 X VJP Fe & Zn-3, ICMA 94555 X VJP Fe & Zn-19, ICMA 94555 X VJP Fe & Zn-24 and ICMA 98222 X VJP Fe & Zn-9 were showed resistance for both rust and blast diseases. Whereas 21 genotypes showed moderately resistance for both rust and blast disease compared to all the checks.

The restorers VJP Fe & Zn-18 is demonstrated resistance (R) to blast and rust diseases, VJP Fe & Zn-19, VJP Fe & Zn-22, VJP Fe & Zn-24 and VJP Fe & Zn-25 were considered to be promising since they demonstrated moderately resistance (R) to blast and resistance to rust diseases as well as high GCA status (Table 3).

The crosses ICMA 98222 X VJP Fe & Zn-18, ICMA 94555 X VJP Fe & Zn-3, ICMA 98222 X VJP Fe & Zn-3, ICMA 98222 X VJP Fe & Zn-22 and ICMA 94555 X VJP Fe & Zn-19 demonstrated high yield (kg ha⁻¹) with varying degrees of resistance to moderately resistant reaction for rust and blast in comparison to checks (Table 4).

Table 1: Reaction of pearl millet hybrids, parents and checks to blast disease (*Pyricularia grisea*) under field condition during *Kharif* 2023 at RARS Vijayapura

Scale	Disease reaction	Number of genotypes	Parents/Inbreds	Hybrids/Checks
0	Immune	-	-	-
1	Resistant	19	ICMB 94555 ICMB 98222 VJP Fe & Zn – 3 VJP Fe & Zn – 11 VJP Fe & Zn – 15 VJP Fe & Zn – 18 VJP Fe & Zn – 21 VJP Fe & Zn – 23	ICMA 94555 × VJP Fe & Zn – 1 ICMA 94555 × VJP Fe & Zn – 3 ICMA 94555 × VJP Fe & Zn – 7 ICMA 94555 × VJP Fe & Zn – 14 ICMA 94555 × VJP Fe & Zn – 15 ICMA 94555 × VJP Fe & Zn – 19 ICMA 94555 × VJP Fe & Zn – 24 ICMA 98222 × VJP Fe & Zn – 1 ICMA 98222 × VJP Fe & Zn – 6 ICMA 98222 × VJP Fe & Zn – 9 ICMA 98222 × VJP Fe & Zn – 13
3	Moderately Resistant	53	VJP Fe & Zn – 1 VJP Fe & Zn – 2 VJP Fe & Zn – 5 VJP Fe & Zn – 6 VJP Fe & Zn – 7 VJP Fe & Zn – 8 VJP Fe & Zn – 9 VJP Fe & Zn – 12 VJP Fe & Zn – 14 VJP Fe & Zn – 16 VJP Fe & Zn – 17 VJP Fe & Zn – 19 VJP Fe & Zn – 20 VJP Fe & Zn – 22 VJP Fe & Zn – 24 VJP Fe & Zn – 25	ICMA 94555 × VJP Fe & Zn – 2 ICMA 94555 × VJP Fe & Zn – 4 ICMA 94555 × VJP Fe & Zn – 5 ICMA 94555 × VJP Fe & Zn – 6 ICMA 94555 × VJP Fe & Zn – 8 ICMA 94555 × VJP Fe & Zn – 9 ICMA 94555 × VJP Fe & Zn – 11 ICMA 94555 × VJP Fe & Zn – 12 ICMA 94555 × VJP Fe & Zn – 13 ICMA 94555 × VJP Fe & Zn – 16 ICMA 94555 × VJP Fe & Zn – 17 ICMA 94555 × VJP Fe & Zn – 18 ICMA 94555 × VJP Fe & Zn – 20 ICMA 94555 × VJP Fe & Zn – 21 ICMA 94555 × VJP Fe & Zn – 22 ICMA 94555 × VJP Fe & Zn – 23 ICMA 94555 × VJP Fe & Zn – 25 ICMA 98222 × VJP Fe & Zn – 2 ICMA 98222 × VJP Fe & Zn – 3 ICMA 98222 × VJP Fe & Zn – 5 ICMA 98222 × VJP Fe & Zn – 10 ICMA 98222 × VJP Fe & Zn – 11 ICMA 98222 × VJP Fe & Zn – 12 ICMA 98222 × VJP Fe & Zn – 14 ICMA 98222 × VJP Fe & Zn – 15 ICMA 98222 × VJP Fe & Zn – 16 ICMA 98222 × VJP Fe & Zn – 17 ICMA 98222 × VJP Fe & Zn – 18 ICMA 98222 × VJP Fe & Zn – 19 ICMA 98222 × VJP Fe & Zn – 20 ICMA 98222 × VJP Fe & Zn – 22 ICMA 98222 × VJP Fe & Zn – 24 ICMA 98222 × VJP Fe & Zn – 23 ICMA 98222 × VJP Fe & Zn – 25 VPMH 7 VPMH 14 Kaveri super boss
5	Moderately Susceptible	8	VJP Fe & Zn – 4 VJP Fe & Zn – 10 VJP Fe & Zn – 13	ICMA 94555 × VJP Fe & Zn – 10 ICMA 98222 × VJP Fe & Zn – 4 ICMA 98222 × VJP Fe & Zn – 7 ICMA 98222 × VJP Fe & Zn – 8 ICMA 98222 × VJP Fe & Zn – 21
7	Susceptible	-	-	-
9	Highly susceptible	-	-	-

Table 2: Reaction of pearl millet hybrids, parents and checks to rust disease (*Puccinia substriata*) under field condition during *kharif* 2023 at RARS Vijayapura

Scale	Disease reaction	Number of genotypes	Parents/Inbreds	Hybrids/Checks
0	Immune	-	-	-
1	Resistant	19	ICMB 94555 ICMB 98222 VJP Fe & Zn – 3 VJP Fe & Zn – 11 VJP Fe & Zn – 15 VJP Fe & Zn – 18 VJP Fe & Zn – 21 VJP Fe & Zn – 23	ICMA 94555 × VJP Fe & Zn – 1 ICMA 94555 × VJP Fe & Zn – 3 ICMA 94555 × VJP Fe & Zn – 7 ICMA 94555 × VJP Fe & Zn – 14 ICMA 94555 × VJP Fe & Zn – 15 ICMA 94555 × VJP Fe & Zn – 19 ICMA 94555 × VJP Fe & Zn – 24 ICMA 98222 × VJP Fe & Zn – 1 ICMA 98222 × VJP Fe & Zn – 6 ICMA 98222 × VJP Fe & Zn – 9 ICMA 98222 × VJP Fe & Zn – 13
3	Moderately Resistant	53	VJP Fe & Zn – 1 VJP Fe & Zn – 2 VJP Fe & Zn – 5 VJP Fe & Zn – 6 VJP Fe & Zn – 7 VJP Fe & Zn – 8 VJP Fe & Zn – 9 VJP Fe & Zn – 12 VJP Fe & Zn – 14 VJP Fe & Zn – 16 VJP Fe & Zn – 17 VJP Fe & Zn – 19	ICMA 94555 × VJP Fe & Zn – 2 ICMA 94555 × VJP Fe & Zn – 4 ICMA 94555 × VJP Fe & Zn – 5 ICMA 94555 × VJP Fe & Zn – 6 ICMA 94555 × VJP Fe & Zn – 8 ICMA 94555 × VJP Fe & Zn – 9 ICMA 94555 × VJP Fe & Zn – 11 ICMA 94555 × VJP Fe & Zn – 12 ICMA 94555 × VJP Fe & Zn – 13 ICMA 94555 × VJP Fe & Zn – 16 ICMA 94555 × VJP Fe & Zn – 17 ICMA 94555 × VJP Fe & Zn – 18 ICMA 94555 × VJP Fe & Zn – 20 ICMA 94555 × VJP Fe & Zn – 21 ICMA 94555 × VJP Fe & Zn – 22 ICMA 94555 × VJP Fe & Zn – 23 ICMA 94555 × VJP Fe & Zn – 25 ICMA 98222 × VJP Fe & Zn – 2

			VJP Fe & Zn – 20 VJP Fe & Zn – 22 VJP Fe & Zn – 24 VJP Fe & Zn – 25	ICMA 98222 × VJP Fe & Zn – 3 ICMA 98222 × VJP Fe & Zn – 5 ICMA 98222 × VJP Fe & Zn – 10 ICMA 98222 × VJP Fe & Zn – 11 ICMA 98222 × VJP Fe & Zn – 12 ICMA 98222 × VJP Fe & Zn – 14 ICMA 98222 × VJP Fe & Zn – 15 ICMA 98222 × VJP Fe & Zn – 16 ICMA 98222 × VJP Fe & Zn – 17 ICMA 98222 × VJP Fe & Zn – 18 ICMA 98222 × VJP Fe & Zn – 19 ICMA 98222 × VJP Fe & Zn – 20 ICMA 98222 × VJP Fe & Zn – 22 ICMA 98222 × VJP Fe & Zn – 24 ICMA 98222 × VJP Fe & Zn – 23 ICMA 98222 × VJP Fe & Zn – 25 VPMH 7 VPMH 14 Kaveri super boss
5	Moderately Susceptible	8	VJP Fe & Zn – 4 VJP Fe & Zn – 10 VJP Fe & Zn – 13	ICMA 94555 × VJP Fe & Zn – 10 ICMA 98222 × VJP Fe & Zn – 4 ICMA 98222 × VJP Fe & Zn – 7 ICMA 98222 × VJP Fe & Zn – 8 ICMA 98222 × VJP Fe & Zn – 21
7	Susceptible	-	-	-
9	Highly susceptible	-	-	-

Table 3: Promising parents showing resistance to rust and blast diseases

Sl. No.	Parents	GCA status	Reaction to blast disease	Reaction to rust disease
1	ICMB 98222	High	MR	MR
2	VJP Fe & Zn –18	High	R	R
3	VJP Fe & Zn –2	Low	R	MR
4	VJP Fe & Zn – 19	High	R	MR
5	VJP Fe & Zn – 22	High	R	MR
6	VJP Fe & Zn – 24	High	R	MR
7	VJP Fe & Zn – 25	High	R	MR

Table 4: Promising hybrids with resistance to rust and blast diseases

Sl. No.	Hybrids	Grain Yield (kg/ha)	SCA status	Reaction to blast disease	Reaction to rust disease
1	ICMA 98222 X VJP Fe & Zn-18	4126	507.79	MR	MR
2	ICMA 94555 X VJP Fe & Zn-3	3926	93.82	R	R
3	ICMA 98222 X VJP Fe & Zn-3	3887	-93.82	MR	MR
4	ICMA 98222 X VJP Fe & Zn-22	3784	424.70	MR	MR
5	ICMA 94555 X VJP Fe & Zn-19	3781	250.85	R	R
6	VPMH 7	3086		MR	MR
7	VPMH 14	3498		MR	MR
8	Kaveri Super Boss	3451		R	MR

Summary and Conclusion

The hybrids viz., ICMA 94555 X VJP Fe & Zn-1, ICMA 94555 X VJP Fe & Zn-3, ICMA 94555 X VJP Fe & Zn-19, ICMA 94555 X VJP Fe & Zn-24 and ICMA 98222 X VJP Fe & Zn-9 were found to be resistant to blast and rust disease. So the results need be further confirmed across the seasons and locations for identification of stable hybrids for yield and resistant to blast and rust diseases under *in vitro* and *in vivo* conditions. Among the parents, ICMB-98222 and VJP Fe & Zn-18 was found to be resistant to blast and rust diseases so, further reconfirmation in both *in vitro* and *in vivo* conditions is required and then this parent can be used as donor of resistance to blast and rust disease in developing resistant hybrids.

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