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Research Article

Evaluation of the Response of Pearl Millet([*Pennisetum glaucum* (L.) R.Br.] varieties to Downey Mildew(*Sclerospora graminicola* (Sacc.) infestation , Agronomic Traits and Yield In Turare (Forestry Experimental Field, Federal University Dutsin-Ma) Katsina state

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Abstract

Millet varieties were tried for two years to study their response to downy Mildew infection, agronomic traits and yield. Five selected varieties that were resistant to downy mildew were crossed with five varieties with various susceptibilities to downy mildew. Crosses were obtained using a factorial mating scheme of North Carolina Design II, where each male was mated to each of the female. The hybrids with their parents were evaluated together during the raining season in the third year. The field evaluation was done using complete Randomized Block Design (CRBD) two replications. Hybrids and parents were allocated to plots using random table number. Fourteen of the genotypes were highly resistant to the pathogen (3 parents and 11 hybrids). The rest of the hybrids were resistant to the pathogens except one (GMC17001XMMC17006, the only susceptible genotype among the 30 genotypes study. Hybrids GMC17005X MMC17006, had the highest grain weight, followed by GMC17004XMMC17008, GMC17002XMMC17009 and GMC17001XMMC170010. It was also observed that these four hybrids combined Downy Mildew resistance with high yield and yield related characters.

Keywords: *Pearl Millet; Downy Mildew; Agronomic Traits*

Introduction

Millets are nutritionally superior to rice and wheat as they contain a high amount of proteins, dietary fibers, iron, zinc, calcium, phosphorus, potassium, vitamin B, and essential amino acids [1,2]. Millets are highly nutritious being rich source of proteins, vitamins, and minerals. About 80% of millet grains are used for food, while the rest is used as animal fodder and in brewing industry for alcoholic products [2]. The grains are ground into flour and consumed as cakes or porridges. In Asian countries, street food vendors serve less expensive, ready-to-eat millet-based foods for poor consumers. Millets are recommended for well-being of infants, lactating mothers, elderly, and convalescents. The grains release sugar slowly into the blood stream and thus considered "gluten-free" [3]. With high fiber and protein content, millets are preferred as dietary foods for people with diabetes and cardiovascular diseases (Muthamilarasan., *et al*. 2016). In addition, they contain health promoting phenolic acids and flavonoids, that play a vital role in combating free-radical mediated oxidative stress and in lowering blood glucose levels [1,4-6]. Pearl millet is rich in Fe, Zn and lysine (17 - 65 mg/g of protein) compared to other millets [7]. International Crop Research Institute for Semi-Arid Tropics (ICRISAT) contains the largest collection of millet germplasm representing 27.4% of total crop accessions in the genebank [8].

Downy mildew of pearl millet is caused by the oomycete, *Sclerospora graminicola*. The presence of spores (sporangia), which produce smaller internal swimming spores with two whip-like threads, and the presence of cellulose not chitin in their cell walls, sets them apart from fungi.

Downy mildew infected plants develop severe disease syndrome from the very beginning and succumb even before reaching maturity. Reduction in the plant height, number of leaves and nodes are commonly observed in susceptible cultivars resulting in reduced grain and fodder yields. Changes in morphological characters in susceptible pearl millet due to downy mildew resulted in reduction of grain and fodder yields [9].

The disease was considered of minor importance till 1970, as its incidence was sporadic on local cultivars. The first epidemic of downy mildew occurred in 1971 on the first popular pearl millet hybrid, HB 3, resulting in severe grain loss of about 4.6 million metric tons (Singh SD 1995, Singh., *et al*. 1993). Because of continued large-scale cultivation of the susceptible hybrids, the disease caused serious epidemics during 1974, 1984, 1987 and 1988 [10].

Sclerospora graminicola reproduces asexually by means of sporangia and sexually through oospores. The fungus is largely heterothallic with two mating types. These characteristics of the fungus make it highly variable and adaptable to diverse environmental conditions. Similarly, its host pearl millet is a highly outcrossing crop species. The information generated for the past few years on genetics of resistance, availability of host differentials and development of molecular techniques, has made it easy to understand *S. graminicola*- pearl millet interaction. Single cross F1 hybrids have greatly contributed to increasing productivity of pearl millet. Early maturity, uniform crop stand and high harvest index of these hybrids have made them popular among the farmers. As a result, hybrid cultivars cover about 55% of the total 10 million ha area under pearl millet in India with the cultivation of around 50 hybrids [11,12]. By the time several races or pathotypes of *S. graminicola* have evolved in India. Stability of resistance in pearl millet lines developed at ICRISAT was studied through a collaborative International Pearl Millet Downy Mildew Virulence Nursery (IPMDMVN). The reactions to downy mildew of 11 pearl millet lines at 17 locations in India, Burkina Faso, Mali, Niger, and Nigeria from 1995 to 1999 were recorded [12-16]. Seven pearl millet lines (IP 18292, IP 18293, 700651, P310-17, P7-4, MBH 110 and 852B) provided differential reactions permitting classification of the 23 populations into 15 putative pathotypes at the global level. Interestingly, the existence of a highly virulent pathotype of *S. graminicola* is reported from Jodhpur, Rajasthan, India [14].

With increasing environmental awareness the focus of managing plant diseases has been shifted towards viable and sustainable alternatives [10]. The biological control of downy mildew disease has been discussed by Shetty and Kumar [17].

Materials and Methodology

Study area

This experiment was conducted at the Agroforestry farm layout, Federal University Dutsin-Ma, Katsina State, Nigeria. Dutsin-Ma lies between latitude 12º 27’ and 22’’N and longitude 7º 30’ and 83’’E (Figure 1).

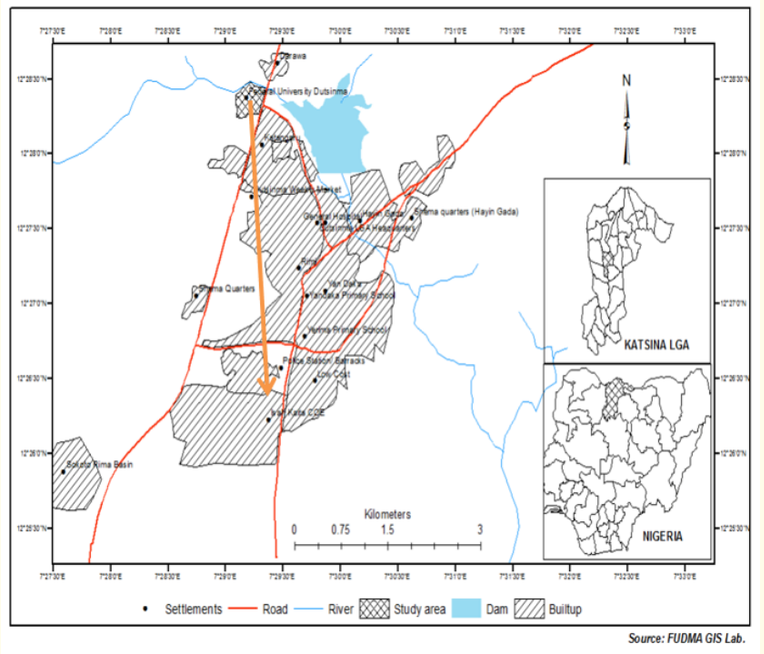

Figure 1: *Map of Katsina State showing Dutsin-Ma LG.A./Federal University, Dutsin-Ma.*
Source: Modified from the Administrative Map of Katsina State.

The daily minimum and maximum temperatures range from 32ºC to 43ºC. Dutsin-Ma, in Katsina State experiences unimodal rainfall pattern with an annual rainfall of about 1100 mm, with a single peak in August. Dry season lasts for a minimum of seven months (November-May) while the wet season spans June to October.

Description of experimental materials used in the study

Ten pearl millet varieties were obtained from ICRISAT Kano Nigeria comprising of five Maiwa varieties were selected as downy mildew resistant varieties and five Gero varieties which have various level of susceptibilities to downy mildew infections.

Design of the study

Five Maiwa varieties were selected as downy mildew resistant varieties and five Gero varieties which have various level of susceptibilities to downy mildew infections were crossed during the off season in a screen house. The Maiwa varieties were designated as male while the Gero varieties were designated as female.

Crosses were obtained using a factorial mating scheme of North Carolina Design II, where each male was mated to each of the female [18,19]. The field evaluation was done using complete Randomized Block Design (CRBD) two replications. Hybrids and parents were allocated to plots using random table number.

Data collected

Data collected included downy mildew incidences and agronomy traits and yield.

Downy Mildew incidence: (Number of diseased plants showing downy mildew symptoms expressed as a percentage of total number of plants in a plot) was assessed at 60 days after sowing (DAS) by scoring for chlorosis of infected plants and at dough stage by scoring for green ears. Downy Mildew incidence (the formula developed by James [20]), as the number of diseased plants express.

The following parameters were measured.

Downey mildew incidence calculated as:

$$DMI = \frac{Number\ of\ diseasesed\ plants}{Total\ number\ of\ plants} X\ 100 - - - - - - - - 1$$

Number of established seedlings per plot: Established seedlings counted at seedling stage of the plant.

Plant vigor: Based on agronomic appreciation, the seedlings that thrives best. Counted 2 - 3 weeks after sowing.

Days to 50% flowering: The number of days from sowing to when for 50% of the plants/plot flowered.

Plant height: determined as the distance from the bases of the plants at ground level to the apex of the panicles measured in centimetres at maturity averaged over 3 randomly chosen plants.

Panicle length: Distance from the bases of the panicles to the tip in centimetres averaged over 3 randomly chosen panicles using tape measure.

Number of harvested panicles per plot: Total number of productive panicles harvested from a plot.

Panicle circumference: Circumference of the panicle measured in cm using tape measure averaged over 3 randomly selected panicles.

Panicle exertion: Measured from boot leaf to the base of the panicle in cm.

Panicle compression: Based on agronomic appreciation, the panicles that have good seed formation or setting.

Panicle weight: The weight of all harvested panicles in a plot weighed in grams per plot before threshing.

Plant number at harvest: number of plants per plot counted at harvest.

Grain weight per plot: Grain threshed from the harvested panicles weighed in grams.

Grain yield per Ha calculated as:

$$\text{Grain yield per Ha} = \frac{\text{Grain weight}}{\text{Plot area}} \text{X } 10000 \quad ---------- 2$$

Threshing percentage calculated as:

$$\text{Thr (\%)} = \frac{\text{Grain weight}}{\text{panicle weight}} \text{X } 100 \quad -------- 3$$

Results and Discussion

Downy mildew incidence

The results indicated two of the male parents that were resistant in the first two seasons became moderately susceptible in the third season at the same location. This indicate either a shift in virulence of the pathogen or a shift in resistance of genotypes used. Similar results were obtained in Ati., *et al* [21]. Thakuret., *et al*. 2009 found that a major change in disease incidence of pearl millet line over time at the same location reflected virulence shift in the pathogen population. Downy mildew pathogen is heterothallic and frequent recombination leads to genetic diversity and evolution of new virulent population. Hence identification of resistance to new virulence population is a prerequisite for resistance breeding (Thakuret., *et al*. 2009). Among five female parents only one maintained it status of being susceptible to the pathogen, the remaining 4 female parents gained resistance to the pathogens while among the male parents, one was resistant, two moderately resistant and two were moderately susceptible. Fourteen of the genotypes were highly resistant to the pathogen (3 parents and 11 hybrids). Ati and Jamala [22] had similar result in their work on millet downy mildew rating. The rest of the hybrids were resistant to the pathogens except one (GMC17001XMMC17006, the only susceptible genotype among the 30 genotypes study) (See table 1).

Days to 50% flowering, 4 hybrids were early with 50 days for 58% flowering (GMC17003 X MMC17008, GMC17003 X MMC17007, GMC17004 X MMC17008 and GMC17004 X MMC17009) these were earlier than some of the parents which shows that these hybrids have higher potentials for earliness. Ati., *et al.* [21,23] had similar result in their work on millet (See table 1).

Yield: In pearl millet, the most important character of interest to the breeder is the grain yield and disease resistant. Since grain yield is a quantitative character that is influenced by environmental factors, direct selection for yield *per se* would be difficult. Therefore, to improve the grain yield it is desirable to select for one or more yield related characters e.g. panicle length, number of harvested panicles, panicle circumference and panicle weight. All the hybrids showed higher yield than the parents indicating that the hybrids have some degree of tolerance for the disease. Ati., *et al*. [21] had similar result on their work on pearl millet. Hybrids GMC17005X MMC17006, had the highest grain weight, followed by GMC17004XMMC17008, GMC17002XMMC17009 and GMC17001XMMC170010. It was also observed that these four hybrids combined Downy Mildew resistance with high yield and yield related characters (See table 1).

SOURCE OF VARIATION	D50%F	DMI	GW	GY_Ha	NHarPan	NSPlt	PanCIR	PanCom	PanEx	PanLen	PanWt	Plant_height	Plant_vig	PlantNo	THR%
DESIGNATION															
GMC17001	63 ab	7.143 bc	59.5 cd	79.4 cd	7 cd	7.5 bcd	8.05 abcd	1.5 ab	1.65 ab	36.85 cde	235 de	215 abcdef	2 ab	11.5 abcd	67.01
GMC17001 X MMC17007	66 ab	0 c	267 bcd	356 bcd	18 abcd	12 abcd	6.85 bcd	1.5 ab	1.5 ab	33.65 cde	595.5 bcde	247.7 a	1.5 ab	6 bcd	39.48
GMC17001 X MMC17010	60.5 ab	0 c	567.5 ab	756.7 ab	39.5 a	17.5 a	6.8 bcd	1 b	1.3 ab	34.2 cde	191.5 de	220.5 abcde	2 ab	9 abcd	60.79
GMC17001X MMC17006	60.5 ab	53.333 a	132 cd	176 cd	7.5 cd	4 cd	8.75 abcd	2 ab	2 ab	33.95 cde	275 de	237.8 ab	2.5 a	9.5 abcd	45.94
GMC17002	58 b	3.846 bc	413.5 abcd	551.3 abcd	16.5 abcd	11 abcd	7.9 abcd	2 ab	2.15 ab	35 cde	227.5 de	227.4 abcd	1 b	9 abcd	59.94
GMC17002 X MMC17006	60.5 ab	0 c	148.5 cd	198 cd	12 abcd	2.5 d	6.4 cd	1 b	1.5 ab	32.15 cde	455.5 bcde	208.7 abcdef	2 ab	14.5 ab	68.37
GMC17002 X MMC17007	60.5 ab	11.538 bc	274 bcd	365.3 bcd	20.5 abcd	10 abcd	8.75 abcd	2 ab	2.15 ab	35 cde	162.5 e	224 abcde	2 ab	12 abcd	64.53
GMC17002 X MMC17009	58 b	0 c	606 ab	808 ab	37.5 ab	11 abcd	7.7 abcd	2 ab	1.8 ab	45.5 bc	245.5 de	238.7 ab	2 ab	10.5 abcd	37.98
GMC17002 X MMC17010	74 a	0 c	149.5 cd	199.3 cd	8.5 cd	11.5 abcd	7.4 bcd	1.5 ab	1.35 ab	45.45 bc	473.5 bcde	179.5 def	2 ab	12 abcd	55.78
GMC17003	58 b	7.143 bc	237 bcd	316 bcd	22 abcd	9.5 abcd	7.65 abcd	2 ab	1.85 ab	25 de	175 e	182.9 cdef	2 ab	6 bcd	64.28
GMC17003 X MMC17006	60.5 ab	0 c	215 bcd	286.7 bcd	17 abcd	9.5 abcd	9.7 abc	2.5 ab	2.5 ab	35.35 cde	575.5 bcde	218 abcde	2 ab	12.5 abc	55.36
GMC17003 X MMC17007	58 b	6.667 bc	145.5 cd	194 cd	16 abcd	13.5 abc	10.8 a	3 a	2.7 a	29.2 cde	215 de	215.7 abcdef	2 ab	7.5 bcd	60.19
GMC17003 X MMC17008	58 b	0 c	460.5 abc	614 abc	29 abcd	9 abcd	8.75 abcd	3 a	2.65 a	30.95 cde	683 abcde	199.5 abcdef	1.5 ab	12 abcd	67.9
GMC17003 X MMC17009	74 a	0 c	246 bcd	328 bcd	24 abcd	6 bcd	7.35 bcd	1 b	1.35 ab	44.85 bc	1243.5 a	188.5 bcdef	1.5 ab	14.5 ab	55.96
GMC17003 X MMC17010	74 a	14.286 bc	120 cd	160 cd	5 cd	9 abcd	5.85 d	1 b	1.3 ab	41.15 bcde	56.5 e	163.9 f	2.5 a	5 bcd	59.42
GMC17004	58 b	4.167 bc	138 cd	184 cd	7.5 cd	12.5 abc	8 abcd	2 ab	2.35 ab	36 cde	137 e	183.9 cdef	1.5 ab	7.5 bcd	43.47
GMC17004 X MMC17006	66 ab	7.143 bc	106.5 cd	142 cd	6 cd	6 bcd	5.865 d	1 b	1.15 b	34.65 cde	1240 a	224.4 abcde	1 b	17.5 a	46.35
GMC17004 X MMC17007	66 ab	17.361 bc	323 abcd	430.7 abcd	22.5 abcd	12.5 abc	7.65 abcd	1.5 ab	1.65 ab	56.5 ab	198.5 de	194.2 bcdef	1.5 ab	4 cd	68.6
GMC17004 X MMC17008	58 b	0 c	585 ab	780 ab	30.5 abc	10.5 abcd	9.75 ab	2.5 ab	2.65 a	33.2 cde	290 de	186.4 bcdef	1 b	2.5 d	51.12
GMC17004 X MMC17009	58 b	0 c	162 cd	216 cd	14.5 abcd	9 abcd	7.4 bcd	1.5 ab	1.65 ab	41.3 bcde	555.5 bcde	184.2 cdef	1 b	10 abcd	45.89
GMC17004 X MMC17010	68.5 ab	7.692 bc	138 cd	184 cd	10 bcd	9 abcd	7.25 bcd	1 b	1.15 b	36.5 cde	398.5 cde	207.5 abcdef	2 ab	9.5 abcd	54.45
GMC17005	58 b	25 bc	269.5 bcd	359.3 bcd	23 abcd	8.5 abcd	8.25 abcd	2.5 ab	2.35 ab	24.3 e	568 bcde	210.2 abcdef	1.5 ab	11 abcd	71.67
GMC17005 X MMC17006	66 ab	14.286 bc	129.5 cd	172.7 cd	9 cd	7.5 bcd	8.85 abcd	1.5 ab	1.8 ab	55.65 ab	1068.5 ab	237.4 ab	1 b	11 abcd	61.4
GMC17005 X MMC17008	66 ab	0 c	368 abcd	490.7 abcd	23 abcd	12 abcd	8.85 abcd	1.5 ab	1.8 ab	29.8 cde	438 bcde	174.4 ef	1 b	9.5 abcd	49.45
GMC17005X MMC17007	66 ab	0 c	692.5 a	923.3 a	30 abc	14.5 ab	8.9 abcd	2 ab	2.3 ab	23.4 e	281.5 de	224 abcde	1.5 ab	13.5 abc	50.25
MMC17006	74 a	25.595 bc	114.5 cd	152.7 cd	8 cd	9.5 abcd	9.2 abc	1.5 ab	1.4 ab	66.6 a	850 abcd	226.9 abcde	1.5 ab	9 abcd	53.53
MMC17007	68.5 ab	9.091 bc	286.5 bcd	382 bcd	16 abcd	14.5 ab	8.6 abcd	2.5 ab	2.3 ab	30.85 cde	212 de	214.9 abcdef	1 b	12.5 abc	65.74
MMC17008	68.5 ab	16.084 bc	105 cd	140 cd	8 cd	12 abcd	7.2 bcd	1.5 ab	1.5 ab	32.35 cde	990 abc	235 abc	1 b	10.5 abcd	59.03
MMC17009	66 ab	30 b	36 d	48 d	2 d	5 bcd	8 abcd	1.5 ab	1.65 ab	30.9 cde	430 bcde	234 abc	1 b	9 abcd	44.06
MMC17010	68.5 ab	15.278 bc	84 cd	112 cd	9 cd	10.5 abcd	8.1 abcd	1 b	1.7 ab	43.65 bcd	373.5 cde	196.7 abcdef	2 ab	8.5 abcd	72.66
P of F	**0.076**	**0.017**	**0.014**	**0.014**	**68**	**0.219**	**0.19**	**0.194**	**0.255**	**0.002**	**0.003**	**0.022**	**0.082**	**0.219**	**0.888**
CV	**9.4**	**123.6**	**65.3**	**65.3**	**0.132**	**40.2**	**16.8**	**41.5**	**31.9**	**21**	**58.8**	**10.2**	**32.7**	**40.2**	**30.4**
Means are seperated using Duncan Multiple range															

Table 1: *Agronomy traits, downy mildew incidences and yield.*

Conclusion

These research aimed at developing superior hybrids that combined downy mildew resistance with high yielding potential and wider adaptability. The people of Turare village were basically farmers and pearl millet is one the most cultivated crop however this crop is plagued with sever downy mildew disease. Twelve hybrids that were highly resistant to downy mildew also exhibited the desired qualities were selected.

The most productive hybrids in terms of grain yield based on the mean performance were GMC17005X MMC17006, GMC17004XMMC17008, GMC17002XMMC17009 and GMC17001XMMC170010.

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