A Comparism of the Response of Some Pearl Millest \textit{(Pennisetum glaucum (L.) R. BR)} Hybrids and Their Parents to Downy Mildew \textit{(Sclerospora graminicola)} Infestation in Bakura and Zaria (North-western Nigeria)

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ABSTRACT

Downy mildew \textit{(Sclerospora graminicola} (Sacc) Schroet.) of pearl millet \textit{(Pennisetum glaucum} (L.) R.Br.) is a devastating disease that has greatly led to \textit{grain yield loss in Nigeria}. A field experiment was carried out in 2010 at Bakura (Zamfara State) and Zaria (Kaduna State) in North West Nigeria. The objective of this paper was to evaluate downy mildew resistance in some pearl millet using Complete Randomized Block Design. Four resistant male varieties (PEO5532, SOSATC88, P1449 and DMR15) and four susceptible female varieties (BDP1, MOP1, LCIC9702 and PEO5984) were used in this study. The resistant varieties were crossed with the susceptible varieties using North Carolina design 11 for the mating to form sixteen (F1) hybrids. The F1 hybrids were further evaluated along with their parents for downy mildew resistance, grain yield and other agronomic traits (such as: Plant height, panicle height, number of tillers per plant, panicle diameter and number panicles per plot). The resistant male parents were found to be susceptible while none of the hybrids was resistant to downy mildew. However, the degree of incidence and severity of downy mildew disease defer in the two locations. The hybrids exhibited tolerance to downy mildew disease and their yields were higher than their parents. The analysis of variance (one tale ANOVA or which one?) showed highly significant difference among parents and hybrids for all agronomic characters except disease severity and number of tillers per plant. Location × genotype interaction effects were only significant for grain yield and number of panicles per plot.

Keywords: downy mildew, hybrids, obligate biotrophs, resistant, tolerance
1. INTRODUCTION

Pearl millet [Pennisetum glaucum (L.) R.Br.] is a collective term referring to a number of small-seeded annual grasses that are cultivated as grain crops, primarily on marginal land in dry areas in temperate, sub-tropical and tropical regions [1]. Millet are widely grown around the world for food and fodder. Pearl millet belongs to the family Poaceae (Graminae) and genus Pennisetum. It is a highly cross-pollinated crop with protogynous flowering and wind borne pollination mechanism, which fulfils one of the essential biological requirements for hybrid development [2]. Pearl millet is diploid (2x = 14) in nature and is commonly known as bajra, cat tail millet, and bulrush millet in different parts of the world [2]. Pearl millet [Pennisetum glaucum (L.) R. Br.], is one of the most important staple cereals for over 40 million subsistence farmers living in the most marginal agricultural lands of Northern Nigeria, due to its high tolerance to drought, high temperatures, saline and marginal soils, and high capacity to buffer variable environmental conditions [3]. Improving production of pearl millet while maintaining its production stability is crucial for food security for poor African smallholder farmers cropping under rain-fed farming systems [4]. The exploitation of diverse germ plasm resources of the crop for breeding improved varieties would therefore always be necessary [5].

Downy mildew of pearl millet (Pennisetum glaucum), sometimes referred to as ‘green ear’ disease, is caused by an obligate biotrophic pathogenic fungi Sclerospora graminicola (Sacc.) Schroet. [6-8]). Downy mildews are obligate biotrophs, i.e. they are host-dependent. Coevolution with plant hosts over a long period has led to divergent forms of pathogen adapted to deferent host taxa. Reproduction is usually both by sexual and asexual means. During the sexual phase oospores are formed. Oospores are thick-walled and long-lived which enable the pathogens to survive crop-free and adverse periods [9-11]). Oospores are the primary inoculum source. When there is conducive weather conditions asexual phase occurs. In Nigeria, several yield loss estimates have been reported ranging from 6-73% depending on variety [12-18]). [19] explained that this disease can assume alarming levels when a single genetically uniform pearl millet cultivar is repeatedly and extensively grown in a region where the downy mildew pathogen is present. Such alarming levels have been reported in India from regions where one single-cross hybrid was widely cultivated for several years [20]. Hence, disease resistance is a major concern in pearl millet improvement and has been the subject of several reviews [21-28]).

This study seeks to identify and select the varieties that performed better in each location and recommend the varieties that perform best for further improvement program.

2. MATERIALS AND METHOD

Study Area

Bakura is located in the northern part of Zamfara state. It is located between 04° to 13° East of the Greenwich meridian and between 10° to 13° North of the Equator. It is located on the Hausa High planes at 450 meters above Sea Level. Bakura enjoys a typical Tropical Continental climate with marked distinct seasonal regimes oscillating between cool to dry and humid to wet seasons that are controlled by the apparent movement of the Intertropical Discontinuity Divide(ITD). The average rainfall is about 942mm. The daily mean temperature is about 27 °C to a mean maximum of 38 °C and is high for most part of the year [29].
Zaria is located at the northern part of Kaduna state in Northern Nigeria on about 11°28’N and about 7°48’E longitude. Zaria is 613 meters above sea level. The climate of Zaria described is a Tropical Continental Climate type comprising of the wet and dry season. The climate is characterized by strong seasonality in rain fall and relatively high temperatures. The mean annual rainfall is 1029.52 mm falling from May to October. The mean annual temperature is 26 °C to a mean maximum of 37 °C ([30], Samaru Map- Satellite Image of Samaru (Map landia. Comp) 22/02/13; 9.51 am.

**Description of Experimental Materials Used in the Study.**

Pearl millet genotypes PEO5532. According to the LCRI, DMRI5, PEO5532, SOSATC88, and P1449 are resistant to Downy mildew disease; whereas LCIC9702 and PEO5984 are susceptible. Additional two susceptible varieties, i.e. BDP1 and MOP1, were acquired from Institute National de Recherche Agronimiques De Niger Cerra de Maradi (INRAN), Maradi in the Republic of Niger.

**Experimental Design**

The experimental designs were the same for the two locations. Crosses were obtained using a factorial mating scheme of North Carolina Design II, where each males was mated to each of the females ([31,32]). The evaluation of hybrids and parents on the fields was done using Complete Randomized block design (CRBD).

**Evaluation of Hybrids and Parents**

Sowing for evaluation was done in Samaru-Zaria,(Kaduna State) and Bakura (Zamfara state). The ridges were five meter long with inter row spacing of 75 cm and intra row spacing of 50 cm. The cultural practices were within the range of the guidelines given for Crop Management by Agriculture Environmental Renewal Canada Inc. and that of Alternative Field Crop Manual from University of Wisconsin Extension. Four seeds were sown per hill and the plants were later thinned to two plants per stand two weeks after sowing (WAS). Compound fertilizer NPK (15:15:15) was applied two weeks after sowing and urea was use as top dress at six weeks after sowing (WAS).

The allocation of hybrids to each plot was done with the aid of random number table and each cell represented a plot. Millet variety 7042S was used as infector row. The infectors’ rows were between the hybrids such that each hybrid was in contact with the infector row. On each hill in the row, a hole of 3 cm was dug and a pinch of the inoculum (Zoospores of downy mildew) was poured after which 4 seeds were planted per hill. The plants were thinned down to 2 plants per hill. This procedure was performed on the hybrids, parents and the infector rows (7042S). The infector rows were planted 2 weeks before the planting of the hybrids and the parents’ seeds.

**Statistical Analysis of Data**

The forms of the general analysis of variance and the genetic component of variances for each location was performed using SPSS. Duncan Multiple Range Test was used to compare treatment means of the parents and the hybrids and also to rank performances of the varieties.
3. RESULTS AND DISCUSSION

Outcome of the statistical analysis of Data

From the analysis of variance, for Bakura (Table 1.) highly significant mean squares were observed among the genotypes in Zaria for days to 50% flowering, Plant Height, Panicle Height, Panicle weight /plot And Grain weight/Ha. Table 2 shows the results of single tail ANOVA for Zaria. There was significant mean squares for Days to 50% flowering, Panicle Height, Number of panicles per plant, Panicle weight per plot And Grain weight/Ha. This is an indication of the presence of considerable amount of genetic diversity in the materials which could be used to enhance selection for further population improvement. [33], reported a similar result in pearl millet studies. The non- significant mean squares see table 2 due to the male x female interaction in both locations indicated that hybrids did not differ significantly in their specific combining ability effects for all the traits. Significant mean square see table 2 was observed among females for Disease Incidence, Days to 50% flowering, Number of panicles per plant Panicle Height and Grain weight/Ha in Bakura but in Zaria, non- significant mean squares was observed for all the traits. Among the males highly significant mean square (see table 2) were observed for Days to 50% flowering, Plant height, Panicle Height and Panicle weight per plot in Bakura. Also in Zaria, significant mean square for Days to 50% flowering Plant Height, Panicle Height, Panicle weight per plot and Grain weight/Ha among the males. The non- significant mean squares might be due to error in both location.

Table 1. Mean squares from 10 characters in pearl millet for Bakura

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>DF</th>
<th>MS</th>
<th>DI</th>
<th>DS</th>
<th>50%DF</th>
<th>PTH</th>
<th>NT</th>
<th>NPP</th>
<th>PANH</th>
<th>PAND</th>
<th>PANWT</th>
<th>GRWT/Ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>2</td>
<td>5005.80**</td>
<td>0.04</td>
<td>1.72</td>
<td>2423.87**</td>
<td>5.73**</td>
<td>175.72</td>
<td>95.11**</td>
<td>1.2</td>
<td>0.92</td>
<td></td>
<td>17.06</td>
</tr>
<tr>
<td>Genotype</td>
<td>23</td>
<td>429.64</td>
<td>0.04</td>
<td>9.13**</td>
<td>421.40**</td>
<td>1.11</td>
<td>321.03</td>
<td>42.92**</td>
<td>0.43</td>
<td>1.41**</td>
<td></td>
<td>43.32**</td>
</tr>
<tr>
<td>Female</td>
<td>3</td>
<td>636.23*</td>
<td>0.03</td>
<td>5.24*</td>
<td>244.83</td>
<td>1.12</td>
<td>18.98*</td>
<td>635.47*</td>
<td>0.45</td>
<td>1.71**</td>
<td></td>
<td>57.70*</td>
</tr>
<tr>
<td>Male</td>
<td>3</td>
<td>674.90*</td>
<td>0.05</td>
<td>31.02**</td>
<td>1065.93**</td>
<td>2.04</td>
<td>135.28**</td>
<td>156.19</td>
<td>1.06*</td>
<td>0.98*</td>
<td></td>
<td>5.3</td>
</tr>
<tr>
<td>Female x Male</td>
<td>9</td>
<td>189.28</td>
<td>0.03</td>
<td>1.68</td>
<td>140.28</td>
<td>0.49</td>
<td>4.35</td>
<td>146.91</td>
<td>0.25</td>
<td>0.23</td>
<td></td>
<td>10.64</td>
</tr>
<tr>
<td>Error</td>
<td>46</td>
<td>269.66</td>
<td>0.03</td>
<td>1.42</td>
<td>106.51</td>
<td>0.70</td>
<td>175.59</td>
<td>6.58</td>
<td>0.46</td>
<td>0.22</td>
<td></td>
<td>6.77</td>
</tr>
</tbody>
</table>

*Significant at (p ≥ 0.05)  ** = highly significant at (0.01)

Table 2. Mean squares from 10 characters in pearl millet for Zaria

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>DI</th>
<th>DS</th>
<th>50%DF</th>
<th>PTH</th>
<th>NT</th>
<th>PANH</th>
<th>NPP</th>
<th>PANWT</th>
<th>GRWT/Ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>2</td>
<td>193.76</td>
<td>0.02</td>
<td>1.35</td>
<td>115.63</td>
<td>29.63**</td>
<td>17.87</td>
<td>1488.76</td>
<td>0.89</td>
<td>1.33</td>
</tr>
<tr>
<td>Genotype</td>
<td>23</td>
<td>702.49**</td>
<td>0.04</td>
<td>6.93**</td>
<td>350.39</td>
<td>2.41</td>
<td>20.58**</td>
<td>1408.26**</td>
<td>0.75</td>
<td>3.27**</td>
</tr>
<tr>
<td>Female</td>
<td>3</td>
<td>352.09</td>
<td>0.01</td>
<td>1.69</td>
<td>160.34</td>
<td>3.25</td>
<td>12.06</td>
<td>997.58</td>
<td>0.57</td>
<td>3.41</td>
</tr>
<tr>
<td>Male</td>
<td>3</td>
<td>275.56</td>
<td>0.02</td>
<td>24.91**</td>
<td>952.99**</td>
<td>7.47*</td>
<td>48.89*</td>
<td>513.41</td>
<td>1.04</td>
<td>8.17*</td>
</tr>
<tr>
<td>Female x Male</td>
<td>9</td>
<td>142.83</td>
<td>0.02</td>
<td>2.21</td>
<td>70.42</td>
<td>1.60</td>
<td>7.74</td>
<td>853.97</td>
<td>0.5</td>
<td>1.93</td>
</tr>
<tr>
<td>Error</td>
<td>46</td>
<td>277.93</td>
<td>0.05</td>
<td>1.56</td>
<td>214.34</td>
<td>1.61</td>
<td>8.76</td>
<td>444.81</td>
<td>0.43</td>
<td>1.37</td>
</tr>
</tbody>
</table>

* Significant at (p ≥ 0.05)  ** = highly significant at (0.01)
Where:
DF = degree of freedom
DI = downy mildew incidence
DS = Downy mildew Severity
50% DF = Days to 50% flowering
NPAN = Number of Panicle/PLOT

Mean performance for millet hybrids and their parents in both locations.

Table 3 and 4 showed the mean performance of the parents and hybrids for ten characters studied. Duncan multiple grouping test SAS was used to test the significant differences between the means of the parents and the hybrids and also to rank performance of the varieties. Fisher's protected least significant difference test was used. The results of the Duncan multiple grouping test SAS indicates that the genotypes performed better in Bakura for plant height, panicle length, panicle diameter, grain weight and yield, while for number of tillers per plant and number of panicles per plot the genotypes performed better in Zaria. The genotypes performances in the two locations were similar for days to 50% flowering and panicle weight per plot. This may be due to the differences in the soil, climatic conditions and environmental conditions of the two locations.

The male parents that were resistant lines became susceptible under field evaluation. This indicated the possibility of breakdown of resistance to downy mildew by the material collected from the research institute or there could be virulence change in the S. graminicola. Moreover, virulence change has been reported in S. graminicola and more virulent pathotypes have evolved in the recent past [34, 36]).

According to [37] the major change in disease incidence (%) of a pearl millet line over time at the same location was a reflection of virulence shift in the pathogen population. This is based on the basic assumptions that variables, such as environmental factors and inoculum load, were optimal for disease development and that the seed of each pearl millet line was genuine at the time of testing. The work of [37] showed that most of the accessions used in the study have lost their resistance to the new virulence(s). The study also indicated the importance of regular monitoring of virulence shift in the pathogen populations and identifying stable resistance for an effective downy mildew resistance breeding in pearl millet.

For resistance breeding programmes to be effective, it require close monitoring of virulence change in the pathogen and identification of new resistance sources to the new virulent strains. Furthermore, virulence change in S. graminicola populations was monitored through a collaborative pearl millet downy mildew nursery, on-farm surveys for downy mildew incidence and by characterizing pathogen isolates collected from highly susceptible cultivars in the farmers’ fields on a set of putative differential hosts [38, 39]). On-farm surveys in the hybrid-intensive states of India during the past several years have indicated increased susceptibility of a hybrid when grown in the same field for more than three consecutive crop seasons suggesting emergence/selection of new virulence traits over time at the same location [40, 41]).

The mean performance for Bakura (Table 3), among the hybrids, the disease severity ranged from 0.62 in PEO5984 × P1449 to 0.88 in BDP1 × P1449. While in Zaria (Table 4) the range of downy mildew severity among the hybrids was 0.82 (BDP1 × SOSATC88) to 1.08 (BDP1 × P1449) [42] attributed the differences in the downy mildew manifestation in
different location to environmental conditions such as high rainfall, greater number of humid months and lower temperatures are conducive for disease development.

In both locations hybrid BDP1 × P1449 had the highest downy mildew severity indicating that hybrid BDP1 × P1449 reacted similarly to downy mildew infection in both locations. While for downy mildew incidence in both locations hybrid LCIC9702 × SOSATC88 had the lowest downy mildew incidence though the hybrid exhibited more tolerance to the disease in Zaria having 31% than in Bakura where it have 37% [42] reported similar result in their work on pearl millet downy mildew incidence in different locations.

Days to 50 per cent flowering, PEO5984 was the earliest among the parents in both location (45 days) the rest were about 50 days. Hybrids PEO5984 × P1449 was the earliest exhibited 45 days to 50 per cent flowering in Bakura. While hybrids PEO5984 × DMR15 and LCIC9702 × DMR15 have 50 days in Zaria. The parents and hybrids showed a wide range of variation in plant height.

The shortest parents have height of 169.60 cm (PEO5984) and the tallest was 206.53 cm (MOP1) in Bakura. In Zaria, the shortest parent exhibited 129.70cm (LCIC9702) and the tallest parent was SOSATC88 (157.17cm). In Bakura the hybrids (225.80 cm) had the tallest plant height, while PEO5984 ×DMR15 (184.63 cm) was the shortest. In Zaria, the tallest hybrid was BDP1 ×P1449 (169.30cm) and the shortest was PEO5984 × DMR15 (136.27cm). Both parents and hybrids were taller in Bakura.

For number of tillers per plot, the parents have number of tiller per plot ranging from 5 tillers to 7 tillers per plot. Among the hybrids, the number of tillers per plot ranged from 5 tillers (BDP1 × SOSATC88 to 7 tillers (PEO5984 × P1449) tillers per plot in Bakura. While in Zaria the number of tillers per plot, the parents have number of tiller per plot ranging from 7(DMR15) tillers to 8 tillers per plot. Among the hybrids, the number of tillers per plot ranged from 5 tillers (BDP1 × DMR15 and PEO5984 × DMR15 to 9 tillers BDP1 ×P1449, MOP1 × SOSATC88 and MOP1 ×P1449) tillers per plot.

In Bakura, the parent with the longest panicle have 31.97 cm (MOP1) while the parent with shortest panicle length have 23.07 cm (PEO5984). Also, among the hybrids, the hybrid with the shortest panicle length was PEO5984 × PEO5532 (25.23 cm) while the hybrid with the longest panicle length was BDP1 × P1449 (36.57 cm). In Zaria, the parent with the longest panicle length had 22.83cm (DMR15) and the parent with the shortest panicle length had 16.70 cm (PEO5984). Also among the hybrids, the hybrid with the longest panicle length was 27.73 cm (BDP1 × PEO5532) and the hybrid with the shortest panicle length was 19.93 cm (PEO5984 × SOSATC88). In both locations, PEO5984 had the shortest panicle length.

In Bakura, Panicle diameter among the parents ranged from 8.30cm (PEO5984) to 9.27 cm (LCIC9702). Among the hybrids, panicle diameter ranged from 7.77cm (MOP1 × SOSATC88) to 9.17cm (LCIC9702 × PEO5532).While in Zaria, panicle diameter among the parents ranged from 6.97cm (P1449) to 8.37cm (PEO5532). Among the hybrids, panicle diameter ranged from 7.20cm (MOP1 × P1449) to 8.77cm (BDP1 × PEO5532).

In Bakura, number of panicles per plot among the parents ranged from 44 (DMR15) to 58 panicles (P1449) per plot. Hybrid BDP1 × SOSATC88 had the highest number of panicles per plot (70) while PEO5984 × PEO5532 had the lowest number of panicles per plot (40). In Zaria, the number of panicles per plot among the parents ranged from 22.00 (DMR15) to 94.67 panicles (PEO5984). Hybrid LCIC9702 × DMR15 (108) had the highest number of panicles per plot while PEO5984 × DMR14 (60.00) had the lowest number of panicles per
plot. DMR15 have the lowest number of panicles per plot in both locations. Though DMR15 performed better in Bakura than Zaria.

The panicle weight per plot for the parents in Bakura ranged from 0.80 Kg (PEO5984) to 2.47Kg (SOSATC88). The lowest panicle weight per plot among the hybrids was 1.90Kg (PEO5984 × P1449) while the highest was 4.67Kg (BDP1 × P1449). For Bakura, the parent with the lowest yield had 1066.70 (PEO5984 × P1449) while the highest was 3288.90 Kg (BDP1 × SOSATC88). While in Zaria, the parent with the lowest yield had 773.30 Kg (PEO5984 × P1449) and the parent with highest yield had 1964.40Kg (MOP1). The lowest panicle weight per plot in both locations. Though DMR15 performed better in Bakura than Zaria.

Table 3. Means Performance of 8 parents and 16 hybrids of Pearl Millet for ten traits in Bakura

<table>
<thead>
<tr>
<th>Genotypes</th>
<th>DI</th>
<th>DS</th>
<th>50% DF</th>
<th>P TH</th>
<th>NT</th>
<th>PANH</th>
<th>NPAN</th>
<th>PAND</th>
<th>PANWT</th>
<th>GRW/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDP1</td>
<td>71.57ab</td>
<td>0.92abc</td>
<td>48.67a-d</td>
<td>191.13</td>
<td>6.03abc</td>
<td>30.93b-e</td>
<td>43.00a-d</td>
<td>8.90ab</td>
<td>1.17hij</td>
<td>1555.60hij</td>
</tr>
<tr>
<td>MOP1</td>
<td>67.73a-d</td>
<td>1.01a</td>
<td>48.67a-d</td>
<td>206.53a-d</td>
<td>5.17c</td>
<td>31.97a-d</td>
<td>38.33bcd</td>
<td>8.70ab</td>
<td>1.47g-j</td>
<td>1955.60g-j</td>
</tr>
<tr>
<td>LCIC9702</td>
<td>65.33a-d</td>
<td>0.77abc</td>
<td>48.33a-d</td>
<td>195.23cde</td>
<td>5.77abc</td>
<td>23.93gh</td>
<td>50.67abc</td>
<td>9.27a</td>
<td>1.77c-i</td>
<td>2355.60e-i</td>
</tr>
<tr>
<td>PEO5984</td>
<td>80.67ab</td>
<td>0.66c</td>
<td>44.67f</td>
<td>169.60f</td>
<td>6.67abc</td>
<td>23.07h</td>
<td>35.00bcd</td>
<td>8.30ab</td>
<td>0.80j</td>
<td>1066.70j</td>
</tr>
<tr>
<td>PEO5532</td>
<td>65.70a-d</td>
<td>0.80abc</td>
<td>50.67a</td>
<td>201.60cde</td>
<td>5.43bc</td>
<td>24.60fg</td>
<td>44.67a-d</td>
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<td>1.67f-i</td>
<td>2222.20h</td>
</tr>
<tr>
<td>SOSATC88</td>
<td>71.80abc</td>
<td>0.62c</td>
<td>48.33a-d</td>
<td>193.93cde</td>
<td>6.27abc</td>
<td>25.77fgh</td>
<td>63.67ab</td>
<td>9.13a</td>
<td>2.47a-f</td>
<td>3288.90a-f</td>
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<td>P1449</td>
<td>72.23abc</td>
<td>0.79abc</td>
<td>50.33a</td>
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<td>6.83abc</td>
<td>31.63a-d</td>
<td>57.67abc</td>
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<td>DMR15</td>
<td>85.00a</td>
<td>0.62c</td>
<td>50.00abc</td>
<td>189.40cde</td>
<td>7.20a</td>
<td>27.30h</td>
<td>44.33a-d</td>
<td>8.47ab</td>
<td>1.07ij</td>
<td>1422.20ij</td>
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<td>BDP1 × PEO5532</td>
<td>53.13a-d</td>
<td>0.82abc</td>
<td>49.67abc</td>
<td>201.63cde</td>
<td>6.67abc</td>
<td>34.70ab</td>
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<td>3111.10b-g</td>
</tr>
<tr>
<td>BDP1 × SOSATC88</td>
<td>51.00bcd</td>
<td>0.80abc</td>
<td>47.00de</td>
<td>208.93abc</td>
<td>5.33bc</td>
<td>35.50abc</td>
<td>70.00a</td>
<td>8.30ab</td>
<td>3.33a</td>
<td>4444.40a</td>
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<tr>
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<td>66.67a-d</td>
<td>0.88abc</td>
<td>48.33a-d</td>
<td>202.83cde</td>
<td>5.77abc</td>
<td>36.57a</td>
<td>58.00abc</td>
<td>8.03ab</td>
<td>2.63a-e</td>
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<tr>
<td>BDP1 × DMR15</td>
<td>65.57a-d</td>
<td>0.82abc</td>
<td>47.67b-e</td>
<td>205.53bcd</td>
<td>6.50abc</td>
<td>31.43bcd</td>
<td>54.33abc</td>
<td>8.93ab</td>
<td>2.20c-g</td>
<td>2933.30c-g</td>
</tr>
<tr>
<td>MOP1 × PEO5532</td>
<td>75.97ab</td>
<td>0.84abc</td>
<td>50.33a</td>
<td>225.80a</td>
<td>5.90abc</td>
<td>31.93a-d</td>
<td>48.00a-d</td>
<td>8.40ab</td>
<td>2.23c-g</td>
<td>2977.80c-g</td>
</tr>
<tr>
<td>MOP1 × SOSATC88</td>
<td>48.73bcd</td>
<td>0.70bc</td>
<td>49.00a-d</td>
<td>223.40ab</td>
<td>5.50bc</td>
<td>32.10a-d</td>
<td>52.67abc</td>
<td>7.77b</td>
<td>2.47a-f</td>
<td>3288.90a-f</td>
</tr>
<tr>
<td>MOP1 × P1449</td>
<td>55.60a-d</td>
<td>75abc</td>
<td>49.33a-d</td>
<td>201.77cde</td>
<td>.33abc</td>
<td>33.90abc</td>
<td>50.33abc</td>
<td>8.47ab</td>
<td>2.43a-f</td>
<td>3244.40a-f</td>
</tr>
<tr>
<td>MOP1 × DMR15</td>
<td>56.13a-d</td>
<td>0.85abc</td>
<td>47.33cde</td>
<td>203.50cde</td>
<td>6.73abc</td>
<td>31.83a-d</td>
<td>61.00ab</td>
<td>8.40ab</td>
<td>2.43a-f</td>
<td>3244.40a-f</td>
</tr>
</tbody>
</table>
Mean performance of 8 parents and 16 hybrids of Pearl Millet for ten traits in Zaria. 

<table>
<thead>
<tr>
<th>Genotypes</th>
<th>DI</th>
<th>DS</th>
<th>50% DH</th>
<th>PTH</th>
<th>NT</th>
<th>PANH</th>
<th>NPAN</th>
<th>PAND</th>
<th>PANWT</th>
<th>GRW/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDP1</td>
<td>55.87bc</td>
<td>1.15ab</td>
<td>50.33a</td>
<td>144.57abc</td>
<td>8.00bac</td>
<td>27.30ab</td>
<td>33.33fg</td>
<td>7.17bc</td>
<td>0.97e</td>
<td>1231.10b-e</td>
</tr>
<tr>
<td>MOP1</td>
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<td>0.99ab</td>
<td>49.00b-d</td>
<td>154.90abc</td>
<td>8.33abc</td>
<td>24.37a-d</td>
<td>68.33a-f</td>
<td>7.67bac</td>
<td>2.50a-e</td>
<td>1964.40ab</td>
</tr>
<tr>
<td>LCIC9702 × PE0532</td>
<td>46.23</td>
<td>1.15ab</td>
<td>50.33a</td>
<td>144.57abc</td>
<td>8.00bac</td>
<td>27.30ab</td>
<td>33.33fg</td>
<td>7.17bc</td>
<td>0.97e</td>
<td>1231.10b-e</td>
</tr>
<tr>
<td>MOP1</td>
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<td>0.85b</td>
<td>49.06ab</td>
<td>140.10abc</td>
<td>8.33abc</td>
<td>21.90a-e</td>
<td>62.00c-f</td>
<td>8.37ab</td>
<td>2.10b-e</td>
<td>1413.30a-e</td>
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<td>SOSATC88</td>
<td>29.73c</td>
<td>1.36a</td>
<td>49.67ab</td>
<td>157.17abc</td>
<td>7.67abc</td>
<td>20.43cde</td>
<td>47.33fg</td>
<td>8.17abc</td>
<td>1.63e</td>
<td>1600.00a-e</td>
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<tr>
<td>P1449</td>
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<td>0.98a</td>
<td>50.00a</td>
<td>137.20bc</td>
<td>7.33abc</td>
<td>21.47c-f</td>
<td>70.33a-f</td>
<td>6.97c</td>
<td>1.40cde</td>
<td>880.00de</td>
</tr>
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<td>DMR15</td>
<td>74.4bc</td>
<td>0.99a</td>
<td>49.06ab</td>
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<td>6.67bc</td>
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<td>21.67</td>
<td>7.47abc</td>
<td>0.43e</td>
<td>1088.90b-e</td>
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<tr>
<td>BDP1 × PE0532</td>
<td>46.23</td>
<td>0.94a</td>
<td>49.33abc</td>
<td>155.13abc</td>
<td>8.33abc</td>
<td>27.43a-f</td>
<td>62.33e-f</td>
<td>8.77a</td>
<td>1.67b-e</td>
<td>1835.60ab</td>
</tr>
</tbody>
</table>

Means followed by the same letter(s) are not significantly different using DMRT. 

Where 

- PTH = Plant height 
- DI = Downy mildew incidence 
- DS = Downy mildew severity 
- 50% DF = 50% Days to flowering 
- NPAN = Number of Panicle 
- NT = Number of Productive Tillers per plant 
- GRW/ha = Grain Weight/Hectare 

Table 4. Means Performance of 8 parents and 16 hybrids of Pearl Millet for ten traits in Zaria.
The means followed by the same letter(s) are not significantly different using DMRT

4. CONCLUSION AND RECOMMENDATIONS

The parent with highest yield had 3288.90Kg (SOSATC88). The most productive hybrids in terms of grain yield based on the mean performance in both locations were LCIC9702 × SOSATC88 and BDP1 × SOSATC88 (4444.40 Kg/Ha for Bakura and 3135.6Kg for Zaria). For downy mildew incidence in both locations hybrid LCIC9702 × SOSATC88 had the lowest downy mildew incidence though the hybrid exhibited more tolerance to the disease in Zaria having 31% than in Bakura where it have 37%. Thus they are considered to have the best performance and can be selected for pearl millet improvement for disease resistance.

However, hybrids LCIC9702 × P1449, MOP1 × SOSATC88, PEO5984 × SOSATC88, BDP1 × P1449 and, MOP1 × P1449 performed better in yield than the parent (SOSATC88) with the best mean performance. BDP1 × PEO5532 and LCIC9702 × PEO5532 also had high mean performance and were all moderately susceptible to downy mildew infestation and were considered to be tolerant to the disease. In other words, although, they were attacked by the pathogens to the same degree as others, they suffered less damage with regards to grain yield. It was obvious from the performance of these hybrids and their parents that they were
inoculated with different strains of the pathogen which appeared to be more virulent than the strain that the male parent s were tested on.

Parent PEO5984 was the earliest among the parents in both location while Hybrids PEO5984 × P1449 was the earliest exhibited 45 days in Bakura and PEO5984 × SOSATC88 in Zaria. PEO5984 sources are the earliest among the hybrids in both location. Thus PEO5984 can be selected for earliness.

In conclusion, hybrids LCIC9702 × SOSATC88 and BDP1 × SOSATC88 are considered to have the best performance and can be selected for pearl millet improvement for yield. Hybrid LCIC9702 × SOSATC88 had the lowest disease resistance thus they are considered to have the best performance and can be selected for pearl millet improvement for disease resistance. Also, PEO5984 × P1449 and PEO5984 × SOSATC88 were considered for earliness.

Reference


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