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**Research Article**

# EVALUATION OF COMBINING ABILITY IN PEARL MILLET (*Pennisetumglaucum* (L.) R. BR) FOR YEILD AND DOWNY MILDEW (*Sclerosporagraminicola*) INFESTATION

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**ABSTRACT**

A field experiment was carried out in Bakura and Zaria in the sudan savanna agro-ecological zone to study downy mildew resistance and yield in some pearl millet varieties and their hybreds using Complete Randomized Block Design (CRBD). Four resistant varieties (PEO5532, SOSATC88, P1449 and DMR15) and four susceptible varieties (BDP1, MOP1, LCIC9702 and PEO5984 were used as male and female respectively. Crosses were made using North Carolina design II. Sixteen (F1) hybrids obtained were evaluated along with their parents for downy mildew incidence, severity and grain yield. Combining ability revealed that, majority of the characters are under the control of non-additive gene action. Combinations were obtained from parents with the following general combining ability (i e, High x High, High x Low, Low x High and Low x Low parents). Among the resistant parents, PEO5532, P1449 and DMR15 were excellent general combiners for downy mildew incidence, severity and yield. The cross MOP1 x SOSATC88 was the best specific combiner for grain yield while the best specific combiner for Downy mildew incidence was MOP1 x P1449 and for downy mildew severity were BDP1× DMR15 and PEO5984× P1449 while BDP1 x SOSATC88, LCIC9702 × DMR15 and PEO5984 ×SOSATC88 have the best specific combine ability for yield and downy mildew severity respectively. The crosses with best specific combine ability for downy mildew incidence and downy mildew severity were MOP1 x PEO5532 and PEO5984 × PEO5532. Crosses BDP1 x SOSATC88, LCIC9702 × DMR15 and PEO5984 ×SOSATC88 were recommended as the good specific combiners for yield and downy mildew severity respectively.



## INTRODUCTION

Millet provide the major source of dietary energy and protein for some one billion people in the semi-arid tropics (1; 2 & 3). The Hunza people living in the remote Himalayan foothills who are known for their extraordinary health and longevity enjoys millet as their staple grain. They use it to make whole grain chapatti flat bread, soups, and porridge. In arid Western India, millet is used to make roti, a dense, flat cake made from millet flour since ancient times. Flat bread from India, bhakri is made from millet and sorghum flours. In Eastern Europe, especially Poland and Hungary, millet is used to make fermented beverages and sweet and savory porridges called kasha. In Africa, millet is used in baby food and a thin porridge called uji. In Ethiopia, the ancient flat bread called injera is still made from teff millet. In much of eastern Africa, millet is used to make beer. Millet stalks are still used in making brooms found in households throughout the world.

A high proportion of the producing areas in Nigeria are in the Sahelian and Sudan zones where moisture conditions are marginal for other crops. This crop grows in these areas just because of its ability to withstand long period of draught. It is grown even in places like Borgu in Nigeria state and in parts of Benue and Kogi states. In some north-eastern and north-western states of the country where the crop contributes to their diet, the production is over 50% of the country's total production. (4) reported that pearl millet is grown in West Africa in the northern parts of Senegal, Serra Leone, Niger Republic, Ghana, Benin and Nigeria. Other African countries where pearl millet is grown include Botswana, Burundi, Egypt, Ethiopia, Gambia, Kenya, Malawi, Mauritania, Mozambique, Ruwanda, Somalia, South Africa, Sudan, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe. (4; 5). (4) reported that pearl millet is grown in West Africa in the northern parts of Senegal, Serra Leone, Niger Republic, Ghana, Benin and Nigeria. Other African countries where pearl millet is grown include Botswana, Burundi, Egypt, Ethiopia, Gambia, Kenya, Malawi,

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Mauritania, Mozambique, Ruwanda, Somalia, South Africa, Sudan, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe (4; 5).

## MATERIALS AND METHOD

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

Pearl millet genotypes used in the study are 4 Susceptible to downy mildew varieties (BDP1, MOP1, LCIC9702 and PEO5984) while 4 resistant to downy mildew varieties (PEO 5532, SOSATC 88, P1449 and DMRI5).

### *Experimental Design*

Crosses were obtained using a factorial mating scheme of North Carolina Design II, where each male was mated to each of the female (6 and 7). The ridges were 10 metre long with 20 hills per ridge and two ridges per plot with inter row spacing of 75cm and intra row spacing of 50cm The evaluation of hybrids and parents on the fields was done using Randomized Complete Block Design (RCBD) with three replications

### *Analysis of Data*

The general combining ability and specific combining ability effect with their variances was estimated according to (8).

### *Combining ability*

In order to estimate the combining ability effects of parents (gca) and the specific combining abilities (sca) for the $F_1$ the Line x Tester analysis suggested by (9) was used.

The general effect for each male and female and specific effect for each hybrid was calculated using SPSS

### *Estimate of Pooled GCA Effect of Parents*

An attempt was made to classify all the 8 parents involved in 4 x 4 crosses by assessing the parental gca for each character using a norm +1 is equal to the mean of positive gca effects of parents for the character while –1 is equal to the mean of negative gca effects of parents for the character. Any parent whose gca effect was positive was classified as high (H) and assigned a score of +1, while any one with negative was classified as low (L) with a score of –1. Considering that negative gca effects is more important for characters such as downy mildew incidence and downy mildew severity, a parent whose effects was negative to these traits was classified as H. All the parents were thus scored for each character and a final score was computed for each parent over seven characters. The parents were thereafter scored based on the mean of total scores as either H or L.

### *Data collected on field evaluation for downy mildew incidence*

Downy Mildew incidence that is number of diseased plants showing downy mildew symptoms expressed as a percentage of total number of plants in a plot (the formula developed by (10), as the number of diseased plants expressed as:

$$DMI = \frac{\text{Number of diseased plants}}{\text{Total number of plants}} \times 100$$

### *Downy Mildew Severity Rating*

The severity of downy mildew infection on plants were recorded using a rating scale as follows: (11)
1 = No disease symptoms.
2 = Disease only on nodal/aerial tillers.
3 = Less than 50% of the basal tillers of plants infected.
4 = More than 50% of basal tillers of plants infected.
5 = No productive panicle is produced/complete destruction of plant

Severity was then calculated using the formula:

$$\text{Disease Severity} = \frac{Y(1-1) + Y(2-1) + Y(3-1) + Y(4-1) + Y(5-1)}{N \times 4}$$

Where
Y = number of plants in each reaction category (1-5) and
N = total number of plants in the genotype under test.
Disease rating scale: For classifying the pearl millet genotypes the rating scale of (8), which is based on the incidence of downy mildew on the basal tillers, was adopted:
0-5% disease incidence = Highly Resistance (HR)
5-10% disease incidence = Resistance (R)
10-25% disease incidence = Moderately Resistance (MR)
25-50% disease incidence = Moderately Susceptible (MS)
50-80% disease incidence = Susceptible(S)
>80% disease incidence = Highly Susceptible (HS)

### *Combining Ability Studies*

All the characters showed high or significant proportion of sca variance than gca variance indicating non-additivity for these characters. This was further supported by the ratio of gca and sca variance. Higher proportion of sca variance was probably due to high genetic diversity in the materials studied. High sca variance for these characters was also reported by earlier workers (9; 12; 13; 14 and 15). They all reported high sca variance for number of tillers, panicle diameter and yield.

Among the parents, PEO5984 and P1449 emerged as the best general combiner by registering positive gca effect for six characters including grain yield/ha for female and male lines respectively. Among the female lines, positive gca effect for panicle diameter, number of panicles / plot, disease incidence and disease severity were recorded for BDP1 while number of tillers / plot, panicle length, number of panicle / plot, panicle weight / plot, and disease incidence were recorded for MOP1. Positive gca effect for number of tillers, panicle diameter, disease incidence and disease severity were also recorded for LCIC9702 and positive gca effect for panicle length, number of panicle / plot and grain yield/ha were recorded for PEO5984.(15); (16) and (17) have also reported similar observations in their line x tester studies in millet. The pollen parents and females lines exhibiting positive gca effect for grain yield /ha and other panicle components can be involved in crossing programme to develop superior hybrid or to derive superior recombinants.

**Table 1** Estimates of general combining ability effects in the parents for 7 different characters in pearl millet across locations (Bakura and Zaria).

| Parents | PANH | PAND | NPP | PANWT | GWTPH | DI | DS |
|---|---|---|---|---|---|---|---|
| GCA Females | | | | | | | |
| BDP1 | -1.14 | 0.18 | 5.77 | -0.19 | -0.79 | 3.51 | 0.06 |
| LCIC9702 | -0.88 | 0.1 | -10.65 | -0.33 | -2.11 | 5.78 | 0.02 |
| MOP1 | 1.58** | -0.01 | 2.02 | -0.02 | -0.16 | 1.28 | -0.05 |
| PEO5984 | 0.43 | -0.27 | 2.85 | 0.53** | 3.05** | -10.57 | -0.03 |
| GCA Males | | | | | | | |
| PEO5532 | 1.44 | -0.33 | -4.56 | -0.16 | -0.44 | 0.81 | 0 |
| SOSATC88 | -4.33 | 0.16 | 1.44 | -0.28 | -0.57 | 8.36 | 0.04 |
| P1449 | -0.66 | 0.33 | 3.94 | 0.37 | 0.89 | -9.89 | -0.09 |
| DMR15 | 3.55 | -0.15 | -0.81 | 0.08 | 0.12 | 0.71 | 0.05 |
| SE.(gi) | 0.74 | 0.2 | 3.83 | 0.13 | 0.75 | 4.74 | 0.05 |
| SE.(gi-gj) | 1.05 | 0.28 | 5.41 | 0.19 | 1.06 | 6.71 | 0.07 |
| CD @ 5% | 1.53 | 0.4 | 7.91 | 0.28 | 1.55 | 9.82 | 0.1 |
| CD @ 1% | 1.55 | 0.41 | 7.98 | 0.28 | 1.57 | 9.9 | 0.1 |
| **Variance Component Estimate** | | | | | | | |
| $\sigma^2$A with F=0 (GCA) | 16.17 | 0.11 | 55.31 | 0.25 | 4.63 | 103.62 | 0 |
| $\sigma^2$D with F=0 (SCA) | -11.92 | -1.12 | -152.97 | 0.09 | 20.68 | -430.85 | 0.01 |
| **Proportional Contribution to total Variance** | | | | | | | |
| Female | 0.11 | 0.2 | 0.52 | 0.5 | 0.61 | 0.34 | 0.17 |
| Male | 0.81 | 0.47 | 0.13 | 0.29 | 0.06 | 0.36 | 0.29 |
| Female x Male | 0.08 | 0.33 | 0.36 | 0.21 | 0.34 | 0.3 | 0.54 |

### *Sca effects in across locations*

The crosses with positive specific combining ability effect for grain yield per plot also exhibited high specific combining ability for other panicle components except MOP1 ×SOSATC88 and BDP1 ×DMR15 indicating that improvement in grain yield /ha could be achieved by improving other panicle components. The present study and earlier reports (18and 19) clearly indicated that the grain yield/plant is predominantly under the control of non-additive gene action.

**Table 2** Estimates of Specific Combining Ability effects for the hybrids for 7 different characters in pearl millet across Locations (Bakura and Zaria combined).

| Hybrid | PANH | PAND | NPP | PANWT | YIELD/Ha | DI | DS |
|---|---|---|---|---|---|---|---|
| BDP1 ×PEO5532 | 1.62 | 0.20 | -0.96 | -0.26 | -0.71 | -4.09 | -0.01 |
| BDP1 ×SOSATC88 | 0.51 | -0.09 | 5.04 | 0.21 | 0.60 | 1.69 | -0.03 |
| BDP1 ×P1449 | -0.21 | -0.42 | 7.96 | 0.62 | -0.36 | 1.72 | 0.12 |
| BDP1 ×DMR15 | -1.93 | 0.31 | -12.04 | -0.58 | 0.48 | 0.68 | -0.08 |
| MOP1 ×PEO5532 | 0.08 | 0.08 | -6.38 | -0.33 | -0.04 | -4.23 | -0.04 |
| MOP1 ×SOSATC88 | -0.42 | -0.01 | -1.29 | -0.20 | 1.47 | 10.08* | 0.01 |
| MOP1 ×P1449 | 0.88 | 0.17 | 10.29 | 0.68* | -0.54 | -7.04 | 0.02 |
| MOP1 ×DMR15 | -0.54 | -0.25 | -2.63 | -0.16 | -0.89 | 1.19 | 0.01 |
| LCIC9702 ×PEO5532 | -0.88 | -0.01 | 6.13 | 0.29 | -0.55 | 0.31 | 0.01 |
| LCIC9702 ×SOSATC88 | 1.36 | 0.15 | -14.04 | -0.20 | 0.12 | 0.16 | 0.03 |
| LCIC9702 ×P1449 | -0.64 | 0.19 | -1.29 | -0.09 | 0.28 | -5.17 | 0.00 |
| LCIC9702×DMR15 | 0.17 | -0.33 | 9.21 | 0.00 | 0.15 | 4.69 | -0.04 |
| PEO5984 ×PEO5532 | -0.32 | -0.18 | -3.88 | 0.16 | -0.20 | -6.31 | -0.01 |
| PEO5984 ×SOSATC88 | -1.33 | 0.19 | 11.63 | 0.15 | 0.17 | -3.05 | 0.00 |
| PEO5984 ×P1449 | 0.77 | 0.15 | -0.29 | -0.20 | 0.11 | 7.69 | -0.08 |
| PEO5984 ×DMR15 | 0.88 | -0.16 | -7.46 | -0.11 | -0.08 | 1.67 | 0.09 |
| SE. | 1.21 | 0.28 | 7.94 | 0.38 | 1.05 | 5.13 | 0.09 |
| SE(Sij-skl) | 1.72 | 0.40 | 11.22 | 0.53 | 1.49 | 7.25 | 0.12 |
| CD @ 5% | 2.13 | 0.49 | 13.91 | 0.66 | 1.85 | 8.99 | 0.15 |
| CD @ 1% | 3.16 | 0.73 | 20.65 | 0.98 | 2.74 | 13.35 | 0.23 |

* Significant @ 5%** Significant @ 1%

### *Pooled gca effects of parents across locations*

PEO5532, source was found to have positive gca effects in the expression of number of productive tillers / plot, panicle height, panicle weight / plot and grain yield / ha; P1449 for panicle diameter, number of panicle per plot, panicle weight / plot and yield and DMR15 forpanicle height, panicle weight / plot and grain yield / ha. On the other hand, SOSATC88 source appeared to be a good combiner for panicle diameter and panicle weight / plot. Among the males, PEO5532, P1449 and DMR15 were found to be excellent general combiners on over all bases. Amongst the good general combiners, P1449 appeared to have good potential for yield as well as panicle diameter, number of panicle / plot and panicle weight / plot. The poor combiners, SOSATC88 was found to be a good general combiner for panicle diameter and panicle weight / plot. Similar results were reported by (19;20; 21 and 22) using other varieties of pearl millet. They all reported that the pearl millet varieties that were poor combiners' for other traits are good combiners' for panicle diameter and panicle weight / plot.

The details of the pooled gca effects for the seven characters are presented in Table 4.0. Five parents scored from four to six positive gca and were rated high (H) with respect to gcaover seven characters while the remaining three parents that scored less than four positive gca were classified as low (L). Among the female parents, MOP1 and PEO5984 were classified as high (H) as they scored four and six + points respectively while, BDP1 and LCIC9702 were rated low (L). Among the male parents, three parents, PEO5532, P1449 and DMR15 were rated high (H) as they scored four, six and four + points respectively while SOSATC88 was rated low having five negative points.

The parents with the highest gca value were compared with crosses with the highest sca value for the different traits studied to check which of the parents contribute positive additive effect to the crosses and for which of the trait(s). Among the parents, P1449 contributed positive additive effect to the cross MOP1 ×P1449 for Panicle weight /plot

**Table 3** Pooled GCA effects of parents in combined locations

| Parents | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Females** | **PANH** | **PAND** | **NPP** | **PNWT** | **PGWTPH** | **DI** | **DS** | **Total +ve** | **Total -ve** | **GCA status** |
| BDP1 | -1 | +1 | +1 | -1* | -1* | -1 | -1 | 2 | 5 | L |
| MOP1 | +1 | -1 | +1 | +1 | -1 | -1 | +1 | 4 | 3 | H |
| LCIC9702 | -1 | +1 | -1 | -1 | -1 | -1 | -1 | 1 | 6 | L |
| PEO5984 | +1 | -1 | +1 | +1 | +1 | +1 | +1 | 6 | 1 | H |
| Males | | | | | | | | | | |
| PEO5532 | +1* | -1 | -1 | +1 | +1 | -1 | +1 | 4 | 3 | H |
| SOSATC88 | -1 | +1 | -1 | +1** | -1 | -1 | -1 | 2 | 5 | L |
| P1449 | -1 | +1 | +1 | +1 | +1 | +1 | +1 | 6 | 1 | H |
| DMR15 | +1** | -1 | -1 | +1 | +1 | +1 | -1 | 4 | 3 | H |

Where + 1= positive gca -1 =negative gca H=high gca and L= low gca
Table 4.0 showed that out of the 16 crosses, 6 crosses scored high (H x H), 8 crosses were of high and low (H x L, or L x H) and the remaining 2 crosses were from L x L parents.

**Table 4** Crosses showing positive and desirable sca effect for 7 Characters in pearl millet hybrids.

| | PANH | PAND | NPP | PANWt | GRWT/Ha | DI | DS | GCA STATUS |
|---|---|---|---|---|---|---|---|---|
| BDP1 ×PEO5532 | + | + | - | - | - | - | - | L × H |
| BDP1 ×SOSATC88 | + | - | + | + | + | + | - | L × L |
| BDP1 ×P1449 | - | - | + | + | - | + | + | L × H |
| BDP1 ×DMR15 | - | + | - | - | + | + | - | L × H |
| MOP1 ×PEO5532 | + | + | - | - | - | - | - | H × H |
| MOP1 ×SOSATC88 | - | - | - | - | + | + | + | H × L |
| MOP1 ×P1449 | + | + | + | + | - | - | + | H × H |
| MOP1 ×DMR15 | - | - | - | - | - | + | + | H × H |
| LCIC9702 ×PEO5532 | - | - | + | + | - | + | + | L × H |
| LCIC9702 ×SOSATC88 | + | + | - | - | + | + | + | L × L |
| LCIC9702 ×P1449 | - | + | - | - | + | - | + | L × H |
| LCIC9702×DMR15 | + | - | + | + | + | + | - | L × H |
| PEO5984 ×PEO5532 | - | - | - | + | - | - | - | H × H |
| PEO5984 ×SOSATC88 | - | + | + | + | + | - | - | H × L |
| PEO5984 ×P1449 | + | + | - | - | + | + | - | H × H |
| PEO5984 ×DMR15 | + | - | - | - | - | + | + | H × H |

## SUMMARY AND CONCLUSION

In pearl millet breeding programme emphasis is always given to developing superior hybrids because of their high yielding potential, early maturity and wider adaptability. In this investigation, an attempt to produce hybrids that were resistant to downy mildew disease which are also high yielding was undertaken under field condition at Bakura and Zaria. This is because Downey mildew is a disease of considerable importance in recent years since it affects the yield, forage and fodder value which are all economically important. The study of combining ability was for the purpose of identifying superior combiners for use in developing commercial hybrids with high yield components, yield and downy mildew resistance.

Among the females parents PEO5984 emerged as the best general combiner followed by MOP1 which showed significant and positive gca effect for majority of the characters. Among the males, P1449 was the best general combiner followed by PEO5532 and then DMR15 which showed significant and positive gca effect for most of the traits. The cross MOP1 x SOSATC88 was the best specific combiner for grain yield followed by BDP1 x SOSATC88 and then BDP1 x DMR15. The best specific combiner for Downy mildew incidence was MOP1 x P1449 followed by PEO5984 × PEO5532, LCIC9702× P1449 and MOP1 x PEO5532 in that order. The best specific combiners for downy mildew severity were BDP1× DMR15 and PEO5984× P1449 followed by MOP1 x PEO5532 and LCIC9702 × DMR15 while BDP1 x SOSATC88, LCIC9702 × DMR15 and PEO5984 ×SOSATC88 have the best Sca for yield and downy mildew severity. The crosses with best SCA for downy mildew incidence and downy mildew severity were MOP1 x PEO5532 and PEO5984 × PEO5532.The Hybrid with the best SCA for yield, downy mildew incidence and downy mildew severity is PEO5984 ×SOSATC88 and is said to the hybrid with the best specific combiner.

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