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SHORT COMMUNICATION

Estimation of heterosis for yield and resistance to downy mildew (*Sclerospora graminicola*) infestation in pearl millet varieties (*Pennisetum glaucum* (L.) R. Br)

Ati Hassana Maryam

Department of Crop Production and Protection, Federal University Dutsin-Ma, Nigeria

E-mail address: ahassana@fudutsinma.edu.ng , maryameleojo@gmail.com

ABSTRACT

A field trial involving twenty-four millet varieties (parents and hybrids) was conducted at Bakura and zaria to determine the hetrotic performance for yield and resistance to Downey mildew infestation using Complete Randomized Block Design. Four resistant varieties (PEO5532, SOSATC88, P1449 and DMR15) and four susceptible varieties (BDP1, MOP1, LCIC9702 and PEO5984 were used as male and female respectively. The resistant varieties were crossed with the susceptible varieties using North Carolina design 11. Sixteen (F1) hybrids obtained were evaluated along with their parents for downy mildew resistance and grain yield. The study selected the best parents that give high heterosis in terms of grain yield and downy mildew resistance. PEO5984 × P1449, PEO5984 × PEO5532, PEO5984 × DMR15 and PEO5984 × SOSATC88 for yield, the best MP and BP heterosis for downy mildew incidence is PEO5984 × P1449. MOP1 × P1449 for MP heterosis and BDP1 × P1449 for BP heterosis.

***Keywords*:** protogynous, obligate, trial, pathogens, hybrid, *Sclerospora graminicola*, *Pennisetum glaucum*

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1. INTRODUCTION

Pearl millet (*Pennisetum glaucum* L.) is a summer fodder crop which is widely cultivated both in rainfed and irrigated areas of the country for fodder and seed production. The crop is grown commonly under the most difficult farming conditions, including those in drought – stricken areas, where soil fertility is low and food supplies are dependent on rainfall. 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. Pearl millet is diploid (2n = 14) in nature and is commonly known as bajra, cat tail millet, and bulrush millet in different parts of the world. Pearl millet is believed to be originated in West Africa (3). Pearl millet growing in areas suffers from erratic rainfall which has high variability within and between years. Grain yield as a trait in pearl millet as well as in all crop plants is quantitative in nature and is poly genetically controlled. The crop is mainly raised under traditional farming methods, where the rainfall is between 200 – 800 mm and the average yield was 653 kg/ha.

Downy mildews are obligate biotrophs that is they are host-dependent. Co evolution with plant hosts over a long period has led to divergent forms of pathogens adapted to different host taxa. Reproduction is usually both by sexual and asexual means. During the sexual phase oospores are formed which are thick-walled and long-lived, and enable the pathogens to survive the crop-free, adverse periods. Rainfall and high RH are critical weather factors for epidemics to develop. The downy mildew pathogens infecting maize, sorghum, and pearl millet require high rainfall and high relative humility for asexual reproduction. Downy mildew, as reported is the most serious disease of pearl millet in Nigeria, where the epiphytotics occur annually and it is common to find systematic infection of up to 50% of the crops on farmer's fields.

Breeding for disease resistance of economic importance, more especially downy mildew will contribute to increased productivity and stability of pearl millet grain, stover and forage yields. To increase the durability of resistance several gene pyramiding and deployment strategies have been proposed. Out of the 111 diseases of pearl millet, fungal diseases are the most serious problem in the production of pearl millet. fungal diseases of pearl millet include downy mildew (*Sclerospora graminicola* (Sacc) shoet), smut (*Tolyposporium penicillariae* Bref.) and ergot (*Claviceps fusiformis* Wall.).

Heterosis may be positive or negative, both of which are useful to crop improvement depending on the breeding objectives. Positive heterosis is desirable for grain yield while negative heterosis is desirable for downy mildew resistance. The level of heterosis exhibited by a hybrid is a function of genetic divergence between parents. High heterosis for grain yield has been reported in pearl millet. In a diallel study, observed good amount of heterosis for productive tillers per plant and ear weight. Recorded the maximum heterobeltiosis for grain yeild per plant this character among all the characters studied. Reported heterosis up to 88% for grain yield [1-22].

2. RESULT / EXPERIMENTAL

2. 1. Experimental Design

Crosses were obtained using a factorial mating scheme of North Carolina Design II, where each males was mated to each of the females. The evaluation of hybrids and parents on the fields was done using Complete Randomized block design (CRBD).

2. 2. Field Evaluation of Hybrids and Parents

Planting for evaluation was done in Samaru- Zaria and Bakura in Zamfara state. 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. Five meter long ridges with inter row spacing of 75 cm and intra row spacing of 50 cm was prepared using tractor. Few seeds were sown per hill and the plants were thinned down to two plants per stand two weeks after sowing. Compound fertilizer NPK (15:15:15) was applied two weeks after planting 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. 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 2weeks before the planting of the hybrids and the parents' seeds.

2. 3. Estimates of heterosis

Mid-parent heterosis (MPH) is the performance of a hybrid relative to the average performance of its parents expressed in percentage.

High-parent heterosis (HPH) is the performance of a hybrid relative to the performance of its best parent expressed in percentage.

$$\boldsymbol{H(\%)Mp = \frac{F1 - Mp}{Mp} \times 100}$$

$$\boldsymbol{H(\%)Hp = \frac{F1 - Hp}{Hp} \times 100}$$

where: F_1 = mean of F_1 generation
Mp = mean of mid-parent 1 and 2
Hp = mean of superior performing parent

3. RESULTS AND DISCUSSION

It was evident from the Tables 1 and 2 that the degree of heterosis varied considerably for grain yield and its components. A critical examination of the heterosis for grain yield/ha indicated that it was mainly the result of heterosis for Panicle weight/plot and Number of panicles / plot. Similar observations were also made by [3-9] for the same combinations showing significant heterosis for grain yield. The heterosis for grain yield/ha is in turn contributed by Number of tillers/plot, panicle length, panicle diameter and number of panicle/ plot reported similar findings. The study on heterosis indicated that highly significant heterotic crosses were generally productive. Negative heterosis observed in downy mildew incidence, downy mildew severity are desirable in breeding for downy mildew resistance. Also, negative heterosis for earliness indicated the scope of developing high yielding and early maturing hybrids. The negative heterosis observed in characters like Panicle weight and Grain weight/ha (Tables 1 and 2) could be due to sample variation, linkage, inadequate statistical and genetic models. Similarly, plant height had very low heterosis. These results revealed that heterosis for grain yield in pearl millet is mainly contributed by the panicle components rather than vegetative traits, observed similar result in his research on pearl millet. The negative heterosis observed in characters like Panicle weight and Grain weight/ha could be due to sample variation, linkage, inadequate statistical and genetic models.

Table 1. Mid Parent Heterosis of hybrids over different characters in Pearl millet.

Hybrids	NPP	PANWt	GRWT/Ha	DI	DS
BDP1 × DMR15	65.81**	126.42**	85.28**	-23.53	-7.91
BDP1 × P1449	73.90**	81.60**	56.99**	-16.71	-16.06
BDP1 × PEO5532	82.15**	105.65**	38.19*	-20.69	-0.1
BDP1 × SOSATC88	36.65*	-10.16	-0.94	8.9	4.36
MOP1 × DMR15	74.13**	167.07**	53.23**	-19.32	8.71
MOP1 × P1449	26.99*	52.29*	44.70**	-30.11	-17.32
MOP1 × PEO5532	17.81	25	33.89*	-12.73	-12.63
MOP1 × SOSATC88	23.74	-15.7	-2.67	25.80**	-17.35
LCIC9702 × DMR15	26.88	83.94*	33.70*	-30.48	7.81
LCIC9702 × P1449	19.94	56.02*	20.76	-24.08	-5.08
LCIC9702 × PEO5532	5.41	10.24	39.75**	6.33	5.76
LCIC9702 × SOSATC88	-4.52	-21.86	-16.78	-5.18	0.49

PEO5984 × DMR15	57.34**	332.32**	174.84**	-49.28	-4.7
PEO5984 × P1449	3.11	133.99**	129.54**	-54.44	-11.81
PEO5984 × PEO5532	20.62	109.58**	99.61**	-40.35	-3.65
PEO5984 × SOSATC88	39.53**	61.58*	52.13**	-36.37	-7.19

* = significant at 5% ($p \geq 0.05$); ** = highly significant at 1% ($p \geq 0.01$)

Table 2. High-parent heterosis (HPH) of hybrids for different characters in Pearl millet.

Hybrids	NPP	PANWt	GRWT/Ha	DI	DS
BDP1 × DMR15	54.59**	92.81**	76.12**	-31.2	-18.08
BDP1 × P1449	38.80**	49.49*	48.71**	-19.19	-21.98
BDP1 × PEO5532	56.25**	61.06**	26.51*	-21.26	-10.26
BDP1 × SOSATC88	15.32	-31.71	-21.02	-2.17	2.02
MOP1 × DMR15	40.94**	84.03**	25.60*	-31.17	-1.74
MOP1 × P1449	16.41	39.50*	29.74*	-32.22	-21.85
MOP1 × PEO5532	17.81	21.85	24.10*	-17.25	-20.23
MOP1 × SOSATC88	21.32	-17.07	-10.56	19.61**	-17.75
LCIC9702 × DMR15	4.22	36.96	9.53	-37.87	6.24
LCIC9702 × P1449	8.07	50.51*	8.2	-25.79	-8.2
LCIC9702 × PEO5532	3.44	0	29.44*	6.28	5.37
LCIC9702 × SOSATC88	-8.11	-31.71	-23.47	-14.24	-7.54
PEO5984 × DMR15	18.81	296.30**	149.91**	-52.27	-9.62
PEO5984 × P1449	2.58	80.81**	90.49**	-62.11	-12.31
PEO5984 × PEO5532	10.05	54.87**	60.98**	-49.44	-7.66
PEO5984 × SOSATC88	29.64*	16.26	9.43	-50.31	-11.37

* = significant at 5% ($p \geq 0.05$); ** = highly significant at 1% ($p \geq 0.01$)

3. 1. Average heterosis (%) of pearl millet hybrids carrying resistance genes

From Table 3, the average heterosis (%) of PEO5532, SOSATC88, P1449 and DMR15 for the traits studied revealed that the direction and magnitude of heterosis was significantly influenced by the male parents. The average heterosis was high for number of panicle per plot, panicle wt per plot and grain yield/ha. The average heterosis was in the desired direction for downy mildew incidence, downy mildew severity and the yield components.

Average heterosis was calculated by using parental and F1 generation means. Positive heterotic values were maximum for panicle weight per plot, grain yield/ha and number of panicle per plot (Table 4).

Table 3. Average heterosis (%) of pearl millet hybrids carrying resistance genes

	Average heterosis (%) (PEO5532, SOSATC88, P1449 and DMR15)	
TRAITS	Maximun	Minimum
Downy mildew Incidence	8.9	-20.14
Downy mildew severity	8.71	-4.792
Number of panicle / plot	82.15	35.593
Panicle wt / plot	332.32	81.124
Yield/ha	174.84	52.639

Table 4. Average performance of parents, MP, F1 generation and average MP.

Characters	Parental mean			Heterosis (%)
	P1	P2	MP	
Disease Incidence	68.27	63.3	65.79	-20.14
Disease severity	0.94	0.88	0.91	-4.79
Number of panicle per plot	51.88	51.46	51.67	35.59
Panicle wt per plot	1.37	1.58	1.48	81.12
Yield/ha	7.01	7.54	7.27	52.64

4. SUMMARY AND CONCLUSION

The study of heterosis was aimed at selecting the best Hybrids with high heterosis in terms of yield components, yield and downy mildew resistance. PEO5984 × SOSATC88, PEO5984 × DMR15, BDP1 × P1449, BDP1 × PEO5532, BDP1 × DMR15 and BDP1 × SOSATC88 and MOP1 × P1449 and MOP1 × DMR15 for number of panicles per plot. PEO5984 × P1449, PEO5984 × PEO5532, PEO5984 × DMR15 and PEO5984 × SOSATC88, BDP1 × P1449, BDP1 × PEO5532 and BDP1 × DMR15, MOP1 × P1449, MOP1 × DMR15 andMOP1 × PEO5532 for yield. The heterosis for grain yield was largely due to panicle weight per plot and number of panicles per plot.

In conclusion the most productive and most heterotic combination was PEO5984 × DMR15 followed by PEO5984 × P1449 then PEO5984 × PEO5532 and PEO5984 × SOSATC88. The best hybrid as shown by Mid parent and Better parent heterosis for downy mildew incidence was PEO5984 × P1449 while BDP1 × P1449 was the best hybrid Mid parent heterosis for downy mildew severity and the best Better parent heterosis for downy mildew severity was MOP1 × SOSATC88.

References

[1] Imran, M, A. Hussain, R. Khalid, S. Khan, M. S. Zahid, Z. A. Gurmani, A. Bakhsh and D. Baig, 2010. Study of correlation among yield contributing and quality parameters in different millet varieties grown under and hwar conditions. *Sarhad J. Agric.* 26(3): 365-368.

[2] Singh. S.D. (1995). Downy mildew of pearl millet. *Plant Diseases* 79: 545-550

[3] Zarafi, A.B., Emechebe, A.M., Akpa, A.D and O. Alabi (2001). The incidence of pearl millet downy mildew, Sclerospora graminicola (Sacc.) in Samaru, Nigeria. *Nigerian Journal of Tropical Agriculture* 3: 14-22

[4] Ashan, N. (2004). Genetic bases of heterosis and inbreeding depression in rice. *Journal of Zhejang University of Science* 5(4) 406-411.

[5] Rewat, R.S. and D.V.S. Tyagi. (1989). Mutant heterosis in pearl millet. *Indian Journal of Genetics and Plant Breeding* 49: 19-24.

[6] Ugale, S. D., Hapse, R. S., and Bharati, D. A., 1989. Heterosis in pearl millet. *Journal of Maharashtra Agricultural University,* vol. 14, pp. 335-337

[7] Manga, V.K. and Dubey, L.K. (2004). Identification of suitable inbreeds on combining ability in pearl millet (Pennisetum glaucum). *Indian Journal of Agricultural Science.* 74: 98-101.

[8] Sheoran, R. K., Govila, O. P., Balzor-Singh, and Singh, B. B., 2000. Genetic architecture of yield and yield contributing traits in pearl millet. *Annual Agricural Resource,* vol. 21, pp. 443-445.

[9] Yadav, O. P., Sabharwal, P. S., Beniwal, C. R., and Hanuman, 2000. Combining ability study for some newly developed male sterile lines for forage attributes in pearl millet. *Forage Resource,* vol. 27, pp. 277280.

[10] Comstock, R.E., and H.F. Robinson, (1948). The components of genetic variancein populations of biparental progenies and their use in estimating the average degree of dominance. *Biometrics* 4: 254-66.

[11] Blummel, M. and Rai, K. N., 2003. Stover quality and grain yield relationship and heterosis in pearl millet. *International. Sorghum and Millet Newsletter*, vol. 44, pp. 141-145.

[12] Pethani, V. K., Afara, S. D., and Monpara, B. A., 2004. Heterosis and combining ability for plant and seed characters in pearl millet. *Nation. Journal of Plant Improvement*, vol. 6, pp. 115-118.

[13] S Shailasree, BR Sarosh, NS Vasanthi and HS Shetty. Seed treatment with β-aminobutyric acid protects Pennisetum glaucum systemically from Sclerospora graminicola. *Pest Management Science* Volume 57, Issue 8 August 2001 Pages 721–72

[14] Moahmed A. E. Hassan, Kamal A. M. Abo-Elyousr, Activation of tomato plant defence responses against bacterial wilt caused by Ralstonia solanacearum using DL-3-aminobutyric acid (BABA), *European Journal of Plant Pathology*, 2013, 136, 1, 145

[15] Piękna-Grochala Justyna, Kępczyńska Ewa, Induction of resistance against pathogens by β-aminobutyric acid, *Acta Physiologiae Plantarum*, 2013, 35, 6, 1735

[16] S.N. Lavanya, S. Niranjan Raj, A.C. Udayashankar, K.R. Kini, K.N. Amruthesh, S.R. Niranjana, H.S. Shetty, Comparative analysis of activities of vital defence enzymes during induction of resistance in pearl millet against downy mildew, Archives Of Phytopathology And Plant Protection, 2012, 45, 11, 1252

[17] Ziguo Zhu, Jiangli Shi, Mingyang He, Jiangling Cao, Yuejin Wang, Isolation and functional characterization of a transcription factor VpNAC1 from Chinese wild Vitis pseudoreticulata, *Biotechnology Letters*, 2012, 34, 7, 1335

[18] Ball SL, Pike DJ (1984) Intercontinental variation in Sclerospora graminicola. *Ann Appl Biol* 104: 41–51

[19] Kohli Y, Morrall RA, Anderson JB, Kohn LM (1992) Local and trans-Canadian clonal distribution of Sclerotina sclerotiorum on canola. *Phytopathology* 82: 875–880

[20] McDonald BA, Miles J, Nelson LR, Pettway RE (1994) Genetic variability in nuclear DNA in field populations of Stagonospora nodorum. *Phytopathology* 84: 250–255

[21] Thakur RP, Shetty KG, King SB (1992) Selection for host-specific virulence in asexual population of Sclerospora graminicola. *Plant Path* 41: 626–632

[22] Xia JQ, Correll JC, Lee FN, Marchetti MA, Rhoads DD (1993) DNA fingerprinting to examine the microgeographic variation in the Magnaporthe grisea (Pyricularia grisea) population in two rice fields in Arkansas. *Phytopathology* 83: 1029–1035