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HERITABILITY ESTIMATES FOR PEARL MILLET (*Pennisetum glaucum* L. R. Br.) CHARACTERS UNDER DOWNY MILDEW (*Sclerospora graminicola* (Sacc.) Schroet) INFESTATION

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ABSTRACT

A study was conducted at the Usmanu Danfodiyo University Dry land farm, Sokoto and Bui village in Arewa local government area of Kebbi State to evaluate pearl millet parental lines and their hybrids under downy mildew disease infestation. The treatment consisted of 42 entries, made up of 12 parents and 30 F_1 hybrids combined in randomized complete block design with 6 blocks per replication, 8 plots per block (7 test rows +1 infector row), 1 row per plot and 10 stands per row replicated 2 times. Data was collected on 12 characters of pearl millet. Analysis of variance indicated significant difference ($P < 0.05$) among the genotypes for all 12 characters studied in each location while combined analysis of variance across locations showed that the genotypes differ significantly ($P < 0.05$) with respect to all characters except for Downy mildew severity (DMS) and threshing percentage (THR%). In terms of the broad sense heritability most of the characters were moderately heritable as panicle circumference (PCIR) recorded the highest (84.32%) in UDUS, grain weight (GWT) recorded (71.4%) in Bui and panicle length (PLEN) recorded (78.54%) in the combined.

Keywords: Pearl millet, Heritability; Characters; downy mildew;

INRODUCTION

Pearl millet (*Pennisetum glaucum* L. R. Br.) is a diploid (2n = 2x = 14), warm-season C4 annual cereal crop grown in West Africa and on the Indian subcontinent for food and forage. It is a robust, quick growing cereal grass with large stems and leaves which are tall and vigorous, with exceptional grain and fodder yielding potentials. Pearl millet is the sixth most important cereal crop in the world (FAOSTAT, 2014). Harvested from an area of 20 million ha in the semi-arid regions of Africa, pearl millet contributes 19% to the total area allocated to cereal production in the region (Macauley, 2015). The world pearl millet production is 28,357,451 tonnes with Nigeria contributing 5.25% as the fifth world top producer (FAOSTAT, 2016). Growth and productivity of pearl millet crop has been hampered by the incidence of diseases and pest (Lakshmana, 2008). Downy mildew (*Sclerospora graminicola* (Sacc.) Schroet) is the most important disease of pearl millet in many countries of the world including Nigeria. Heritability is a statistic used in the fields of breeding and genetics that estimates the degree of variation in a phenotypic trait in a population that is due to genetic variation between individuals in that population (Wray and Visscher, 2008). In crop improvement, only the genetic component of variation is important since only this component is transmitted to the next generation (Singh 2015). Therefore estimate of heritability serves as a useful guide to a breeder as it will help the breeder appreciate the proportion of variation that is due to genetic or additive effects. Pearl millet improvement program in Nigeria is concerned with higher yield for human food and this will likely play a major role in easing the world food shortage as population increases. According to Zoclanclounon *et al.* (2018) multi-location monitoring of downy mildew virulence is one of the efficient ways to assess genotypes. The aim of this research is to estimate broad sense heritability, genotypic variance, phenotypic variance and genotypic and phenotypic coefficients of variation for pearl millet characters measured under downy mildew infestation.

MATERIALS AND METHODS

The field experiment was conducted at two locations, The first location Usmanu Danfodiyo University Sokoto (UDUS) dryland farm lies on latitude 13° 08´N and longitude 5° 13´E on an altitude of 278m above sea level about 11 km from Sokoto town. Sokoto falls under the Sudan Savanna ecological zone and it is characterized by a long dry season and a short wet season. Rainfall mainly starts in May and

ends in early October with a peak in August. The annual rainfall for Sokoto ranges between 300 mm and 800 mm. The mean annual temperature is 34.5°C, although dry season temperatures in the region often exceed 40°C (Ekpoh and Ekponyong, 2011).The second experimental site was Bui village in Arewa local government area of Kebbi state and lies on an altitude of 244m above sea level on latitude 12° 11´E and longitude 4° 15´E. It receives a mean annual rainfall of 800mm between April to October with a peak period in August, while the remaining period of the year is dry (Gulma, 2013). The maximum and minimum temperature ranges from 40.3°C and 16.6°C respectively (Ismail *et al.,* 2012).

The genetic materials consists of 42 entries, made up of 12 parents and 30 F_1 hybrids (Table 1) combined in randomized complete block design with 6 blocks per replication, 8 plots per block (7 test rows +1 infector row), 1 row per plot and 10 stands per row replicated 2 times. Each plot contained a row made up of 10 stands. Each plot has measured 5m long with intra and inter row spacing of 0.75m × 0.5m. The gross plot size was 10.5m × 37m. A highly downy mildew susceptible variety (Jirani) was sown as the infector row after 11 rows of the test lines. The test lines were sown 2 weeks after sowing the infector row and disease incidence level in these lines indicates the distribution of disease pressure in the field. Thinning was done 2 weeks after sowing to maintain 2 plants per hill/stand and Weeding operations were carried out manually using hoe. The first weeding was carried out 2 weeks after sowing while the second weeding was carried out 5 weeks after sowing. Harvesting was done manually at physiological maturity 18 weeks after sowing. Each plot was manually threshed separately using a mortar and pestle to separate the seeds from the panicle. Data was collected on days to 50% flowering, plant height (cm), plant length (cm), number of harvested panicles, plant weight (g), panicle circumference (cm), panicle compactness, grain weight (kg/ha), 1000 grain weight (g), threshing percentage (%), downy mildew incidence (%) and downy mildew severity (%).The data collected were analyzed using GenStat 17th edition. The estimates of phenotypic and genotypic variances were calculated using mean square values obtained from individual and combined ANOVA.

Broad Sense Heritability was estimated using the formula described by Fehr (1987):

$$H^2 = \frac{\sigma_g^2}{\sigma_{ph}^2} \times 100$$

Genotypic and phenotypic variance for single environment was calculated as follows;

Error mean square $\sigma_e^2 = M_1$

Genotypic variance $\sigma_g^2 = \frac{M_2 - M_1}{r}$

Phenotypic variance $\sigma_{ph}^2 = \sigma_e^2 + \sigma_g^2$

Where:

M_2 = genotype mean square

M_1 = error mean square

r = replication

Genotypic, G× E variance and phenotypic variance for combined environment was calculated as follows;

Error variance $\sigma_e^2 = \frac{M_4 - M_2}{rg}$

Genotypic variance $\sigma_g^2 = \frac{M_3 - M_2}{re}$

G × E variance $\sigma_{ge}^2 = \frac{M_2 - M_1}{r}$

Phenotypic variance $\sigma_{ph}^2 = \sigma_g^2 + \frac{\sigma_{ge}^2}{e} + \frac{\sigma_e^2}{re}$

Where:

M_1 = error mean square

M_2 = G × E mean square

M_3 = genotype mean square

M_4 = environment mean square

r = replication

e = environment

g = genotype

Genetic coefficient of variation, phenotypic coefficient of variation and error coefficient of variation was calculated as follows:

GCV= $\frac{\sqrt{\sigma_g^2}}{\bar{X}} \times 100$

PCV= $\frac{\sqrt{\sigma_{ph}^2}}{\bar{X}} \times 100$

ECV= $PCV - GCV$

Where:

GCV = Genetic coefficient of variation

PCV = Phenotypic coefficient of variation

ECV = Error coefficient of variation

$\bar{X}$ = Grand mean.

RESULTS AND DISCUSSION

Broadsense heritability

According to Singh (2015), heritability of 80% or more is considered high and selection for characters with such heritability could be fairly easy. This is because there would be a close correspondence between the genotype and the phenotype due to the relative small contribution of the environment to the phenotype. Heritability of 40% or less is considered low. Thus selection may be considerably difficult or virtually impractical due to the masking effect of environment. Heritability estimates between 40% and 80% are considered moderate. On this basis UDUS is the only panicle circumference (PCIR) recorded high heritability value in indicating that the character can be selected for easily, days to 50% flowering (D50%F) and 1000 grain weight

(1000GW) are moderately heritable indicating that the characters can be selected for despite environmental influence while plant height (PHT), downy mildew severity (DMS), downy mildew incidence (DMI), number of panicles harvested (NPH), panicle compactness (PCMP), panicle weight (PWT), panicle length (PLEN), threshing percentage (THR%) and grain weight (GWT) recorded low heritability indicating that it will be difficult to select for the characters in the population under downy mildew infestation. In Bui days to 50% flowering (D50%F), downy mildew incidence (DMI), panicle length (PLEN), threshing percentage (THR%) and grain weight (GWT) are moderately heritable while plant height (PHT), downy mildew severity (DMS), number of panicles harvested (NPH), panicle compactness (PCMP), panicle weight (PWT), 1000 grain weight (1000GW) and panicle circumference (PCIR) recorded low heritability. In combined, days to 50% flowering (D50%F), panicle length (PLEN) and panicle circumference (PCIR) are moderately heritable while all the remaining characters recorded low heritability values.

Grain weight (GWT), downy mildew incidence (DMI) and threshing percentage (THR%) were moderately heritable in Bui but low in UDUS and combined indicating the difficulty with which the characters may be selected under downy mildew infestation. In UDUS, Bui and combined days to 50% flowering (D50%F) was moderately heritable indicating that the character can be selected for despite environmental influence. In Bui and combined 1000 grain weight (1000GW) was moderately heritable but low in UDUS indicating the difficulty with which the character may be selected under downy mildew infestation. The moderate broad sense heritability estimates obtained for some of the characters in this study indicated that these characters can be selected for despite environmental influence. Other characters such as plant height (PHT), downy mildew severity (DMS), number of panicles harvested (NPH), panicle compactness (PCMP) and panicle weight (PWT) all recorded low heritability in UDUS, Bui and combined indicating that it will be difficult to select for these characters in the population under downy mildew infestation. The findings of this study are in line with Bhasker *et al*. (2017) who also reported moderate and low heritability for most of the characters studied in this research.

Table 1: Estimates of UDUS and Bui values for components of variance, broad sense heritability and Genotypic and phenotypic coefficients of variations for characters of pearl millet evaluated during 2018 raining season

	UDUS						BUI					
TRAITS	σ_g^2	σ_e^2	σ_{ph}^2	H^2	GCV	PCV	σ_g^2	σ_e^2	σ_{ph}^2	H^2	GCV	PCV
D50%F	78.46	42.71	121.17	64.75	11.88	14.76	27.49	27.08	54.58	50.38	7.46	10.51
PHT	269	908	1177	22.86	10.66	22.31	329.7	711.8	836.45	31.66	11.71	20.81
DMI(%)	20.8	499.8	520.6	3.99	6.61	33.06	495.25	341.2	836.45	59.21	47.24	61.4
DMS(%)	5.15	230.2	235.35	2.18	52.78	54.73	142.3	679	821.3	17.33	27.11	65.13
NPH	10.11	41.63	51.73	19.53	37.88	85.73	6.92	33.71	40.63	17.04	41.25	99.91
PLEN	34.43	77.53	111.96	30.57	16.07	34.52	85.37	35.56	120.93	70.59	29.56	35.2
PCIR	2.17	0.40	2.58	84.32	21.08	22.96	0.31	0.55	0.86	36.32	7.69	12.75
PCMP	0.08	2.59	2.67	3.22	6.99	39.03	0.47	1.45	1.91	42.36	14.28	28.94
PWT	2783	14312	17095	16.28	38.23	94.74	301	41346	41647	0.72	11.41	98.13
GWT	37022	66634	103656	35.72	55.45	92.78	220843.5	88457	309300.5	71.4	95.23	99.51
THR%	23.15	145.2	168.35	13.75	15.62	42.13	88.91	56.52	145.43	61.14	18.59	23.78
1000GW	2.17	2.89	5.07	42.85	18.21	27.82	0.06	4.85	4.91	1.34	3.92	33.84

σ_g^2 = genotypic variance, σ_e^2 = environmental variance, σ_{ph}^2 = phenotypic variance, H^2= broad sense heritability, GCV= genotypic coefficient of variation and PCV= phenotypic coefficient of variation.

Phenotypic, Genotypic And Environmental Variances

Results of the study revealed that genotypic variance was most responsible for the phenotypic variance observed for D50%F and PCIR while environmental variance was most responsible for the phenotypic variance observed for, PHT, PLEN, NPH, PWT, PCMP, DMI, DMS, GW, 1000GW and THR% at UDUS dry land farm. The results at Bui indicated that the genotypic variance was most responsible for the phenotypic variance observed for D50%F, PLEN, DMI, GW and THR% while environmental variance was responsible for the phenotypic variance observed for PHT, NPH, PWT, PCIR, PCMP, DMS and 1000GW.The combined results shows that genotypic variance was most responsible for the phenotypic variance observed for PLEN while environmental variance was responsible for the phenotypic variance observed for D50%F, PHT, NPH, PWT, PCMP, PCIR, DMI, DMS, GW, THR% and 1000GW (Table 1).

This means that the phenotypic differences observed in the character PLEN is purely genetic with less influence of environment its expression across the two locations. Also this implies that the character can easily be selected for. On the same note the selection of the characters D50%F, PCIR, DMI, GW and THR% with genetic variances responsible for the phenotypic variances in only one location and not across the two locations will be difficult due to the influence of environment in the expression of such characters under downy mildew infestation. The genotypic variance obtained in this study for grain yield is in line with the finding of Borkhataria *et al*. (2005) who also reported high genotypic and phenotypic variances for grain yield.

Phenotypic And Genotypic Coefficients of Variation

The phenotypic coefficients of variation (PCV) estimates were higher than genotypic coefficients of variation (GCV) for all the 12 characters studied among the pearl millet genotypes (Table 2). This indicated that there is substantial influence of environment in the expression of these characters. Bhasker *et al*. (2017); Borkhataria *et al*. (2005) and Hepziba *et al*. (1993) all reported similar findings in their studies on pearl millet. Deshmukh *et al.* (1986) suggested that PCV and GCV values greater than 20% are high, values between 10% and 20% are medium, whereas values less than 10% are considered to be low. On this basis, DMI, DMS, NPH, PWT, PLEN and GW had high PCV and GCV values in the two locations and combined while the other characters such as THR%, PCMP, 1000GW, D50%F, PHT and PCIR recorded PCV and GCV values that were medium and low in UDUS, Bui and combined. High PCV and GCV value for grain weight was reported in pearl millet by Govindaraj *et al*. (2011). Also in terms of the differences between the GCV and PCV values of the characters, the closer the gap in the differences the higher the chance of selection of such characters meaning that there is less influence of environment on such character. From this study, D50%F, PLEN, PCIR and PCMP are characters with a close gap between the GCV and PCV values has higher chance of selection than other characters studied.

Table 2: Estimates of combined values for components of variance, broad sense heritability and Genotypic and phenotypic coefficients of variations for characters of pearl millet evaluated during 2018 raining season at UDUS and Bui.

Traits	Components of variance				GCV(%)	PCV(%)	H^2(%)
	σ_g^2	σ_e^2	σ_{ge}^2	σ_{ph}^2			
D50%F	16.85	38.19	17.04	34.92	5.66	8.15	48.26
PHT(cm)	174.75	1028	147	505.25	8.58	14.59	34.59
DMI(%)	110.58	536.1	172.35	330.78	44.94	77.72	33.43
DMS(%)	41.65	375.2	149.1	210	31.63	71.04	19.83
NPH	7.43	44.43	7.83	22.45	37.75	65.63	33.09
PLEN(cm)	58.01	53.5	4.95	73.85	24.79	27.97	78.54
PCIR(cm)	0.36	0.48	0.16	0.56	8.42	10.51	64.15
PCMP	0.25	1.89	0.19	0.82	17.02	20.01	30.18
PWT(g)	3158	31684	4884	13521	40.14	83.06	23.36
GWT(Kg/Ha)	13942	78168	130308	98638	34.03	90.51	14.16
THR%	5.38	91.1	89.52	72.91	5.73	21.09	7.78
1000GW(g)	0.12	3.99	1.79	2.01	4.66	19.39	5.78

σ_g^2 = genotypic variance, σ_e^2 = environmental variance, σ_{ge}^2 = genotype and environment variance, σ_{ph}^2 = phenotypic variance, H^2= broad sense heritability, GCV= genotypic coefficient of variation and PCV= phenotypic coefficient of variation.

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