Direct Research Journal of Agriculture and Food Science
Vol. 12(1), Pp. 76-82, March 2024
ISSN: 2354-4147
DOI: https://doi.org/10.26765/DRJAFS12219610
Article Number: DRJAFS12219610

https://journals.directresearchpublisher.org/index.php/drjafs

Genetic variability and heritability among indigenous pearl millet (*Pennisetum glaucum* L. R. Br.) in striga infested fields of Sudan Savanna, Nigeria

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Received 9 January 2024; Accepted 25 February 2024; Published 4 March 2024

ABSTRACT: Pearl millet (*Pennisetum glaucum* L. R. Br.) is a cereal cultivated in arid and semi-arid areas of the world. It supports more than 100 million people around the world. Parasitic weed (*Striga hermonthica* Del. Benth*)* is a major constraint to its production. Estimated yield losses are put at 10 - 95% depending on variety, ecology and cultural practices. Potentials in selection of traits in pearl millets for grain yield have been reported and it depends on genotypic variability and heritability among landraces. Variability and heritability among cultivars could offer opportunities for improvement. The study was conducted to determine the genetic variability among cultivars and estimate broad sense heritability among grain yield and related traits. The crosses i.e. the F_1 breeding populations were generated with 9 parental cultivars, *viz*; Ex-Gubio, Ex-Monguno, Ex-Baga as males and PEO 5984, Super-SOSAT, SOSAT-C88, Ex-Borno and LCIC9702 as females through Line × Tester mating during 2017 dry season at Lushi Irrigation Station, Bauchi Metropolitan in Bauchi State, Nigeria. The F_1 population and the parents were evaluated during cropping season of 2018 at Bauchi and Maiduguri. Data collected were subjected to analysis of variance. Results showed significant difference among cultivars and among traits indicating variability. Number of plants at emergence, days to 50% flowering, days to 100% flowering, plant height, panicle length, number of plants at harvest, *Striga* count at 90 days after sowing, panicle weight and grain yield were significantly different. Significant variability offer opportunity for improvement as superior individuals can be isolated. Genotypic variance estimates of traits were largely greater than environmental variances except in plant height and 1000 seed weight. Environmental variances were low and in some cases negligible. The phenotypic variances of all traits were higher than genotypic variances. Similarly phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV). High heritability was found in days to 50% flowering (90.27%), *Striga* count at 90 days after sowing (90.07%), number of plants at harvest (87.97%), days to 100% flowering (83.89%), number of plants at emergence (82.19%) and plant height (73.18%). Greater heritability estimates could be due to presence of additive gene. The result revealed wider variability among genotypes and traits. Traits having high heritability could easily respond to selection. High value of GCV, PCV and heritability estimates indicate that selection for these traits are possible and could be effective.

Keywords: Variability, heritability, phenotypic, genotypic, *Striga*
Citation: Balami, G. S., and Izge, A. U. (2024). Genetic Variability and Heritability among Indigenous Pearl Millet (*Pennisetum glaucum* L. R. Br.) in Striga Infested Fields of Sudan Savanna, Nigeria. Direct Res. J. Agric. Food Sci. Vol. 12(1), Pp. 76-82. https://doi.org/10.26765/DRJAFS12219610. This article is published under the terms of the Creative Commons Attribution License 4.0.

INTRODUCTION

Pearl millet (*Pennisetum glaucum* L. R. Br.) is one of the most important cereals cultivated as rain fed crop on millions of hectares in arid and semi-arid areas of the world. It is grown in over 40 countries predominantly in Africa and Asia as a staple food grain and source of feed, fuel and construction material. The crop supports more than 100 million people around the world (FAO, 2021). Parasitic weed (*Striga hermonthica* Del. Benth*)* has been a major biotic constraint among many others to pearl millet production, particularly in Northern Nigeria.

Table 1: Description of cultivars used as parents in the study.

Lines	Description	Source
Ex-Borno	Medium maturing/medium sized seeds and adapted to the Sahel region of Nigeria.	LCRI Maiduguri, Nigeria.
SOSAT-C88	Long/compacted panicle, early maturing and large seeded.	LCRI Maiduguri, Nigeria.
Super SOSAT	Long panicle and meduim maturing.	LCRI Maiduguri, Nigeria.
LCIC 9702	Long compacted panicle, early maturing and large seeded.	LCRI Maiduguri, Nigeria.
PEO 5984	Medium maturing, medium sized and compacted panicle.	LCRI Maiduguri, Nigeria.
Testers PS 202	Short and small seeded panicle, hairy, profuse tillers and striga resistant.	ICRISAT Niamey
Ex-Gubio	Medium height and small yellow-seeded panicle, profuse tillers, late maturing and tolerant to striga.	LCRI Maiduguri, Nigeria.
Ex-Baga	Medium and small brown-seeded panicle, profuse tillers, late maturing and tolerant to striga.	LCRI Maiduguri, Nigeria.
Ex-Monguno	Medium and small purple-seeded panicle, hairy, profuse tillers and tolerant to striga.	LCRI Maiduguri, Nigeria.

The exceptional degree to which the weed damages pearl millet is one of the several characteristics which make *Striga hermonthica* in pearl millet the most serious of all parasitic weed problems (Parker and Riches, 1993). Estimated yield losses have been put between 10 - 95% depending on varietal reaction, ecology and cultural practices Wilson *et al*. (2011) and Izge *et al*. (2005) reported higher potentials for making progress in selection of traits in pearl millet towards higher grain yield, because of higher genotypic variability existing among the landraces.

The vital objective of any crop improvement program is to increase yield potential of a crop. Information on genetic variability of a crop is a requirement in crop improvement program. Higher potential for progress in selection of traits of pearl millets towards higher grain yield have been reported to depend on genotypic variability and heritability that exist among landraces. Significant variability and heritability among cultivars and their traits could offer opportunity for improvement. In particular the genotypic and phenotypic coefficients of variability can be used as tools. Heritability can also be used for phenotypic variation in a population and to also determine whether certain traits are heritable and transmissible as reported by Ogunniyan and Olakojo, (2015). It is for this reason therefore, this study was conducted to assess the magnitude of genetic variability, and heritability for quantitative traits in pearl millet parental cultivars and their hybrid crosses using a line × tester mating design.

MATERIALS AND METHODS

A nursery experiment which generated an initial F_1 population was conducted among eight pearl millet cultivars viz: Ex-Gubio, Ex-Monguno, Ex-Baga as males and PEO 5984, Super-SOSAT, SOSAT-C88, Ex-Borno and LCIC9702 as females through a line × tester mating design during 2017 dry season at Lushi Irrigation Station at the outskirt of Bauchi Metropolitan in Bauchi State, Nigeria. The F_1 population and their parental lines were evaluated during the cropping season of 2018 at Bauchi and in Maiduguri Borno State, Nigeria.

The pearl millet cultivars; PEO 5984, Super SOSAT, SOSAT C-88, Ex-Borno and LCIC 9702 were obtained from the mandate Research Institute, the Lake Chad Research Institute in Maiduguri, Nigeria. In addition, wild millet (*Monodii)* PS 202 which has *Striga* resistance gene was obtained from International Crop Research Institute of the Semi-Arid Tropics (ICRISAT) in Niamey in addition to the three local wild ones which were also obtained from Lake Chad Research Institute (LCRI). The wild millets were used as males referred to as testers. The cultivars were used as females, referred to as lines. The pearl millet materials used in the study are as described in (Table 1). Data on yield and agronomic traits were collected and subjected to analysis of variance. Data collection were carried out on number of plants at emergence, days to 50% flowering, days to 100% flowering, plant height, panicle length, number of plants at harvest, number of leaves per plant, panicle weight/plot, striga count at 90 days after sowing, grain yield and 1000 seed weight. All the data collected were subjected to analysis of variance and genetic analysis. Genotypic and phenotypic (σ^2g and σ^2p) variances were computed according to Al-Jibouri *et al.* (1958). The phenotypic and genotypic coefficients of variability were computed according to the method suggested by Burton (1952). Heritability in broad sense estimates (h^2b) as percent of means were categorized as suggested by Johnson *et al*. (1955).

RESULTS AND DISCUSSION

The mean squares for the traits under study of pearl millet evaluated during the 2018 cropping season from the analysis of variance are presented in (Table 2). In the present study, large differences in mean values for all the traits were observed. The results indicated that all the genotypes exhibited significant or highly significant difference for all the traits except in number of plants at

Table 2: Mean Squares from Analysis of Variance of Traits of Pearl Millet Genotypes in a Line × Tester Analysis

Source of Variation	DF	NPE	DFF	DHF	PLH	PNL	NPH	NLP	STC	PNW	GRY	TGW
Replication	2	18.37	25.69	15.52	847.65	22.08	10.68	1.84	30070.78	92012.13	19678.49	16.78
Genotype	30	51.53	64.26**	63.62**	1358.44*	14.76*	66.14**	1.31	18833.11*	144930.11**	53089.98*	44.52
C vs (PH)	1	483.54**	51.29	99.88**	13871.43**	3.42	882.67**	0.17	111135.05	585546.90*	179081.64*	12.89
P vs H	1	90.73	18.14	45.49	257.47	0.07	25.02	0.09	1712.77	141060.03*	77689.29	16.70
Parent (P)	8	27.73	89.12**	90.87**	1322.00	11.65	34.48	1.67	27352.81*	247662.04*	97004.39**	2.39
Hybrid (H)	19	39.46	60.29**	54.55**	844.64	18.22*	42.14*	1.35	17543.31	86315.79	29468.07	67.74
Lines (L)	4	99.94**	147.86**	164.43**	1351.85	18.78	94.43	2.98	9919.56	196354.17	70879.58*	65.54
Tester (T)	3	18.98	40.77	17.60	266.09	15.24	6.60	0.86	1778.55	47333.33	16214.44	86.55
L × T	12	24.41	35.98*	27.16*	820.21	18.79*	33.60	0.93	24025.76*	59381.94	18977.64	63.77
Error	60	33.82	14.97	13.27	698.38	8.82	22.03	0.99	10115.69	88766.13	31967.94	44.25

Key:
NPE = Number of Plants at Emergence
DFF = Days to 50% Flowering
DHF = Days to 100% Flowering
PLH = Plant Height
PNL = Panicle Length
NPH = Number of Plants at Harvest
NLP = Number of Leaves/Plants
STC = Striga Count at 90 days after sowing
PNW = Panicle Weight
GRY = Grain Yield
TGW = 1000 Seed Weight

emergence, number of leaves/plant, and in 1000 grain weight. The differences among parents were significant or highly significant in days to 50% flowering, days to 100% flowering, striga count, panicle weight and grain yield. All the other parameters were not significantly different among the parents. On the other hand the results for hybrids shows that significant or highly difference were found only in days to 50% flowering, days to 100% flowering and number of plants at harvest. Similarly there was significant difference among lines i.e. females in number of plants at emergence, days to 50% flowering, days to 100% flowering and grain yield. There was however no significant difference in all the traits among the testers i.e. the male parents. The result further indicates that the interaction between line x tester were significant in days to 50% flowering, days to 100% flowering, panicle length and striga count at 90 days after sowing. All the other traits did not show any significant difference in line x tester interaction.

A close look at the results shows that difference were found among parents, lines, testers, among hybrids and as well as among the interaction between parents and hybrids and as well as between the interaction between line and tester. The interaction between parents and hybrids were significant only panicle weight.

The development of superior varieties or hybrids mainly depends on the magnitude of variation and heritability present in a base material. The results in this study exhibited significant differences among many traits, revealing tremendous levels of variability among cultivars and their hybrid crosses. The experimental material had a wide range of variability and had favourable mean performance for most of the traits investigated and these possible combinations could be exploited as potential hybrids aimed for simultaneous improvement of grain yield and other yield-attributing traits. Significant variability among traits have been reported to offer great opportunity for genetic improvement as superior hybrid crosses in traits of interest can easily be isolated from the rest. Genetic variability has been reported by Izge *et al*. (2017) as an important prerequisite to improvement of certain traits among pearl millet population. Similar outcome was also reported in pearl millet by Sanjana *et al*. (2020) and Balami *et al*. (2022).

Table 3: Mean Performance of Traits of Pearl Millets among Lines, Testers and their Corresponding Hybrid Crosses

Parents	Genotypes	NPE	DFF	DHF	PLH	PNL	NPH	NLP	STC	PNW	GRY	TGW
Testers												
1	PS 202	20.22abc	76.33a	80.33a	150.67c-f	24.33a-e	13.33cde	9.67a-d	100.33b-f	416.7b-g	233.3c-f	10.55b
2	Ex-Baga	14.33b-e	70.33a-f	75.00a-f	174.33a-f	27.67ab	8.33def	10.67ab	45.00ef	350.0e-g	191.7d-f	10.420b
3	Ex-Gubio	18.00a-d	70.67a-f	75.67a-e	173.33a-f	22.67c-f	12.67cdf	10.00a-d	65.67ef	450.0b-g	250.0b-f	10.47b
4	Ex-Monguno	18.67a-d	69.67b-f	74.67a-f	173.33a-f	25.00a-e	15.00b-d	9.00cd	29.33f	683.3a-g	383.3b-f	9.12b
Lines												
5	PEO 5984	20.00abc	57.00e	61.67j	155.00b-f	20.67ef	15.00b-d	8.67d	94.00c-f	483.3b-g	283.3b-f	10.12b
6	Super SOSAT	21.00ab	67.67d-i	70.00f-i	196.67ab	25.00a-e	16.33bc	10.67ab	348.67a	1166.7a	700.0a	11.99b
7	SOSAT C-88	23.00ab	67.33d-i	72.67d-g	196.67ab	25.67a-d	15.33cd	10.33abc	95.67c-f	900.0ab	533.3ab	11.95b
8	Ex-Borno	13.67b-e	67.33e-i	72.00d-h	133.33ef	23.33b-e	6.33ef	9.00cd	55.67ef	283.3fg	143.3ef	10.53b
9	LCIC 9702	19.67a-d	62.33h-k	66.33h-j	157.33b-f	24.00a-e	14.00b-d	10.00a-d	98.00b-f	700.0a-g	425.0a-f	10.18b
Hybrids												
10	PEO 5984 × PS 202	20.33abc	64.00h-j	69.33f-i	173.33a-f	24.33z-e	15.67bcd	9.67a-d	163.33b-f	683.3a-g	383.3b-f	9.70b
11	Super SOSAT × PS 202	15.33b-e	73.00a-e	78.00abc	155.00b-f	23.67abe	10.00c-f	10.00a-d	23.00f	383.3d-g	191.7d-f	10.52b
12	PS 202 × SOSAT C88	22.67ab	68.00c-i	75.00a-f	175.00a-e	26.67abc	15.33b-d	10.67ab	256.67abc	883.3abc	500.0abc	9.93b
13	Ex-Borno × PS 202	10.67de	67.67d-i	74.00b-f	173.33a-f	25.67a-d	9.67c-f	9.33b-d	134.33b-f	383.3d-g	211.7c-f	10.61b
14	PS 202 × LCIC 9702	16.00b-e	61.00jk	67.00g-j	141.67d-f	23.00b-f	10.33c-f	9.33b-d	54.33ef	400.0c-g	241.7b-f	10.73b
15	Ex-Baga × PEO 5984	16.00b-e	62.00i-k	67.00g-j	143.33c-f	21.33d-t	21.00ab	9.67a-d	144.33b-f	633.3b-g	33.3b-f	10.67b
16	Super SOSAT × Ex-Baga	15.00b-e	70.00b-g	74.33b-f	158.33b-f	25.33a-e	11.67c-f	10.00a-d	260.67ab	483.3b-g	283.3b-f	10.33b
17	SOSAT C88 × Ex-Baga	18.33a-d	68.33c-h	73.67b-f	185.00abc	25.00a-e	12.33c-f	11.00a	68.67ef	766.7a-f	425.0a-f	31.52a
18	Ex-Borno × Ex-Baga	8.33e	73.67a-d	79.00ab	163.33b-f	21.67d-f	5.33f	9.33bcd	31.00f	350.0e-g	166.7ef	12.19b
19	LCIC 9702 × Ex-Baga	16.67b-e	64.67f-j	69.33f-i	170.00b-f	23.33b-e	12.00c-f	10.33abc	77.67ef	533.3b-g	323.3b-f	10.67b
20	PEO 5984 × Ex-Gubio	17.33a-e	69.33b-g	72.33c-g	141.67d-f	27.67ab	10.33c-f	9.00cd	48.67ef	600.0b-g	316.7b-f	10.61b
21	Super SOSAT × Ex-Gubio	17.33a-e	70.00b-g	75.33a-e	175.67a-e	23.33b-e	9.67c-f	9.00cd	60.00ef	350.0e-g	200.0d-f	11.24b
22	SOSAT C88 × Ex-Gubio	15.33b-e	71.67a-e	76.33a-d	158.33b-f	26.67a-c	8.67d-f	10.00a-d	86.67d-f	433.3b-g	233.3c-f	11.09b
23	Ex-Borno × Ex-Gubio	15.67b-e	70.67a-f	75.67a-e	176.67a-d	22.33c-f	11.67c-f	9.33b-d	110.33b-f	500.0b-g	266.7b-f	11.38b
24	LCIC 9702 × Ex-Gubio	21.00ab	68.33c-h	72.33c-g	196.67ab	27.00abc	15.67b-d	10.33abc	240.67a-d	783.3a-e	433.3a-e	10.42b
25	PEO 5984 × Ex-Monguno	18.00a-d	59.00jk	64.33ij	131.67f	18.33f	13.33cde	8.67d	94.33c-f	383.3d-g	200.0d-f	9.29b
26	Super SOSAT × Ex-Monguno	11.33c-e	74.00abc	78.67ab	158.33b-f	21.67d-f	8.33d-f	11.00a	52.00ef	383.3d-g	200.0d-f	10.21b
27	SOSAT C88 × Ex-Monguno	19.00a-d	69.33b-g	74.33b-f	183.33a-d	24.33a-e	14.00b-d	10.00a-d	207.00a-e	616.7b-g	366.7b-f	10.21b
28	Ex-Borno × Ex-Monguno	14.67b-e	75.00ab	79.00ab	151.67c-f	24.33a-e	5.33f	9.67a-d	33.33f	250.0g	133.3f	9.42b
29	LCIC 9702 × Ex-Monguno	21.67ab	72.67a-e	77.00a-d	173.33a-f	28.33a	15.00b-d	10.67ab	116.67b-f	533.3b-g	283.3b-f	10.06b
	S E±	3.36	2.23	2.10	15.26	1.71	2.71	0.58	58.07	172.01	103.23	3.84

Key:
NPE = Number of Plants at Emergence, NLP = Number of Leaves/Plants
DFF = Days to 50% Flowering,
DHF = Days to 100% Flowering, STC = Striga at 90 Days after Sowing
PNW = Panicle Weight, NPH = Number of Plants at Harvest
PLH = Plant Height, GRY = Grain Yield
PNL = Panicle Length, TGW = 1000 Seed Weight

Mean Performance of Lines, Testers and their Hybrid Crosses

The average mean performances in respect of the traits evaluated among lines, testers and their corresponding hybrid crosses are presented in (Table 3). The results indicated that SOSAT C88, among the parents and PS 202 × SOSAT C88, LCIC 9702 × Ex-Gubio and LCIC 9702 × Ex-Monguno among the hybrids had the best establishment rates in terms of number of plants at emergence. The results also indicated that PEO 5984 was the earlier to flower among parents and even among hybrid crosses with days to 50% flowering and days to 100% flowering of

57 and 62 respectively. The tester PS 202 took longer period of time to reach 50% and 100% flowering compared to the other parents and all the hybrid crosses. However, Ex-Borno x Ex-Monguno took longer periods to reach 50% and 100% flowering among the other hybrid crosses. Super SOSAT, SOSAT C88 are parents having the tallest plants (196.67 cm) among parents and incidentally the hybrid LCIC 9702 × Ex-Gubio was the tallest plants among the hybrid crosses also with a height of 196.67 cm. Similarly the result for panicle length shows that the hybrid cross LCIC × Ex-Monguno had the longest panicle length of 28.33 cm surpassing all the panicle lengths across parents and hybrid crosses. In another development the results shows that Ex-Baga × PEO 5984 had the highest number of plants at harvest. Highest number of plants at harvest did not correspond with the number of plants at emergence as should be expected. It is indicative that most plants at emergence did not live to be counted at harvest probably due to effect of striga on the crop. The highest number of leaves/plant was recorded from the hybrid SOSAT C88 × Ex-Baga. The highest striga count at 90 days after sowing was recorded from Super SOSAT. Even though highest striga infestation was found on Super SOSAT, the results shows that Super SOSAT had the highest panicle weight of 1166.7 grams and a grain yield of 700 kg/ha. This result affirms the superiority of Super SOSAT as a tolerant variety to striga followed by SOSAT C88 which gave a yield of 500 kg/ha coming in second position in terms of grain yield. SOSAT C88 has also been reported to have some degree of tolerance to striga. Among the hybrids, PS 202 × SOSAT C88 had the highest grain yield and was incidentally among hybrid cross with high number of striga count. Most of the hybrids that were found to have high yield had Super SOSAT or SOSAT C88 as one of their parents.

SOSAT C88 × Ex-Baga had the heaviest seed compared to the parents and other hybrids. The same hybrid is among the hybrids that had the best results in terms of panicle weight. The results demonstrate significant variations across all traits among the testers, lines, and their respective hybrids. Parents or hybrid crosses that perform better in grain yield even under striga condition can be chosen for further breeding programmes targeting resistance to striga. Izge *et al*. (2017) have reported similar reported under non infested striga field and found that SOSAT C88 was among the best cultivar in terms of grain yield.

Genetic analysis

The variance components, genotypic coefficient of variation, phenotypic coefficient of variation and broad sense heritability are presented in (Table 4). The phenotypic variance (δ^2p) estimates of all the traits were greater than the genotypic variances (δ^2g). Generally, the environmental variances were very low and in some cases negligible as was similarly reported by Saleh *et al*. (2022). The result also shows that the phenotypic coefficients of variation are higher than all the corresponding genotypic coefficient of variation in all the traits. Since the genotypic variances are greater than the corresponding environmental variances in all the traits it means that genetic factors are preponderant than environmental factor in expression of the traits and this could lead to a swift progress in selection for certain traits of interest.

High phenotypic coefficient of variation of 154.46%, 88.26%, 70.4%, 66.43%, 55.69% and 46.74% were recorded for striga count, 1000 seed weight, grain yield, panicle weight, number of plants at harvest and number of plant at emergence respectively. On the other hand, low PCV were obtained in days to 50 percent flowering (13.35%) and days to 100 percent flowering 15.76%). Genotypic coefficient of variation within the range of 12.12% in days to 100% flowering to 125.37% in striga count was found. The GCV obtained for 1000 seed weight (62.37%), grain yield (56.62%) and panicle weight per plot (54.03) were intermediate between the extremes. This result is corroborating the one of Shaija *et al.* (2020). The broad sense and the narrow sense heritability are also presented in (Table 4). The result shows that broad sense heritability values are large in all the traits. The broad sense heritability values are greater in plants at emergence, days to 50% flowering, days to 100% flowering, plant height, plants at harvest and striga count. High estimates of broad sense heritability demonstrate very much the influence of environment in inheritance of traits. The higher values of heritability show that additive gene effects could be dominant in the expression of the traits. Similar result was reported by Upasna *et al*. (2021). All the traits had PCV values greater than GCV values, demonstrating tremendous level of genetic variability among the cultivars and the likelihood of greater scope for selection based on the traits. Higher PCV values than GCV values were also reported by Poonam *et al*. (2023). The traits involved could be influenced by much environmental factors and show high genetic variability.

Table 4 provides the estimates of numerous genetic parameters. Higher magnitude as indicated by the high PCV and GCV values for the numbers of plants at emergence, number of plants at harvest, striga count, panicle weight, grain yield and 1000 seed weight indicating the higher magnitude of variability for these traits and consequently more scope for their improvement through selection. Higher estimates of PCV than GCV have also been reported by Manga (2013) and Basavaraj *et al*. (2017). PCV and GCV estimates were moderate for plants at emergence, plants at harvest and panicle weight. This implied equal importance of additive and

Table 4: Variance components, phenotypic coefficient of variation, genotypic coefficient of variation and heritability estimates among traits of pearl millet

Traits	$\sigma^2 g$	$\sigma^2 p$	$\sigma^2 e$	PCV (%)	GCV (%)	h^2_{bs} (%)
No. Plants at Emergence	60.39	88.34	27.95	46.74	38.64	82.19
Days to 50% Flowering	83.55	104.55	21.00	15.76	14.09	90.27
Days to 100% Flowering	73.14	88.73	15.59	13.35	12.12	83.89
Plant Height	762.32	1557.36	795.04	22.55	15.78	73.18
Panicle Length	23.57	41.21	17.64	27.35	20.69	55.31
No. Plants at Harvest	58.97	79.01	20.04	55.69	48.12	87.97
Number of Leaves/Plant	1.39	2.62	1.23	19.32	14.07	49.08
Striga Count	10819.86	16423.96	5604.1	154.46	125.37	90.07
Panicle Weight	125817.30	190176	64358.68	66.43	54.03	36.30
Grain Yield	59871.69	92542.87	32671.18	70.40	56.62	69.76
1000 Seed Weight	37.05	74.2	37.15	88.26	62.37	57.50

non-additive gene action for the traits recorded. Similar results were reported by Talawar *et al.* (2017) and Anuradha *et al.* (2018). Low GCV and PCV were recorded for days to 50% flowering, days to 100% flowering and number of leaves per plant. These results are in agreement with the findings of Kumar *et al.* (2016), Pallavi *et al.* (2020) and Chauhan *et al.* (2020). Higher heritability of between 49.08% and 90.27% was recorded for all the traits except panicle weight which showed low heritability of 36.3%. The results are in corroborates the findings of Sumathi *et al.* (2010), Kumar *et al.* (2014), Singh and Singh (2016) and Talawar *et al.* (2017).

Conclusion

The performance among parents and particularly hybrid crosses had a wide range of variability and favourable mean performance for most of the traits investigated. These favorable combinations could be exploited as potential hybrids aimed for simultaneous improvement of grain yield and other yield attributing traits. The phenotypic variance was generally higher than the genotypic variances, revealing the role of environment in the expression of the cultivars used. It can be concluded that the values of PCV were higher than GCV for all the studied traits indicating high influence of the environment. Higher heritability of between 49.08% and 90.27% was recorded for all the traits except panicle weight which showed low heritability of 36.3%.

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