

IDENTIFYING PROMINENT GENOTYPES AND YIELD CONTRIBUTING TRAITS IN FINGER MILLET (*Eleusine coracana* L.)

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Bairwa U., B.R. Choudhary, R. Bhardwaj (2023). *Identifying prominent genotypes and yield contributing traits in finger millet (Eleusine coracana L.)*. - Genetika, Vol 55, No.3, 807-817.

The knowledge about genetic variability and determining the criteria for employing effective selection is always prerequisite to develop a sound breeding programme. Therefore, the present experiment was conducted with 35 genotypes of finger millet in Randomized Block Design (RBD) with three (03) replications and observations were recorded for morphological and quality traits. The analysis of variance exhibited substantial degree of variability among the genotypes for all the traits under study. The higher value of phenotypic coefficient of variance (PCV) than genotypic coefficient of variance (GCV) for all the traits under study indicated the influence of environment on expression of these traits. High heritability coupled with high genetic advance as percent of mean suggested that direct selection for the traits *viz.* iron content, test weight, calcium content, finger length, protein content, flag leaf area and days to 80% maturity may be carried out as these traits have preponderance of additive gene action. Similarly, character association results depicted that direct selection for the traits *viz.* flag leaf area, test weight, biological yield/plant, harvest index and iron content will be effective for tangible advancement in grain yield of this important millet. Further, Genetic divergence study for identifying such promising genotypes revealed that among the seven clusters, Cluster III and cluster VII were most divergent hence genotypes *viz.*, MLS 1, MLS 5, GPU 67, VL 376 and Indira Ragi from these clusters may throw useful segregates in upcoming generations.

Keywords: Genetic Variability, Genetic Divergence, Selection Criteria, Heritability, Character Association

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INTRODUCTION

Finger millet is an important millet crop which is largely grown in the arid and semi-arid areas of Africa and Asia. In India, it is cultivated in an area of 11.94 lakh hectares with the production of 19.85 lakh tones and productivity of 1662 kg per hectare (ANONYMOUS, 2019). Presently the cultivation of finger millet is increasing in western part of India due to its amazing qualities to withstand long drought, higher temperature and low soil fertility. It is usually called as "Nutritional Millet" as its grains are nutritionally superior over other cereals. The grains contain high amount of calcium (162.0-358.0 mg/100g) (MANJULA *et al.*, 2015) and some other minerals *viz.*, iron (3-20 mg/100g), magnesium (78-201 mg/100g) and zinc (2.3 mg/100g) (RAJIV *et al.*, 2011; SHUKLA and SRIVASTAVA, 2014).

Despite of its nutritional quality and ability to withstand in adverse climatic conditions, the crop has not gained enough attention especially in western part of India due to the lack of sufficient research on the genetic parameters like variability, inheritance and determination of selection criteria in this crop. As it is very well known that the presence of ample amount of variability always allows a breeder to choose from various traits and develop a superior variety in all possible aspects while on the other hand heritability plays a predictive role in breeding value which determines how much of the phenotype would be passed onto the next generation (TAZEEN *et al.*, 2009). Likewise, correlation and path analysis provide a measure of determining yield contributing characters which may be useful in direct and indirect selection. Therefore, the knowledge of genetic diversity and inheritance pattern in such a new crop is pre-requisite for establishing a successful breeding programme.

MATERIALS AND METHODS

Experimental detail

The field experiment was conducted with 35 genotypes at Agricultural Research Station, Mandor (Jodhpur) during *kharif*, 2020. The experiment laid out in Randomized Block Design (RBD) with three replications. Each entry was grown in four rows of 3 meter length with the spacing of 45 cm between rows and 10 cm between the plants. All recommended cultural practices were carried out to raise a good crop.

Observations recorded

Data were recorded for 14 morphological and quality parameters. Among which two observations *viz.*, days to 50% flowering and days to 80% maturity were recorded on whole plot basis while characters *viz.*, plant height, flag leaf area, effective tillers/plant, fingers/ear, finger length, grain yield/plant, biological yield/plant and harvest index were recorded by randomly selecting five plants from each replication. Likewise, test weight and quality parameters *viz.* protein content, calcium content and iron content were analyzed by taking a sample of required seed quantity from the bulk produce of the plot. Protein content in seed (%) was calculated by estimating nitrogen in the sample using Micro-Kjeldal method (A.O.A.C., 1970), calcium content (mg/100g) using the Versenate titration method (JACKSON, 1967) while Iron content was estimated by the procedure of Atomic Absorption Spectrophotometer method (VARIAN A.A.S.).

Analysis

Statistical analysis was performed using Window Stat version 9.1 software (SAS, 2003). On the basis of heritability values, traits were categorized into low (<30%), moderate (30-60%) and highly (>60%) heritable. Similarly, genetic advance was also classified into three categories i.e. low (<10%), moderate (10-20%) and high (>20%) influence on the respective trait (JOHNSON *et al.*, 1955).

RESULTS AND DISCUSSION

Analysis of variance revealed the presence of ample amount of variability among different genotypes for all the traits under investigation (Table 1). The presence of sufficient variability in finger millet has also been previously reported by KARAD *et al.* (2013), SAUNDARYA and SATISH (2015) and ULAGANATHAN and KUMARI (2015).

Table 1. Analysis of variance (ANOVA) for grain yield and its contributing traits

Source	Replication	Treatment	Error
Degree of freedom	2	34	68
Days to 50% flowering	3.00	20.31**	1.36
Days to 80% maturity	0.6	256.81**	17.01
Plant height (cm)	1.99	156.50**	16.71
Flag leaf area (cm ²)	0.26	18.92**	0.81
Effective tillers/plant	0.05	0.24**	0.09
Fingers per ear	0.01	1.32**	0.26
Finger length (cm)	0.01	4.80**	0.06
Test weight(g)	0.00	0.82**	0.00
Grain yield/plant (g)	2.58	7.48**	1.03
Biological yield/plant (g)	10.12	13.24**	3.91
Harvest index(%)	21.95	143.89**	13.51
Protein (%)	0.24	3.00**	0.09
Calcium (mg/100g)	43.20	2904.41*	14.05
Fe (mg/100g)	0.05	1.45**	0.01

The phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all the characters studied indicating the influence of environment on the traits. High estimates of PCV and GCV (Fig. 1) were recorded for the characters *viz.* iron content, grain yield/plant and finger length while low estimates were found for days to 80% maturity and effective tillers/plant. These results indicated greater scope of selection for the characters having high values, as substantial variability is present in the studied material for these traits. Similar trend of high variability was also reported by SAUNDARYA and SATISH (2015) for grain yield/plant and of low variability by KARAD and PATIL (2013). High heritability coupled with high genetic advance (Fig. 1) as per cent of mean was observed for days to 50% flowering, days to 80% maturity, finger length, flag leaf area, test weight, protein content and iron content indicating lesser influence of environment in expression of these characters. These results depicted the preponderance of additive gene action hence; simple selection will be effective scheme for improvement of these traits. These results are in conformity with the earlier findings

of SATISH *et al.* (2007) and JAYSHREE and NAGARAJAIAH (2013) for finger length, test weight and protein content; SAUNDARYA and SATISH (2015) and KARAD and PATIL (2013) for days to 80% maturity and flag leaf area; SALINI *et al.* (2010) for days to 50% flowering and iron content.

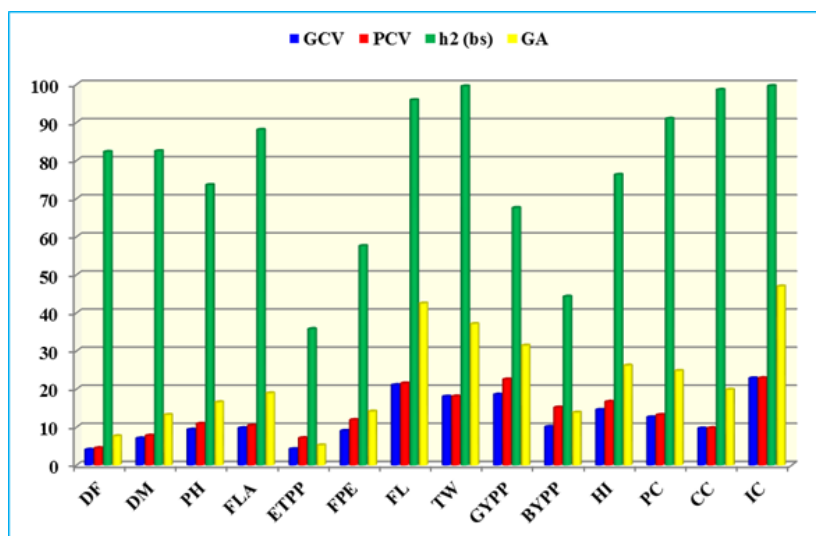


Fig. 1. GCV, PCV, Heritability and Genetic Advance as percent of mean

DF: days to 50% flowering; DM: days to 80% maturity; PH: plant height; FLA: flag leaf area; ETPP: effective tillers/ plant; FPE: fingers/ ear; FL: finger length; TW: test weight; GYPP: grain yield/ plant; BYPP: biological yield/ plant; HI: harvest index; PC: protein content; CC: calcium content; IC: iron content

Perusal of Table 2. exhibited that grain yield/plant had positive significant correlation coefficient at both genotypic and phenotypic level with harvest index, biological yield/plant, flag leaf area and test weight; protein content with days to flowering; calcium content with plant height and iron content with test weight and flag leaf area whereas flag leaf area with grain yield/plant; days to maturity with calcium content and harvest index with iron content showed the same results at phenotypic level only. These results advocated that selection for the traits having positive significant correlation may be helpful in improvement of grain yield/plant and other quality traits. These results are in agreement with reports of GANAPATHY *et al.* (2011) for finger length; BHASKER *et al.* (2017) for biological yield/plant and harvest index; SINGH *et al.* (2018) for harvest index. Hence under such circumstances, judicious and effective selection programme might be formulated for simultaneous improvement of such important developmental and component traits.

Further, negative significant correlation of days to maturity was revealed with grain yield/plant which revealed that grain yield decreased in late maturing genotypes. Likewise, finger length and finger per ear also showed negative significant correlation at both the levels with protein content and iron content, receptively. Fingers per ear showed negative significant correlation only at phenotypic level with protein content and at only at genotypic level with calcium content.

Table 2. Genotypic and Phenotypic correlation coefficient of different traits with yield and quality traits

Traits	Genotypic/ Phenotypic	Correlation Coefficient	
		Positive Significant	Negative Significant
Grain yield/ plant	G	HI (0.835), BYPP (0.674), FLA (0.425), TW (0.346), FL (0.233),	DM (-0.508)
	P	BYPP (0.728), HI (0.698), FLA (0.326), TW (0.289),	DM (-0.375)
Protein content	G	DF (0.262)	FL (-0.325)
	P	DF (0.241)	FL (-0.305), FPE (-0.258)
Calcium content	G	PH (0.352)	FPE (-0.272)
	P	PH (0.308), DM (0.282)	
Iron content	G	TW (0.600), FLA (0.293)	FPE (-0.262)
	P	TW (0.598), FLA (0.274), HI (0.258)	FPE (-0.201)

DF: days to 50% flowering; days to 80% maturity; PH: plant height; FLA: flag leaf area; FPE: fingers/ ear; FL: finger length; TW: test weight; GYPP: grain yield/ plant; BYPP: biological yield/ plant; HI: harvest index;

The result of path coefficient analysis (Table 3a & 3b) showed that the characters like biological yield/plant, harvest index and calcium content had direct and positive effect on grain yield/plant at both phenotypic and genotypic levels. Negative direct effects were shown by days to maturity, days to 50% flowering and number effective tillers/plant on grain yield/plant at both the levels whereas with plant height at genotypic level only. The traits *viz.*, flag leaf area, test weight, biological yield/plant and harvest index had positive indirect effect on grain yield/plant. These results are in agreement with the reports of KUMAR *et al.* (2014), BHASKER *et al.* (2017) and NEGI *et al.* (2017) for direct positive effect of biological yield/plant and harvest index. Negative direct effect of plant height with grain yield/plant was reported by DAS *et al.* (2013) and JADHAV *et al.* (2015). The residual effect found the dependency of grain yield/plant on independent characters for variability. The value of residual effects at genotypic and phenotypic level was 0.02 and 0.09 respectively. Out of fourteen causal factors studied for path coefficient analysis only two traits *viz.*, biological yield/plant and harvest index showed positive significant correlation along with maximum positive direct as well as indirect contributions through other characters on grain yield. Hence these traits are to be considered as important quantitative traits in finger millet improvement program and direct selection for these traits would be fruitful.

Out of the seven clusters formed (Fig. 2), cluster I was the largest comprising of fifteen genotypes followed by cluster II (12), cluster III (04) and clusters IV, V, VI and VII were mono-genotypic clusters, suggesting the existence of high degree of heterogeneity among the genotypes. The highest contribution in genetic divergence (Fig. 3) was incorporated by test weight (42.52%) followed by finger length (4.54%) and protein content (2.18%), indicating that the studied genotypes were more variable for these traits

Intra cluster D^2 values ranged (Fig. 4) from zero (cluster IV, V, VI, VII) to 179.19 (cluster III). Maximum intra cluster distance was observed in cluster III (179.19), followed by cluster II (155.60). The inter cluster distance was greater than intra cluster distance (Fig 3), indicating the presence of wide genetic diversity among the genotypes of different clusters.

Table 3a: Phenotypic and genotypic path coefficients among yield attributes in finger millet genotypes

Characters		Days to 50% flowering	Days to maturity	Plant height	Flag leaf area	Effective tillers/plant	Fingers Per ear	Finger length	Test weight	Biological yield/plant	Harvest index	Protein content	Calcium content	Iron content
Days to 50% flowering	P	-0.047	-0.003	0.004	-0.004	-0.003	0.004	0.002	-0.009	-0.001	-0.006	-0.011	0.001	-0.005
	G	-0.034	-0.003	0.003	-0.003	-0.006	0.005	0.002	-0.007	-0.003	-0.004	-0.009	0.004	-0.004
Days to 80% maturity	P	-0.005	-0.006	0.002	0.002	0.004	0.001	0.001	-0.003	0.002	0.001	0.001	-0.001	-0.002
	G	-0.004	-0.048	-0.012	0.020	0.008	0.015	0.012	-0.002	0.030	0.009	0.001	-0.015	-0.001
Plant height(cm)	P	-0.000	0.003	0.001	0.000	0.001	0.000	-0.001	-0.002	0.001	-0.001	0.001	0.000	-0.002
	G	0.002	-0.005	-0.021	-0.006	-0.003	0.003	0.001	0.003	-0.001	0.001	-0.014	-0.007	0.003
Flag leaf area(cm ²)	P	-0.000	0.002	0.000	-0.007	0.007	-0.002	-0.001	-0.003	-0.001	-0.001	-0.006	-0.001	-0.002
	G	0.014	-0.071	0.004	0.166	-0.036	0.081	0.035	0.074	0.064	0.041	0.009	0.002	0.048
No. of Effective tillers/plant	P	-0.000	0.007	-0.007	0.009	-0.009	-0.000	-0.001	0.001	-0.009	0.001	-0.003	0.003	0.003
	G	-0.006	0.006	-0.005	0.007	-0.035	-0.001	-0.013	0.011	-0.004	0.001	0.006	0.001	0.022
No. of Fingers per ear	P	-0.001	-0.003	0.003	0.005	0.001	0.001	0.000	-0.001	0.001	-0.001	-0.04	-0.003	-0.003
	G	0.028	0.055	0.025	-0.085	-0.007	-0.174	-0.014	0.025	0.001	0.016	0.063	0.047	0.045
Finger length (cm)	P	-0.001	-0.004	-0.001	0.003	0.003	0.001	0.019	0.005	0.002	0.001	-0.005	0.0021	-0.002
	G	0.002	0.007	0.002	-0.006	-0.001	-0.002	-0.002	-0.000	-0.006	-0.003	0.009	-0.00	0.003

Residual effect (G) =0.02, (P) =0.09, Bold values represents direct effects, P =Phenotypic path coefficient and G=Genotypic path coefficient

Table 3b: Phenotypic and genotypic path coefficients among yield attributes in finger millet genotypes

Characters		Days to 50% flowering	Days to maturity	Plant height	Flag leaf area	Effective tillers/plant	Fingers Per ear	Finger length	Test weight	Biological yield/plant	Harvest index	Protein content	Calcium content	Iron content
Test weight (g)	P	0.008	0.002	-0.005	0.018	-0.008	-0.004	0.001	0.044	0.014	0.015	-0.058	0.000	0.026
	G	-0.005	-0.001	0.003	-0.011	0.008	0.003	-0.007	-0.025	-0.009	-0.010	0.003	0.000	-0.015
Biological yield/plant (g)	P	0.028	-0.253	0.042	0.154	0.071	0.053	0.104	0.021	0.706	0.023	0.017	-0.055	-0.019
	G	0.048	-0.297	0.001	0.180	0.061	-0.004	0.109	0.015	0.465	0.079	0.040	-0.051	-0.021
Harvest index (%)	P	0.085	-0.121	-0.031	0.155	-0.006	-0.031	0.065	0.235	0.021	0.663	-0.034	0.012	0.171
	G	0.090	-0.146	-0.056	0.178	-0.031	-0.066	0.075	0.295	0.123	0.721	-0.055	0.013	0.215
Protein content (%)	P	0.005	-0.005	0.007	0.001	0.007	-0.005	-0.007	-0.003	0.006	-0.001	0.022	0.004	-0.003
	G	-0.014	0.001	-0.003	-0.003	0.001	0.020	0.018	0.008	-0.005	0.004	-0.056	-0.011	0.008
Calcium content (mg/100g)	P	-0.008	0.008	0.009	0.003	-0.009	-0.005	0.003	0.001	-0.002	0.005	0.005	0.029	-0.001
	G	-0.001	0.003	0.003	0.001	-0.005	-0.002	0.001	0.001	-0.001	0.002	0.002	0.009	-0.005
Iron content (mg/100g)	P	0.003	0.001	-0.003	0.006	-0.009	-0.005	-0.002	0.001	-0.001	0.006	0.000	-0.001	0.002
	G	-0.011	-0.003	0.012	-0.024	0.053	0.022	0.009	-0.050	0.003	-0.025	0.001	0.003	-0.083
Grain yield/plant (g)	P	0.076	-0.375	0.018	0.326**	0.048	0.010	0.187	0.289**	0.728**	0.698**	-0.012	-0.007	0.172
	G	0.109	-0.508	-0.044	0.425**	0.011	-0.097	0.233	0.346**	0.674**	0.839**	-0.003	-0.063	0.209
Partial R ²	P	-0.036	0.002	0.000	-0.002	-0.004	0.000	0.003	0.012	0.515	0.463	-0.003	-0.002	0.004
	G	-0.003	0.024	0.001	0.070	-0.004	0.017	-0.006	-0.009	0.314	0.602	0.000	-0.001	-0.017

Residual effect (G) =0.02, (P) =0.09, Bold values represents direct effects, P =Phenotypic path coefficient and G =Genotypic path coefficient

Maximum inter cluster distance was recorded between cluster III and cluster VII (1227.61) having genotypes (Fig. 2) MLS 1, 56 MLS 5, GPU 67, VL 376 and Indira ragi followed by cluster I and cluster VII (1200.82) having genotypes (Fig. 2) MLS 4, MLS 7, BM 1, KOPN 235, CO 14, VR 847, ML 365, Paiyur 2, Indaf 7, KMR 301, MLS 9, MLS 2, MR 6, GPU 45, GPU 66 and Indira Ragi. Cluster distance is directly proportional to the wider genetic diversity between the genotypes of concerned clusters. Highly divergent genotypes would be of great use in recombination breeding programme in order to make highly desirable recombinants.

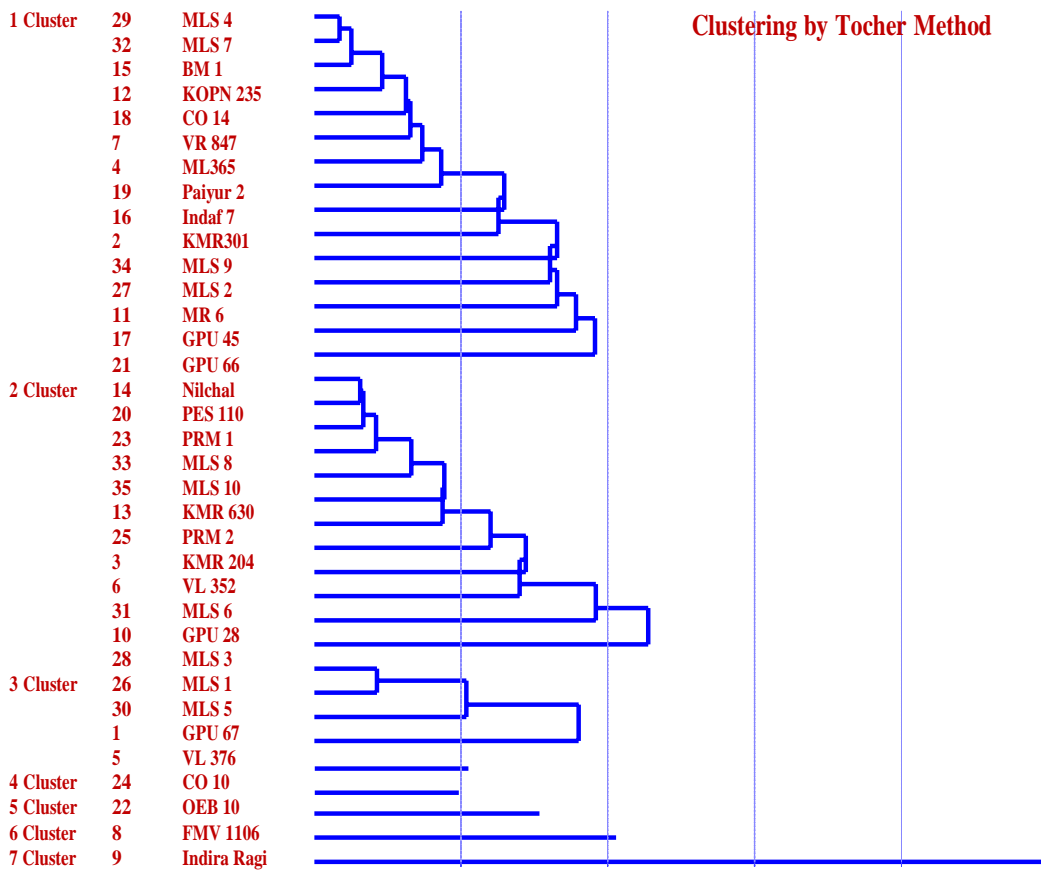


Fig. 2. Clustering by Tocher's Method

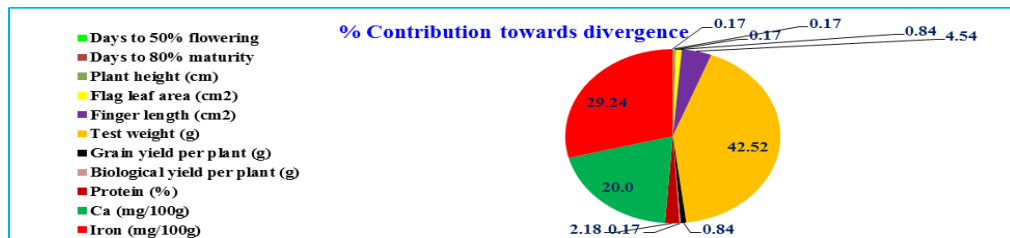


Fig. 3. Percent contribution of different traits toward genetic divergence

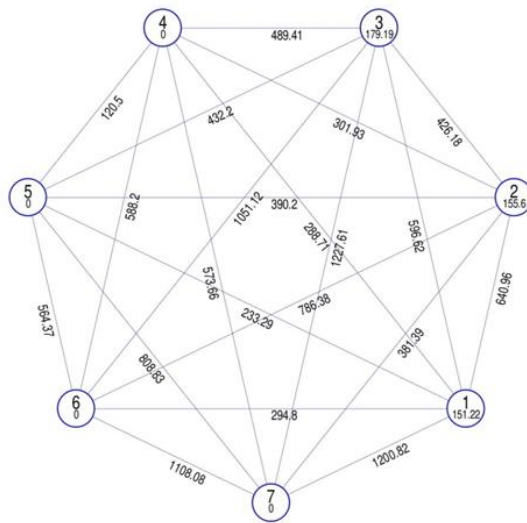


Fig. 4. Mahalanobis Euclidean Distance

The mean values of different characters (Table 4) revealed the superiority of respective genotypes for different traits. The genotypes grouped in cluster I had more number of Effective tillers/plant and fingers per ear; genotype OEB 10 in cluster V had early maturity with high protein content. Likewise, the genotype Indira ragi (cluster VII) had high grain yield/plant, biological yield/plant, calcium content and early maturity. Therefore, the genotypes from these clusters may be selected as a parent in future crossing programme to incorporate the characters for which these genotypes have depicted superiority.

Table 4. Cluster means of finger millet genotypes for grain yield and its contributing traits

Characters	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI	Cluster VII
Days to 50% flowering	60.53	61.78	60.75	62.67	64.33 ^H	60.00 ^L	60.00 ^L
Days to 80% maturity	125	128.58	127.33	133.00 ^H	114.00 ^L	122.33	115.33
Plant height(cm)	73.62	73.52	68.88	69.87	80.40 ^H	68.27 ^L	68.53
Flag leaf area (cm ²)	24.27	26.21	23.77 ^L	25.83	26.23	24.07	28.23 ^H
Effective tillers/plant	5.39 ^H	5.15	4.98 ^L	5.33	5.20	5.33	5.07
fingers per ear	6.69 ^H	6.51	6.37	6.60	6.60	6.60	6.33 ^L
Finger length (cm)	6.21	5.91	5.04	7.65 ^H	3.93 ^L	6.09	6.77
Test weight (g)	2.47 ^L	3.43	2.58	2.93	2.75	2.86	4.21 ^H
Grain yield/Plant (g)	7.74	7.98	7.34	5.41 ^L	8.93	8.74	12.22 ^H
Biological yield/plant	18.00	16.86	16.23	14.34 ^L	19.67	17.84	21.59 ^H
Harvest index (%)	42.99	47.44	45.14	37.52 ^L	45.22	49.32	56.63 ^H
Protein (%)	7.93	7.63	7.85	8.35	9.23 ^H	6.27 ^L	7.42
Calcium (mg/100g)	319.56	317.44	309.42	372.00 ^H	351.67	266.67 ^L	350.67
Iron (mg/100g)	2.44	3.61	3.96 ^H	2.93	2.75	1.94 ^L	3.24

H=highest, Lowest

CONCLUSION

Conclusively, this may be advocated that simple selection scheme would be sufficient for the traits finger length, test weight and iron content to bring genetic improvement in desired direction as they were having high heritability associated with high genetic advance. Further,

selection for the traits *viz.*, flag leaf area, test weight, biological yield/plant, harvest index and iron content may lead to the direct improvement in grain yield/plant. Likewise, tangible advancement for grain yield and quality in finger millet could be possible by including the most divergent genotypes namely MLS 1, MLS 5, GPU 67, VL 376 and Indira ragi from Cluster III and cluster VII in hybridization programme as they are supposed to throw advantageous segregates for grain yield and quality in upcoming generations.

ACKNOWLEDGEMENT

The authors would like to acknowledge the AICRP Small Millet, PC Unit, UAS, GKVK, Bengaluru and AICRP on Small millet center of College of Forestry, Ranichauri for providing the experimental material. We are also thankful to the authorities of CoA, Jodhpur and ARS, Mandor for providing necessary facilities and resources for conducting the research work successfully.

Received, April 16th, 2023

Accepted November 28th, 2023

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IDENTIFIKOVANJE ISTAKNUTIH GENOTIPOVA I OSOBINA KOJE DOPRINOSU PRINOSU KOD PROSA (*Eleusine coracana* L.)Ujala BAIRWA¹, B.R. CHOUDHARY² and Rahul BHARADWAJ^{2*}¹Odeljenje za genetiku i oplemenjivanje biljaka, Poljoprivredni fakultet, Džodpur, Poljoprivredni univerzitet, Džodpur, Indija²Genetika i oplemenjivanje biljaka, ARS, Mandor, Poljoprivredni univerzitet, Džodpur, Indija**Izvod**

Poznavanje genetske varijabilnosti i određivanje kriterijuma za primenu efektivne selekcije uvek su preduslov za razvoj dobrog programa oplemenjivanja. Prema tome, ovaj eksperiment je sproveden sa 35 genotipova prosa u Randomizovanom Blok Dizajnu (RBD) sa tri (03) ponavljanja i zapažanja su zabeležena za morfološke i kvalitetne osobine. Analiza varijanse pokazala je značajan stepen varijabilnosti među genotipovima za sve ispitivane osobine. Veća vrednost fenotipskog koeficijenta varijanse (PCV) od genotipskog koeficijenta varijanse (GCV) za sve ispitivane osobine ukazuje na uticaj sredine na ekspresiju ovih osobina. Visoka naslednost u kombinaciji sa visokim genetskim napretkom kao procentom srednje vrednosti sugerise da direktna selekcija za osobine, tj. sadržaj gvožđa, težina testa, sadržaj kalcijuma, sadržaj proteina, površinu lista i dani do 80% zrelosti mogu da se sprovedu jer ove osobine imaju prevagu aditivnog delovanja gena. Slično, rezultati povezanosti osobina oslikavaju direktnu selekciju za osobine, tj. površina lista zastavičara, testna težina, biološki prinos/biljka, indeks žetve i sadržaj gvožđa biće efikasni za poveanje prinosa zrna prosa. Dalje, studija genetičke divergencije za identifikaciju takvih obećavajućih genotipova otkrila je da su među sedam klastera, klaster III i klaster VII bili najdivergentniji, stoga genotipovi MLS 1, MLS 5, GPU 67, VL 376 i Indira Ragi iz ovih klastera mogu biti korisni u narednim generacijama.

Primljeno 16.IV.2023.

Odobreno 28. XI 2023.