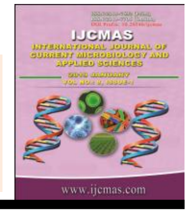
Int.J.Curr.Microbiol.App.Sci (2019) *8*(1): 613-624

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 8 Number 01 (2019)**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2019.801.069

Genetic Analysis for Micronutrients and Grain Yield in Relation to Diverse Sources of Cytoplasm in Pearl Millet [*Pennisetum glaucum* (L.) R. Br.]

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Keywords

Combining ability, Micronutrients, Total carotenoid, Gene action, Heterosis and pearl millet

Article Info

Accepted:
07 December 2018
Available Online:
10 January 2019

A B S T R A C T

Combining ability and heterosis studies with respect to grain quality traits viz., iron, phosphorus, calcium, magnesium, total carotenoids and grain yield were carried out from a 8 x 10, line x tester mating design in pearl millet. The analysis of variance for combining ability revealed that hybrids and parents exhibited significant differences for all characters studied. The general combing ability effects of lines and specific combing ability effects of hybrids showed significant differences for micronutrients, total carotenoids and grain yield. The cytoplasmic sources $81A_{egp}$ and $81A_4$ for grain yield, $81A_1$ and $81A_2$ for iron content, phosphorus and calcium; $81A_{egp}$ and $81A_4$ for magnesium content; and $81A_5$ and $842A_1$for total carotenoids proved to be good general combiners for specific characters. Beside grain yield, $81A_1$ also exhibited significant and positive gca effects for iron, calcium, magnesium, phosphorus and total carotenoids in one or more than one environment. The predictability ratio $[2\sigma^2gca/(2\sigma^2gca + \sigma^2sca)]$ was not near unity for all grain quality traits and grain yield, implying preponderance of non additive gene action clearly indicting that usefulness of heterosis breeding for these traits. A few crosses combined high grain yield with mineral content and total carotenoids e.g. the cross $842A_1$ x H77/833-2 expressed high significant positive heterosis for grain and total carotenoids; and $81A_1$ x H77/29-2 not only manifested high positive heterosis for grain yield but also exhibited high significant and positive heterosis for iron, phosphorus and calcium content. These two crosses deserve to be tested multilocationally to confirm their performance.

Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is a major source of dietary energy and nutritional security for a vast population in arid and semi-arid regions of Asia and Africa. Dietary deficiency of mineral micronutrients has been recognized as a worldwide human health problem, especially in the developing countries (Welch and Graham, 2004). One sustainable agricultural approach to reducing micronutrient malnutrition among people at highest risk (i.e., resource-poor women, infants and children) globally is to enrich major staple food crops with micronutrients through plant-breeding strategies (Welch, 2002; Bouis, 2002). In the developing countries where sorghum and millets are important food crops, a large number of populations suffer from chronic malnutrition.

Improving nutritional equally along with increased grain yield by breeding, offers a cost effective and sustainable solution to micronutrients malnutrition in resource poor communities.

Pearl Millet possesses the highest amount of calories 360 per 100 g (Burton *et al.,* 1972) which is mainly supplied by carbohydrates, fat and protein. It is also cheapest source of micronutrients compared to cereals and vegetables (Rao, 2006). Velu, *et al.,* (2008) reported large genetic variability for minerals (iron and zinc content) among pearl millet germplasm, breeding lines and populations. Therefore, an estimate of genetics and combining ability is important in selection of parents to be used in a breeding programme aimed at improving mineral contents, total carotenoids and grain yield. The present investigation was undertaken to evaluate the nature of combining ability and standard heterosis for iron, calcium, magnesium, phosphorus, total carotenoids and grain yield by using diverse source of iso-nuclear cytoplamic male sterile lines across three environments.

Materials and Methods

The material for present study consisted of eight male sterile lines representing six cytoplasmic male sterility systems. Three iso-steriles of A_1 system, (MS81 A_1, MS842A_1, MS843A_1) and one each of A_2 (MS81A_2), A_3 (MS81A_3), A_4 (MS81A_4), A_5 (MS81A_5), and A_{egp} (MS 81A_{egp}) and ten male fertility restorer lines viz. H90/4-5, H77/833-2, H77/371, H78/711, H77/29-2, G73-107, INB 87/74, INB 427, INB 526 and INB 1250. The eight male sterile lines were crossed with ten restorers in line × tester mating design at the Research Farm, Chaudhary Charan Singh Haryana Agricultural University, Hisar, during *kharif* 2002. The 80 hybrids, thus produced along with check hybrid (HHB 94) were grown in three environments, designated here as E1, E2 and E3. The crop in environment (E1) was planted on 7th July, 2003 at dry land research station, RRS Bawal, CSS HAU Hisar. The crop in environment E2 in Department of Plant Pathology and in E3 at Research Farm, Bajra Section, CCS HAU, Hisar, was planted on 15th July, 2003. The experiment was raised in a simple lattice design with two replications in each environment. Each entry was accommodated in a single row of 4 m length spaced at 0.45 m with 20 cm intra-row spacing. All the recommended agronomic practices were followed to raise a good crop.

The observations on grain yield (g/plant) were recorded on five randomly taken competitive plants of each genotype in each replication. The bulk grain samples of these five plants in each replication were taken for estimation of mineral contents. Iron (mg/100g) was estimated on Atomic Absorption Spectrophotometer. The estimation of calcium (mg/100g) was made by using the Versenate method (Cheng and Bray, 1951); the phosphorus content (mg/100g) was determined by Vanado-molybdo phosphoric acid yellow colour method (Koening and Johnson, 1942). The total carotenoids content (mg/100g) was analysed by using the method given in AOAC (1990). The analysis of variance was done using simple lattice experimental design (Cochran and Cox, 1950). The combining ability analysis was performed following Kempthorne (1957). Standard heterosis was estimated as per standard procedure.

Results and Discussion

Combining ability analysis

Mean sum of squares due to genotypes exhibited highly significant variation for all the character studied. Thus partitioning of the genotype sum of squares into hybrid, line, tester and line × tester was appropriate. The analysis of variance for combining ability (Table 1) revealed that the mean sum of squares due to line, testers and lines × testers were highly significant indicting variation for general and specific combing ability effects.

Higher estimates of specific combining ability (SCA) variances than general combing ability (GCA) variances were observed for all the micronutrients, total carotenoids and grain yield reflect greater role of non-additive type of gene action in expression of these traits (Table 1). The predictability ratio ($2\sigma^2$gca/($2\sigma^2$gca + σ^2sca)) was less than unity for grain yield, total carotenoid and all the micronutrients under investigation supported for non-additive gene action. These results are in conformity with to the earlier reports for grain yield (Karale *et al.,* 1997), total carotenoid in grains (Khangura *et al.,* 1980), calcium in stem (Gill *et al.,* 1993) and calcium and phosphorus in leaves and stem (Chawla and Gupta, 1982) in pearl millet.

General combining ability (GCA) effects for lines and testers are presented in Table 2. None of cytoplsmic male sterility source proved to be good general combiner for all the traits. However, GCA effects for grain yield were significant and positive for $842A_1$, 81 A_{egp} and $81A_4$ cytoplasm lines and negative for $81A_2$ in all most all the environments. This suggests superiority of A_1 A_{egp} and A_4 cytoplasm over other sources for producing high yielding hybrids. For micronutrients, the lines $81A_1$ & $81A_2$ for iron content, phosphorus and calcium, $81A_{egp}$ and $81A_4$ for magnesium content; and $81A_5$ and $842A_1$for total carotenoids proved to be good general combiners for these characters. But nevertheless, $81A_1$ exhibited significant and positive gca effects for grain yield (E1), iron (E1, E2, E3), calcium (E1, E2), magnesium (E2), phosphorus (E2, E3) and total carotenoids (E1). The male sterile lines from different sources showed substantial difference for combining ability for one or more characters. Kumar *et al.,* (1996) and Kumar (2002) also reported that none of the male sterile cytoplasmic source in general was good combiner for all the traits studied by them. A_1 and A_4 source turned to be good general combiner for grain yield in addition to some quality traits. $81A_1$ combined significantly positive in E1 and significantly negative in E3 could be due to environmental differences. Earlier workers, Virk and Brar (1993), Yadav (1994), Kumar *et al.,* (1996) and Yadav (1999) also reported that combining ability of pearl millet lines is strongly influenced by the type of cytoplasm they carried. Positive significant gca effect of male sterility sources lines in one environment and negative in another environments for most of the characters may be due to the differences in maintainer nuclear background or and cryptic and subtle effects of interaction between cytoplasm(s) and micro climatic environmental variations coinciding with various phenophases.

Testers H77/29-2 and INB 427 exhibited significant and positive gca effects in at least one of three environments for grain yield, total carotenoids and minerals. None of testers combined significantly for all the traits studied uniformly in all environments. This could be due to development and use of the testers/restorers for grain yield and not for trait specific characters. Testers INB 526 for grain yield, INB 1250 for magnesium content, H77/29-2 for phosphorus content, INB 427 for calcium, H90/4-5 and G73-107 for iron and total carotenoids showed their utility for these characters. These restorers could be utilized in developing trait specific hybrids. Also these could be combined to develop a base population following recurrent selection for GCA with objectives of developing improved population either to be released as a synthetic /

or as a source of variability for developing superior inbreds to develop nutritionally superior hybrids.

The estimates of SCA effects were inconsistent across the environments for all the characters studied. Sagar (1982) and Kumar (2002) also reported similar observations. Out of 64 crosses, seven cross combinations viz 81 A_2 x INB 526, 81A_3 x INB 526, 81A_5 x INB 427, 81A_5 x INB 1250, 81 A_{egp} x H77/29-2, 842A_1 x H77/371 and 842A_1 x INB 1250 exhibited consistently significant positive SCA effects for grain yield in all the environments. The top five crosses selected on the basis of SCA effects along with their *per se* performance for grain yield, total carotenoids and mineral elements have been presented in Table 3. The crosses 81A_4 x INB526, 81A_{egp} x INB 87/74, 843A_1 x H77/833-2, 81A_3 x H77/29-2 and 842A_1 x H77/371 were found to be associated with high magnitude of significant and positive sca effects for this trait. For mineral contents, crosses 81A_2 × INB1250 for iron, 81A_2 × INB427 for calcium, 81A_3 × INB427 for magnesium; 81A_2 × INB1250 for phosphorus and 81A_1 × H77/371 for total carotenoids, exhibited high SCA effects and high *per se* performance for specific traits. The cross combination 81A_2 x H77/29-2 expressed high SCA effect for iron and phosphorus content. The cross combination 81A_3 x H77/29-2 not only manifested high SCA effect for grain yield but also exhibited high SCA effect for magnesium content. Therefore, there is a possibility of combining combing high yield with high density of mineral in grains through hybrid breeding. Majority of crosses with high magnitude of significant and positive SCA effects involved the parents having one good and poor combiners for all the characters except calcium content involve average and poor combiners Therefore, there is need to isolate both parent for good general combing ability.

Heterosis

The standard heterosis was calculated as per cent increase or decrease over best check HHB 94. The direction and magnitude of heterosis varied from cross to cross under different environments. This indicates environmental specificity in the expression of hybrid vigour. The number of heterotic crosses, range of heterosis and best five hybrids showing high heterosis for grain yield, total carotenoids and micronutrients are presented in Table 4.

Six cross combinations namely 81A_4 × INB526, 81A_{egp} × H77/29-2, 81A_{egp} × H90/4-5, 81A_{egp} × INB87/74 and 81A_5 × INB427 exhibited not only high heterosis for grain yield but also showed positive heterosis for most of micronutrient. The high magnitude of heterosis for grain yield reported by Virk, 1988; Karale, 1997); for total carotenoid (Khangura *et al.*, 1980), calcium (Devanand and Das, 1996) in pearl millet. The high positive significant heterosis for iron content in cob (ear- leaf) and low in grains was reported by Hen *et al.*, (2007) in maize.

The estimates of standard heterosis over check hybrid HHB 94 for grain yield, total carotenoids and some mineral content revealed that among the top five hybrids based on various male sterility inducing cytoplasms, A_1 hybrids had maximum heterosis for most of the grain quality traits followed by A_3 hybrids indicating a distinct advantage of these cytoplasms over other sources. The cross 842A_1 x H77/833-2 expressed high significant positive heterosis for grain and total carotenoids, 81A_2 x H77/371 and 81A_2 x H77/833-2 for iron and phosphorus content; and cross combination 81A_1 x H77/29-2 not only manifested high positive heterosis for grain yield but also exhibited high significant and positive heterosis for iron, phosphorus, calcium content (Table 5).

Table.1 ANOVA for combining ability for micronutrients, total carotenoids and grain yield in different environments

Source of variation	d.f.	Mean sum of square					
		Iron content (ppm)			Calcium (mg/100g)		
		E1	E2	E3	E1	E2	E3
Replication	1	59.78	41.00	117.30	41.00	117.30	66.30
Hybrids	79	1956.13**	403.65**	137.71**	403.65**	137.71**	260.88***
Lines	7	9103.66**	2823.39**	387.24**	2823.39**	387.24**	112.76
Tester	9	1008.74	227.75	119.97	227.75	119.97	205.16
Lines x testers	63	1297.30**	159.92**	112.52**	159.92**	112.52**	285.29**
Error	79	14.37	7.03	3.53	7.03	3.53	9.64
GCA variances		208.82	75.86	7.83	75.86	7.83	7.01
SCA variances		1059.15	228.22	70.20	228.22	70.20	67.67
Predictability ratio		0.28	0.39	0.18	0.39	0.18	0.17
		Magnesium (mg/100g)			**Phosphorus (mg/100g)**		
		E1	E2	E3	E1	E2	E3
Replication	1	129.60	113.90	4.55	11.02	94.55	2.50
Hybrids	79	2603.10**	4833.00**	2905.61**	15326.49**	9983.66**	4384.92**
Lines	7	5004.74	12359.98**	2995.61	150955.48**	39203.59**	9639.62**
Tester	9	1068.71	3914.07	2928.00	2014.80	4888.71	4105.68
Lines x testers	63	2555.45**	4127.95**	2892.41**	2158.28**	7464.85**	3840.95**
Error	79	6.41	6.04	6.60	8.24	69.50	6.63
GCA variances		26.73	222.72	3.85	4129.27	810.07	168.42
SCA variances		1328.19	2506.43	1450.63	9333.56	5317.82	2254.04
Predictability ratio		0.03	0.15	0.005	0.46	0.23	0.13
		Total carotenoids (mg/100g)			**Grain yield (g/plant)**		
		E1	E2	E3	E1	E2	E3
Replication	1	0.563	0.027	0.026	11.18	7.87	0.049
Hybrids	79	1.65**	1.01**	1.17**	80.33**	54.91**	126.01**
Lines	7	10.85**	3.28**	4.57**	246.71**	145.73**	292.60**
Tester	9	0.748	1.72*	1.14	122.57*	60.91	134.46
Lines x testers	63	0.766**	0.66**	0.804**	55.81**	43.97**	106.3**
Error	79	0.018	0.023	0.025	2.61	3.59	5.12
GCA variances		0.27	0.10	0.11	8.70	3.29	5.95
SCA variances		0.96	0.53	0.63	34.74	28.81	62.5
Predictability ratio		0.36	0.27	0.25	0.33	0.18	0.15

*P = 0.05, **P = 0.01

Table.2 Estimates of general combining ability effects of lines and testers for micronutrients, total carotenoids and grain yield in different environments

S. No.	Genotype	Grain yield (g/plant)			Iron content (ppm)			Calcium (mg/100g)		
		E1	E2	E3	E1	E2	E3	E1	E2	E3
	Lines									
1.	$81A_1$	1.60*	-0.49	-5.24*	31.07*	9.21*	8.05*	24.10*	1.79*	1.75
2.	$81A_2$	-1.47*	-0.97	-3.40*	35.44*	16.97*	8.10*	10.25*	8.24*	2.30*
3.	$81A_3$	0.44	2.97*	2.69*	-5.97*-	-1.09	3.81*	-5.29*	-3.80*	-0.79
4.	$81A_4$	1.84*	1.85	2.35*	-3.80*	-26.63*	-6.97*	-5.19*	-3.55*	0.85
5.	$81A_5$	-0.61	-0.06	0.62	-10.31*	-19.02*	-2.88*	-3.49*	1.44*	1.50
6.	$81A_{egp}$	4.46*	2.76*	2.62*	-22.27*	16.70	5.38*	-1.49	0.79	-2.04*
7.	$842A_1$	1.24*	-0.62	4.81*	-15.21*	3.09*	-9.85*	-4.24*	0.89	1.10
8.	$843A_1$	-7.49*	-5.42*	-4.47*	-8.94*	0.78	-5.65*	-14.64*	-5.80*	-4.69*
	S.E. (d)	0.51	0.59	0.71	1.19	0.84	1.40	0.83	0.59	0.98
	Testers									
9.	H90/4-5	1.12	-0.92	-0.81	9.61*	5.63*	5.11*	-1.44	0.13	0.70
10.	H77/833-2	-1.55*	-0.22	1.64*	9.04*	-2.75*	3.60*	-2.56*	-3.43*	-6.29*
11.	H77/371	-2.29*	-2.07*	-6.74*	-3.52*	8.41*	-7.64*	-5.13*	-1.93*	-2.60*
12.	H78/711	2.42*	0.35	0.17	-16.89*	-8.78*	-8.99*	-1.06	0.44	-3.73*
13.	H77/29-2	2.64*	3.05*	0.88	2.32	18.11*	-0.94	2.61*	0.25	0.33
14.	G73-107	-3.05*	-1.68*	1.64*	3.63*	1.30	6.41*	2.49*	4.63*	0.39
15.	INB 87/74	-3.99*	-1.59*	2.63*	-0.94	-5.86*	2.28	-0.06	2.81*	5.83*
16.	INB 427	2.15*	2.99*	-3.01*	-4.22*	-1.76*	7.95*	4.49*	1.63*	4.14*
17.	INB 526	3.90*	1.67*	2.46*	-4.87*	-11.35*	-0.78	5.74*	-0.11	1.70
18.	INB 1250	-1.36*	-1.56*	1.12	5.84*	-2.95*	-7.00*	-5.06*	-4.43*	-0.48
	S.E. (d)	0.57	0.67	0.80	1.34	0.94	1.57	0.93	0.66	1.09

*Significant at 5%

S. No.	Genotype	Magnesium (mg/100g)			Phosphorus (mg/100g)			Total carotenoi(mg/100g)ds		
		E1	E2	E3	E1	E2	E3	E1	E2	E3
	Lines									
1	81A$_1$	-20.07*	40.73*	-7.53*	-38.68*	15.33*	7.73*	0.80*	-0.24*	-0.65*
2	81A$_2$	10.22*	0.73	-1.98*	118.36*	59.08*	39.98*	0.47*	-0.48*	-0.10*
3	81A$_3$	-24.07*	-0.46	9.26*	88.81*	4.03	17.03*	-0.93*	-0.32*	-0.29*
4	81A$_4$	-6.77*	-35.86*	18.31*	93.21*	-72.71*	-18.41*	-1.26*	0.10*	-0.12*
5	81A$_5$	-1.72*	-30.06*	-16.68*	-26.18*	-24.76*	-4.36*	0.63*	0.27*	0.40*
6	81A$_{egp}$	11.57*	-4.86*	12.16*	-76.93*	55.73*	-7.16*	-0.07*	-0.30*	-0.05
7	842A$_1$	17.12*	12.98*	-11.68*	-51.23*	-6.11*	-3.11*	0.22*	0.72*	0.93*
8	843A$_1$	13.72*	16.83*	-1.88*	-107.33*	-30.56*	-31.71*	0.13*	0.24*	-0.09*
	S.E. (d)	0.80	0.77	0.81	0.90	2.63	0.81	0.04	0.04	0.05
	Testers									
9	H90/4-5	5.92*	4.19*	0.38	-4.37*	-6.50*	5.66*	0.39*	0.27*	0.03
10	H77/833-2	- 11.32*	-12.49	-12.49*	-3.81*	-11.44*	-34.83*	0.15*	0.63*	-0.27*
11	H77/371	3.80*	-14.68*	-4.24*	4.37*	-18.75*	27.53*	0.10*	0.22*	-0.03
12	H78/711	-7.82*	29.44*	11.75*	-12.12*	24.11*	-0.33	-0.29*	-0.21*	-0.37*
13	H77/29-2	-5.20*	13.94*	0.50	16.75	10.61*	10.78*	0.12*	-0.20*	-0.23*
14	G73-107	-9.51*	-11.80*	-6.18*	-15.75*	-3.38	-0.33	0.01	0.20*	0.18*
15	INB 87/74	-0.20	-11.36*	-6.05*	6.12*	9.43*	4.10*	-0.15*	-0.01	--0.17*
16	INB 427	2.55*	14.00*	-12.55*	-1.68	22.24*	-6.46*	-0.01	-0.18*	0.32*
17	INB 526	10.30*	-16.18*	-4.05*	-7.18*	-30.31*	-10.52*	-0.01	-0.27*	0.43*
18	INB 1250	11.48*	4.94*	32.94*	17.68*	3.99	4.41*	-0.33*	-0.45*	0.12*
	S.E. (d)	0.89	0.86	0.90	1.01	2.94	0.91	0.04	0.05	0.05

Table.3 Top five crosses selected on the basis of sca effects along with their *per se* performance and gca effects of parental lines for micronutrients, total carotenoids and grain yield in pearl millet

Hybrids	Code	Environ-ment	SCA effects	Mean	Gca effect of parents	
					Lines	testers
		Iron content (ppm)				
$81A_2$ x INB 526	2x17	E1	93.19*	195.65	Good	Poor
81 A_5 x H77/833-2	5x10	E2	85.63*	156.25	Good	Poor
81 A_{egp} x H77/833-2	6x10	E3	63.26*	132.45	Good	Good
$81A_2$ x H77/29-2	2x13	E1	39.77*	159.40	Poor	Good
81 A_4 x G73-107	4x14	E1	37.42*	109.50	Good	Good
		Calcium content (mg/100g)				
$842A_1$ x INB 1250	7x18	E1	23.36*	46.00	Average	Poor
$81A_{egp}$ x H90/4-5	6x9	E3	22.54*	**34.00**	Poor	Average
$842A_1$ x G73-107	7x14	E3	21.70*	20.00	Average	Average
$81A_1$ x H77/29-2	1x13	E2	17.33*	80.50	Good	Good
$843A_1$ x INB 427	8X 16	E3	14.75*	43.00	Poor	Good
		Magnesium content (mg/100g)				
$81A_3$ x H 77/29-2	3x13	E2	124.15*	232.00	Poor	Good
$81A_3$ x H90/4-5	3x9	E2	116.40*	214.50	Poor	Good
$81A_{egp}$ x INB 427	6x16	E1	87.30*	185.50	Good	Good
$81A_4$ x H78/711	4x12	E3	86.24*	201.50	Good	Good
$842A_1$ x H90/4-5	7x9	E1	81.37*	188.50	Good	Good
		Phosphorus content (mg/100g)				
$81A_2$ x H77/371	2x11	E2	177.10*	490.00	Good	Poor
$81A_1$ x H78/711	1x12	E2	157.97*	291.50	Good	Good
$81A_2$ x H 77/29-2	2x 13	E2	140.73*	483.00	Good	Good
$843A_1$ x G73-107	8x 14	E2	103.38*	342.00	Poor	Average
$81A_3$ x INB 427	3x16	E2	97.15*	396.00	Average	Good
		Total carotenoids (mg/100g)				
$81A_{egp}$ x H77/371	6x11	E1	2.06*	6.62	Poor	Good
$81A_5$ x INB 526	5x17	E2	1.66*	4.53	Good	Poor
$81A_1$ x H77/371	1x11	E2	1.43*	4.98	Poor	Good
$81A_2$ x G73-107	2x14	E1	1.32*	6.32	Poor	Good
$81A_3$ x G73-107	3x14	E3	1.25*	5.37	Poor	Good
		Grain yield (g/plant)				
$81A_4$ x INB 526	4x17	E3	18.76*	54.50	Poor	Good
81 A_{egp} x INB 87/74	6x15	E3	18.57*	54.50	Good	Poor
$843A_1$ x H77/833-2	8x 10	E3	16.17*	44.00	Average	Average
$81A_3$ x H 77/29-2	3x13	E3	12.20*	46.45	Good	Poor
81 A_5 x H78/711	7x 12	E1	11.69*	42.25	Poor	Poor

Table.4 Range of heterosis over standard check and number of significant positive heterosis in parenthesis for micronutrients, total carotenoids and grain yield in pearl millet

Character	Range of heterosis (%)			Best five hybrids on basis of highest heterosis over standard check HHB 94				
	E1	E2	E3	Hybrids	Code	Environment	Heterosis (%)	*Per se*
Iron (ppm)	-53.96 to 106.13 (25)	-36.34 to 95.21(56)	-56.85 to 87.08 (8)	81A5 x H77/833-2	5x 10	E1	106.13	156.25
				81A1 x H77/29-2	1x 13	E2	95.21	136.45
				81A2 x H77/371	2x11	E3	91.27	57.00
				81A2 x INB 1250	2x18	E1	73.94	131.85
				81A1 x G73-107	1x14	E2	84.89	77.30
Calcium (mg/100g)	-54.80 to 127.40 (31)	-75.12 to 24.38 (3)	-87.11 to 34.02 (11)	81A1 X H77/29-2	1X13	E1	127.40	80.50
				81A1 x INB 427	1X16	E1	104.80	72.50
				81A1 x INB 87/74	1X15	E1	86.44	66.00
				81A2 x INB 427	2x 16	E1	86.44	50.00
				842 A1 x G73-107	7X14	E3	34.02	52.00
Magnesium (mg/100g)	-64.78 to 107.17 (22)	-63.87 to 170.40 (35)	-61.07 to 104.12 (26)	81A3 x G73-107	3x13	E2	170.40	232.00
				81A3 x H 90/4-5	3x9	E3	150.00	161.50
				81A2 x H78/711	2x12	E2	149.42	214.00
				81A2 x INB 427	2x 16	E2	148.83	213.50
				842 A1 x H 90/4-5	7x9	E1	101.17	188.50
Phosphorus (mg/100g)	-26.26 to 100.81(58)	-39.74 to 99.51 (24)	-33.92 to 59.47 (27)	81A2 x INB 526	2x17	E1	100.81	497.00
				81A2 x INB 87/74	2x15	E1	99.80	494.50
				81A2 x H77/371	2x11	E2	99.51	490.00
				81A2 x H77/29-2	2x13	E2	96.99	483.00
				81A3 x H77/29-2	3x 13	E1	93.94	480.00
Total carotenoids (mg/100g)	-32.65 to 60.56 (51)	-36.28 to 53.21 (18)	-26.30 to 74.55 (50)	81Aegp x 77/371	6X11	E1	60.56	6.62
				842A1 x H77/833-2	7X10	E2	53.21	5.98
				81A5 x INB 526	5X17	E3	74.55	6.72
				81A1 x H77/833-2	1X10	E1	57.28	6.48
				842A1 x INB 427	7X16	E3	65.97	6.39
Grain yield (g/plant)	-45.64 to 53.64 (29)	-45.90 to 54.17 (23)	-40.25 to 73.45 (48)	81A3 x H77/29-2	3X13	E3	73.45	46.45
				842A1 x H77/833-2	7X10	E3	68.60	45.15
				842A1 x H 78/711	7x12	E1	65.80	42.25
				843A1 x H77/833-2	8x10	E3	64.30	44.00
				81Aegp x H77/29-2	6X13	E2	54.17	39.90

Table.5 Top five crosses selected on the basis of sca effects along with heterosis, *per se* performance and gca effects of parental lines for micronutrients, total carotenoids and grain yield in pearl millet

Hybrids	Code	Environ-ment	SCA effects	Heterosis (%)	Mean	GCA effect of parents	
						Lines	testers
	Iron content (ppm)						
81A_2 x INB 526	2x17	E1	93.19*	58.11*	195.65	Good	Poor
81 A_5 x H77/833-2	5x10	E2	85.63*	106.13*	156.25	Good	Poor
81 A_{egp} x H77/833-2	6x10	E3	63.26*	84.10*	132.45	Good	Good
81A_2 x H77/29-2	2x13	E1	39.77*	12.93*	159.40	Poor	Good
81 A_4 x G73-107	4x14	E1	37.42*	44.00*	109.50	Good	Good
	Calcium content (mg/100g)						
842A_1 x INB 1250	7x 18	E1	23.36*	42.66*	46.00	Average	Poor
81A_{egp} x H90/4-5	6x9	E3	22.54*	28.87*	50.00	Poor	Average
842A_1 x G73-107	7x14	E3	21.70*	34.02*	52.00	Average	Average
81A_1 x H77/29-2	1x13	E2	17.33*	127.40*	80.50	Good	Good
843A_1 x INB 427	8x 16	E3	14.75*	10.82*	43.00	Poor	Good
	Magnesium content (mg/100g)						
81A_3 x H 77/29-2	3x13	E2	124.15*	170.40*	232.00	Poor	Good
81A_3 x H90/4-5	3x9	E2	116.40*	150.00*	214.50	Poor	Good
81A_{egp} x INB 427	6x16	E1	87.30*	97.97*	185.50	Good	Good
81A_4 x H78/711	4x 12	E3	86.24*	124.14*	201.50	Good	Good
842A_1 x H90/4-5	7x9	E1	81.37*	101.17*	188.50	Good	Good
	Phosphorus content (mg/100g)						
81A_2 x H77/371	2x11	E2	177.10*	177.10*	490.00	Good	Poor
81A_1 x H78/711	1x12	E2	157.97*	91.37*	470.00	Good	Good
81A_2 x H 77/29-2	2x 13	E2	140.73*	96.66*	483.00	Good	Good
843A_1 x G73-107	8x 14	E2	103.38*	39.25*	342.00	Poor	Average
81A_3 x INB 427	3x16	E2	97.15*	61.24*	396.00	Average	Good
	Total carotenoids (mg/100g)						
81A_{egp} x H77/371	6x11	E1	2.06*	60.50*	6.62	Poor	Good
81A_5 x INB 526	5x17	E2	1.66*	74.55*	4.53	Good	Poor
81A_1 x H77/371	1x11	E2	1.43*	27.69*	4.98	Poor	Good
81A_2 x G73-107	2x14	E1	1.32*	53.60*	6.32	Poor	Good
81A_3 x G73-107	3x14	E3	1.25*	39.48*	5.37	Poor	Good
	Grain yield (g/plant)						
81A_4 x INB 526	4x17	E3	18.76*	12.58*	54.50	Poor	Good
81 A_{egp} x INB 87/74	6x15	E3	18.57*	13.51*	54.50	Good	Poor
843A_1 x H77/833-2	8x 10	E3	16.17*	64.30*	44.00	Average	Average
81A_3 x H 77/29-2	3x13	E3	12.20*	73.45*	46.45	Good	Poor
81 A_5 x H78/711	7x 12	E1	11.69*	53.64*	42.25	Poor	Poor

Therefore, these crosses offering a scope for the simultaneous improvement of grain yield and grain quality characters after multi location evaluation. Hybrid $81A_1$ x H77/29-2 identified for testing in boifortification trials.

The hybrids based on diverse male sterility systems, A_3, A_1 & A_4 has maximum heterosis for grain yield, A_5 & A_1 for iron, A_1 for calcium, A_3 and A_2 for magnesium A_2 for phosphorus indicating the a distinct advantage of these cytoplasm over other sources. Rai el al.(1996) reported that A_2 and A_3 source is highly unstable and is commercially inviable. However, A_4 and A5 sources have been shown to be highly stable. Therefore, the results of this study on combining ability and heterosis suggest that other than A_1 source, A_4 and A_5 systems should provide a good opportunity to diversity the cytoplasmic base of pearl millet.

Acknowledgement

Authors acknowledge the support of CCS, Haryana Agricultural University to carry out this research work.

References

AOAC. 1990. Official Methods of Analysis. Association of Official Analytical Chemists. Washington DC, USA.

Bous, H. E. 2002. Micronutrient fortification of plants through plant breeding: can it improve nutrition in man at low cost. Proc. Nutr. Soc. 62(2): 403-411.

Burton, G.W. 1965. Pearl millet Tift 23 A released. Crops and Soils, 17: 19.

Burton, G.W., Wallace A.T., and Rachie K.O.1972. Chemical composition and nutritive value of pearl millet (*Penisetum typhoides* (Burm) Stapf and E.C. Hubbard) grains. Crop Science, 12: 187-188.

Chawla H. S. and Gupta V.P. 1982. Combining ability analysis of oxalic acid, minerals and green fodder yield in pearl millet. Theor. Appl. Genet., 61: 109-112.

Cheng, K.L. and Bray, R.H. 1951. Determination of calcium and magnesium in soil and plant material. Soil Sci., 72: 449-458.

Cochran and Cox. 1950. Experimental designs. John Wiley and Sons, Inc., New York.

Devanand, P.S. and Das, L.D.V. 1997. Diallel analysis in fodder pearl millet. Int. Sorghum and Millets Newsl., 38: 106-109..

Gill, C.B.S., Sastry, E.V.D. and Sharma, K.C. 1993. Line x Tester analysis in local ecotypes of pearl millet (*Pennisetum typhoides* (Burm.) S & H.) of Sikar district of Rajasthan for quality attributes. Ann. Arid Zone, 32(3): 171-174.

Hen, F.C., Hun, L.C. and Ong, G.M. 2007. Heterosis and genetic analysis of iron concentration in grains and leaves of maize. Plant Breed., 126(1): 107-109.

Karale, M.V., Ugale, S.D., Suryavanshi, Y.B. and Patil, B.D. 1997. Heterosis in line x tester crosses in pearl millet. Indian J. Agric. Res., 31(1): 39-42.

Kempthorne, O. 1957. An Introduction to Genetic Statistics. John Wiley and Sons, Inc., New York, USA.

Khangura, B.S., Gill, K.S. and Phul, P.S. 1980. Combining ability analysis of beta-carotene, total carotenoids and other grain characteristics in pearl millet. Theor. Appl. Genet., 56: 91-96.

Koening, R.A. and Johnson, C.R. 1942. Colorimetric determination of P in biological materials. Ind. Eng. Chem. Anal., 14: 155-156.

Kumar, Anil., Kumar, R., Devvart and Dehniwal, A.K. 2017. Combining ability for grain yield and its components involving Alloplasmic

Iso-Nuclear lines of Pearl Millet. *Int.J.Curr.Microbiol.App.Sci*. 6(8):554-561

Kumar, R., 2002. Studies on effect of cytoplasm on productivity traits and combining ability in direct sown and regenerated pearl millet (*Pennisetum glaucum* (L.) R. Br.). Ph.D. Dissertation (Unpublished), Haryana Agricultural University, Hisar.

Kumar, S., Chahal, G.S. and Virk, D.S. 1996. Combining ability of diverse male sterility sources in pearl millet. Crop Improv., 23(1): 107-110.

Rai, K.N., Virk, D.S., Harinarayana, G., and Rao A.S. 1996. Stability of male sterility sources and fertility restoration of their hybrids in pearl millet. Plant Breed., 115: 494-500.

Sagar, Prem 1982. Genetics of grain yield and other quantitative characters under different levels of water stress in pearl millet (*Pennisetum typhoides* (Burm) S&H). Ph.D. Dissertation (Unpublished), Haryana Agricultural University, Hisar.

Singh, F. and Nainawatee, H.S. 1999. Grain quality traits. *In*: (Khairwal, I.S., Rai, K.N., Harinaraina, G. and Andrews, D.J. (Eds.). Pearl Millet Breeding, Oxford and IBH, New Delhi. pp. 156-183.

Velu, G., Rai, K.N, Sahrawat, K.L. and Sumalini, K. 2008. Variability for grain iron and zinc contents in pearl millet hybrids Journal of SAT Agricultural Research, 6:1-4.

Virk, D.S. 1988. Biometrical analysis in pearl millet- a review. Crop Improv., 15(1): 1-29.

Virk, D.S. and Brar, J.S. 1993. Assessment of cytoplasmic differences in near-isonuclear male sterile lines in pearl millet. Theor. Appl. Genet., 87: 106-112.

Welch R. M. 2002. Breeding strategies for boifortified staple plant foods to reduce micronutrients malnutrition globally. J. Nutr., 132(3): 4958-4998.

Welch, R. M. and Graham, R. D. 2004. Breeding for micronutrients in food crops from a human nutrition perspective. J. Expt. Bot., 55(396): 353-364.

Yadav, O.P. 1994. Influence of A_1 cytoplasm in pearl millet. Plant Breed. Abst., 64: 1375-1379.

Yadav, O.P. 1999. Heterosis and combining ability in relation to cytoplasmic diversity in pearl millet. Indian J. Genet., 59(4): 445-450.

How to cite this article:

Sudhir Sharma, H.P. Yadav, R. Kumar and Dev Vart. 2019. Genetic Analysis for Micronutrients and Grain Yield in Relation to Diverse Sources of Cytoplasm in Pearl Millet [*Pennisetum glaucum* (L.) R. Br.]. *Int.J.Curr.Microbiol.App.Sci.* 8(01): 613-624.
doi: https://doi.org/10.20546/ijcmas.2019.801.069