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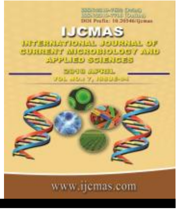

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Exploring the Barnyard Millet (*Echinochloa frumentacea* Roxb. Link) Segregating Population for Isolation of High Yielding, Iron and Zinc Content Genotype

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ABSTRACT

A field study was carried out involving three F_2 and F_3 population of barnyard millet crosses during 2016-2017. The high PCV and GCV values and high heritability were noticed in F_2 population of three crosses for number of tillers, iron and zinc content, indicated the predominance of additive gene effects in their expression and would respond to selection effectively as they are least influenced by environment. In the F_3 generation, the identified superior families in all the three crosses revealed that mean performance of yield and yield component characters progressively increased when compared to control [Co (Kv) 2] except for days to maturity and number of racemes (ACM 331 x ACM335, ACM 331 x ACM333) and single ear head weight (ACM 331 x ACM335). Three out of ten families of ACM 331 x MA10 cross exhibited superior mean performance than the control for most of the yield attributing and micronutrient traits. The coefficient of variation among the progenies of ACM 331 x MA10 cross was low indicated the settling down of homozygosity in F_3 generation itself. These selected families are recommended for promoting to advanced generation for varietal development program with respect to high yield coupled with high iron and zinc content. The parent progeny correlation and regression between two generation (F_2 and F_3) of all the three crosses showed their lesser susceptible to environmental effect (i.e.) consistence performance.

Keywords

Barnyard millet, Parent progeny regression, F_2 and F_3 population, Micronutrient

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Introduction

Small millets are nutrient-rich food sources traditionally grown and consumed by subsistence farmers in Asia and Africa. They include finger millet, foxtail millet, proso millet, little millet, barnyard millet, kodo millet, teff and fonio. All these crops have an old history of cultivation, going behind 3000 – 5000 years and probably were amongst the first few crops to have been domesticated for cultivation. Of them, barnyard millet (*Echinochloa frumentacea*), a highly self-pollinated crop which belongs *Poaceae* family has ability to persist under severe drought, salinity, heat, floods and have excellent climate resilient capacity compared to other cereal crops (Gupta *et al.*, 2010). Barnyard millet has also been used for the reclamation of sodicity, arsenic and cadmium affected soils (Sherif, 2007; Abe *et al.,* 2011). It is also cultivated at high hills under double cut production system with increased yield (Bandyopadhyay, 2009). Barnyard millet being a promising source of micronutrients and protein besides energy, can make a contribution to alleviating micronutrient and protein malnutrition, also called 'hidden-hunger', affecting more than half of the world's population, especially women and pre-school children in most countries of Africa and south-east Asia (Underwood, 2000). The iron and zinc content in grains of barnyard millet ranged from 2.29 to 18.00 mg/100g and 1.5 to 7.5 mg/100g respectively (Renganathan *et al.,* 2017). So there is a greater scope for exploiting its nutritional potential of the crop to fight against hidden hunger in developing countries. However systematic analysis of genotypes for their breeding value remains to be undertaken and the genetic studies leading to the understanding of the nature of gene action are also not attempted in this crop. Therefore, there is a need to collect more precise information on the inheritance pattern of grain yield, yield components and micronutrient traits their nature of association with each other in segregating populations in order to formulate dependable selection criteria.

Materials and Methods

The present study was conducted during 2016-17 at the experimental plot of Department of Plant Breeding and Genetics, Agricultural College & Research Institute, Madurai, Tamil Nadu, India. The experimental material included are ACM 331, ACM 333, ACM 335 and MA 10 that utilized for hybridization which is based on variation in iron and zinc content (ACM 331 low in Fe and Zn, where ACM 333 and MA 10 are rich in both), and F_2 segregating population of ACM 331 x ACM 333, ACM 331 x ACM 335 and ACM 331x MA 10. The F_2 segregating population were raised in 40 rows consists of 500 plants with the spacing of 30 x 10 cm. Individual plant selection was made in each of the three F_2 population and forwarded to F_3 with the objective of studying the breeding potential of each cross, parent progeny regression and isolation of some superior lines for yield along with micronutrient traits. Observations were recorded for the following parameters: days to maturity, number of racemes, single ear head weight, number of tillers, thousand grain weight, iron and zinc content, fodder and grain yield. The estimation of micronutrient content was done through Atomic Absorption Spectrophotometer. Selected plants in each F_2 cross was raised as family wise. A total of top ten individual plants from each crosses were raised as family. Two rows per family in each cross were maintained and observations were recorded in a random of five plants in each family of the cross. Observed data of F_3 generation were subjected to statistical analysis. The simple descriptive statistics such as mean, standardized range, variance and PCV were used as criteria to assess the breeding potential of the selected crosses. The parent progeny regression analysis was carried out by regressing the mean values of a character in the progeny (F_3) upon the value of a character in the parents (F_2). The regression coefficient 'b' was calculated by using the formula suggested by Lush (1940).

Results and Discussion

Development and identification of superior lines derived from heterotic crosses appear to be a better strategy for genetic enhancement of barnyard millet for the traits considered in the present study. The data on different characters along with the estimates on variability indicating genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) and heritability are presented (Table 1). High PCV and GCVs were noticed for number of tillers, iron content, zinc content and fodder yield in all the three cross (ACM 331 x ACM 333, ACM 331 x ACM 335, ACM 331 x MA 10). Values of phenotypic and genotypic variance were high for these characters and are indicative of stable nature of these characters. These were concomitant with Govindraj *et al.,* (2011) in pearl millet for grain iron concentration, Akinwale *et al.,* (2011) and Ravindra Babu *et al.*, (2012) in rice for grain yield per plant, Bisne *et al.,* (2009), Brar *et al.,* (2011), Ashok *et al.,* (2013) and Soman *et al.,* (2014) for number of productive tillers per plant, iron content and grain yield. Moderate PCV was obtained for number of raceme, single ear head weight and grain yield for all the same crosses. Low PCV and GCV were observed for days to maturity and thousand grain weight in all the crosses. This suggests that the genetic improvement through selection for these traits may not be always effective. Similar results were obtained in rice by Arpita *et al.*, (2014), Khare *et al.,* (2014), Soman *et al.,* (2014), Bekele *et al.,* (2013) and Laxuman *et al.*, (2010) for days to maturity. According to Ansari *et al.,* (2004), high heritability percentage reflects the large heritable variance which may offer the possibility of improvement through selection. High heritability reported for all the studied traits in three crosses suggesting that environmental factors did not affect greatly the phenotypic performance of these traits.

Crop improvement for grain yield has been achieved through effective use of F_2 and F_3 segregating population fixing desirable character combinations (Anilkumar *et al.,* 2011). The parent progeny correlation and regression between two generations shows lesser susceptible to environmental effect and is very useful for selection in segregating population for the development of new improved genotypes (Suwarto *et al.,* 2015). The selection of the plants is effective only when the performance of progeny is more dependable on the performance of the parent. Lush (1940) suggested that selection of best genotypes based on its genetic potentiality can be ascertained by regression of the progeny mean over the value of corresponding parent. All the characters in this study showed strong correlation and regression between F2 and F3 generation in all crosses (Table 2). It indicated that all characters are having high heritability and this is consistent with earlier report of Vogel *et al.,* (1980) in Indian grasses. Banumathy *et al.,* (2017) and Kahani and Hittalmani (2016) in rice reported positive significant regression and correlation coefficient between all morphological traits of F_2–F_3 generation. The positive significant regression and correlation coefficient estimate for all character in F3-F4 generation was also reported by Kavithamani *et al.,* (2013). Based on parent progeny analysis, it can be concluded that selection will be effective in the test materials used in this study as revealed by the significant substantial variations among the genotypes for all the characters observed. Therefore, the F_2 of ACM 331 x ACM 333, ACM 331 x ACM 335 and ACM 331 x MA 10 material could be used for the development of potential breeding materials like RILs for grain yield and micronutrient traits and to select for high yielding with maximum micronutrient genotypes along with the feature of female that exhibits stay green type under drought condition.

All crosses showed less coefficient of variation compared to F_2 and it indicated the settling down nature of homozygosity in F3 generation. The mean, standard error and coefficient of variation for observed traits of selected F3 families of three crosses were depicted in Table 3a, 3b and 3c. The cross ACM 331 x ACM 335 showed high Fe and Zn content coupled with moderate yield whereas ACM 331 x MA 10 cross recorded high yield with moderate Fe and Zn. High Fe and Zn content along with low yield was observed in all crosses of families.

Table.1 Estimates of variability parameters in F_2 generation for three crosses

Characters	Cross	Mean	SE	Minimum	Maximum	PCV (%)	GCV (%)	Heritability (BS) (%)
Days to maturity	ACM 331 x ACM 335	99.16	0.04	90.00	106.00	4.14	4.03	94.73
	ACM 331 x ACM 333	99.30	0.04	92.00	108	4.04	3.93	94.39
	ACM 331 x MA 10	99.89	0.04	93.00	108.00	4.07	3.94	94.04
Number of raceme	ACM 331 x ACM 335	50.77	0.13	40.00	67.00	13.42	12.75	90.26
	ACM 331 x ACM 333	54.84	0.15	41.00	73.00	14.55	14.29	96.61
	ACM 331 x MA 10	57.22	0.12	42.00	75.00	11.88	11.31	90.62
Single ear head weight (g)	ACM 331 x ACM 335	14.40	0.19	10.20	20.60	19.57	19.01	94.42
	ACM 331 x ACM 333	16.86	0.20	10.73	22.60	20.20	19.17	89.95
	ACM 331 x MA 10	18.37	0.20	11.60	24.60	20.21	19.18	90.07
Number of tillers	ACM 331 x ACM 335	8.25	0.27	4.00	12.00	26.67	24.90	87.19
	ACM 331 x ACM 333	7.24	0.30	3.00	12.00	29.46	26.88	83.29
	ACM 331 x MA 10	7.89	0.29	4.00	13.00	29.01	26.20	81.55
Thousand grain weight (g)	ACM 331 x ACM 335	3.20	0.14	2.80	3.63	4.74	4.12	94.75
	ACM 331 x ACM 333	3.30	0.11	2.9	3.8	6.00	5.96	90.00
	ACM 331 x MA 10	3.20	0.12	2.80	3.80	6.0	5.85	97.43
Iron (mg/100 g)	ACM 331 x ACM 335	13.26	0.29	7.00	18.25	28.64	28.32	97.82
	ACM 331 x ACM 333	11.53	0.21	7.42	15.62	20.49	20.19	97.08
	ACM 331 x MA 10	11.4	0.28	6.70	16.13	25.93	25.77	98.78
Zinc (mg/100 g)	ACM 331 x ACM 335	5.60	0.28	2.71	7.61	27.54	26.86	95.13
	ACM 331 x ACM 333	4.54	0.28	2.81	6.14	27.54	26.86	95.13
	ACM 331 x MA 10	4.6	0.27	2.53	7.16	24.56	23.55	91.94
Fodder yield (g)	ACM 331 x ACM 335	54.5	0.27	34.56	103.2	30.13	28.76	76.53
	ACM 331 x ACM 333	76.1	0.26	60.4	104.3	26.34	25.82	76.53
	ACM 331 x MA 10	70.0	0.29	40.3	103.5	29.74	28.20	81.26
Grain yield (g)	ACM 331 x ACM 335	32.01	0.14	23.05	40.41	14.03	11.11	62.65
	ACM 331 x ACM 333	35.97	0.21	24.11	50.16	20.39	16.88	68.51
	ACM 331 x MA 10	38.71	0.20	26.35	56.41	20.03	19.18	91.17

Table.2 Parent offspring correlation and regression for different characters in selected three F_2 and F_3 population

Parameters	**Correlation coefficient**			**Regression coefficient**		
	ACM331x ACM335	**ACM 331xACM 333**	**ACM331x MA10**	**ACM331x ACM335**	**ACM 331xACM 333**	**ACM331x MA10**
Generation	**F_2 –F_3**	**F_2-F_3**	**F_2 –F_3**	**F_2-F_3**	**F_2 –F_3**	**F_2-F_3**
Days to maturity	0.77^{**}	0.85^{**}	0.79^{**}	0.63^{**}	0.88^{**}	0.61^{**}
Number of raceme	0.80^{**}	0.85^{**}	0.91^{**}	0.58^{**}	0.74^{**}	0.66^{**}
Single ear head weight (g)	0.79^{**}	0.93^{**}	0.87^{**}	0.77^{**}	0.89^{**}	0.52^{**}
Number of tillers	0.66^{**}	0.88^{**}	0.97^{**}	0.56^{**}	0.92^{**}	0.72^{**}
Thousand grain Weight(g)	0.58^{**}	0.71^{**}	0.65^{**}	0.91^{**}	0.88^{**}	0.75^{**}
Iron (mg/100 g)	0.74^{**}	0.66^{**}	0.67^{**}	0.78^{**}	0.48^{**}	0.46^{**}
Zinc (mg/100 g)	0.96^{**}	0.73^{**}	0.71^{**}	0.77^{**}	0.68^{**}	0.52^{**}
Fodder Yield (g)	0.58^{**}	0.92^{**}	0.91^{**}	0.75^{**}	0.80^{**}	0.59^{**}
Grain yield (g)	0.94^{**}	0.90^{**}	0.94^{**}	0.52^{**}	0.50^{**}	0.61^{**}

Table.4 Mean performance of superior families among three crosses

Crosses	**DM**	**NR**	**SEW**	**NT**	**TW**	**Fe**	**Zn**	**FY**	**GY**
ACM 331 x ACM333	4 & 10 (96.35)	4 (56.30)	4 (18.60)	4 (9.05)	4 (3.50)	4 (13.05)	4 (5.42)	5 (91.05)	4 (46.50)
% over control	-7.36	-2.93	9.09	81	2.94	16.52	72.06	74.76	17.72
ACM 331 x ACM335	4 (94.20)	1 (51.45)	9 (16.90)	1 (8.10)	5 (3.75)	5 (17.05)	5 (6.87)	1 (95.50)	6 (39.75)
% over control	-9.42	-11.29	-0.88	62	10.29	52.23	118.09	83.30	0.63
ACM 331 x MA10	3 (95.50)	3 (60.15)	3 (20.65)	3 (9.50)	3 (3.60)	9 (15.45)	3 (6.00)	4 (98.65)	3 (49.80)
% over control	-8.17	3.71	21.11	90	5.88	37.95	90.48	89.34	26.08

() Parenthesis-mean values; DM Days to maturity; NR Number of raceme; SEW Single ear head weight; NT Number of tillers; Thousand grain weight; Fe Iron; Zn Zinc; FY Fodder yield per plant; GY Grain yield per plant

Table.3a Mean, standard error and coefficient of variation for ACM 331 x ACM 335 cross of selected families studied in F_3 generation

Families	**ACM331 x ACM335**								
	DM	**NR**	**SEW**	**NT**	**TW**	**Fe**	**Zn**	**FY**	**GY**
Co (Kv) 2 (control)	104.00 ± 0.08	58.00 ± 0.25	17.05 ± 0.10	5.00 ± 0.25	3.40 ± 0.15	11.20 ± 0.24	3.15 ± 0.30	52.10 ± 0.75	39.50 ± 0.40
1	98.48 ± 0.48 (4.86)	51.45 ± 1.28 (8.41)	16.85 ± 0.48 (5.97)	8.10 ± 0.74 (11.69)	3.58 ± 1.06 (9.94)	14.85 ± 0.75 (5.27)	6.34 ± 0.57 (9.33)	95.50 ± 1.07 (10.47)	37.60 ± 1.95 (10.57)
2	100.05 ± 1.06 (5.62)	51.40 ± 1.43 (11.05)	16.35 ± 1.74 (11.97)	7.70 ± 1.56 (7.66)	3.50 ± 0.26 (5.56)	13.85 ± 0.69 (8.51)	6.05 ± 1.17 (12.8)	90.45 ± 0.50 (4.42)	36.95 ± 0.82 (11.26)
3	95.50 ± 0.91 (4.57)	49.65 ± 1.30 (9.11)	14.95 ± 1.90 (10.05)	6.10 ± 0.73 (8.28)	3.24 ± 0.36 (5.10)	12.45 ± 1.19 (16.48)	4.99 ± 0.52 (6.67)	80.50 ± 1.52 (11.66)	35.90 ± 0.82 (7.33)
4	94.20 ± 1.03 (4.93)	51.05 ± 0.72 (6.45)	15.95 ± 1.96 (6.92)	6.90 ± 0.69 (10.26)	3.45 ± 1.16 (9.36)	11.80 ± 0.26 (5.54)	4.05 ± 1.62 (10.07)	65.95 ± 0.76 (12.26)	36.35 ± 1.50 (8.79)
5	95.10 ± 1.69 (4.77)	49.35 ± 0.76 (6.93)	15.05 ± 0.98 (11.83)	7.00 ± 1.42 (9.59)	3.75 ± 0.73 (8.95)	17.05 ± 0.57 (9.51)	6.87 ± 1.56 (9.27)	90.05 ± 0.93 (6.57)	36.80 ± 1.91 (9.33)
6	96.00 ± 0.88 (5.61)	50.70 ± 1.75 (6.71)	16.20 ± 1.29 (12.88)	7.50 ± 1.21 (7.49)	3.54 ± 0.94 (9.26)	12.29 ± 1.33 (5.47)	5.35 ± 1.13 (9.39)	87.90 ± 1.28 (8.56)	39.75 ± 1.68 (10.75)
7	97.00 ± 0.96 (6.68)	51.25 ± 1.01 (10.15)	16.45 ± 0.59 (5.86)	7.20 ± 1.32 (11.68)	3.51 ± 0.57 (10.49)	16.78 ± 1.61 (9.78)	6.01 ± 1.36 (6.00)	75.40 ± 0.57 (5.36)	39.20 ± 0.53 (6.24)
8	101.00 ± 0.41 (7.93)	50.86 ± 0.53 (7.63)	15.85 ± 0.66 (5.05)	6.40 ± 1.04 (6.75)	3.25 ± 0.39 (10.17)	13.20 ± 1.20 (7.17)	4.95 ± 0.69 (5.05)	69.85 ± 0.88 (10.83)	36.00 ± 0.53 (6.70)
9	99.20 ± 1.40 (4.52)	50.95 ± 1.01 (10.15)	16.90 ± 0.76 (6.36)	7.00 ± 0.48 (8.33)	3.45 ± 0.63 (12.20)	14.05 ± 1.17 (9.56)	5.75 ± 0.81 (11.77)	70.50 ± 1.32 (8.97)	36.70 ± 1.16 (10.23)
10	98.30 ± 0.36 (4.31)	49.05 ± 1.09 (7.63)	14.50 ± 1.07 (12.27)	6.25 ± 0.36 (8.16)	3.10 ± 0.79 (11.98)	13.95 ± 1.02 (9.10)	5.5 ± 1.44 (5.92	65.40 ± 1.29 (10.23)	35.95 ± 0.69 (12.27)

() Parenthesis-coefficient of variation; DM Days to maturity; NR Number of raceme; SEW Single ear head weight; NT Number of tillers; Thousand grain weight; Fe Iron; Zn Zinc; FY Fodder yield per plant; GY Grain yield per plant

Table.3b Mean, standard error and coefficient of variation for ACM 331 x ACM 333 cross of selected families studied in F_3 generation

Families	ACM331 x ACM333								
	DM	NR	SEW	NT	TW	Fe	Zn	FY	GY
Co (Kv) 2 (control)	104.00 ± 0.08	58.00 ± 0.25	17.05 ± 0.10	5.00 ± 0.25	3.40 ± 0.15	11.20 ± 0.24	3.15 ± 0.30	52.10 ± 0.75	39.50 ± 0.40
1	97.85 ± 0.08 (5.31)	53.65 ± 0.24 (8.75)	16.80 ± 0.12 (6.82)	8.05 ± 0.42 (10.38)	3.37 ± 0.24 (7.39)	12.00 ± 0.13 (5.27)	4.98 ± 0.24 (9.59)	87.56 ± 0.26 (9.09)	44.26 ± 0.38 (8.55)
2	98.65 ± 0.43 (6.52)	54.25 ± 0.35 (8.94)	17.65 ± 0.27 (7.23)	8.95 ± 0.42 (11.54)	3.43 ± 0.16 (5.89)	12.65 ± 0.32 (8.82)	5.05 ± 0.24 (8.22)	86.40 ± 0.16 (6.64)	43.68 ± 0.27 (8.81)
3	99.45 ± 0.20 (5.52)	55.40 ± 0.39 (8.73)	18.25 ± 0.24 (7.80)	9.00 ± 0.24 (10.99)	3.40 ± 0.14 (6.98)	10.50 ± 0.23 (10.69)	3.76 ± 0.18 (5.76)	88.24 ± 0.31 (10.92)	45.30 ± 0.21 (7.40)
4	96.35 ± 0.25 (4.16)	56.30 ± 0.16 (11.59)	18.60 ± 0.18 (7.81)	9.05 ± 0.39 (15.57)	3.50 ± 0.27 (10.22)	13.05 ± 0.11 (8.14)	5.42 ± 0.41 (10.63)	90.15 ± 0.34 (12.03)	46.50 ± 0.26 (9.67)
5	98.60 ± 0.26 (6.33)	52.40 ± 0.16 (12.30)	16.85 ± 0.25 (6.97)	7.80 ± 0.29 (9.68)	3.45 ± 0.23 (7.84)	11.90 ± 0.22 (7.04)	5.24 ± 0.76 (12.44)	91.05 ± 0.24 (10.83)	45.25 ± 0.30 (10.17)
6	99.75 ± 0.29 (7.28)	53.78 ± 0.38 (9.96)	17.45 ± 0.44 (11.94)	8.00 ± 0.11 (6.58)	3.25 ± 0.20 (8.61)	12.43 ± 0.27 (10.73)	5.13 ± 0.27 (7.94)	85.60 ± 0.39 (10.83)	42.90 ± 0.33 (8.58)
7	100.50 ± 0.32 (4.26)	54.60 ± 0.23 (9.01)	17.90 ± 0.12 (8.40)	8.65 ± 0.28 (9.58)	3.24 ± 0.26 (8.41)	10.85 ± 0.23 (7.35)	4.08 ± 0.24 (7.99)	84.25 ± 0.12 (9.37)	44.75 ± 0.12 (6.20)
8	97.60 ± 0.14 (4.41)	53.80 ± 0.21 (8.28)	16.95 ± 0.33 (7.44)	7.90 ± 0.18 (5.79)	3.42 ± 0.25 (10.65)	11.90 ± 0.22 (8.57)	4.90 ± 0.14 (1.69)	80.78 ± 0.24 (9.33)	43.90 ± 0.15 (7.44)
9	98.20 ± 0.25 (4.21)	54.35 ± 0.23 (9.01)	17.85 ± 0.26 (9.48)	8.20 ± 0.36 (8.24)	3.45 ± 0.33 (11.23)	12.35 ± 0.27 (5.09)	4.80 ± 0.30 (10.78)	85.40 ± 0.25 (9.27)	42.65 ± 0.28 (9.29)
10	96.35 ± 0.12 (7.81)	55.00 ± 0.21 (8.28)	18.00 ± 0.29 (8.59)	8.50 ± 0.12 (8.86)	3.48 ± 0.35 (11.51)	12.28 ± 0.13 (7.95)	5.15 ± 0.37 (9.59)	89.35 ± 0.23 (8.99)	44.65 ± 0.29 (10.32)

() Parenthesis-coefficient of variation; DM Days to maturity; NR Number of raceme; SEW Single ear head weight; NT Number of tillers; Thousand grain weight; Fe Iron; Zn Zinc; FY Fodder yield per plant; GY Grain yield per plant

Table.3c Mean, standard error and coefficient of variation for ACM331 x MA10 cross of selected families studied in F_3 generation

Families	ACM331 x MA10								
	DM	NR	SEW	NT	TW	Fe	Zn	FY	GY
Co (Kv) 2 (control)	104.00 ± 0.08	58.00 ± 0.25	17.05 ± 0.10	5.00 ± 0.25	3.40 ± 0.15	11.20 ± 0.24	3.15 ± 0.30	52.10 ± 0.75	39.50 ± 0.40
1	98.50 ± 0.07 (4.41)	58.25 ± 0.08 (10.25)	19.65 ± 0.08 (6.54)	8.90 ± 0.15 (9.77)	3.25 ± 0.10 (11.87)	11.00 ± 0.08 (12.33)	4.10 ± 0.09 (7.09)	83.95 ± 0.13 (8.69)	45.85 ± 0.1 (10.88)
2	97.00 ± 0.10 (6.54)	57.45 ± 0.15 (10.53)	19.20 ± 0.12 (11.99)	8.50 ± 0.11 (10.39)	3.38 ± 0.07 (14.23)	12.80 ± 0.11 (7.04)	4.25 ± 0.14 (10.82)	85.30 ± 0.08 (5.79)	44.63 ± 0.13 (10.27)
3	95.50 ± 0.04 (6.96)	60.15 ± 0.10 (9.44)	20.65 ± 0.15 (12.23)	9.50 ± 0.11 (9.36)	3.60 ± 0.07 (10.28)	15.15 ± 0.07 (11.15)	6.00 ± 0.06 (6.32)	92.35 ± 0.11 (10.20)	49.80 ± 0.10 (9.35)
4	98.00 ± 0.07 (9.97)	58.20 ± 0.08 (11.49)	19.00 ± 0.10 (12.79)	9.00 ± 0.13 (8.74)	3.54 ± 0.12 (9.93)	13.05 ± 0.06 (9.37)	5.85 ± 0.11 (10.62)	98.65 ± 0.08 (6.96)	48.20 ± 0.12 (11.29)
5	99.00 ± 0.05 (9.89)	57.60 ± 0.08 (12.76)	18.95 ± 0.13 (8.69)	8.40 ± 0.09 (10.83)	3.41 ± 0.05 (8.05)	12.85 ± 0.10 (8.06)	4.95 ± 0.12 (10.42)	90.45 ± 0.10 (6.98)	44.89 ± 0.10 (10.49)
6	100.00 ± 0.06 (5.94)	58.30 ± 0.05 (10.49)	19.10 ± 0.11 (10.98)	8.75 ± 0.10 (7.14)	3.48 ± 0.07 (9.69)	11.01 ± 0.13 (9.12)	4.30 ± 0.16 (9.03)	96.30 ± 0.07 (9.71)	46.10 ± 0.11 (12.20)
7	99.00 ± 0.10 (7.62)	56.90 ± 0.10 (9.45)	18.34 ± 0.09 (12.35)	8.20 ± 0.12 (13.20)	3.25 ± 0.09 (6.62)	12.90 ± 0.09 (9.34)	4.90 ± 0.13 (10.24)	85.30 ± 0.10 (14.61)	45.85 ± 0.08 (5.45)
8	96.50 ± 0.09 (5.98)	59.00 ± 0.10 (6.80)	19.85 ± 0.07 (11.65)	8.95 ± 0.08 (9.03)	3.39 ± 0.08 (7.20)	12.78 ± 0.11 (8.67)	3.98 ± 0.08 (14.95)	92.10 ± 0.11 (7.97)	47.00 ± 0.08 (10.67)
9	97.50 ± 0.07 (8.41)	53.00 ± 0.10 (9.45)	17.90 ± 0.09 (9.80)	7.90 ± 0.05 (8.41)	3.30 ± 0.12 (11.76)	15.45 ± 0.09 (10.22)	5.87 ± 0.14 (7.08)	82.15 ± 0.11 (10.83)	43.60 ± 0.06 (9.93)
10	103.00 ± 4.42 (6.29)	54.00 ± 0.10 (12.91)	18.20 ± 0.12 (8.92)	8.60 ± 0.07 (9.20)	3.40 ± 0.15 (9.88)	12.55 ± 0.11 (8.76)	4.65 ± 0.09 (10.16)	88.60 ± 0.12 (10.53)	45.90 ± 0.15 (7.04)

() Parenthesis-coefficient of variation; DM Days to maturity; NR Number of raceme; SEW Single ear head weight; NT Number of tillers; Thousand grain weight; Fe Iron; Zn Zinc; FY Fodder yield per plant; GY Grain yield per plant

This showed that grain yield and micronutrient traits are having non-significant association. The non-significant correlation of grain Fe concentration with grain yield per plant was reported by Nagesh *et al.*, (2012) in rice and Govindaraj *et al.*, (2013) in maize supporting the present study. It may be used for hybridization programme for improvement of Fe and Zn in high yielding varieties. In the F3 generation, the identified superior families in all the three crosses revealed that yield and yield component characters progressively increased when compared to control [Co (Kv) 2] except for days to maturity and number of racemes (ACM 331 x ACM335, ACM 331 x ACM333) and single ear head weight (ACM 331 x ACM335). Among the families of ACM 331 x MA10 cross, third, fourth and ninth exhibited superior performance than the control for most of the yield attributing and micronutrient traits and low co efficient variation. These selected families are recommended for promoting to advanced generation for varietal development program with respect to high yield coupled with high iron and zinc content. The superior performances of families are presented in Table 3c.

In the present investigation, in order to isolate high yielding barnyard millet genotypes with maximum micronutrient content simultaneously, these three crosses were analyzed for variability in F_2 population. The high PCV and GCV values and high heritability were noticed for number of tillers, iron and zinc content in all the crosses, indicated the predominance of additive gene effects in their expression and would respond to selection effectively as they are least influenced by environment. All these crosses showed less coefficient of variation compared to F2, suggested that the settling down nature of homozygosity in F_3 generation. Superior families from ACM 331 x MA 10 that exhibited higher mean values than the parent and local check [CO (Kv) 2] for most yield attributing and micronutrient traits were selected for promoting to advanced generation.

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