International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(5): 1042-1044

Received: 06-07-2017
Accepted: 08-08-2017

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Genetic variability, heritability and association in advanced breeding lines of finger millet [*Eluesine coracana* (L.) gaertn.]

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Abstract
The present investigation was undertaken to study the genetic variability, heritability and correlation of grain yield and yield related traits. Analysis of Variance of 25 finger millet advanced breeding lines revealed significant variation for all the traits studied. The mean grain yield was 31.50 q/ha, with a minimum of 29.22 and maximum of 39.74 q/ha. Grain yield recorded genotypic coefficient of variation of 12.86, while phenotypic coefficient of variation was 18.06 q/ha. Heritability ranged from 0.35 (number of finger per ear) to 0.88 (days to 50% flowering), while heritability for yield was 0.51. Number of tillers per plant and number of fingers per ear were observed to be highly associated with yield. The present findings implies the presence of larger variability for yield and other related traits which can be exploited in finger millet improvement.

Keywords: finger millet, correlation, variability.

Introduction
Finger millet (*Eluesine coracana* (L.) Gaertn.) is one of the important millets grown for food and fodder in Africa and Asia. Finger millet alone occupies ten per cent of total area (34.6 mha) of millets. It is cultivated in an area of 2.6 mha, with a production of 3.0 mt and this crop ranks next to pearl millet in India (www.indiastat.com, 2015) [14]. It has many names like ragi, birds foot, mandua, chodi etc., in different parts of the country. Nowadays it is drawing the attention of people for daily consumption because of its high nutritional value. The grain is rich in micronutrients especially calcium, iron and zinc. More over its special properties like anti-tumerogenic, anti-diabetic, antioxidant and antimicrobial propertiesmake this crop highly valued for its utilization (Sharma *et al.*, 2016 [10]; Devi *et al.*, 2015 [4]).

Further, finger millet is very hardy and can be raised in poor soils with low nutrients and less moisture where other cereals fail to grow. It can withstand drought and even salinity and water logging to some extent. Ragi can challenge the changing climate because of its less requirement of moisture. It can survive with less than one fourth of paddy’s water requirement. It is the future crop.

The challenge to changes in climate can be addressed by crop improvement. Development of new varieties over existing varieties is a pre-requisite to cater the needs of present and future. For any crop, genetic variability among the available breeding lines provides a hope for improvement of the crop through selection (Suryanarayana *et al.*, 2014) [11]. Selection will be effective when the trait is highly heritable. Heritability of a character provides an insight into the heritable variance and it is needed for any plant breeding programme. Grain yield is a complex character governed by many genes and further influenced by the nearby environment (Owere *et al.*, 2015) [7]. Hence, direct selection of yield is not worthy. Consequently, a sound knowledge on correlation of yield contributing traits with grain yield helps in indirect selection of yield *via* highly heritable traits (Bezaweletaw *et al.*, 2006) [2]. Hence, in the present study 25 finger millet advanced breeding lines were studied for variability, heritability and correlation of yield and other important traits.

Material and Methods
The present study comprised of 25 finger millet advanced breeding lines including two check varieties *viz.*, Champavathi (VR 708) and Sri Chaitanya (VR 847). They were evaluated at Agricultural Research Station, Vizianagaram, Andhra Pradesh during *kharif*, 2016.

Genotypes were sown in a randomized complete block design (RCBD) in three replications with a spacing of 22.5 × 7.5 cm per each entry.

Each genotype was grown in 10 lines of 3 m length. Recommended doses of fertilizers, DAP (87 kg/ha), MOP (42 kg/ha) and Urea (22 kg/ha) were applied basally at the time of land preparation and remaining 22 kg/ha Urea was applied three weeks after sowing. Healthy crop was maintained following standard management practices. Observations were recorded for plant height and main ear length in cm; productive tillers per plant and fingers per main ear in numbers. maturity and 50% flowering were recorded in days by visualizing the entire plot. Grain yield and Fodder yield were recorded in q/ha and t/ha respectively.

Analysis of variance and summary statistics was calculated as per Panse and Sukathme (1967) [8]. Phenotypic and genotypic coefficients of variation (PCV and GCV) were computed as per Burton and Devane (1953) [3]. Heritability in broad sense was computed as per Allard (1960). Genotypic and phenotypic correlations were calculated according to Falconer (1981) [5]. Heritability and genetic advancement were categorized into low, medium and high as per Johnson *et al.*, (1955) [6].

Results and Discussion

Genetic variability studies outline the basis for crop improvement. It also helps us to know the main root cause of variation whether it is sensitive to environment or not, whether it can be transformed to the next generation or not, based on this breeding programme can be planned.

The results from ANOVA revealed existence of large variability for 25finger millet advanced breeding lines under study for all the characters considered. Substantial variation was reported by earlier workers (Reddy *et al.*, 2013 [9]; Ulaganathan and Nirmalakumari 2013 [12] and 2015 [13]). All the summary statistics were presented in table 1. Coefficient of variation was maximum (14.35 %) for number of productive tillers/ plant followed by fodder yield (13.84%). Grain yield ranged from 20.99 to 39.74 q/ha, while the mean was 31.50 q/ha. The difference in duration was from 96 to 117.33 days with a mean of 110.08 days. PCV of all the traits was higher than GCV (Table 2). GCV ranged from low to moderate. Highest GCV and PCV were observed for fodder yield and number of productive tillers per plant indicating more variability of these two traits among finger millet advanced breeding lines. Days to 50% flowering and plant height were observed to have low GCV and PCV indicating lesser variability of these traits in the population. Grain yield recorded moderate GCV (12.86) and PCV (18.06) implying ample variability for this trait.

Table 1: Summary statistics of 25 finger millet advanced breeding lines

Character	Days to 50% Flowering	Plant Height (cm)	Productive Tillers/ Plant	Ear Head Length (cm)	Fingers/ Ear	Days to Maturity	Grain Yield (q/ha)	Fodder Yield (t/ha)
Mean	78.53	118.39	2.73	7.21	7.44	110.08	31.50	7.65
C.V.	2.28	5.31	14.35	8.13	11.04	2.54	11.86	13.84
C.D. 5%	2.94	10.33	0.64	0.96	1.35	4.60	6.13	1.74
Minimum	65.67	106.27	1.93	5.91	5.93	96.00	20.99	4.63
Maximum	86.00	136.33	3.87	8.33	9.00	117.33	39.74	10.55

Table 2: Genetic parameters of 25 finger millet advanced breeding lines

	Days to 50% Flowering	Plant Height (cm)	Productive Tillers/ Plant	Ear Head Length (cm)	Fingers / Ear	Days to Maturity	Grain Yield In (q/ha)	Fodder Yield (t/ha)
GCV	6.07	6.62	18.25	7.76	8.19	4.48	12.86	18.81
PCV	6.49	8.49	23.22	11.24	13.75	5.16	18.06	23.36
ECV	2.28	5.31	14.35	8.13	11.04	2.54	12.68	13.84
h^2 (Broad Sense)	0.88	0.61	0.62	0.48	0.35	0.76	0.51	0.65
Genetic Advance	9.20	12.59	0.81	0.80	0.75	8.85	5.94	2.39
GAM	11.71	10.63	29.56	11.04	10.04	8.04	18.87	31.21

Heritability was moderate to high for the characters studied while genetic advance as per cent mean (GAM) ranged from low to high for the traits studied. Days to 50% flowering, plant height and grain yield had high heritability with moderate GAM indicating presence of both additive and non additive gene action while days to maturity had high heritability with low GAM indicating predominance of non additive gene action. Ear length and number of fingers per ear also have both additive and non additive gene action. High heritability and high GAM was observed for number of productive tillers per plant and fodder yield indicating predominance of additive genes which responds well to simple selection. Similar results were reported earlier in finger millet (Owere *et al.*, 2015 [7]; Ulaganathan and Nirmala kumari, 2013 [12]).

Association of different characters gives an insight about simultaneous selection of characters. In this study, both pheontypic and genotypic correlations (Table 3a &b) were significantly high and in positive direction for grain yield with number of fingers per ear, number of productive tillers per plant and fodder yield implying selection of these traits will lead to simultaneous improvement in yield. Days to 50% flowering was highly and positively associated with days to maturity and ear length but these traits did not show significant association with yield. Hence, in this panel, selection for number of fingers per ear and number of productive tillers per plant will lead to higher grain yield, whereas as other traits like maturity has no influence.

Table 3a: Phenotypic correlation of yield and related traits

Character	Plant Height (cm)	Productive Tillers/ Plant	Ear Head Length (cm)	Fingers/ Ear	Days to Maturity	Grain Yield (q/ha)	Fodder Yield (t/ha)
Days to 50% Flowering	0.2223	0.1613	0.2915*	0.0984	0.9214**	0.0629	-0.0127
Plant Height (cm)		0.4057**	0.1154	0.1475	0.1772	0.1532	0.3612*
Productive Tillers/ Plant			0.2252	0.1692	0.1977	0.5394**	0.4925*
Ear Head Length (cm)				0.4413**	0.2761*	0.0606	-0.0167
Fingers/ Ear					0.0795	0.2749*	0.0879
Days to Maturity						0.1659	0.0183
Grain Yield (q/ha)							0.3436*

Table 3b: Genotypic correlation of yield and related traits

Character	Plant Height (cm)	Productive Tillers/ Plant	Ear Head Length (cm)	Fingers/ Ear	Days to Maturity	Grain Yield (q/ha)	Fodder Yield (t/ha)
Days to 50% Flowering	0.3230*	0.2098	0.4936**	0.2303	0.9991**	0.0864	-0.0125
Plant Height (cm)		0.5994**	0.1807	0.0056	0.2970	0.1590	0.6557**
Productive Tillers/ Plant			0.3193*	0.1404	0.1655	0.7401**	0.6872**
Ear Head Length (cm)				0.6406**	0.5092**	0.3055	0.0165
Fingers/ Ear					0.2206	0.5110**	0.2134
Days to Maturity						0.1648	-0.0192
Grain Yield (q/ha)							0.5381**

Conclusion

Significant variation for all the traits studied was observed in the present study for 25 genotypes of finger millet. GCV and PCV were low to moderate for the traits studied indicating low to moderate variability in the present population. Higher variability is exhibited by number of productive tillers per plant where GCV and PCV are high. Grain yield is controlled by both additive and non additive gene action, hence direct selection may not be effective. As this trait is highly associated with number of productive tillers per plant which is predominantly controlled by additive gene action, selection of grain yield via this trait is desirable.

Acknowledgements

Facilities provided by Agricultural Research Station, Vizianagaram are highly acknowledged. The work was carried out by utilizing the grants received from Acharya N.G. Ranga Agricultural University, Guntur.

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