The Pharma Innovation Journal 2023; 12(12): 2073-2077

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(12): 2073-2077

www.thepharmajournal.com
Received: 24-09-2023
Accepted: 28-10-2023

Thakre AR
PG Scholar, Department of Agriculture, Botany RCSM College of Agriculture, Kolhapur, MPKV, Maharashtra, India

Mote MS
Assistant Professor, Department of Agril. Botany RCSM College of Agriculture, Kolhapur, MPKV, Maharashtra, India

Ban YG
Junior Breeder, AICRP on small millets ZARS, Kolhapur, Maharashtra, India

Wagh KA
PG Scholar, Department of Agriculture, Botany RCSM College of Agriculture, Kolhapur, MPKV, Maharashtra, India

Kamble MS
Assistant Professor, Department of Agriculture, Botany RCSM College of Agriculture, Kolhapur, MPKV, Maharashtra, India

Karad SR
Maize Breeder, AICRP on Maize, Maize Improvement Project, Kasba Bawda, Kolhapur, Maharashtra, India

Corresponding Author:
Thakre AR
PG Scholar, Department of Agriculture, Botany RCSM College of Agriculture, Kolhapur, MPKV, Maharashtra, India

Study of genetic variability, heritability and genetic advance in foxtail millet (*Setaria italica* (L.) Beauv)

Thakre AR, Mote MS, Ban YG, Wagh KA, Kamble MS and Karad SR

Abstract
Thirty-four genotypes of foxtail millet were studied at AICRP on small millets, ZARS, Kolhapur (M.S.) India in *kharif* 2022. The evaluation study was conducted to assess its genetic variability, heritability (b.s.) and genetic advance as percent of mean for nine characters. PCV estimations were higher than their corresponding GCV estimates, revealing that the characters were less influenced by the environment. High PCV coupled with high GCV was observed for grain yield per ear head and grain yield kg per hectare. The traits days to 50 percent flowering, days to maturity and 1000 grain weight showed lowest GCV as well as PCV. Among all nine characters plant height (cm), no. of productive tillers per plant, carbohydrate percentage and protein content were exhibited moderate GCV and PCV. High heritability with high genetic advance were exhibited by the characters grain yield kg per hectare, plant height, carbohydrate percentage, days to maturity and days to 50 percent flowering. The high heritability with low genetic advance was observed for 1000 grain weight, no. of productive tillers per plant, grain yield per ear head and protein content (%). High genetic advance as a percent of mean was observed for grain yield kg per ha while low genetic advance as a percent of mean was observed for days to 50 percent flowering.

Keywords: Foxtail millet, genetic variability, heritability, genetic advance, genetic advance as percent of mean, characters

Introduction
The history of the food, particularly in the context of India, would be insufficient without recognizing the significant role played by millets. Millets are termed as 'nutraceuticals,' as they hold a distinctive position in the culinary heritage of the region. Farmers favor millets, and they are environmentally sustainable due to their robust ability to withstand arid conditions and harsh environments. Rajasthan, Karnataka, Maharashtra, Uttar Pradesh, and Haryana stand out as the leading states in millet production. Despite the cultivation of various millet varieties, both major and minor, across the country, India holds the global record as the largest millet producer. The nation annually produces over 170 lakh tonnes of millets, constituting approximately 20 percent of the world's total and 80 percent of Asia's total production, according to FAO Stat, 2021.

The genus *Setaria* belongs to the family Poaceae in the grass family. Approximately 125 species are widely distributed in the warm and temperate regions of the world. Globally, foxtail millet secures the second position in millet production, registering a yield of approximately 2166 Kg/ha, as reported by icrisat.org in 2023. It surpasses all other millets in terms of productivity. Because of its short growing season, foxtail millet exhibits a certain degree of resilience to drought. Its minimal input requirements make it highly adaptable to the existing farming practices of resource-limited farmers.

Foxtail millet has a large genetic variability that has to be characterized in order for its cultivars to become more genetically superior. The first step in a plant breeding program for crop enhancement is to analyse genetic variability. The high degree of variability not only enhances the adaptability of foxtail millet to diverse environments but also offers valuable opportunities for the development of improved cultivars with desirable traits.

Characterizing these genotypes for their genetical variability offers enormous promise for their use in the breeding program. They also work as a tool for informative selection of genotypes for future breeding programme. The grain yield of a crop is a complex and crucial attribute influenced by various dependant features, many of which are governed by polygenes and external factors. Consequently, comprehending genetic advance, heritability, and the relationships between different traits becomes essential for the effective selection of parents in order to enhance crop productivity. Therefore, the present experimental study was conducted to study genetic variability, heritability and genetic advance in foxtail millet genotypes.

Materials and Methods

For the current study, the experimental material consisted of 32 genotypes of foxtail millet, along with 2 reference checks, namely PS-4 and DHFt-109-3. These genotypes were sourced from AICRP on small millets, Zonal Agricultural Research Station, Shenda Park, Kolhapur, Maharashtra, India. The sowing of these genotypes was carried out in a randomized block design with three replications during the Kharif season of 2022 at AICRP on small millets, Zonal Agricultural Research Station, Shenda Park, Kolhapur, Maharashtra, India. The name of genotypes used for study given in table no. 1.

Table 1: List of foxtail millet genotypes included in the studies

Sr. No.	Genotype	Sr. No.	Genotype
01.	KOPFX-2103	18.	KOPFX-2109
02.	KOPFX-2105	19.	KOPFX-2110
03.	KOPFX-2108	20.	KOPFX-2111
04.	KOPFX-2112	21.	KOPFX-2114
05.	KOPFX-2113	22.	KOPFX-2117
06.	KOPFX-2115	23.	KOPFX-2118
07.	KOPFX-2116	24.	KOPFX-2120
08.	KOPFX-2119	25.	KOPFX-2122
09.	KOPFX-2121	26.	KOPFX-2124
10.	KOPFX-2123	27.	KOPFX-2125
11.	KOPFX-2132	28.	KOPFX-2126
12.	KOPFX-2128	29.	KOPFX-2127
13.	KOPFX-2101	30.	KOPFX-2129
14.	KOPFX-2102	31.	KOPFX-2130
15.	KOPFX-2104	32.	KOPFX-2131
16.	KOPFX-2106	33.	DHFt-109-3(Check)
17.	KOPFX-2107	34.	PS-4-(Check)

Data recorded: Observations were recorded on five randomly selected plants for nine characters which include *viz.*, days to 50 percent flowering, days to maturity, plant height (cm), number of productive tillers per plant, grain yield per ear head, grain yield kg per ha and 1000 grain weight(g) and for biochemical characters carbohydrate (%) and protein content (%).

Table 2: Analysis of variance for nine characters in foxtail millet

Sr. No.	Characters	Mean sum of square (MSS)		
		Replications df=2	Treatments df=33	Error df= 66
1.	Days to 50% flowering	46.15	33.15**	5.19
2.	Days to maturity	157.09	144.20**	14.31
3.	Plant height (cm)	103.89	1006.53**	48.21
4.	No. of productive tillers per plant	0.05	0.98**	0.18
5.	Grain yield per ear head	0.14	1.07**	0.05
6.	Grain yield kg per ha	115778	466255.22**	20843.77
7.	1000 grain weight (g)	0.03	0.33*	0.04
8.	Carbohydrate (%)	0.88	185.36**	0.80
9.	Protein content (%)	0.05	6.45**	0.05

*, ** significant at 5 and 1 percent, respectively

Results and Discussion

The analysis of variance revealed that the mean sum of squares due to genotypes for all the characters studied were highly significant which indicated presence of greater amount of variability among the genotypes (Table No. 2).

The mean performance of 34 genotypes for nine characters (Table no. 3) indicated that, variation in days to 50 percent flowering were ranged from 57 to 69 days with general mean of 61 days and days to maturity were ranged from 83 to 113 days with general mean of 93 days. The variability for plant height were ranged from 72.5 to 131.5 cm with general mean were observed was 102.2 cm. The mean of number of productive tillers per plant were ranged from 2.5 to 4.8 with the general mean of 3.8, the general mean for grain yield per ear head is 2.65 gram and the mean ranges from 1.62 to 4.26 gram. The general mean for grain yield kg per hectare was 1585.9 kg/ha, the mean value for this trait were ranged from 720 to 2522 kg/ha. A 1000 grain weight among 34 genotypes were ranged from 2.57 to 3.74 gram with general mean of 3.35 gram. The mean value for carbohydrate percent were ranged from 52.98 percent to 74.49 percent with general mean of 63.60 percent and the general mean for protein content was 10.04 percent while the general mean ranged from 7.5 percent to 12.3 percent.

The characters days to 50 percent flowering (4.96, 5.41), days to maturity (7.10, 7.48) and 1000 grain weight (g) (7.10, 7.48) estimated lowest GCV as well as PCV, whereas the characters grain yield per ear head (g) (22.02, 22.55) and grain yield kg per ha (24.29, 24.85) had highest GCV and PCV. Among all nine characters plant height (17.49, 17.92), no. of productive tillers per plant (13.52, 14.98), carbohydrate percent (12.33, 12.35) and protein content % (14.54, 14.61) were exhibited moderate (10% to 20%) GCV and PCV.

Table 3: Mean performance of 34 genotypes of foxtail millet for nine characters

Sr. No.	Genotypes	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of productive tillers per plant	Grain yield per ear head (gm)	Grain yield kg per ha	1000 grain weight (g)	Carbohydrate (%)	Protein content (%)
1.	KOPFX-2103	57	88	111.1	4.7	2.61	1566	3.17	68.91	12.3
2.	KOPFX-2105	58	89	126.6	3.5	2.57	1443	3.65	55.91	11.9
3.	KOPFX-2108	64	90	120.5	4.1	3.09	2220	3.43	59.24	10.9
4.	KOPFX-2112	64	92	118.5	3.4	2.08	1225	3.21	57.57	11.4
5.	KOPFX-2113	63	86	125.3	4.8	2.55	1555	3.46	70.18	12.1
6.	KOPFX-2115	61	87	117.9	4.3	1.62	720	3.53	58.92	9.6
7.	KOPFX-2116	61	91	125.5	3.9	2.32	1544	3.53	58.36	11.3
8.	KOPFX-2119	63	85	121.2	3.7	2.83	1338	3.16	70.09	9.8
9.	KOPFX-2121	58	90	115.2	4.5	2.70	1906	2.97	57.28	11.4
10.	KOPFX-2123	60	93	131.5	4.3	2.57	1602	3.72	69.30	11.6
11.	KOPFX-2132	60	95	123.1	3.7	1.96	1251	3.28	74.49	8.7
12.	KOPFX-2128	60	85	131.5	3.8	2.82	1704	3.36	55.05	9.2
13.	KOPFX-2101	69	113	74.8	3.7	2.23	1438	3.49	54.66	8.4
14.	KOPFX-2102	67	105	84.2	4.3	2.33	1243	2.66	74.46	10
15.	KOPFX-2104	60	92	77.7	4.1	2.15	1211	3.16	73.12	7.5
16.	KOPFX-2106	64	90	84.9	4.4	2.16	1218	3.44	72.76	10.5
17.	KOPFX-2107	57	87	90.9	3.4	4.26	2522	3.68	63.05	8.0
18.	KOPFX-2109	58	85	101.7	3.8	2.22	1304	3.58	57.82	11.0
19.	KOPFX-2110	58	92	96.5	4.1	2.23	1493	3.59	70.09	10.6
20.	KOPFX-2111	57	85	103.2	4.5	2.16	1287	3.23	71.73	8.0
21.	KOPFX-2114	61	89	85.6	4.3	1.91	1127	3.62	72.86	11.2
22.	KOPFX-2117	60	89	104.9	3.7	3.38	1937	3.55	61.39	9.3
23.	KOPFX-2118	60	95	94.8	2.7	2.75	1409	2.57	71.81	8.1
24.	KOPFX-2120	62	92	93.5	3.9	2.46	1416	3.08	73.82	9.0
25.	KOPFX-2122	62	97	72.5	2.7	2.78	1650	3.65	56.42	7.5
26.	KOPFX-2124	65	98	85.9	4.2	2.69	1434	3.67	54.45	11.8
27.	KOPFX-2125	65	100	83.5	3.9	3.26	1747	2.66	52.98	8.7
28.	KOPFX-2126	61	93	82.2	3	3.93	2238	3.56	54.15	9.8
29.	KOPFX-2127	64	107	94.7	3.2	3.24	1937	3.63	54.20	10.5
30.	KOPFX-2129	66	98	92.2	3.7	2.75	1747	3.59	59.34	11.9
31.	KOPFX-2130	67	95	89.4	2.5	3.14	2106	2.8	55.63	8.0
32.	KOPFX-2131	65	105	78.5	3.1	3.64	2405	3.74	56.87	9.8
33.	DHFt-109-3 (C)	57	88	115	3.7	2.91	1688	3.36	72.70	10.2
34.	PS-4 (C)	58	83	119.5	4.1	1.77	1285	3.16	72.82	11.5
	Mean	61	93	102.2	3.8	2.65	1585.9	3.35	63.60	10.04
	Minimum	57	83	72.5	2.5	1.62	720	2.57	52.98	7.5
	Maximum	69	113	131.5	4.8	4.26	2522	3.74	74.49	12.3
	S.Em±	1.32	2.18	4.00	0.25	0.13	83.35	0.12	0.52	0.13
	C.V. %	3.71	4.08	6.79	11.17	8.43	9.10	6.22	1.41	2.33
	C.D. (5%)	3.72	6.17	11.32	0.69	0.36	235.35	0.34	1.46	0.38

Table 4: Parameters of genetic variability of nine characters in 34 genotypes of foxtail millet

Sr. No.	Characters	Coefficient of variation (%)		Heritability in broad sense (h^2bs)	Genetic advance (GA)	Genetic advance as percent of mean (GAM)
		Genotypic (GCV)	Phenotypic (PCV)			
1.	Days to 50% flowering	4.96	5.41	84.3	5.77	9.39
2.	Days to maturity	7.10	7.48	90.1	12.86	13.88
3.	Plant height (cm)	17.49	17.92	95.2	35.92	35.15
4.	No. of productive tillers per plant	13.52	14.98	81.5	0.95	25.15
5.	Grain yield per ear head (g)	22.02	22.55	95.3	1.17	44.30
6.	Grain yield kg per ha	24.29	24.85	95.5	775.78	48.91
7.	1000 grain weight (g)	9.05	9.73	86.4	0.58	17.33
8.	Carbohydrate (%)	12.33	12.35	99.6	16.12	25.34
9.	Protein content (%)	14.54	14.61	99.2	2.99	29.84

The highest difference between genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) was observed for no. of productive tillers per plant (1.46) followed by 1000 grain weight (0.68) and grain yield kg/ha (0.56), while, the carbohydrate percent (0.02) and protein content percent (0.07) had the lowest difference between GCV and PCV. The PCV values was higher than the GCV value for all characters. This showed that, all the characters were influenced by environmental factors.

These results were in consonance with the reports of Muhammed *et al.*, (2004) [8], Shingane *et al.*, (2017) [13] and Nirmalakumari *et al.*, (2010) [10]. Prasanna *et al.*, (2013a) [11], Banu *et al.*, (2017) [2] and Venkatesh *et al.*, (2020) [15] were also noticed high GCV and PCV values for grain yield.

Shanthi *et al.*, (2017) [12] in their study revealed that phenotypic coefficients of variation (PCV) estimates were higher than genotypic coefficients of variation (GCV) estimates for all characters showing the influence of environmental effects. Yogeesh *et al.*, (2015) [16] also observed similar results for tillers per plant and plant height. The characters grain yield per ear head (g) and grain yield kg per ha showed high estimates of GCV and PCV. This reveals the presence of large variation in the genotypes for these characters. Hence simple selection can be applied for the improvement of these characters.

The estimates of heritability (b.s.) were ranged from 81.5 (%) to 99.6 (%). It was highest for carbohydrate (99.6%) followed by protein content (99.2%), grain yield kg per ha (95.5%), grain yield per ear head (95.3%), plant height (95.2%), days to maturity (90.1%), 1000 grain weight (86.4%), days to 50 percent flowering (84.3%) and no. of productive tillers per plant (81.5%). This indicated that variation observed was under genetic control and the characters were least influenced by environment.

These findings are in confirmation with Nirmalakumari *et al.*, (2010) [10], Anuradha and Patro (2019) [9], Jyothsna *et al.*, (2016c) [5], Kamatar *et al.*, (2014) [6], Kavya *et al.*, (2017) and Tyagi *et al.*, (2011) [14] for grain yield, Tyagi *et al.*, (2011) [14], Yogeesh *et al.*, (2015) [16] and Kamatar *et al.*, (2014) [6] for days to 50 percent flowering, Kamatar *et al.*, (2014) [6] for days to maturity, no. of productive tillers per plant and test weight (1000 grain weight). Jyothsna *et al.*, (2016c) [5], Kavya *et al.*, (2017) [7], Venkatesh *et al.*, (2020) [15] and Banu *et al.*, (2017) [2] obtained similar outcomes for no. of productive tillers. Kavya *et al.*, (2017) [7] revealed similar findings for 1000 grain weight.

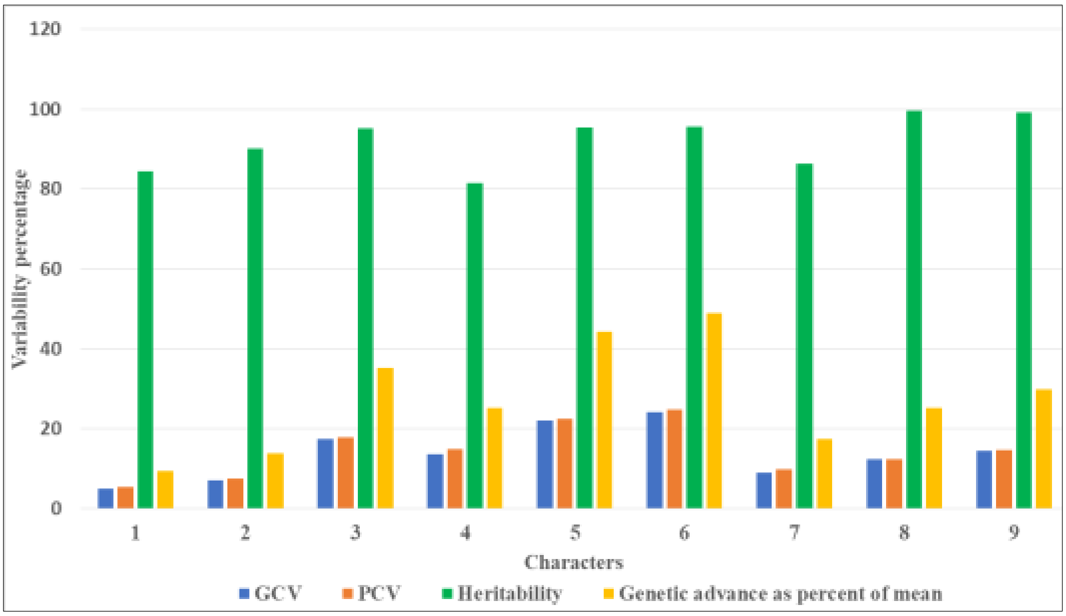
The highest genetic advance showed by the character grain yield kg per ha (775.78) followed by plant height (35.92), carbohydrate (%) (16.12), days to maturity (12.86) and days to 50 percent flowering (5.77). The lowest genetic advance was observed for 1000 grain weight (0.58) followed by no. of productive tillers per plant (0.95), grain yield per ear head (1.17) and protein content (%) (2.99).

Venkatesh *et al.*, (2020) [15] reported comparable findings in terms of days to 50 percent flowering and the number of days to maturity. Similarly, Kavya *et al.*, (2017) [7], Banu *et al.*, (2017) [2], Tyagi *et al.*, (2011) [14], Jyothsna *et al.*, (2016c) [5], and Anuradha and Patro (2019) [9] obtained consistent results regarding grain yield. Additionally, Kavya *et al.*, (2017) [7] and Jyothsna *et al.*, (2016c) [5] observed analogous outcomes for the number of tillers and 1000-grain weight.

The highest genetic advance as percent of mean was observed for grain yield kg per ha (48.91%) followed by grain yield per ear head (44.30%), plant height (35.15%), protein content (29.84%), carbohydrate (25.34%) and no. of productive tillers per plant (25.15%). Whereas, it was moderate (10 to 20%) for 1000 grain weight (17.33%) and days to maturity (13.88%) while it was low for days to 50 percent flowering (9.39%).

The traits with high heritability and high genetic advance indicate additive gene effects which is improved by selection (grain yield kg/ha, grain yield/ear head (g), plant height, protein content, carbohydrate (%), no. of productive tillers per plant, 1000 grain weight (g) and days to maturity). On the other side, high heritability with low genetic advance indicates non-additive gene action; these characters can be improved by hybridization (days to 50 percent flowering).

Muhammed *et al.*, (2004) [8] and Johar (2015) [4] reported parallel findings for both days to 50 percent flowering and days to maturity. Similarly, Nirmalakumari *et al.*, (2010) [10] documented comparable results concerning grain yield and days to 50 percent flowering. Regarding the number of tillers per plant and grain yield, Kamatar *et al.*, (2014) [6], Banu *et al.*, (2017) [2], Kavya *et al.*, (2017) [7] and Jyothsna *et al.*, (2016c) [5] observed similar outcomes. Yogeesh *et al.*, (2015) [16] and Anuradha and TSSK Patro (2019) [9] identified parallel results for grain yield. Additionally, Venkatesh *et al.*, (2020) [15] noted analogous outcomes for days to maturity.



1. Days to 50% flowering
2. Days to maturity
3. Plant height (cm)
4. No. of productive tillers per plant
5. Grain yield per ear head
6. Grain yield kg per ha
7. 1000 grain weight (g)
8. Carbohydrate (%)
9. Protein content (%)

Fig 1: Different Parameters of Variability in 34 Genotypes of Foxtail millet for 9 characters

Conclusion

According to studies on coefficients of variation, all of the characters' PCV estimations were slightly higher than their corresponding GCV estimates, revealing that the characters were less influenced by the environment. Therefore, selection on the basis of phenotype alone can be effective for the improvement of these traits. High PCV coupled with high GCV was observed for grain yield per ear head and grain yield kg per hectare. These results revealed presence of greater variability for these characters in the genotypes studied. The traits days to 50 percent flowering, days to maturity and 1000 grain weight showed lowest GCV as well as PCV. High heritability with high genetic advance were exhibited by the characters *viz.*, grain yield kg per hectare, plant height, carbohydrate (%), days to maturity and days to 50 percent flowering revealing that the characters were governed by additive gene action in the inheritance of these traits and improvement for these characters is possible through simple selection. Therefore, it can be inferred that environmental effects are least on the characters studied. So, there is a scope for improvement of these traits having high heritability in future breeding programme. The high heritability with low genetic advance was observed for 1000 grain weight, no. of productive tillers per plant, grain yield per ear head and protein content (%). It shows the presence of non-additive gene action and hence, heterosis breeding effective for improving these traits. High genetic advance as a percent of mean was observed for grain yield kg per ha while low genetic advance as a percent of mean observed for days to 50% flowering.

Acknowledgment

The authors express their gratitude to the AICRP on Small Millets, Zonal Agricultural Research Station in Shenda Park, Kolhapur (M.S.), India, for offering material support and guidance.

References

1. Anonymous. FAOSTAT; c2021. Available from: http://faostat.fao/org.
2. Banu H, Gowda J, Gowda CMV. Genetic variability and multivariate analysis in a reference set for yield characters in foxtail millet (*Setaria italica* (L.) Beauv). Green Farming. 2017;8(5):1024-1028.
3. https://www.icrisat.org; 2023.
4. Johar SJ. A study on the nature of gene action for yield and yield components in exotic genotypes of Italian millet [*Setaria italica* (L.) Beauv]. Int J Agric Sci. 2015;5(4):667-670.
5. Jyothsna S, Patro TSSK, Rani SY, Ashok S, Neeraja B, Triveni U, *et al*. Studies on genetic variability and inter-relationship between grain yield and its components in foxtail millet (*Setaria italica*). Int J Agric Sci. 2016;8(5):1015-1017.
6. Kamatar MY, Brunda SM, Naveenkumar KL, Sowmya HH, Hundekar R. Genetic variability in foxtail millet germplasm across different soil moisture situations and seasons. In: National Symposium on Crop Improvement for Inclusive Sustainable Development; c2014 p. 884-885.
7. Kavya P, Sujatha M, Pandravada SR, Hymavathi TV. Variability studies in foxtail millet (*Setaria italica* (L.) P. Beauv). Int J Curr Microbiol Appl Sci. 2017;6(9):955-960.
8. Muhammed B, Hussain SK. Genetic variability and correlation studies in foxtail millet (*Setaria italica* (L.) Beauv.). Crop Res. 2004;28(1-3):94-97.
9. Anuradha N, Patro TSSK. Genetic variability, heritability, and genetic advance in foxtail millet breeding lines. Int J Chem Stud. 2019;7(3):2967-2969.
10. Nirmalakumari A, Vetriventhan M. Characterization of foxtail millet germplasm collections for yield-contributing traits. Electron J Plant Breed. 2010;1:140-147.
11. Prasanna LP, Murthy SJSV, Kumar RPV, Rao SV. Gene frequency diversity studies in Indian genotypes of Italian millet (*Setaria italica* (L.) Beauv). Int J Curr Res. 2013;5(6):1552-1554.
12. Shanthi P, Kumari RC, Niveditha M, Reddy PKY, Reddy SB. Genetic variability studies in Italian millet (*Setaria italica* (L.) Beauv) varieties under rainfed conditions in scarce rainfall zone of Andhra Pradesh. Andhra Agric J. 2017;64(2):330-334.
13. Shingane S, Gomashe S, Ganapathy KN, Patil JV. Genetic variability and association analysis for grain yield and nutritional quality in foxtail millet. Int J Bio-resource Stress Manage. 2017;7(6):1239-1243.
14. Tyagi V, Ramesh B, Kumar D, Sukram P. Genetic architecture of yield-contributing trait (*Setaria italica*). Curr Adv Agric Sci. June 2011;3(1):29-32.
15. Venkatesh R, Pallavi LN, Ram JB, Suresh BG. Genetic divergence analysis in foxtail millet (*Setaria italica*) germplasm as determined by phenotypical traits. Int J Curr Microbiol App Sci. 2020;9(12):1119-1127.
16. Yogeesh LN, Shankar KA, Prashant SM, Lokesh GY. Genetic variation and morphological diversity in foxtail millet. Int J Sci Environ Technol. 2015;4(6):1496-1502.