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Phenotype Based Selection in Kodo Millet (*Paspalum Scrobiculatum* L.) to Identify Elite Accessions

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ABSTRACT

Background: Kodo millet (*Paspalum scrobiculatum* L) is an annual hardy crop grown in India from Kerala and Tamil Nadu in the south, to Rajasthan, Uttar Pradesh, and West Bengal in the north. It is known to have high drought tolerance and, for its potential to sustain in marginally less fertile soil. The grain has high nutritional properties thus possess medicinal values. Owing to multiple utility factors and sustainable growth rate amidst climate change, makes it an ideal crop for cultivation. In the present study accessions of Kodo millet (*Paspalum scrobiculatum* L) from twelve different geographical regions of India were evaluated for quantitative and qualitative traits to determine its growth conditions under varied climatic conditions.

Methods: Total of 96 indigenous germplasm were collected across the country and were sown in a breeding farm to grow selectively healthy crops in a randomized block design manner during *kharif* 2012 and 2013. Observations of quantitative traits were recorded on five arbitrarily selected plants in each replication for different physiological traits.

Result: The statistical data revealed significant differences among all the studied accessions. Mainly IC482729 and IC404789 from Tamil Nadu had high biomass, straw yield and yield per plant. IC396004 from Chhattisgarh showed advantageous performance in earliness with medium plant height. Therefore, the present findings helped in identifying elite germplasm accessions and could be effectively used in the Kodo millet enhancement program.

Key words: Accessions, Characterization, Kodo millet, Plant biomass, Yield per plant.

INTRODUCTION

Kodo millet (*Paspalum scrobiculatum* L) is a hardy crop and has the ability to thrive well in moderate rainfall. It belongs to the family poaceae (Graminae) and is grown throughout India. It is an indigenous crop and was domesticated 3000 years ago in the country (de Wet *et al*., 1983). It is grown in India from Kerala and Tamil Nadu in the south, to Rajasthan, Uttar Pradesh and West Bengal in the north (de Wet *et al*., 1983) Fig 1. It is an annual herb having chromosome number 2n=2x=40. (Burton, 1940). It is highly drought tolerant (de Wet *et al*., 1983; M'Ribu and Hilu, 1996) and has considerable production potential in marginal, low fertility soils and chronic moisture deficient areas of the country. This makes it as one of the ideal crops in the era of changing climate. The grain consists of high degree of nutritional properties and has anti-diabetic (Sanjay *et al*., 2010) and anti-cancer properties (Hegde and Chandra, 2005; Hegde *et al*., 2005; Chandrasekara and Shahidi, 2011). It has diverse range of protein and has a good source of fiber (Kulkarni and Naik, 2000). The area, annual production and productivity is 9.08 lakh ha, 3.11 lakh tons and 342 kg/ha, respectively. The productivity per unit area is maximum in kodo millet (Ahamed and Yadava, 1996) as compared to other minor millets. It matures in 3-4 months and has a problem of grain shattering therefore, the genotypes with earlier maturity can be considered (de Wet *et al*., 1983). It is the crop with varied yield 250 to 1000 kg/ha (Hulse *et al*., 1980), a potential yield of 2000kg/ha (Harinarayana, 1989) and it has an average test weight 4.3 g (Subramanian *et al*., 2010).

Germplasm characterization and evaluation is the base for any crop improvement programme. Germplasm conservation and use of genetic resources play an immense role for introduction. It may either be introduced from other sources or may be developed by concerned breeder from his own material. Maintaining all the records of any germplasm is essential to provide information on the traits of accessions assuring the maximum utilization of the germplasm collection to the final users. The recording and compilation of data on the important characteristics which distinguish accessions within a species, enables an easy and quick discrimination among phenotypes. Therefore, in the present investigation, germplasm of *Paspalum scrobiculatum* was characterized and evaluated for qualitative and quantitative traits and the superior germplasms were identified for future crop improvement programme.

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MATERIALS AND METHODS

The experimental material consists of 96 indigenous germplasm from twelve different regions of the country (Table 1), were sown in two rows of 2m length in a

randomized block design with three replications at Genetics and Plant Breeding farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad during *kharif* 2012 and 2013. The experimental site is located at 25.4° N latitude, 81.8° E longitude. The average temperature during the crop cycle was 30 to 35°C. The spacing between rows was 30cm and between plants in a row was 10cm apart. All cultural practices were done to grow selectively healthy crop. Observations of quantitative traits were recorded on five arbitrarily selected plants in each replication for germination percentage, days to 50% flowering, number of productive tillers, spike length (cm), number of grains per spikelet, plant height (cm), days to maturity, biomass (g), straw yield (g), yield per plant (g) and test weight (g) and spikelet shattering, grain covering by glumes and seed colour. The pooled data of two years of quantitative traits were subjected to mean, range and analysis of variance (Panse and Sukathme, 1967) by using WINDOSTAT VERSION 9.2 from Indostat services, Hyderabad. Qualitative data is discussed separately by using frequency table.



Fig 1: Distribution of Kodo millet accessions India.

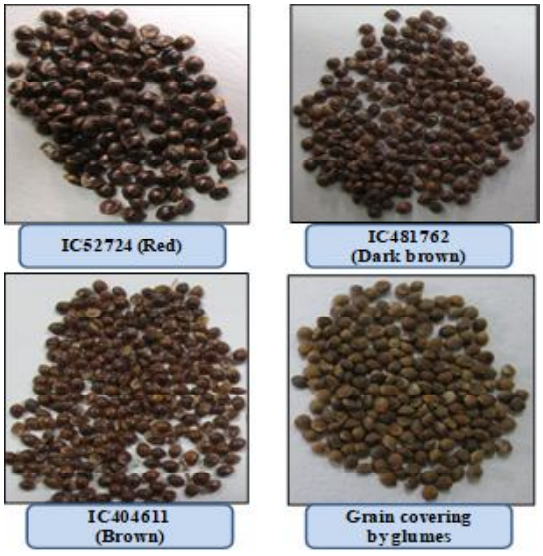

Fig 2: Representing three different types of seed color and in different regions of Grain covering by glumes.

RESULTS AND DISCUSSION

Quantitative traits

Data for yield and yield attributing traits was evaluated by the analysis of variance (ANOVA) using RBD to calculate the significance by magnitude of F value ($P<0.01$). Analysis of variance revealed significant differences among germplasm for all the eleven characters studied (Table 2). The mean, standard error, range and their groups of all the characters studied are discussed individually (Table 3).

Germination percentage

Germination percentage expresses the proportion of the total number of seeds that are alive. The variability among genotypes ranged from 70.83 (KD47) to 90.83 (KD21) with a grand mean of 82.01±2.45%. Whereas, the minimum germination percentage standard of kodo millet is 75 as per the standards of Indian minimum seed certification standards.

Days to 50% flowering

The days to 50% flowering in different accessions ranged from 53.50 (KD62) to 85.33 (KD94) with an average mean of 67.80±1.76. Earliness of germplasm is an important agronomic trait in breeding for high yielding varieties. It has a great importance in the areas where drought and heavy rainfall is common occurrence. It also escapes from pest and disease attack, abnormal weather conditions and improve cropping system (Sumathi *et al.,* 2007).

Plant Height (cm)

Plant height ranged from 80.00 (KD40) to 107.33 cm (KD37) with an overall mean of 92.34±2.20 cm. In kodo millet shortness and tallness both the traits plays a versatile role for the enhancement of crop. Shortness gives the target of more grains and lodging resistance, on the contrary tallness gives the target of more fodder (Jayarame Gowda *et al.,* 2007).

Number of productive tillers

The mean number of productive tillers recorded 9.43±0.66 with a range of 6.83 (KD16) to 13.17 (KD56). The maximum productive tillers recorded in KD56 (13.17) followed by KD23 (12.33), KD64 (11.83) and KD61 (11.67). Among 96 accessions maximum accessions showed number of productive tillers on higher side (Table 4). More number of productive tillers will give more yield in the crop (Bedis *et al.,* 2006; Jayarame Gowda *et al.,* 2007).

Spike length (cm)

The mean spike length ranged from 9.68 (KD35) to 17.68 cm (KD25) with an overall mean of 13.53±0.65 cm. The maximum spike length recorded for KD25 (17.68 cm) followed by KD80 (17.21 cm), KD23 (16.92 cm), KD68 (16.88

Table 1: List of 96 Kodo millet accessions used for morphological characterization.

Accession Code	IC Number	Regions	Donor Institute	Accession Code	IC Number	Regions	Donor Institute
KD 1	IC268136	Andhra Pradesh	ICRISAT	KD 25	IC404727	Andhra Pradesh	ICRISAT
KD 2	IC268141	Andhra Pradesh	ICRISAT	KD 26	IC404728	Andhra Pradesh	ICRISAT
KD 3	IC268145	Gujarat	ICRISAT	KD 27	IC404786	Tamil Nadu	ICRISAT
KD 4	IC268146	Gujarat	ICRISAT	KD 28	IC404789	Tamil Nadu	ICRISAT
KD 5	IC28444	Maharashtra	NBPGR, Akola	KD 29	IC41857	Maharashtra	NBPGR, R/S, Akola
KD 6	IC326826	Chhattisgarh	UAS, Bangalore	KD 30	IC481474	Andhra Pradesh	UAS, Bangalore
KD 7	IC342541	Chhattisgarh	IGAU, Ambikapur	KD 31	IC481477	Karnataka	UAS, Bangalore
KD 8	IC342542	Chhattisgarh	IGAU, Ambikapur	KD 32	IC481478	Karnataka	UAS, Bangalore
KD 9	IC342543	Chhattisgarh	IGAU, Ambikapur	KD 33	IC481481	Karnataka	UAS, Bangalore
KD 10	IC342544	Chhattisgarh	IGAU, Ambikapur	KD 34	IC481536	Gujarat	UAS, Bangalore
KD 11	IC342545	Chhattisgarh	IGAU, Ambikapur	KD 35	IC481540	Gujarat	UAS, Bangalore
KD 12	IC345040	Andhra Pradesh	-	KD 36	IC481549	Gujarat	UAS, Bangalore
KD 13	IC396004	Chhattisgarh	IGKVV	KD 37	IC481642	Karnataka	UAS, Bangalore
KD 14	IC396005	Chhattisgarh	IGKVV	KD 38	IC481644	Orissa	UAS, Bangalore
KD 15	IC404561	West Bengal	ICRISAT	KD 39	IC481645	Orissa	UAS, Bangalore
KD 16	IC404569	West Bengal	ICRISAT	KD 40	IC481737	Karnataka	UAS, Bangalore
KD 17	IC404611	West Bengal	ICRISAT	KD 41	IC481744	Karnataka	UAS, Bangalore
KD 18	IC404629	West Bengal	ICRISAT	KD 42	IC481746	Karnataka	UAS, Bangalore
KD 19	IC404666	Tamil Nadu	ICRISAT	KD 43	IC481753	Tamil Nadu	UAS, Bangalore
KD 20	IC404672	Orissa	ICRISAT	KD 44	IC481762	Tamil Nadu	UAS, Bangalore
KD 21	IC404673	Orissa	ICRISAT	KD 45	IC481482	Karnataka	-
KD 22	IC404675	Orissa	ICRISAT	KD 46	IC482379	Andhra Pradesh	UAS, Bangalore
KD 23	IC404709	Andhra Pradesh	ICRISAT	KD 47	IC482383	Andhra Pradesh	UAS, Bangalore
KD 24	IC404720	Andhra Pradesh	ICRISAT	KD 48	IC482496	West Bengal	NBPGR, R/S, Akola
KD 49	IC482497	West Bengal	NBPGR, Akola	KD 73	IC482593	Tamil Nadu	NBPGR, Akola
KD 50	IC482498	West Bengal	NBPGR, Akola	KD 74	IC482595	Tamil Nadu	NBPGR, Akola
KD 51	IC482503	Bihar	NBPGR, Akola	KD 75	IC482596	Orissa	NBPGR, R/S, Akola
KD 52	IC482504	Bihar	NBPGR, Akola	KD 76	IC482597	Orissa	NBPGR, R/S, Akola
KD 53	IC482510	Bihar	NBPGR, Akola	KD 77	IC482603	Uttar Pradesh	NBPGR, R/S, Akola
KD 54	IC482511	Bihar	NBPGR, Akola	KD 78	IC482607	Uttar Pradesh	NBPGR, R/S, Akola
KD 55	IC482513	Bihar	NBPGR, Akola	KD 79	IC482615	Uttar Pradesh	NBPGR, R/S, Akola
KD 56	IC482514	Bihar	NBPGR, Akola	KD 80	IC482619	Uttar Pradesh	NBPGR, R/S, Akola
KD 57	IC482523	Bihar	NBPGR, Akola	KD 81	IC482623	Uttar Pradesh	NBPGR, R/S, Akola
KD 58	IC482526	Bihar	NBPGR, Akola	KD 82	IC482696	Gujarat	NBPGR, R/S, Akola
KD 59	IC482528	Bihar	NBPGR, Akola	KD 83	IC482725	Gujarat	NBPGR, R/S, Akola
KD 60	IC482529	Bihar	NBPGR, Akola	KD 84	IC482729	Tamil Nadu	NBPGR, R/S, Akola
KD 61	IC482532	Bihar	NBPGR, Akola	KD 85	IC52705	Maharashtra	NBPGR, R/S, Akola
KD 62	IC482537	Gujarat	NBPGR, Akola	KD 86	IC52708	Maharashtra	NBPGR, R/S, Akola
KD 63	IC482541	Gujarat	NBPGR, Akola	KD 87	IC52714	Maharashtra	NBPGR, R/S, Akola
KD 64	IC482544	Gujarat	NBPGR, Akola	KD 88	IC52716	Maharashtra	NBPGR, R/S, Akola
KD 65	IC482553	Madhya Pradesh	NBPGR, Akola	KD 89	IC52720	Maharashtra	NBPGR, R/S, Akola
KD 66	IC482555	Madhya Pradesh	NBPGR, Akola	KD 90	IC52724	Maharashtra	NBPGR, R/S, Akola
KD 67	IC482561	Madhya Pradesh	NBPGR, Akola	KD 91	IC842499	West Bengal	NBPGR, R/S, Akola
KD 68	IC482562	Madhya Pradesh	NBPGR, Akola	KD 92	IC88478	Kerala	NBPGR R/S, Thrissur
KD 69	IC482566	Madhya Pradesh	NBPGR, Akola	KD 93	IC88479	Kerala	NBPGR R/S, Thrissur
KD 70	IC482570	Madhya Pradesh	NBPGR, Akola	KD 94	IC88480	Kerala	NBPGR R/S, Thrissur
KD 71	IC482575	Madhya Pradesh	NBPGR, Akola	KD 95	IC88481	Kerala	NBPGR R/S, Thrissur
KD 72	IC482581	Madhya Pradesh	NBPGR, Akola	KD 96	IC344989	Andhra Pradesh	-

ICRISAT=International Crop Research Institute for Semi - Arid Tropics; NBPGR=National Bureau of Plant Genetic Resources; R/S= Regional station; UAS- University of Agricultural Sciences; IGAU=Indira Gandhi Agricultural University; IGKVV=Indira Gandhi Krishi Vishwavidyalaya; IC= Indigenous collection

cm) and KD2 (16.58 cm). This is an important trait for crop breeding and has a direct relation with grain yield.

Number of grains per spikelet

Number of grains per spikelet varies from accession to accession. The maximum grains per spikelet were recorded for KD86 (50.50) followed by KD93 (49.83), KD57 (49.67) and KD13 (49.50) and minimum were KD43 (33.67) with an overall mean of 43.28±2.09. The accessions with high number of grains per spikelet give an indication of high yield per plant.

Days to maturity

Days to maturity is an important trait for crop enhancement in the era of climate change. It ranged from 94.17 (KD67) to 124.00 (KD44) days with an average mean of 108.38±0.70 days. Early matured accessions were recorded for KD67 (94.17) followed by KD65 (95.17), KD39 (95.67), KD72 (95.67) and KD56 (96.33). These accessions can be grown in the areas to withstand heavy rainfall and drought (Sumathi *et al.,* 2007) (Table 6).

Table 2: Analysis of variance for eleven traits in Kodo millet germplasm.

Characters	Mean sum of squares		
	Replications	Treatments	Error
Degree of freedom	2	95	475
Germination percentage	2.12	87.16**	36.02
Days to 50 % flowering	33.63	189.14**	18.66
Plant height (cm)	13.39	137.94**	29.16
Number of productive tillers	0.91	7.88**	2.64
Spike length (cm)	4.57	22.10**	2.55
Number of grains per spikelet	11.41	71.58**	26.11
Days to maturity	0.22	616.28**	2.90
Biomass (g)	5.96	4686.86**	481.47
Straw yield (g)	26.69	1956.82**	229.32
Yield per plant (g)	1.53	217.41**	41.99
Test weight (g)	0.58	4.54**	0.65

*P<0.05, **P<0.01, ***P<0.005.

Table 3: Mean, overall mean and range of eleven morpho-agronomic traits in Kodo millet germplasm.

Characters	Mean±SE	Range	
		Min.	Max.
Germination percentage	82.01±2.45	70.83	90.83
Days to 50 % flowering	67.80±1.76	53.50	85.33
Plant height (cm)	92.34±2.20	80.00	107.33
Number of productive tillers	9.43±0.66	6.83	13.17
Spike length (cm)	13.53±0.65	9.68	17.68
Number of grains per spikelet	43.28±2.09	33.67	50.50
Days to maturity	108.38±0.70	94.17	124.00
Biomass (g)	72.75±8.96	26.33	168.50
Straw yield (g)	45.33±6.18	17.50	99.17
Yield per plant (g)	14.99±2.65	4.95	38.08
Test weight (g)	4.47±0.33	2.17	7.13

Biomass (g)

Biomass is the important trait for crop improvisation. The range was observed from 26.33 (KD73) to 168.50 (KD15) with a grand mean of 72.75±8.96 g. The maximum biomass were recorded for KD15 (168.50) followed by KD84 (147.67), KD28 (143.67), KD13 (134.33) and KD12 (133.67) (Table 4). Kodo millet is the crop which is used as food and fodder. Therefore, high biomass in the accessions will aid in enhancing the food and fodder quantity.

Straw yield (g)

Straw of kodo millet is used as a fodder for animals. Hence, it attracts the breeders for crop improvement in terms of grain yield and fodder yield. The mean of straw yield ranged from 17.50 (KD73) to KD15 (99.17) with average mean of 45.33±6.18 g. The maximum straw yield were recorded for KD15 (99.17) followed by KD84 (97.33), KD14 (94.83), KD28 (81.50) and KD27 (81.50) (Table 4).

Yield per plant (g)

In any plant breeding programme, yield is the foremost target. In the present investigation, the mean yield per plant ranged from 4.95 (KD61) to 38.08 g (KD74) with an overall mean of 14.99±2.65 g. The maximum yield per plant were recorded for KD74 (38.08 g) followed by KD28 (34.80 g), KD77 (29.13 g), KD53 (28.03 g) and KD44 (27.60g). There is a vast difference observed among the accessions (Table 4) as reported by Subramanian *et al.,* 2010.

Test weight (g)

The 1000 seed weight ranges from 2.17 g (KD64) to 7.13 g (KD27) with an average mean of 4.47±0.33 g. The maximum 1000 seed weight were measured for KD27 (7.13 g) followed by KD54 (7.03), KD60 (6.48), KD5 (6.42) and KD39 (5.97).

In the present investigation, the traits like plant height (cm), days to 50 % flowering, days to maturity, biomass (g), straw yield (g) and yield per plant were given top priority during selection. The accessions mainly IC482729 and IC404789 from Tamil Nadu having high biomass, straw yield and yield per plant can be used for hybridization programme (Table 5). In kodo millet, lodging is the cause of major dilemma (de Wet *et al*., 1983). Therefore, plant height, days to 50% flowering and days to maturity should be considered for earliness is targeted and the accession IC482581 from Madhya Pradesh having early maturity with short/medium plant height can be grown in drought, adverse weather conditions and heavy rainfall regions (Table 6) to stay away from lodging of the plant. The accession IC396004 from Chhattisgarh can be given more attention in Allahabad agro-climatic conditions or in similar conditions because the accession showed better performance in earliness along with high yield and its attributing traits than other compared accessions.

Qualitative traits

The frequency table of spikelet shattering, grain covering by glumes and seed colour was shown in Table 7. The

Table 4: Distribution of 96 kodo millet accessions into different groups based on Quantitative traits.

Character	Promising Accessions
Germination percentage	**Low:** KD47 (70.83), KD64 (72.50) and KD92 (72.50).
	High: KD21 (90.83), KD4 (90.00), KD32 (89.17), KD48 (89.17), KD52 (89.17), KD51 (88.33), KD83 (88.33), KD 91 (88.33), KD39 (87.50), KD69 (87.50).
Days to 50% flowering	**Early:** KD62 (53.50), KD63 (56.33), KD65 (56.83), KD37 (57.67), KD67 (58.50), KD21 (58.67), KD80 (59.17), KD61 (60.00), KD73 (60.17), KD83 (60.50), KD68 (60.83), KD22 (61.33), KD41 (61.33), KD5 (61.67), KD34 (61.83).
	Late: KD40 (76.33), KD92 (79.67), KD43 (80.83), KD93 (83.33), KD95 (83.83), KD94(85.33).
Plant height (cm)	**Short:** KD40 (80.00), KD55 (80.83), KD35 (83.00), KD62 (84.50), KD45 (85.00), KD75 (85.00).
	Tall: KD7 (100.00), KD6 (100.33), KD4 (101.00), KD92 (106.83), KD37 (107.33).
Number of productive tillers	**Less:** KD16 (6.83), KD48 (7.00), KD28 (7.33).
	More: KD46 (11.00), KD49 (11.00), KD82 (11.00), KD51 (11.17), KD55 (11.33), KD32 (11.33), KD61 (11.67), KD64 (11.83), KD23 (12.33), KD56 (13.17).
Spike length (cm)	**Short:** KD35 (9.68), KD34 (9.92), KD10 (10.27), KD9 (10.30), KD3 (10.49), KD60 (10.51), KD58 (10.61), KD83 (10.91), KD54 (10.94).
	Long: KD71 (16.03), KD49 (16.38), KD43 (16.47), KD84 (16.54), KD28 (16.56), KD2 (16.58), KD68 (16.88), KD23 (16.92), KD80 (17.21), KD25 (17.68).
Number of grains per spikelet	**Less:** KD43 (33.67).
	More: KD73 (48.00), KD84 (48.17), KD89 (48.33), KD10 (48.67), KD67 (48.67), KD59 (49.33), KD13 (49.50), KD57 (49.67), KD93 (49.83), KD86 (50.50).
Days to maturity	**Early:** KD67 (94.17), KD65 (95.17), KD39 (95.67), KD72 (95.67), KD56 (96.33), KD63 (96.33), KD68 (96.50), KD70 (96.67), KD60 (97.17), KD66 (97.17), KD8 (97.33), KD20 (97.33), KD57 (97.33), KD71 (97.33), KD9 (97.50), KD69 (97.67), KD58 (98.00), KD52 (95.50), KD55 (98.50), KD59 (98.50), KD38 (98.67), KD61 (98.67), KD64 (98.67).
	Late: KD95 (121.00), KD94 (121.33), KD18 (121.67), KD73 (121.83), KD80 (122.33), KD84 (122.33), KD90 (122.33), KD43 (123.67), KD19 (123.83), KD40 (123.83), KD44 (124.00).
Biomass (g)	**Low**: KD73 (26.33), KD91 (28.17), KD23 (28.83), KD55 (33.00), KD22 (35.33), KD5 (35.83), KD49 (37.00), KD61 (38.50), KD66 (40.33).
	High: KD47 (121.17), KD14 (121.33), KD27 (121.50), KD29 (126.50), KD12 (133.67), KD13 (134.33), KD28 (143.67), KD84 (147.67), KD15 (168.50).
Straw yield (g)	**Low:** KD73 (17.50), KD23 (19.00), KD22 (20.00), KD55 (21.67), KD91 (21.83), KD5 (22.00), KD66 (22.00), KD61 (23.67), KD64 (24.17), KD2 (24.50).
	High: KD10 (71.83), KD29 (76.67), KD12 (78.50), KD13 (79.33), KD27 (81.50), KD28 (81.50), KD14 (94.83), KD84 (97.33), KD15 (99.17).
Yield per plant (g)	**Low:** KD61 (4.95), KD73 (5.12), KD23 (6.23), KD93 (6.30), KD91 (6.88), KD70 (7.15), KD57 (7.28), KD49 (8.50), KD94 (8.53), KD79 (8.88), KD20 (8.93).
	High: KD84 (20.40), KD13 (20.42), KD47 (21.27), KD78 (21.55), KD89 (21.72), KD48 (23.23), KD86 (23.73), KD15 (23.87), KD87 (24.37), KD29 (27.43), KD44 (27.60), KD53 (28.03), KD77 (29.13), KD28 (34.80), KD74 (38.08).
Test weight (g)	**Low:** KD64 (2.17).
	High: KD20 (5.03), KD57 (5.03), KD74 (5.10), KD78 (5.10), KD59 (5.17), KD3 (5.23), KD30 (5023), KD18 (5.30), KD12 (5.35), KD6 (5.37), KD75 (5.42), KD34 (5.42), KD10 (5.52), KD89 (5.52), KD17 (5.60), KD65 (5.60), KD47 (5.67), KD32 (5.80), KD39 (5.97),KD5 (6.42), KD60 (6.48), KD54 (7.03), KD27 (7.13).

Table 5: Elite accessions for High biomass, straw yield and yield per plant in Kodo millet.

Code NO.	IC NO.	State	GP	DFF	PH (cm)	NPT	SL (cm)	NGS	DM	BM (g)	SY (g)	YPP (g)	TW (g)
KD12	IC345040	Andhra Pradesh	77.50	71.17	90.67	10.33	15.28	38.00	115.50	133.67	78.50	17.52	5.35
KD47	IC482383	Andhra Pradesh	70.83	67.83	93.33	9.50	14.78	41.00	114.50	121.17	59.83	21.27	5.67
KD6	IC326826	Chhattisgarh	83.33	72.50	100.33	8.50	11.55	45.33	103.00	91.83	62.17	13.82	5.37
KD14	IC396005	Chhattisgarh	80.83	73.67	99.17	9.00	11.84	46.67	103.67	121.33	94.83	16.43	4.53
KD10	IC342544	Chhattisgarh	83.33	68.67	93.67	10.50	10.27	48.67	100.50	110.33	71.83	14.43	5.52
KD13	IC396004	Chhattisgarh	80.00	73.50	98.67	10.50	11.63	49.50	99.33	134.33	79.33	20.42	5.00
KD87	IC52714	Maharashtra	83.33	69.67	88.50	8.50	12.42	46.83	113.83	97.33	54.67	24.37	4.37
KD86	IC52708	Maharashtra	80.83	69.83	90.17	8.83	14.59	50.50	110.33	53.00	36.67	23.73	4.48
KD27	IC404786	Tamil Nadu	82.50	69.00	92.00	7.67	14.77	40.83	118.17	121.50	81.50	15.03	7.13
KD84	IC482729	Tamil Nadu	82.50	72.50	97.50	8.50	16.54	48.17	122.33	147.67	97.33	20.40	3.35
KD28	IC404789	Tamil Nadu	86.67	71.50	94.33	7.33	16.56	43.17	118.33	143.67	81.50	34.80	4.90
KD19	IC404666	Tamil Nadu	82.50	69.67	91.83	8.83	15.81	43.33	123.83	87.83	65.67	17.33	3.90
KD44	IC481762	Tamil Nadu	80.00	70.50	90.83	9.83	15.75	43.33	124.00	97.67	65.67	27.60	4.62
KD15	IC404561	West Bengal	84.17	72.83	91.17	10.00	14.91	38.83	120.50	168.50	99.17	23.87	4.35

GP- Germination Percentage, DFF- Days to 50 % Flowering, PH- Plant Height, NPT- No. of Productive Tillers, SL- Spike Length, NGS- No. of Grains per Spikelet, DM- Days to Maturity, BM- Biomass, SY- Straw Yield, YPP- Yield per Plant, TW- Test Weight.

Table 6: Elite accessions for early maturity and medium plant height in Kodo millet.

Code NO.	IC NO.	State	GP	DFF	PH (cm)	NPT	SL (cm)	NGS	DM	BM (g)	SY (g)	YPP (g)	TW (g)
KD56	IC482514	Bihar	77.50	63.67	90.00	13.17	11.95	43.50	96.33	76.83	47.33	12.40	4.28
KD64	IC482544	Gujarat	72.50	63.17	97.00	11.83	11.01	45.33	98.67	48.50	24.17	9.30	2.17
KD63	IC482541	Gujarat	85.00	56.33	89.50	8.17	11.11	38.83	96.33	50.67	31.17	10.42	4.07
KD67	IC482561	Madhya Pradesh	81.67	58.50	92.17	9.83	12.18	48.67	94.17	53.17	37.17	10.72	3.47
KD65	IC482553	Madhya Pradesh	80.00	56.83	97.67	8.67	11.98	36.67	95.17	50.50	26.50	11.27	5.60
KD71	IC482575	Madhya Pradesh	85.00	68.00	87.00	8.67	16.03	43.50	97.33	84.67	41.33	16.10	3.72
KD72	IC482581	Madhya Pradesh	80.83	69.17	92.67	8.67	14.11	41.67	95.67	95.83	50.67	15.90	4.33
KD70	IC482570	Madhya Pradesh	79.17	66.17	87.00	9.33	14.50	43.17	96.67	53.67	28.33	7.15	3.02
KD68	IC482562	Madhya Pradesh	79.17	60.83	92.00	10.33	16.88	41.83	96.50	74.33	45.50	13.38	4.75

GP- Germination Percentage, DFF- Days to 50% Flowering, PH- Plant Height, NPT- No. of Productive Tillers, SL- Spike Length, NGS- No. of Grains per Spikelet, DM- Days to Maturity, BM- Biomass, SY- Straw Yield, YPP- Yield per Plant, TW- Test Weight.

Table 7: Frequency table for four qualitative characters of 96 Kodo millet accessions.

Traits	Number of accessions	Frequency (%)
Spikelet shattering		100.00
1 Yes	96.00	
2 No	0.00	
Grain covering by glumes		100.00
1 Yes	96.00	
2 No	0.00	
Seed colour		
1 Brown	77.00	80.20
2 Dark brown	15.00	15.63
3 Red	4.00	4.17

present study showed that all the 96 accessions have the trouble of spikelet shattering at the time of maturity. Similar observation was matched with the finding of (de Wet *et al.,* 1983) and proposed that early maturity in the genotypes might also be targeted. All the accessions were covered by glumes explained the scaly protective casing of the seed. These glumes are indigestible by humans but live stock can eat it and is used as a livestock fodder (Nevo, Eviatar *et al.,* 2002). Seed colour characterizes the accessions in three different groups (Brown, Dark Brown and Red) as shown in Table 8 and Fig 2. Brown seed coat colour was calculated for 77.00 accessions with the maximum frequency of 80.20% followed by Dark brown (15.00 accessions) with 15.63% frequency and Red (4.00 accessions) with 4.17 % frequency (Table 7). The distribution of all the accessions on the basis of seed colour was given in Table 8.

Table 8: Distribution of 96 kodo millet accessions into different groups based on seed colour.

Seed colour	No. of accessions	Name of accessions
Brown (B)	77	KD7, KD8, KD10, KD12, KD13, KD16, KD19, KD20, KD21, KD23, KD24, KD28, KD29, KD35, KD38, KD40, KD42, KD46, KD47, KD48, KD59, KD50, KD51, KD52, KD54, KD55, KD56, KD57, KD58, KD59, KD60, KD63, KD66, KD67, KD69, KD70, KD71, KD72, KD73, KD74, KD75, KD76, KD77, KD78, KD79, KD81, KD84, KD86, KD87, KD89,KD91, KD94, KD95, KD1, KD2, KD3, KD4, KD5, KD6, KD11, KD14, KD17, KD18, KD26, KD27, KD31, KD32, KD33, KD34, KD36, KD37, KD41, KD61, KD62, KD64, KD68, KD96.
Dark Brown (DB)	15	KD9, KD22, KD25, KD30, KD44, KD45, KD53, KD65, KD80, KD82, KD83, KD85, KD88, KD92, KD93.
Red (RE)	4	KD15, KD39, KD43, KD90.

CONCLUSION

All the accessions showed varied range of enhanced yield, biomass and straw and thus resulting in identification of elite genotypes for each character under study. Hence, from the present investigation those accessions having high yield, biomass and straw yield should be considered for breeding; those having earliness with short plant height can be grown in heavy rainfall areas where lodging is the major problem. For future studies, the collected data can be utilized to plan further explorations to collect kodo millet germplasm from the identified diversity rich areas for its conservation, enhancement and utilization.

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