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Genetic variability, character association and path analysis for fibre yield and component characters in Kenaf (*Hibiscus cannabinus* L.)

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Abstract
Fifty-two kenaf (*Hibiscus cannabinus* L.) germ lines were evaluated to study genetic variability, heritability, genetic progress, correlation coefficient and path analysis for yield and yield attributes. Differences were statistically significant between genotypes for all traits. Genotype KIM-14 was found promising for fiber yield and yield contributing traits. Stick weight per plant showed the highest variance at genotypic and phenotypic levels followed by plant height, days to flower initiation, days to 50% flowering, fiber yield and percent fiber recovery and the lowest variance was in green biomass and basal diameter. A higher phenotypic coefficient of variation (PCV) than genotypic coefficient of variation (GCV) for all traits revealed that the characters were strongly influenced by the environment. Days to 50% flowering showed high heritability followed by days to flowering, fiber yield, stick weight and plant height indicating a good amount of additive genetic components that can be easily utilized for further crop improvement program. Stick weight and plant height remained higher and green weight remained lower with genetic advance. Moderate to high genetic advance with higher heritability above the mean percentage was in stick weight and plant height indicating the predominance of additive gene action. Thus, selection should consider these traits to develop kenaf varieties with high fiber content. The value of the genotypic correlation was higher than that of the phenotypic correlation to eliminate the influence of the environment on the strengthening of the genetic association. Yield contributing traits were significantly associated with fiber yield per plant at both genotypic and phenotypic levels. Basal diameter at genotypic level and stick yield, fiber recovery percentage and days to flowering maintained a positive phenotypic and genotypic direct effect on fiber yield per plant.

Keywords: Mean performance, variability, heritability, genetic advance, path coefficient, PCV, GCV

Introduction
Kenaf is getting prominence as a fiber crop in Bangladesh, with reports indicating that it is grown on approximately 0.04 million hectares of land (Mostafa, 2012) [1]. During the growing season, kenaf can reach a height of 14 to 18 feet and produce 5 to 10 tons of dry fiber (bast and core fibers) per acre (Islam, 2019) [2]. Kenaf has the capability to produce a high yield even in fallow and char lands with poor soil health (Hiron, 2007) [3]. The plant is one of the most valuable crops grown for the production of smooth fiber. It has high air permeability, antibacterial properties, and biological properties like salinity tolerance, drought resistance, adaptability and yield. Traditionally, kenaf has been grown primarily for its fiber, which is used to make sacks, ropes, carpets, and canvases (Al-Mamun *et al*., 2022) [4]. Since World War II, China, the USSR, Thailand, South Africa, Cuba and Egypt have been established sources of fiber for the production of pulp, paper and other fiber products. Paper products, building materials, absorbents and livestock feed are new applications that continue to expand and include issues from basic agricultural production methods to marketing of kenaf products (Bhaskara *et al*., 2012) [5]. Kenaf is a fast-growing crop that produces higher biomass and is a versatile source of fiber (Arbaoui *et al*., 2016) [6]. Genetic diversity in a random population can benefit the selection of parental lines. Evaluation of germplasm for the correct level and pattern of genetic diversity aids the analysis of genetic variability (Cox *et al*., 1986) [7]. Selection of diverse parental lines for hybridization produces segregating progeny with high genetic variability for further selection (Barrett and Kidwell, 1998) [8]. Broad hybridization involving wild germplasm of desired genes must be adapted as a high-yielding source of germplasm (Thompson *et al*., 1998) [9]. This type of information is useful for constructing heterotic and potential cross combinations, which saves time and resources (Hallauer and Miranda, 1988) [10].

Kenaf is an important fiber crop grown in rainfed areas of Madhya Pradesh, Andhra Pradesh and Tamil Nadu. Fifty two kenaf germplasm lines were evaluated for correlation and pathway analysis for fiber yield and traits contributing to yield.

Materials and Methods

Fifty-two genotypes of Kenaf (*Hibiscus cannabinus* L.) obtained from AINP JAF through ICAR-CRIJAF, Barrackpore (WB) evaluated in a randomized block design (RBD) with three replications in an area of 4.50 m × 0.60 m for each genotype at the Cotton Improvement Project experimental farm, MPKV, Rahuri during Kharif, 2023. A recommended package of practices was adopted to achieve the production potential of the crop. 10 plants of each genotype were randomly marked and each replicate and observations were recorded on days taken to flower initiation, days to 50% flowering, plant height, basal diameter, green biomass, stick weight, fiber yield and percent fiber recovery. Analysis of variance for RBD was done according to Panse and Sukhatme (1989) [11]. Differences at genotypic and phenotypic levels and genetic advancement (GA) were calculated according to Comstock and Robinson (1952) [12] and Johnson *et al*. (1955) [13], respectively. Coefficients of variation at genotypic and phenotypic levels were analyzed by Singh and Choudhary (1985) [14]. Broad-sense heritability for fiber yield and yield attributes was discussed by Hanson *et al*. (1956) [15]. Genotypic and phenotypic correlations were calculated according to Dewey and Lu (1959) [16].

Results and Discussion

Crop improvement is highly dependent on genetic variation, heretabilityy and diversity (Dudley, 1969) [17]. Identification of desirable genes accelerates yield improvement through a hybridization program. Crop yield is controlled by various environmental factors as well as genetic factors. Forsman (2014) [18] stated that genetic characteristics depend on variation and variation at the genotypic and phenotypic levels and increase the importance of germplasm for more than a few reasons. The breeding program fulfills the objective of improving the yield potential of the crop depends on the selection of parental lines based on variability and information on genotypic and phenotypic correlation coefficients is very necessary. PCV and heritability information helps predict genetic advancement (GA) for contributing characters. Thus, the important parameters of variability i.e. variances, coefficient of variation, heritability, genetic advance at genotypic and phenotypic level for fiber yield and its contributing traits were treated in this research.

In this investigation, differences between genotypes were statistically significant for all traits, showing that there was a wide range of variation (Table 1). Higher magnitude of variance was recorded for stick weight followed by plant height, days to initiation of flowering and days to 50% flowering.

Germplasm genetic makeup and adapted research area create variation in agronomic traits (Mudher *et al*., 2020; Zhao *et al*., 2020) [19, 20]. Selection of cultivars and growing conditions, i.e., light duration and intensity during the day increases plant height, resulting in higher crop yield (Shukor *et al*., 2009) [21].

In this investigation, KIJ-170 and KIJ-178 showed the highest values (109.00), while KIN-258 genotypes showed the lowest values (68.00) for days to flowering (Table 2). Genotypes KIJ-170 (119.00) required maximum while KIN-258 (81.67) required minimum number of days for 50% flowering. In the case of plant height, genotypes KIJ-182 showed the highest mean values (427.22 cm) where KIN-259 was the lowest (323.34 cm) for plant height. Genotypes KIN-258 (2.56 cm) and KIN-261 (1.77 cm) maintained the highest and lowest basal diameter, respectively. The highest green weight per plant was recorded by KIN-258 and KIJ-182 (0.66 kg), on the contrary, the lowest by KIN-259 (0.36 kg). Stick yield per plant varied between 140.13 g (KIN-261) and 337.15 g (KIJ-170). The maximum and minimum fiber recovery percentages were recorded for genotypes KIJ-194 (9.89) and KIJ-195 (5.41). Genotypes KIJ-170 (20.70 g/plant) were promising for fiber yield per plant followed by KIJ-174 (20.68 g/plant), KIJ-194 (20.50 g/plant), KIN-234 (20.49 g/plant), KIJ-178 (20.43 g/plant), KIJ-176 (20.41 g/plant), KIJ-178 (20.33 g/plant), KIN-258 (20.29 g/plant), KIN-258 (20.29 g/plant), KEX-7 (20.26 g/plant), KEX-6 (20.17 g/plant) while genotype KIN-259 (13.07) have the lowest fiber yield per plant. Faruq (2013) [22] reported significant variation in basal diameter, nodes per plant, green and stamen weight in kenaf germplasm for fiber yield.

The variance and coefficient of variation at the genotypic and phenotypic levels show the relevance of genetic characteristics useful in supporting population importance for several reasons (Forsman, 2014) [18]. Genetic variability parameters showed a considerable degree of variability for all traits (Table 3). The highest genotypic variance was for stick weight per plant (5876.227) followed by plant height (747.667), days to initiation of flowering (110.740), days to 50% flowering (99.037), fiber yield per plant (18.363), percent fiber recovery (2.200) and the lowest genotypic variance was for green weight per plant (0.010) and basal diameter (0.110). Phenotypic variance was also highest for stick weight per plant (7023.407) followed by plant height (805.757), days to initiation of flowering (116.050), days to 50% flowering (106.347), fiber yield per plant (19.783), percent fiber recovery (3.310) and the lowest phenotypic variance was that of green weight per plant (0.011) and basal diameter (0.117).

In a recent research, the phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) in all cases, showing that the traits were mainly influenced by the environment (Kumar *et al*., 2021) [23]. High GCV and PCV values were recorded for stick weight (13.738, 20.263), green weight (12.227, 12.972), fiber yield per plant (10.278, 12.127), days to initiation of flowering (10.158, 10.426%) and days to 50 blooming (8.811, 9.160). Relatively basal diameter (7.037, 8.000) and plant height (6.773, 7.045) showed low values for GCV and PCV. However, fiber recovery percentage showed lower GCV (6.695) and higher values for PCV (15.207). The results were consistent with Singh *et al*., (2013) [24], Quatadah *et al*. (2012) [25], Anandrao *et al*. (2011) [26] and Paul *et al*. (2011) [27]. A narrow range of variation between GCV and PCV for initiation of flowering, days to 50% flowering and green weight indicated that these traits were less influenced by environment, while a wider range for fiber recovery, basal diameter and stick weight showed a higher degree of environmental influence (Senapati *et al*., 2006) [28]. Kumar *et al*. (2021) [23] reported a larger range of phenotype coefficient of variation (PCV) and genotype coefficient of variation (GCV) for seed yield, number of productive branches and internode length in sesame.

Days to flowering (94.926%) showed higher heritability followed by days to 50% flowering (92.521%), plant height (92.418%), green weight (88.843), basal diameter (77.360), fiber yield (71.836%) 45,968) and showed a good amount of additive genetic components that can be used for further crop improvement. Plant height (52.697) and stick yield (43.632) recorded the highest and green weight (0.127) recorded the lowest genetic advance. High heritability with medium to high genetic advance above the mean percent was observed for green weight (88.843, 23.740), days to initiation of flowering (94.929, 20.388), days to 50% flowering (92.521, 17.459) and fiber yield (71.836, 17.945) which indicates the predominance of additive genetic action (Senapati *et al*., 2006) [28]. High heritability with low genetic advance above the mean percent was observed for plant height (92.418, 13.413). A low heritability with a low genetic advance above the percent mean was observed in percent fiber recovery (19.382, 6.072) indicating the presence of both additive and non-additive gene effects. Selection based on the phenotypic performance of these characters appears to be reliable and effective. Ishwarya Lakshmi *et al*. (2019) [29] reported a high range of variation, PCV, GCV and high heritability associated with high genetic progress for days to 50% flowering and number of spikelets per panicle in rice.

Estimates of the phenotypic and genotypic correlation coefficients between each pair of traits showed that the magnitude of the genotypic correlation was higher than the phenotypic correlation, suggesting that exclusion of environmental effects led to a strengthening of the genetic association (Table 4). Correlation analysis revealed that all yield component traits in kenaf were significantly associated with fiber yield per plant at both genotypic and phenotypic levels, except fiber recovery percentage. A non-significant correlation was observed between days to flowering and days to 50% flowering with basal diameter, green weight, stick yield, fiber recovery percentage and fiber yield. Plant height, basal diameter and green weight showed non-significant correlation with fiber recovery percentage at genotypic and phenotypic level. Other traits of yield components showed highly significant correlation at both genotypic and phenotypic levels. It shows that direct selection of traits will be effective in ensuring seed and fiber yield of kenaf and this assumption is supported by various researchers (Faruq *et al*., 2011) [22]. The results were consistent with Alam *et al*. (2011) [30] and Ibrahim *et al*. (2013) [31].

Green biomass had the highest positive direct effect on fiber yield at genotypic (6.072) and phenotypic levels (6.072) followed by stick yield (2.281, 1.083), fiber recovery percentage (1.449, 0.909) and days to initiation of flowering (0.241, 0.056). In addition, plant height (0.482) and basal diameter (0.447) maintained positive phenotypic direct effects on fiber yield per plant (Senapati *et al*., 2006) [28]. Therefore, direct selection based on these characters would be feasible. Days to 50% flowering at genotypic (-0.265) and phenotypic (-0.101) levels and plant height (-2.668) and basal diameter (-2.500) at genotypic level had a negative direct effect on fiber yield. However, its significant positive correlation with fiber yield per plant suggests that indirect selection could be made for high-yielding kenaf genotypes through most traits that have positive indirect effects (Table 5). The residual direct effect on the path coefficient was 0.01805 and 0.08424 of genotypic and phenotypic levels, respectively. This suggests that there were also some other traits that, although not studied, influenced the fiber yield per plant. Stick weight per plant had higher values of direct effects, even than their respective correlation coefficients, indicating their major importance in fiber yield. Thus, the result of this investigation indicated that the stick weight, fiber recovery, plant height, green biomass weight and basal diameter would be selection parameters for the production of kenaf varieties with acceptable production.

The qualitative parameters studied among 52 germplasms of kenaf are shown in Table 6. All the germplasm lines were upright growth habit. In terms of leaf type, 38 lines were Loabed, 11 partially loabed and 3 were unloabed. Six lines had predominantly primary, 15 lines had weekly branching and 31 lines had absent branching habit. Green leaf petiole color was observed in 48 lines, while purple and light purple color in 2 lines each. Petiole hairiness and stem hairs were absent in all lines. 40 lines lapped and 6 lines had detached and spiral flower morphology. All lines have creamy white flowers. Green stem color was observed in 46 lines, while 4 lines were light purple and 2 lines weredark purple stem color.

Table 1: Analysis of variance (ANOVA) for studied traits

Sources	df	Days to initiation of flowering	Days to 50% flowering	Plant height (cm)	Basal Diameter (cm)	Green weight (kg/ plant)	Stick yield (g/plant)	Fibre recovery (%)	Fibre yield (g/ plant)
Replication	2	28.79	18.49	60.69	0.25	0.018	13553.62	4.69	42.7*
Treatment	51	303.43**	278.62**	2182.31**	0.08**	0.013**	4075.06**	1.91**	12.30**
Error	102	5.31	7.31	58.09	0.007	0.001	1147.18	1.11	1.42

Table 2: Mean performance of fibre yield and yield contributing characters

Accession No.	Days to initiation of flowering	Days to 50% flowering	Plant height (cm)	Basal Diameter (cm)	Green weight (kg/plant)	Stick yield (g/plants)	Fibre recovery (%)	Fibre yield (g/plant)
KIN-234	79.67	87.67	415.00	2.38	0.60	230.17	8.55	20.49
KIN-243	81.67	90.67	353.00	2.43	0.52	207.97	8.15	18.45
KIN-247	79.33	89.00	373.89	2.17	0.50	205.25	7.90	17.52
KIN-255	78.33	84.00	359.45	2.03	0.45	252.11	6.96	19.03
KIN-256	97.00	107.00	365.56	2.43	0.54	224.52	7.77	18.94
KIN-257	92.67	102.67	367.22	2.48	0.56	266.76	7.15	19.46
KIN-258	68.00	81.67	417.78	2.56	0.66	284.49	6.78	20.29
KIN-259	78.33	97.33	323.34	1.83	0.36	160.36	7.57	13.07

KIN-260	76.67	87.33	343.33	1.84	0.39	177.41	7.24	13.64
KIN-261	96.00	105.67	345.56	1.77	0.38	140.13	8.88	13.51
KIN-262	76.33	87.00	397.78	2.14	0.52	235.48	7.36	18.36
KEX-1	100.33	110.33	398.34	2.17	0.53	210.39	8.61	18.66
KEX-2	100.67	111.67	413.33	2.28	0.58	264.10	7.27	19.77
KEX-3	103.33	114.33	400.00	2.27	0.56	237.92	7.84	19.69
KEX-4	96.67	107.67	418.89	2.19	0.56	244.05	7.56	19.89
KEX-5	101.33	112.67	404.44	2.23	0.55	213.88	8.44	19.57
KEX-6	102.33	113.33	406.67	2.28	0.57	207.55	8.94	20.17
KEX-7	100.67	112.00	417.78	2.24	0.57	251.15	7.47	20.26
KEX-8	99.00	109.33	405.00	2.23	0.55	259.50	6.97	19.29
KIM-37	101.00	111.00	408.33	2.21	0.55	224.94	8.09	19.61
KIJ-167	101.00	111.00	374.45	2.21	0.51	238.25	6.97	17.64
KIJ-168	95.67	106.00	415.00	2.26	0.57	251.77	7.49	19.99
KIJ-169	102.00	111.33	392.78	2.17	0.52	225.00	7.50	18.15
KIJ-170	109.00	119.00	414.44	2.30	0.58	337.15	5.83	20.70
KIJ-171	100.00	110.00	347.22	2.08	0.44	161.09	9.00	15.92
KIJ-172	97.67	107.67	399.44	2.22	0.54	238.46	7.62	19.55
KIJ-174	83.67	93.33	422.78	2.36	0.61	254.54	7.52	20.68
KIJ-175	108.00	118.00	389.45	2.11	0.50	207.71	7.90	17.79
KIJ-176	103.33	112.33	419.44	2.25	0.58	217.07	8.67	20.41
KIJ-177	105.33	114.33	400.56	2.32	0.57	234.78	8.05	20.33
KIJ-178	109.00	118.00	412.78	2.28	0.58	257.86	7.39	20.43
KIJ-179	99.00	108.33	367.78	2.16	0.49	199.04	8.27	17.50
KIJ-180	105.33	114.33	421.67	2.37	0.61	242.34	7.73	20.09
KIJ-182	101.67	110.67	427.22	2.52	0.66	230.25	7.90	19.49
KIJ-183	103.67	112.67	417.22	2.23	0.57	249.54	7.58	19.88
KIJ-184	104.00	113.00	430.56	2.32	0.61	237.08	7.81	20.09
KIJ-185	105.33	114.33	376.67	2.15	0.50	180.15	8.55	16.82
KIJ-188	106.00	115.00	336.11	1.97	0.41	181.71	7.16	13.95
KIJ-189	107.00	117.00	337.78	1.94	0.40	162.51	7.85	13.78
KIJ-193	103.33	112.33	425.00	2.22	0.58	239.40	7.54	19.08
KIJ-194	108.00	117.00	424.44	2.28	0.59	192.58	9.89	20.50
KIJ-195	102.67	111.67	383.33	2.07	0.49	291.52	5.41	16.54
KIJ-197	103.67	112.67	395.56	2.19	0.53	220.70	8.00	18.49
KIJ-199	103.33	112.33	397.22	2.26	0.55	223.68	7.94	19.04
KIJ-202	103.67	112.67	406.11	2.32	0.58	237.18	7.50	19.12
KIJ-203	109.00	118.00	390.56	2.23	0.53	302.75	5.83	18.59
KIJ-204	104.00	112.67	405.00	2.21	0.55	193.23	9.00	19.07
KIJ-206	103.33	112.67	401.67	2.17	0.53	230.09	7.62	18.90
KIJ-207	103.67	112.67	377.78	1.90	0.44	185.99	7.52	15.12
KIJ-208	102.00	111.00	393.89	2.17	0.52	243.21	7.27	18.20
HC 583	99.33	108.67	396.67	2.25	0.55	229.25	7.84	18.96
AMC 108	101.00	109.33	395.00	2.24	0.54	230.48	7.56	18.84

Table 3: Range, mean, variability, heritability and other genetic parameters

Character	Range	GV	PV	GCV	PCV	H^2	GA	GA (%)
Days to initiation of flowering	68.00-109.00	110.740	116.050	10.158	10.426	94.926	20.008	20.388
Days to 50% flowering	81.67-119.00	99.037	106.347	8.811	9.160	92.521	18.843	17.459
Plant height (cm)	323.34-427.22	747.667	805.757	6.773	7.045	92.418	52.697	13.413
Basal Diameter (cm)	1.77-2.56	0.110	0.117	7.037	8.000	77.360	0.282	12.749
Green weight (kg/plants)	0.36-0.66	0.010	0.011	12.227	12.972	88.843	0.127	23.740
Stick yield (g/plant)	140.13-337.15	5876.227	7023.407	13.738	20.263	45.968	43.632	19.188
Fibre recovery (%)	5.41-9.89	2.200	3.310	6.695	15.207	19.382	0.468	6.072
Fibre yield (g/plant)	13.07-20.70	18.363	19.783	10.278	12.127	71.836	3.324	17.945

Table 4: Genotypic (G) and phenotypic (P) correlations coefficient among different yield component characters

		Days to initiation of flowering	Days to 50% flowering	Plant height (cm)	Basal Diameter (cm)	Green weight (kg/plants)	Stick yield (g/plants)	Fibre recovery (%)
Days to 50% flowering	G	0.989^{**}						
	P	0.979^{**}						
Plant height (cm)	G	0.261^{**}	0.236^{**}					
	P	0.250^{**}	0.229^{**}					
Basal Diameter (cm)	G	0.013^{NS}	-0.012^{NS}	0.686^{**}				
	P	0.009^{NS}	-0.016^{NS}	0.577^{**}				
Green weight (kg/plants)	G	0.138^{NS}	0.114^{NS}	0.920^{**}	0.915^{**}			
	P	0.128^{NS}	0.104^{NS}	0.875^{**}	0.898^{**}			

Stick yield (g/plants)	G	0.073^{NS}	0.052^{NS}	0.676**	0.685**	0.733**		
	P	0.023^{NS}	0.002^{NS}	0.453**	0.469**	0.514**		
Fibre recovery (%)	G	0.115^{NS}	0.104^{NS}	0.031^{NS}	-0.023^{NS}	0.005^{NS}	-0.649**	
	P	0.071^{NS}	0.068^{NS}	0.030^{NS}	-0.010^{NS}	0.013^{NS}	-0.768**	
Fibre yield (g/plants)	G	0.140^{NS}	0.100^{NS}	0.910**	0.888**	0.968**	0.780**	-0.039^{NS}
	P	0.103^{NS}	0.065^{NS}	0.785**	0.751**	0.858**	0.542**	0.078^{NS}

Table 5: Genotypic (G) and phenotypic (P) Path coefficient analysis showing direct (bold) and indirect effects for component traits in *olitorius* jute

		Days to initiation of flowering	Days to 50% flowering	Plant height (cm)	Basal Diameter (cm)	Green weight (kg/ plant)	Stick yield (g/plant)	Fibre recovery (%)	Fibre yield (g/plant)
Days to initiation of flowering	G	0.241	0.238	0.063	0.003	0.033	0.018	0.028	0.140^{NS}
	P	0.056	0.055	0.014	0.000	0.007	0.001	0.004	0.103^{NS}
Days to 50% flowering	G	-0.262	-0.265	-0.063	0.003	-0.030	-0.014	-0.028	0.100^{NS}
	P	-0.099	-0.101	-0.023	0.002	-0.011	0.000	-0.007	0.065^{NS}
Plant height (cm)	G	-0.697	-0.631	-2.668	-1.831	-2.455	-1.803	-0.084	0.910**
	P	0.120	0.110	0.482	0.278	0.422	0.218	0.014	0.785**
Basal Diameter (cm)	G	-0.032	0.031	-1.716	-2.500	-2.287	-1.713	0.058	0.888**
	P	0.004	-0.007	0.258	0.447	0.402	0.210	-0.004	0.751**
Green weight (kg/plant)	G	0.555	0.457	3.705	3.683	6.072	2.953	0.019	0.968**
	P	-0.068	-0.055	-0.464	-0.476	6.072	-0.273	-0.007	0.858**
Stick yield (g/plant)	G	0.167	0.118	1.542	1.563	1.673	2.281	-1.481	0.780**
	P	0.025	0.002	0.490	0.508	0.557	1.083	-0.832	0.542**
Fibre recovery (%)	G	0.167	0.151	0.045	-0.034	0.007	-0.941	1.449	-0.039^{NS}
	P	0.065	0.061	0.027	-0.009	0.011	-0.698	0.909	0.078^{NS}

Residual effect (Genotypic): 0.01805
Residual effect (Phenotypic): 0.08424

Table 6: Quality parameters influenced by kenaf germplasm lines.

Character		Genotypes
Growth habit	Upright	All
	Intermediate	--
Type of leaves	Loabed	KIN-234, KIN-243, KIN-247, KIN-255, KIN-256, KIN-257, KIN-258, KIN-259, KIN-260, KIN-261, KIN-262, KEX-8, KIM-37, KIJ-167, KIJ-168. KIJ-169, KIJ-170, KIJ-171, KIJ-172, KIJ-174, KIJ-175, KIJ-176, KIJ-177, KIJ-178, KIJ-179, KIJ-180, KIJ-182, KIJ-183, KIJ-184, KIJ-185, KIJ-188, KIJ-189, KIJ-194, KIJ-195, KIJ-207, KIJ-208, AMC 108 (38)
	Partially loabed	KEX-1, KEX-5, KEX-7, KIJ-193, KIJ-197, KIJ-199, KIJ-202, KIJ-203, KIJ-204, KIJ-206, HC 583 (11)
	Unloaded	KEX-2, KEX-3, KEX-4 (3)
Branching habit	Predominantly primary	KIN-234, KIJ-183, KIJ-189, KIJ-204, KIJ-206, KIJ-207 (6)
	Weak	KIN-247, KIN-255, KIN-259, KIN-260, KIN-261, KIN-262, KEX-1, KEX-2, KEX-8, KIJ-168, KIJ-169, KIJ-170, KIJ-171, KIJ-172, KIJ-182 (15)
	Absent	KIN-243, KIN-256, KIN-257, KIN-258, KEX-3, KEX-4, KEX-5, KEX-6, KEX-7, KIM-37, KIJ-167, KIJ-174, KIJ-175, KIJ-176, KIJ-177, KIJ-178, KIJ-179, KIJ-180, KIJ-184, KIJ-185, KIJ-188, KIJ-193, KIJ-194, KIJ-195, KIJ-197, KIJ-199, KIJ-202, KIJ-203, KIJ-208, HC 583, AMC 108 (31)
Leaf petiole colour	Green	KIN-234, KIN-243, KIN-247, KIN-255, KIN-256, KIN-257, KIN-258, KIN-261, KIN-262, KEX-1, KEX-2, KEX-3, KEX-4, KEX-5, KEX-6, KEX-7, KIM-37, KIJ-167, KIJ-168, KIJ-170, KIJ-171, KIJ-172, KIJ-174, KIJ-175, KIJ-176, KIJ-177, KIJ-178, KIJ-179, KIJ-180, KIJ-182, KIJ-183, KIJ-184, KIJ-185, KIJ-188, KIJ-189, KIJ-193, KIJ-194, KIJ-195, KIJ-197, KIJ-199, KIJ-202, KIJ-203, KIJ-204, KIJ-206, KIJ-207, KIJ-208, HC 583 (48)
	Purple	KIN-259, KIN-260 (2)
	Light purple	KEX-8, KIJ-169 (2)
Petiole hairiness	Absent	All
Flower morphology	Lapped	KIN-234, KIN-243, KIN-247, KIN-255, KIN-256, KIN-257, KIN-258, KIN-259, KIN-260, KIN-261, KIN-262, KIJ-167, KIJ-168, KIJ-169, KIJ-170, KIJ-171, KIJ-172, KIJ-174, KIJ-175, KIJ-176, KIJ-179, KIJ-180, KIJ-183, KIJ-184, KIJ-185, KIJ-188, KIJ-189, KIJ-193, KIJ-194, KIJ-195, KIJ-197, KIJ-199, KIJ-202, KIJ-203, KIJ-204, KIJ-206, KIJ-207, KIJ-208, HC 583, AMC 108 (40)
	Detached	KEX-1, KEX-2, KEX-3, KEX-4, KEX-5, KEX-6 (6)
	Spiral	KEX-7, KEX-8, KIM-37, KIJ-177, KIJ-178, KIJ-182 (6)
Flower colour	Creamy white	All
Stem colour	Green	KIN-234, KIN-243, KIN-247, KIN-255, KIN-256, KIN-257, KIN-258, KIN-259, KIN-262, KEX-1, KEX-2, KEX-3, KEX-4, KEX-5, KEX-6, KEX-7, KEX-8, KIJ-167, KIJ-168, KIJ-169, KIJ-170, KIJ-171, KIJ-172, KIJ-175, KIJ-176, KIJ-177, KIJ-178, KIJ-180, KIJ-182, KIJ-183, KIJ-184, KIJ-185, KIJ-188, KIJ-189, KIJ-193, KIJ-194, KIJ-195, KIJ-197, KIJ-199, KIJ-202, KIJ-203, KIJ-204, KIJ-206, KIJ-207, KIJ-208, HC 583 (46)
	Light purple	KIM-37, KIJ-174, KIJ-179, AMC 108 (4)

	Dark Purple	KIN-260, KIN-261 (2)
Stem hairs	Absent	All

Conclusion
The study of genetic variability, trait association and path coefficient analysis in kenaf examines the relationships between genotypes that are needed for the production, conservation and utilization of this green resource. It will be very useful for varietal breeding of kenaf in tropical environment by selecting genotypes with different genetic background. This information will facilitate effective breeding programs for improved yield of adaptive vertices to support better crude fiber resource environments.

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