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Research Article

Genetic variability, character association, path coefficient analysis in kenaf (*Hibiscus cannabinus* L.)

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Abstract

Fifty germplasm lines of kenaf (*Hibiscus cannabinus* L.) were evaluated to study the genetic variability, heritability, genetic advance, correlation coefficient and path analysis for yield and yield attributes. The differences were statistically significant among the genotypes for all the characters. The genotype KIM-14 was found promising for fibre yield and yield contributing characters. The stick weight per plant recorded the highest variance at genotypic and phenotypic levels followed by plant height, days to flower initiation, days to 50% flowering, fibre yield and per cent fibre recovery and the lowest variance was for green weight and basal diameter. The higher phenotypic coefficient of variability (PCV) than genotypic coefficient of variability (GCV) for all the traits revealed that the characters were highly influenced by the environment. Days to 50% flowering showed high heritability followed by days to flower initiation, fibre yield, stick weight and plant height indicates a good amount of additive genetic components, can be easily utilized for the further crop improvement programme. Stick weight and plant height maintained higher and green weight maintained lower genetic advance. The moderate to high genetic advance with higher heritability over per cent of the mean was in stick weight and plant height indicates a preponderance of additive gene action. Thus, selections should make considering these characters to develop high fibre yielding varieties of kenaf. The value of genotypic correlation was higher than the phenotypic correlation indicates to eliminate the environmental effects for strengthening genetic association. The yield contributing characters were significantly associated with fibre yield per plant at both genotypic and phenotypic levels. Basal diameter (1.679) at a genotypic level and stick yield, per cent fibre recovery and days to flower initiation maintained positive phenotypic and genotypic direct effect on fibre yield per plant.

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

INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.) is a warm season annual fibre crop of tropical and subtropical world inhabitants to east central Africa grown for several years for food and fibre. It has been a source of textile fibre for rope, twine, bagging and rugs. Since the 2nd world war, a source of raw material fibre for pulp, paper and other fibre products has been introduced in China, USSR, Thailand, South Africa, Cuba and Egypt. Paper products, building materials, absorbents and livestock feed are the new applications that continue to increase and involve issues ranging from basic agricultural production methods to the marketing of kenaf products (Bhaskara *et al*., 2012). Kenaf is a fast growing crop produces higher biomass and is a versatile source of fibre (Arbaoui *et al*., 2016). The genetic diversity in a random population might be benefited for the selection of parental lines. The assessing of germplasm at a proper level and pattern of genetic diversity helps the analysis of genetic variability (Smith, 1984;

Cox *et al*., 1986). The selection of diverse parental lines for hybridization creates segregating progenies with high genetic variability for further selections (Barrett and Kidwell, 1998). The wide hybridization involving wild germplasm of desirable genes must be adapted as a high yielding germplasm resource (Thompson *et al*., 1998). This type of information is useful to frame up the heterotic and potential cross combinations which saves the time and resources (Hallauer and Miranda, 1988). Kenaf is an important fibre crop cultivated in rainfed areas of Madhya Pradesh, Andhra Pradesh and Tamil Nadu. Fifty kenaf germplasm lines were evaluated for correlation and path analysis for fibre yield and yield contributing traits.

MATERIALS AND METHODS

Fifty genotypes of Kenaf (*Hibiscus cannabinus* L.) procured from AINP JAF through ICAR-CRIJAF, Barrackpore (WB) evaluated in a randomized block design (RBD) with three replications in a plot size of 4.50 m × 0.60 m for each genotype at the experimental farm of Cotton Improvement Project, MPKV, Rahuri during *kharif,* 2021. The recommended package of practices was adopted to achieve the production potential of the crop. Randomly 10 plants were tagged from each genotype and each replication and observations were recorded on days required for initiation of flowering, days to 50% flowering, plant height, basal diameter, green weight, stick weight, fibre yield and percent fibre recovery. The analysis of variance for RBD was worked out as per Panse and Sukhatme (1989). The variances at the genotypic and phenotypic levels and genetic advance (GA) were calculated according to Comstock and Robinson (1952) and Johnson *et al.* (1955), respectively. Coefficients of variation at a genotypic and phenotypic levels were analyzed by Singh and Choudhary (1985). Heritability in the broad sense for fibre yield and yield attributes was worked out by Hanson *et al.* (1956). The genotypic and phenotypic correlations were calculated as per Dewey and Lu (1959).

RESULTS AND DISCUSSION

Crop improvement is highly depends on genetic variation, heritability and diversity (Clegg, 1968; Dudley, 1969). The identification of desirable genes accelerates yield improvement through the hybridization programme. Crop yield is governed by various environmental as well as genetic factors. Forsman (2014) mentioned that the genetic characteristics were depends on variances and variation at genotypic and phenotypic levels and improves germplasm importance due to more than a few reasons. Breeding programme fulfils the objective to improve yield potential of the crop depends on selection of the parental lines on the basis of variability and the information on genotypic and phenotypic correlation coefficients is highly necessary. The information on PCV and heritability helps to predict genetic advance (GA) for contributing characters. Thus, in this investigation, important variability parameters i.e. variances, coefficient of variation, heritability, genetic advance at the genetic and phenotypic levels were worked out for fibre yield and it's contributing traits.

In the present investigation, the differences among the genotypes were statistically significant for all the characters revealed that there was a wide range of variation (**Table 1**). The higher magnitude of variance was recorded by stick weight followed by plant height, days to flower initiation and days to 50% flowering.

The genetic makeup of germplasm and adapted area for research creates the variation in agronomic traits (Mudher *et al*., 2020; Zhao *et al*., 2020). The selection of cultivars and growing conditions i.e. light period and intensity during day time increases the plant height resulting higher yield of the crop (Shukor *et al*., 2009). In the present investigation, KIM-02 and KIM-04 showed the highest values (94.33), while the genotypes KIN-259 and KIM-36 showed the lowest values (69.33) for days to flower initiation (**Table 2**). The genotypes KIN-233 and KIM-21 (101.33) required a maximum, whereas, KIN-259 and KIM-36 (77.00) required a minimum number of days for 50% flowering. In the case of plant height, genotypes KIN-235 and KIM-23 showed the highest mean values (355.00 cm) where KIN-255 was the lowest (183.67 cm) for plant height. The genotypes KIN-257 and KIM-34 maintained the highest basal diameter (2.44 cm), green weight per plant (0.488 kg) and stick weight per plant (240.00 g), while the genotypes KIN-255 and KIM-32 recorded the lowest base diameter (0.78 cm),

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

Source of variationn	DF	Mean sum of squares							
		Days to flower initiation	Days to 50% flowering	Plant height	Basal diameter	Green weight/ plant	Fibre yield/ plant	Stick weight/ plant	Fibre recovery
Replication	2	4.82	8.0265	2689.474	0.005	0.000	130.3915	23871.0465	1.3635
Treatment	49	129.620**	124.915**	2,322.364**	0.203**	0.008**	54.930**	5,054.466**	2.379**
Error	98	1.289	1.061	456.675	0.059	0.002	4.637	652.624	0.748

** indicates significance at 1% level

Table 2. Fibre yield and yield attributing traits influenced by kenaf germplasm lines

Accession Number	Days to flower initiation	Days to 50% flowering	Plant height (cm)	Basal diameter (cm)	Green weight/ plant (kg)	Stick weight/ plant (g)	Fibre recovery (%)	Fibre yield/ plant (g)
KIN-232	92.67	99.33	349.00	2.19	0.437	176.40	8.51	16.40
KIN-233	93.33	101.33	351.33	2.02	0.404	194.67	8.43	17.87
KIN-234	92.67	98.67	346.00	2.10	0.420	197.33	8.19	17.67
KIN-235	92.00	99.33	355.00	1.93	0.387	186.67	7.82	16.00
KIN-237	92.33	98.33	323.67	1.76	0.352	125.33	7.44	10.07
KIN-238	92.67	99.33	349.67	2.15	0.431	236.00	7.44	19.13
KIN-242	93.00	100.33	329.00	1.79	0.357	162.67	7.21	12.53
KIN-243	83.33	92.00	319.33	1.65	0.329	104.00	7.99	9.07
KIN-247	84.33	90.67	324.67	1.72	0.344	138.67	7.48	11.20
KIN-254	90.33	97.00	313.33	2.00	0.400	185.33	10.69	21.20
KIN-255	76.33	84.00	183.67	0.78	0.156	73.73	5.82	4.60
KIN-256	93.67	101.00	353.67	2.42	0.484	156.13	8.94	14.87
KIN-257	91.67	99.33	348.67	2.44	0.488	240.00	9.12	23.80
KIN-258	71.33	79.00	318.00	1.97	0.393	215.33	8.89	21.07
KIN-259	69.33	77.00	318.67	1.72	0.344	136.00	8.54	12.47
KIN-260	74.67	82.67	293.33	1.78	0.356	132.67	7.99	11.60
KIN-262	72.33	80.00	275.00	1.54	0.308	88.33	7.61	7.20
KIN-266	73.67	81.33	298.00	1.58	0.316	114.67	7.60	9.13
KIN-268	92.33	100.33	307.67	2.01	0.403	210.67	7.10	15.93
KIM-01	92.33	99.00	307.00	1.99	0.399	190.00	7.94	16.20
KIM-02	94.33	100.67	292.00	1.88	0.376	184.00	7.75	15.33
KIM-03	92.33	99.00	323.00	2.06	0.412	190.00	8.06	16.60
KIM-04	94.33	100.67	330.67	2.08	0.416	202.00	8.57	18.87
KIM-05	92.33	99.33	343.67	2.15	0.431	223.33	7.70	18.53
KIM-06	92.33	99.33	343.33	2.24	0.448	228.67	7.46	18.40
KIM-07	92.33	98.67	350.33	2.29	0.459	202.67	8.42	18.73
KIM-08	92.33	99.33	334.00	1.87	0.375	210.00	7.22	16.07
KIM-10	92.33	100.00	353.00	1.94	0.388	151.33	7.81	12.73
KIM-11	93.00	100.67	329.67	1.92	0.384	188.67	7.93	16.27
KIM-13	92.33	97.33	334.33	1.95	0.389	108.67	6.28	7.27
KIM-14	92.67	99.33	348.00	2.27	0.453	233.33	9.43	24.13
KIM-15	92.67	100.33	311.67	1.79	0.357	164.00	8.35	14.93
KIM-17	92.33	99.33	351.67	2.13	0.425	146.00	7.95	12.53
KIM-18	92.67	99.33	349.00	2.19	0.437	176.40	8.51	16.40
KIM-21	93.33	101.33	351.33	2.02	0.404	194.67	8.43	17.87
KIM-22	92.67	98.67	346.00	2.10	0.420	197.33	8.19	17.67
KIM-23	92.00	99.33	355.00	1.93	0.387	186.67	7.82	16.00
KIM-24	92.33	98.33	323.67	1.76	0.352	125.33	7.44	10.07
KIM-25	92.67	99.33	349.67	2.15	0.431	236.00	7.44	19.13
KIM-26	93.00	100.33	329.00	1.79	0.357	162.67	7.21	12.53
KIM-28	83.33	92.00	319.33	1.65	0.329	104.00	7.99	9.07
KIM-30	84.33	90.67	324.67	1.72	0.344	138.67	7.48	11.20
KIM-31	90.33	97.00	313.33	2.00	0.400	185.33	10.69	21.20
KIM-32	76.33	84.00	183.67	0.78	0.156	73.73	5.82	4.60
KIM-33	93.67	101.00	353.67	2.42	0.484	156.13	8.94	14.87
KIM-34	91.67	99.33	348.67	2.44	0.488	240.00	9.12	23.80
KIM-35	71.33	79.00	318.00	1.97	0.393	215.33	8.89	21.07
KIM-36	69.33	77.00	318.67	1.72	0.344	136.00	8.54	12.47
HC 583+	74.67	82.67	293.33	1.78	0.356	132.67	7.99	11.60
AMC 108+	72.33	80.00	275.00	1.54	0.308	88.33	7.61	7.20

green weight per plant (0.156 kg) and stick weight per plant (73.73 g). The maximum and minimum fibre recovery percentage was recorded by the genotypes KIN-254 and KIM-31 (10.69) and KIM-32 (5.82), respectively. The genotype KIM-14 (24.13 g) was found promising for fibre yield per plant followed by KIN-257 (23.80 g), KIM-34 (23.80 g) KIN-254 (21.20 g), KIM-31 (21.20 g), KIN-258 (21.07 g) and KIM-35 (21.07 g), while the genotypes KIN-255 and KIM-32 (4.60) were lowest for fibre yield per plant. Faruq (2013) reported the significant variation for basal diameter, nodes per plant, green weight and stick weight in kenaf germplasm for fibre yield.

The variances and coefficient of variation at genotypic and phenotypic levels depicts the relevance of genetic characteristics useful to promote the importance of population due to several reasons (Forsman, 2014). The genetic variability parameters showed the substantial amount of variability for all the characters (**Table 3**). The highest genotypic variance was for stick weight per plant (4401.851) followed by plant height (1865.693), days to flower initiation (128.708), days to 50% flowering (123.854), fibre yield per plant (50.291), per cent fibre recovery (1.631) and the lowest genotypic variance was that of green weight per plant (0.006) and basal diameter (0.144). The phenotypic variance was also the highest for stick weight per plant (5054.471) followed by plant height (2322.368), days to flower initiation (129.963), days to 50% flowering (124.915), fibre yield per plant (54.929), per cent fibre recovery (2.379) and the lowest phenotypic variance was that of green weight per plant (0.008) and basal diameter (0.203).

In the recent investigation, phenotypic coefficient of variability (PCV) was higher than genotypic coefficient of variability (GCV) in all the cases revealed the characters were mainly influenced by the environment (Kumar *et al*., 2021). High values for GCV and PCV were recorded for fibre yield per plant (26.32, 29.74), stick weight (21.31, 25.61), basal diameter and green weight (11.21, 16.75), fibre recovery (9.28, 14.30) and plant height (7.63, 10.05). Comparatively days to initiation of flowering (7.29, 7.40) and 50% flowering (6.62, 7.40) exhibited low values for GCV and PCV (Singh *et al*., 2013; Quatadah *et al*., 2012; Anandrao *et al*., 2011; Paul *et al*., 2011; Singh *et al*., 2011). The narrow range of variation between GCV and PCV for initiation of flowering and days to 50% flowering indicated that these characters were less influenced by the environment, whereas, a wider range for basal diameter, fibre recovery, green weight and stick weight exhibited a higher degree of environmental influences (Senapati *et al*., 2006). Kumar *et al.* (2021) reported a larger magnitude of the phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) for seed yield, the number of productive branch and inter-node length in sesame.

Days to 50% flowering (97.49%) recorded higher heritability followed by days to flower initiation (97.15%), fibre yield (78.33%), stick weight (69.21%) and plant height (57.65%) exhibited a good amount of additive genetic components which can be utilized for further crop improvement. Stick weight (65.64) and plant height (39.00) recorded the highest and green weight (0.06) recorded the lowest genetic advance. The high heritability with moderate to high genetic advance over a percentage of mean was observed in stick weight (69.21, 65.64) and plant height (57.65, 39.00) which indicate a preponderance of additive genetic action (Senapati *et al*., 2006). The high heritability with low genetic advance over the percentage of mean was observed in days to flower initiation (97.15, 13.30), days to 50% flowering (97.49, 13.06) and fibre yield (78.33, 7.46). Low heritability with low genetic advance over the percentage of mean was observed in basal diameter (44.75, 0.30), green weight (44.75, 0.30), Fibre recovery (42.10, 0.98) indicated the presence of both additive and non additive gene effects. Selection based on the phenotypic performance of these characters seems to be reliable and effective. Ishwarya Lakshmi *et al*. (2019) recorded a high range of variation, PCV, GCV and high heritability coupled with high genetic advance for days to 50% flowering and the number of spikelets per panicle in rice.

Table 3. Genetic characteristics influenced by various fibre yield contributing traits of kenaf

Character	Range	GV	PV	GCV (%)	PCV (%)	H^2(ns) (%)	GA	GAM
Days to flower initiation	69.33-94.33	128.708	129.963	7.29	7.40	97.15	13.30	14.81
Days to 50% flowering	77.00-101.33	123.854	124.915	6.62	6.70	97.49	13.06	13.46
Plant height (cm)	183.67-355.00	1865.693	2322.368	7.63	10.05	57.65	39.00	11.94
Basal diameter (cm)	0.78-2.44	0.144	0.203	11.21	16.75	44.75	0.30	15.45
Green weight/ plant (kg)	0.156-0.488	0.006	0.008	11.21	16.75	44.75	0.06	15.45
Stick weight/ plant (g)	73.73-240.00	4401.851	5054.471	21.31	25.61	69.21	65.64	36.52
Fibre recovery (%)	5.82-10.69	1.631	2.379	9.28	14.30	42.10	0.98	12.40
Fibre yield/ plant (g)	4.60-24.13	50.291	54.929	26.32	29.74	78.33	7.46	48.00

Phenotypic and genotypic correlation coefficient estimates between each pair of characters showed that the magnitude of the genotypic correlation is higher than the phenotypic correlation indicating that exclusion of environmental effects led to strengthen genetic association (**Table 4**). The correlation analysis revealed that all the yield component characters in kenaf were significantly associated with fibre yield/ plant at both genotypic and phenotypic levels. The non significant correlation was observed between days to flower initiation and days to 50% flowering with fibre recovery (%) at the genotypic and phenotypic levels and stick yield with fibre recovery (%) at the genotypic level. Other yield component characters were shown highly significant correlation at

Table 4. Phenotypic (PCV) and Genotypic (GCV) correlation coefficient among different yield component characters in kenaf

		Days to flower initiation	Days to 50% flowering	Plant height	Basal diameter	Green weight/ plant	Stick yield/ plant	Fibre recovery
Days to 50% flowering	P	0.985**						
	G	0.995**						
Plant height	P	0.454**	0.451**					
	G	0.612**	0.594**					
Basal diameter	P	0.445**	0.439**	0.764**				
	G	0.664**	0.643**	0.923**				
Green weight/ plant	P	0.445**	0.439**	0.764**	1.000**			
	G	0.664**	0.643**	0.923**	1.000**			
Stick yield/ plant	P	0.447**	0.447**	0.501**	0.595**	0.595**		
	G	0.550**	0.541**	0.616**	0.860**	0.860**		
Fibre recovery	P	0.043	0.025	0.178*	0.246**	0.246**	0.061	
	G	0.053	0.045	0.556**	0.745**	0.745**	0.479**	
Fibre yield/ plant	P	0.376**	0.362**	0.468**	0.588**	0.588**	0.848**	0.558**
	G	0.432**	0.418**	0.640**	0.912**	0.912**	0.935**	0.747**

*, ** significant at 5% and 1% level, respectively

Table 5. Path coefficient (genotypic and phenotypic) analysis showing direct (bold) and indirect effects of constituent characters in kenaf

		Days to flower initiation	Days to 50% flowering	Plant height	Basal diameter	Green weight/ plant	Stick yield/ plant	Fibre recovery	Correlation with Fibre yield
Days to flower initiation	P	**0.163**	-0.165	-0.016	-0.326	0.321	0.377	0.021	0.376**
	G	**0.378**	-0.356	-0.112	1.115	-1.000	0.387	0.020	0.432**
Days to 50% flowering	P	0.160	**-0.167**	-0.016	-0.322	0.317	0.377	0.012	0.362**
	G	0.376	**-0.358**	-0.109	1.079	-0.968	0.380	0.016	0.418**
Plant height	P	0.074	-0.075	**-0.036**	-0.561	0.552	0.422	0.091	0.468**
	G	0.231	-0.212	**-0.183**	1.550	-1.390	0.433	0.211	0.640**
Basal diameter	P	0.072	-0.073	-0.027	**-0.735**	0.722	0.501	0.126	0.588**
	G	0.251	-0.230	-0.169	**1.679**	-1.506	0.605	0.282	0.912**
Green weight/ plant	P	0.072	-0.073	-0.027	-0.735	**0.722**	0.501	0.126	0.588**
	G	0.251	-0.230	-0.169	1.679	**-1.506**	0.605	0.282	0.912**
Stick yield/ plant	P	0.073	-0.074	-0.018	-0.437	0.429	**0.843**	0.031	0.848**
	G	0.208	-0.193	-0.113	1.443	-1.295	**0.704**	0.181	0.935**
Fibre recovery	P	0.006	-0.004	-0.006	-0.180	0.177	0.051	**0.513**	0.558**
	G	0.020	-0.015	-0.102	1.250	-1.121	0.337	**0.379**	0.747**

Residual effect for path coefficient (Direct)= 0.003 (Genotypic) and 0.022 (Phenotypic), both genotypic and phenotypic levels. It indicates that direct selection of traits will be effective in ensuring seed and fibre yield of kenaf and this assumption is supported by different researchers (Adeniji and Aremu, 2007; Faruq *et al*., 2011). The results were in accordance with Alam *et al*. (2011), Islam *et al*. (2001), Shakhes *et al*. (2009) and Ibrahim *et al*. (2013).

Basal diameter (1.679) at genotypic level had the highest positive direct effect on fibre yield per plant followed by stick yield at the phenotypic (0.843) and genotypic (0.704) levels (**Table 5**). In addition to this, per cent fibre recovery (0.513, 0.379) and days to flower initiation (0.163, 0.378) maintained positive phenotypic and genotypic direct effects on fibre yield per plant, respectively (Senapati *et al*., 2006). Therefore direct selection based on these characters would be practicable. Days to 50% flowering and plant height exhibited high and negative direct phenotypic and genotypic effects towards fibre yield. Basal diameter (0.735) and green weight (1.506) had a negative direct effects at a phenotypic and genotypic levels, respectively. However, its significant positive correlation with fibre yield per plant indicates the indirect selection could be made for high yielding kenaf genotypes through most of the characters having positive indirect effects. The residual direct effect for path coefficient was 0.003 and 0.022 genotypic and phenotypic levels. It indicates there were also some other characters which although not studied but influenced the yield of fibre per plant. The stick weight per plant had higher values of direct effects even than their respective correlation coefficients indicating their major importance in fibre yield. Thus, the result of this investigation suggested that stick weight, fibre recovery, plant height, green weight and basal diameter would be the selection parameters to produce kenaf varieties with acceptable production.

The study of genetic variability, character association and path coefficient analysis in kenaf explores the relationships between the genotypes which are in need for production, conservation and utilization of this green resource. It will be very useful for varietal improvement of kenaf in a tropical environment by selecting genotypes with different genetic backgrounds. This information will facilitate efficient breeding programs for better yielding adaptive verities to promote a better environment with raw fibre resources.

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