SAARC J. Agric., 20(2): 31-42 (2022) *DOI: https://doi.org/10.3329/sja.v20i2. 63449*

APPRAISEMENT OF GENETIC VARIABILITY AND CHARACTER ASSOCIATION OF KENAF (*Hibiscus cannabinus*)

J. Ahmed[1], F. Mahmud[1], S. Sultana[2*] and M. Shamsuzzaman[2]

[1]Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh.

[2] Department of Biochemistry, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka,

ABSTARCT

Twenty five genotypes of Kenaf (*Hibiscus cannabinus* L.) from different geographic origins were grown at the Central Jute Agricultural Experiment station of Bangladesh Jute Research Institute (BJRI), Jagir, Manikganj to study their variability, correlation for nine morphological characters. Significant variation was found for all the characters among the genotypes. PCV was greater than GCV and high GCV values were observed for green weight with leaves, green weight without leaves, stick weight and fibre weight. The high heritability (more than 85%) coupled with high genetic advance in percent of mean were observed for most of the traits. All the characters except green bark thickness and internode length showed significant and positive correlation with fibre weight. Path co-efficient analysis revealed that green weight with leaves, green weight without leaves, green bark thickness and stick weight showed positive direct effect on fibre yield. Considering these agronomic performance genotypes G22 and G25 are suggested for future hybridization program.

Keywords: *Hibiscus cannabinus*, Genetic advance, Heritability, Interrelationship, Path coefficient.

INTRODUCTION

Kenaf (*Hibiscus cannabinus*), a fast-growing plant in the Malvaceae family, and its fibre, one of the bast fibre group. It is primarily used as a jute substitute. Kenaf is native to Africa, but it is grown all over the world. Kenaf grows quickly, producing a lot of biomass and serving as a source of multipurpose fiber (Arbaoui et al., 2016). Kenaf is an allotetraploid (2n=4x=72) plant. It is an annual or biennial herbaceous plant (rarely a short-lived perennial) with a woody base that grows to 1.5-3.5 m tall (Dempsey, 1975 Only two Hibiscus species, kenaf (*Hibiscus cannabinus* L.) and Roselle (*Hibiscus sabdariffa* L. var. altissima), are economically significant for pulp

* Corresponding author: sau.sharmin007@gmail.com

Received: 06.10.2022 *Accepted: 28.11.2022*

and paper manufacture despite the fact that there are over 50 Hibiscus species that grow in tropical and subtropical conditions on every continent. (Rowell et al., 1997).

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). 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). Kenaf has the capability to produce a high yield even in fallow and char lands with poor soil health (Hiron, 2007).

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. (M. Al-Mamun et.al., 2020). Traditionally, kenaf has been grown primarily for its fiber, which is used to make sacks, ropes, carpets, and canvases. (M. Al-Mamun et.al., 2020). Manufacturing of kenaf products has been reported to evaluate for textiles and discovered as additional potential uses that can benefit Bangladesh's national economy. (Paridah, 2017). Although the Bangladesh Jute Research Institute has identified several new kenaf genotypes, yield varies throughout all Bangladesh's agro-ecological zones (Islam, 2019). BJRI has over 6031 germplasm of exotic and indigenous Jute, Kenaf, Tosha, and Mesta. (BJRI, 2021). Kenaf seeds produce a vegetable oil that is edible. Kenaf oil is high in omega polyunsaturated fatty acids (PUFAs), which are thought to be beneficial to cardiovascular health. Its dried stems are also used as fuel, fencing, match sticks, and vegetable climbing sticks (BJRI, 1993). It can contribute to a country's economic development by creating job opportunities and earning foreign currency. The country’s yearly total export earnings from jute and jute goods are 9.17 crore taka in 2020-21 of which 1.26 crore taka was obtained from raw jute. The contribution of jute is about 4% in GDP and earns about 5% of foreign exchange in 2019 (BBS, 2021).

The development of new kenaf varieties that produce high biomass is critical for the successful cultivation of kenaf. Any crop's genetic improvement is dependent on the presence of initial genetic variability in the population. As a result, knowledge of the initial variability as well as the degree and direction of correlation among yield attributes is required for genetic improvement of economic yield through selection approaches in a diverse genotype population. If environmental factors change, the yield and quality of Kenaf fiber may vary (Mantineo et al., 2009). Yield is a complicated character, and improving it is dependent on some yield contributing traits. Path analysis assists in determining the true contribution of these traits to yield. Prior to beginning a breeding program, knowledge and identification of differences among available germplasm are required for the selection of appropriate genetic resources adapted to specific environments. Similarly, commercial cultivation selection and recommendation is only appropriate after thorough research and information. As a result, this study conceptualized the presence of genetic variation among genotypes, the degree and direction of relationship between yield and yield contributing characters, the direct and indirect contribution of yield contributing traits on yield, and the superior genotypes for use in future breeding programs.

MATERIALS AND METHODS

Experimental site

The research work relating to genetic variability and character association in kenaf (*Hibiscus cannabinus* L.) was conducted with 25 kenaf genotypes at Central Jute Agricultural Experiment Station of Bangladesh Jute Research Institute (BJRI), Jagir, Manikganj.

Experimental materials

Twenty five genotypes of *Hibiscus cannabinus* L. were taken as experimental material. The seeds were collected from the gene bank of Bangladesh Jute Research Institute (BJRI), Dhaka. The seeds were physically healthy and genetically pure. The name and origin of these genotypes are presented in Table 1.

Design and layout of the experiment

The experiment was carried out in Randomized complete block design (RCBD) with three replications. The genotypes were distributed into every plot of each block according to layout of the experiment. The individual plot was 3 m × 1 m in size. The twenty-five genotypes of the experiment were assigned at random into plots of each replication. The spacing distance maintained as row to row 30 cm and plant to plant 5-7 cm. The distance maintained between two lines was 3 m.

Data Collection

The following data on nine morphological characters viz., base diameter (mm), no. of nodes per plant, internode length (cm), green weight with leaves (g), green weight without leaves (g), green bark thickness (mm). dry stick weight (g) and dry fiber weight (g) were recorded from 5 randomly selected plants of each genotype from each replication during the experiment.

Statistical analyses

Genotypic and phenotypic variances were estimated according to the formula given by Johnson et al. (1955), genotypic and phenotypic co-efficient of variation were calculated by the formula suggested by Burton (1952), broad sense heritability was estimated by Lush (1943) through the formula, suggested by Johnson et al. (1955),

$H^2 = V_G/V_{P,}$ where, H^2 = Broad-sense heritability, σ^2_g = Genotypic variance

σ^2_p = Phenotypic variance

genetic advance as percentage of mean was calculated from the formula as proposed by Comstock and Robinson (1952), for calculating the genotypic and phenotypic correlation co-efficient for all possible combinations, the formula suggested by Miller et al. (1958), path co-efficient analysis was done according to the procedure employed by Dewey and Lu (1959) also quoted in Singh and Chaudhary (1985) using simple correlation values. All statistical analyses were carried out using MSTATC.

Table 1. Name and origin of 25 selected genotypes of Kenaf

Genotype No.	Accession	Origin/Country name
G1	BJRI Kenaf 3 (HC-3)	Check (Australia)
G2	Acc-1653 (HC 95)	Check (Iran)
G3	Acc-1583	USA
G4	Acc-1585	USA
G5	Acc-1589	USA
G6	Acc-1592	USA
G7	Acc-1593	USA
G8	Acc-1594	USA
G9	Acc-1611	Iran
G10	Acc-1612	Iran
G11	Acc-1626	Iran
G12	Acc-1633	Iran
G13	Acc-3741	Kenya
G14	Acc-3746	Kenya
G15	Acc-4622	USA
G16	Acc-4623	USA
G17	Acc-4627	USA
G18	Acc-4718	USA
G19	Acc-4750	USA
G20	Acc-4823	Kenya
G21	Acc-1575	Pakistan
G22	Acc-1607	Iran
G23	Acc-4415 (PI-329192)	Elsalvador
G24	Acc-1576	Pakistan
G25	Acc-1876	Kenya

RESULTS AND DISCUSSION

The data on yield and its contributing characters of 25 kenaf genotypes were statistically analyzed and the analysis of variance indicated higher amount of significant variability among the genotypes for all the characters studied such as plant height, base diameter, number of nodes per plant, internode length, green weight with leaves per plant, green weight without leaves per plant, green bark thickness, dry stick weight and dry fibre weight (Table 2). The variation due to replication was non-significant for all the characters studied. This variation might be due to the diverse geographic origin and distribution of genotypes.

Table 2. Analysis of variance for different characters of kenaf genotypes

Source	Df	Mean sum of square								
		PH	BD	NPP	IL	GWL	GWWL	GBT	SW	FW
Replication	2	0.000	3.539	11.853	0.004	91.240	79.053	0.012	2.520	1.213
Treatment	24	0.148**	15.751**	191.835**	0.577**	21,318**	12,649**	0.150**	330.60**	41.858**
Error	48	0.001	0.853	3.867	0.014	44.017	31.039	0.002	4.783	0.352
CV%		1.24	4.81	2.94	3.00	2.57	2.64	2.53	6.20	4.23

** indicate significant at the 0.01 level

PH = Plant height (m), BD = Base diameter (mm), NPP = Number of nodes per plant, IL = Internode length (cm), GWL = Green weight with leaves per plant (g), GWWL = Green weight without leaves per plant (g), GBT = Green bark thickness (mm), SW = Stick weight (g) and FW = Fibre weight (g).

Genetic Variability

Results of analysis of variance of the studied data on different yield components of 25 Kenaf genotypes summarized in Table 2. The analysis of variance indicated higher amount of significant variability among the genotypes for all the characters studied. The estimates of mean, range, genotypic and phenotypic coefficients of variation, heritability, genetic advance and genetic advance in percent mean for all the characters were studied and the results are presented in Table 3. A narrow range of difference between the phenotypic coefficient of variation and genotypic coefficient of variation for all the characters that studied indicating less environmental influence. Here, selection will be effective on the basis of phenotype. Significant variation also observed for these traits was cited by Samsal and Chakrabarty (1978) in kenaf. Joseph (1974) and Chaudhury et al. (1981) noted that green weight and fibre weight showed higher genetic variability in *Corchorus capsularis*.

All the characters except base diameter had more than 90% heritability (Table 3). Number of nodes per plant, green weight with leaves per plant, green weight without leaves per plant and stick weight showed high genetic advance. These characters expressed also high heritability with their phenotypic coefficient of variation. These results revealed that most likely heritability was due to additive gene effects. Mostofa et al. (2002) also reported the highest heritability for base diameter in Tossa Jute. Higher heritability was found for the plant height were reported by Dutta et al.

(1973). Plant height, base diameter, number of nodes per plant, internode length and green bark thickness showed moderate genetic advance over percentage of mean. High heritability coupled with moderate genetic advance for plant height indicating the predominance of additive gene effects on plant height. Chaudhury et al. (1981) observed the same findings in plant height of Tossa Jute. The heritability estimate was high 94.42 percent with moderate genetic advance over mean of 20.86 percent could be noted (Table 3). This notifies that additive genes are predominant for green bark thickness. So, we have to improve this trait before using it in breeding program.

Table 3. Estimation of genetic parameters for nine characters in 25 Kenaf genotypes

Characters	σ^2_p	σ^2_g	σ^2_e	PCV	GCV	ECV	Heritability	Genetic advance (5%)	Genetic advance (% mean)
PH	0.05	0.05	0.00	9.36	9.28	1.24	98.23	0.45	18.94
BD	5.82	4.97	0.85	12.56	11.61	4.81	85.33	4.24	22.08
NPP	66.52	62.66	3.87	12.21	11.85	2.94	94.19	15.82	23.69
IL	0.20	0.19	0.01	11.41	11.01	3.00	93.08	0.86	21.88
GWL	7135.4	7091.3	44.02	32.76	32.65	2.57	99.38	172.94	67.06
GWWL	4237.1	4206.0	31.04	30.89	30.78	2.64	99.27	133.11	63.17
GBT	0.05	0.05	0.00	10.72	10.42	2.53	94.42	0.44	20.86
SW	113.39	108.61	4.78	30.18	29.54	6.20	95.78	21.01	59.55
FW	14.19	13.84	0.35	26.85	26.52	4.23	97.52	7.57	53.95

PH = Plant height (m), BD = Base diameter (mm), NPP = Number of nodes per plant, IL = Internode length (cm), GWL = Green weight with leaves per plant (g), GWWL = Green weight without leaves per plant (g), GBT = Green bark thickness (mm), SW = Stick weight (g), FW = Fibre weight (g), PCV = Phenotypic coefficient of variation, GCV = Genotypic coefficient of variation and ECV = Environmental coefficient of variation.

Character Association

Yield is the result of combined effect of several components and environment. Understanding the interaction of characters among themselves and with environment have been of great use in the plant breeding. Correlation studies provide information on the nature and extent of association between only two pairs of metric characters. Genotypic and phenotypic correlation coefficients among 10 characters are presented in Table 4. In most instances, there was a close agreement between genetic correlations and phenotypic correlations. The results of correlation analysis showed that all characters were positively correlated with fiber weight except internode length and green bark thickness (r_g = -0.556, r_p = -0.523 and r_g = -0.428, $r_{p=}$ -0.353) (Table 4). The characters viz. plant height, base diameter, number of nodes per plant, green weight with leaves, green weight without leaves and stick weight appeared to be predominant consideration for fibre yield as they exhibited highly significant correlation with fibre weight and among themselves. Therefore, selection based on these characters bring out improvement towards enhancing the fibre yield in kenaf. These results were supported by Chaudhury et al. (1981) and Singh (1970). Pervin and Haque (2012), studied eleven genotypes of Deshi Jute and reported that fibre yield per plant was significantly positively correlated with plant height, base diameter, green weight and stick weight. Green bark thickness showed nonsignificant and negative correlation with stick weight (-0.177 and -0.111) at both genotypic and phenotypic level (Table 4). The r_p value is smaller than r_g value showing that the apparent association between the green bark thickness and stick weight was mainly for genes. Fibre yield per plant was positively and significantly correlated with plant height, base diameter, green weight with leaves and stick weight. Similar relationship was also reported in white jute and kenaf. Similar relationship was also reported in white jute and kenaf (Alam et al., 2015). In general, most of the characters showed

Table 4. Genotypic and phenotypic correlation coefficients among different pairs of yield andyield contributing characters in Kenaf

Characters	rg/ rp	BD (mm)	NPP	IL(cm)	GWL (g)	GWWL (g)	GBT (mm)	SW (g)	FW (g)
PH (m)	r_g	0.819**	0.831**	-0.943**	0.843**	0.869**	-0.016	0.800**	0.665**
	r_p	0.736**	0.794**	-0.909**	0.819**	0.835**	-0.001	0.761**	0.643**
BD (mm)	r_g		0.766**	-0.837**	0.907**	0.920**	-0.175	0.894**	0.858**
	r_p		0.716**	-0.719**	0.830**	0.845**	-0.085	0.824**	0.769**
NPP	r_g			-0.899**	0.746**	0.791**	0.177	0.788**	0.586**
	r_p			-0.844**	0.737**	0.780**	0.235*	0.756**	0.556**
IL (cm)	r_g				-0.739**	- 0.779**	-0.079	-0.756**	-0.556**
	r_p				-0.703**	- 0.736**	-0.090	-0.702**	-0.523**
GWL (g)	r_g					0.993**	-0.225*	0.905**	0.854**
	r_p					0.991**	-0.147	0.884**	0.848**
GWWL(g)	r_g						-0.184	0.928**	0.852**
	r_p						-0.091	0.902**	0.841**
GBT(mm)	r_g							-0.177	-0.428**
	r_p							-0.111	-0.353**
SW (g)	r_g								0.909**
	r_p								0.897**

** indicate significant at 1% * indicate significant at 5%

PH = Plant height (m), BD = Base diameter (mm), NPP = Number of nodes per plant, IL = Internode length (cm), GWL = Green weight with leaves per plant (g), GWWL = Green weight without leaves per plant(g), GBT = Green bark thickness (mm), SW = Stick weight (g), FW = Fibre weight (g), PCV = Phenotypic coefficient of variation, GCV = Genotypic coefficient of variation and ECV = Environmental coefficient of variation that the genotypic correlation co-efficient were higher than the corresponding phenotypic correlation co-efficient. the strong genetical association of this traits having low environmental interaction. Manjunatha and sheriff (1991) found positive association among the characters in Kenaf.

Path Co-efficient

Path coefficient analysis measures the direct influence of one variable upon other. Such information would be of great value in enabling the breeder to specifically identify the important component traits of yield and utilize the genetic stock for improvement in a planned way. The direct effect of a trait on fibre weight and its indirect effect through other characters were computed and the results are presented in Table 5.

Fibre weight per plant showed the highest positive direct effect (8.61) with green weight without leaves per plant. Green weight with leaves, green bark thickness and stick weight also showed positive direct effect on fibre weight indicating that direct selection for this trait might be effective and there is a possibility of improving fibre weight through selection based on those characters. On the other hand, negative direct effect on fibre weight was showed by plant height (-10.63), base diameter (-7.49), number of node (-5.56) and internode length (-13.08) (Table 5). The highest indirect effect of fibre weight was observed with plant height via internode length. Akter et al. (2005); reported that fresh weight without leaves had highest direct effect on fibre yield in Jute.

Table 5. Path coefficient analysis of different characters of kenaf

Parameters	Direct effect	Indirect effect via								Genotypic correlation with yield
		PH	BD	NPP	IL	GWL	GWWL	GBT	SW	
PH	-10.63	-	-6.14	-4.62	12.33	0.87	7.48	0.00	1.37	0.665**
BD	-7.49	-8.71	-	-4.26	10.94	0.94	7.92	-0.03	1.53	0.858**
NPP	-5.56	-8.84	-5.74	-	11.75	0.77	6.81	0.03	1.35	0.586**
IL	-13.08	10.03	6.27	5.00	-	-0.77	-6.71	-0.01	-1.29	-0.556**
GWL	1.04	-8.96	-6.79	-4.15	9.66	-	8.55	-0.03	1.55	0.854**
GWWL	8.61	-9.24	-6.89	-4.40	10.19	1.03	-	-0.03	1.59	0.852**
GBT	0.16	0.17	1.31	-0.98	1.03	-0.23	-1.58	-	- 0.30	-0.428**
SW	1.71	-8.51	-6.70	-4.38	9.88	0.94	7.99	-0.03	-	0.909**

Residual effect: 0.357

** indicate significant at 1%., * indicate significant at 5%.

PH = Plant height (m), BD = Base diameter (mm), NPP = Number of nodes per plant, IL = Internode length (cm), GWL = Green weight with leaves per plant (g), GWWL = Green weight without leaves per plant (g), GBT = Green bark thickness (mm), SW = Stick weight (g).

The genotypic correlation with fibre yield per plant was positive and considerably higher in magnitude except internode length and green bark thickness which was significant but negative. Das (1987), conducted an experiment where plant height followed by base diameter, leaf area had a positive effect on fibre yield. The value of residual effect was 0.357. It indicated that beside the characters studied, there were some other attributes (approx. 35.7%) which contributed towards fibre yield in kenaf.

CONCLUSION

Considering heritability, genetic advance, genetic advance in percentage of mean, correlation, path coefficient analysis for the characters under study, and comparing on the basis of agronomic performance, genotypes G22 and G25 could be included in a future study to improve kenaf fibre yield as green weight with leaves, green weight without leaves, stick weight and fibre weight showed positive results of these genotypes. Fibre yield per plant can be increased by improving the characters such as plant height, base diameter, number of nodes per plant, green weight with leaves, green weight without leaves, stick weight selection based on characters such as green weight with leaves, green weight without leaves, stick weight, and fibre weight could be effective for kenaf yield improvement.

ACKNOWLEDGEMENT

The author expresses his gratitude to the Ministry of Science and technology, Government of the People's Republic of Bangladesh for providing him financial support to conduct the experiment.

REFERENCES

Arbaoui, S., Soufi, S., Roger, P. and Bettaieb, T. (2016). Phytoremediation of trace metal polluted soil with fiber crop: Kenaf (Hibiscus cannabinus L.). *International Journal of Advances in Agricultural and Environmental Engineering*, 3 (2), Pp. 2.

BBS. (Bangladesh Bureau of Statistics). (2021). Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics, Stat. Div., Ministry Planning, Govt. Peoples Rep. Bangladesh, Dhaka. Pp.621.

BJRI. (1993). Annual Report. Bangladesh Jute Research Institute, Dhaka-1207.

BJRI. (2021). Annual Report. Bangladesh Jute Research Institute, Dhaka-1207. https://bjri.portal.gov.bd/sites/default/files/files/bjri.portal.gov.bd/page/980f040c_ecdc_4d2a_8d9e_818a7ca0e82b/2021-02-22-12-26-382ddee056b8b3f3d80e207728f54331.pdf

Burton, G.W. (1952). Quantitative inheritance in Grasses. *Proceedings of the 6th International Grassland Congress: Pennsylvania State College, State College*, 1(5): 277-283.

Chaudhury, S.K., Sinha, M.K. and Singh, D.P. (1981). Path analysis in Tossa Jute. *Indian Journal Agricultural Sci*ence, 51(11): 772-775.

Comstock, R.E. and Robinson, H.F. (1952). Genetic parameters and their estimation and significance. *Proceeding of 6th International Grassland Congress:* Pennsylvania State College, State College. 1(2): 284- 289.

Dempsey, J.M. *(*1975*)*. In: Fiber Crops Rose Printing Company, Tallahassee. *The Journal of Agricultural Science*, 6(5): 203-233.

Dewey, D.K. and Lu, K.H. (1959). A correlation and path co-efficient analysis of components of crested wheat grass and production. *Agronomy Journal*, 51(2):515-518.

Dutta, A.N., Srivasta, S.K. and Yadav, R.K. (1973). Heritability and correlation studies in Kenaf. *Indian Journal of Genetics and Plant Breeding*, 55(3): 279-282.

Hiron, N., Alam, N., Ahmed, F.A., Begum, R. and Alam, S.S. (2006). Differential fluorescent banding and isozyme asay of *Hibiscus cannabinus* L. and *H. sabdariffa* L. (Malvaceae). Cytologia, 71 (2), Pp. 175-180.

Islam, M.M. (2019). Kenaf (Hibiscus cannabinus L.) research and development advances in Bangladesh: a review. *Journal of Nutrition and Food Processing*, 2(1): 1-11.

Islam, M.M. and Ali, M.S. (2017). Economic importance of jute in Bangladesh: Production, research achievements and diversification. *International Journal of Economic Theory and Application,* 4(6):45-57.

Islam, M.R., Islam, M.M., Nuruzzaman, M., Akhter, S., Mollah, A.F., Ghosh, R.K., Hossain, A.K.M.S. and Rahman, L. (2002). Study on harvest index and genetic variability in White jute (*Corchorus capsularis* L.). *Online Journal of Biological Science*, 2(6): 358-360.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. (1955). Estimates of genetic and environmental variability in soybean. *Agronomy Journal*, 47: 314-318.

Joseph, F.C. (1974). A new approach to the bio bleaching of flax pulp using natural mediators. *Bioresource Technology,* 101(11): 4104 - 4110.

Lush, J.L. (1943). Animal breeding plans. Iowa State Press, Ames, Iowa. 437.

Mantineo, M., D'Agosta, G.M., Copani, V., Patane, C. and Cosentino, S.L. (2009). Biomass yield and energy balance of three perennial crops for energy use in the semi-arid Mediterranean environment. *Field Crops Research*, 114(2): 204-213.

Miller, P.J., Williams, J.C., Robinson, H.F. and Comstock, R.E. (1958). Estimation of genotypic and environmental variance and co-variance in upland cotton and their implications in selection. *Agronomy Journal*, 50: 126-131.

Al-Mamun, M., Rafii, M., Oladosu, Y., Misran, A.B., Berahim, Z., Ahmad, Z., Arolu, F. and Khan, M.H. (2022). Genetic Diversity among kenaf mutants as revealed by qualitative and quantitative traits. *Journal of Natural Fibers,* 19:11: 4170-4187.

Mostafa, M.G. (2012). Genetic divergence combining ability, heterosis and gene action for field characters in kenaf (*Hibiscus cannabinus* L.). Ph.D. Thesis, Department of Genetics & Plant Breeding, Bangladesh Agricultural University, Bangladesh. Pp. 14.

Mostofa, M.G., Islam, M.R., Alam, A.T.M.M., Ali, S.M.M. and Mollah, M.A.F. (2002). Genetic variability, heritability and correlation studies in Kenaf (*Hibiscus Cannabinus* L.). *Online Journal of Biological Science,* 2(6): 422-424.

Paridah, M.T., Abdelrhman, A.H. and Shahwahid, M. (2017). Cost benefit analysis of kenaf cultivation for producing fiber in Malaysia. *Arabian Journal of Business and Management Review*, 7, Pp 4.

Rowell, M.R., Anand, R., Sanadi, Daniel, F. and Jacobson, R.E. (1997). Utilization of natural fibers in plastic composites: problems and opportunities. *Journal of Oxford Science*, 32(5): 103-108.

Sasmal, B.C. and Chakroborty, K. (1978). Correlation and path coefficient analysis of yield component in Mesta. *Indian Journal Heredity*, 10(2): 19-27.

Singh, R.K. and Chaudhury, B.D. (1985). Biometrical methods of quantitative genetic analysis. *Haryana Journal of Horticultural Science*, 12(2): 151-156.