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Research Article

Assessment of genetic variability in different kenaf (*Hibiscus cannabinus*) germplasm using morpho-agronomic traits

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ABSTRACT

Kenaf (*Hibiscus cannabinus* L.) is a fiber crop classified in the genus Hibiscus (Malvaceae), and has a great potential for its multipurpose utilization, in addition to its traditional usage. Varietal identification of kenaf is always problematic and knowledge on genetic variability of kenaf varieties is also limited, which significantly hindered our effective utilization and conservation of the valuable kenaf germplasm. In order to find a proper method for identifying kenaf varieties and studying their variation, morpho-agronomic characters were analyzed. Fifty-eight accessions of kenaf germplasm collected from Gene Bank Department of Bangladesh Jute Research Institute were characterized at Jute Agriculture Experiment Station, Manikganj during April 2014 to December 2014. The accessions were characterized for fifteen morpho-agronomic attributes as per Hibiscus descriptor in order to select superior genotypes for the genetic improvement of kenaf. Considerable ranges of variability were observed in stem colour, petiole colour, plant height, base diameter, dry fibre weight, dry core weight, green weight with leaves and green weight without leaves. Based on major yield contributing characters accessions 1653, 3384, 3928 and 4202 performed better than the control varieties HC-2 and HC-95.

INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.) is a plant under the Malvaceae family and Hibiscus genus which is one of the most economically important fibre crop in the world. It is locally known as Deccan hemp, Roselle, Saimi jute, Java jute and so on. It is probably native to southern Asia, though its exact natural origin is unknown. It has been cultivated in its native Africa since 4000 B.C. [1]. It is a close relative of Cotton and Jute. It is mostly grown in wide latitudinal range like 16° S to 41° N [2]. Kenaf is cultivated for its fibre mostly in China, India, Bangladesh, United States of America, Indonesia, Malaysia, South Africa, Viet Nam, Thailand, parts of Africa, and to a small extent in southeast Europe.

Kenaf is an allotetraploid plant (2n=4x=72). It is an annual or biennial herbaceous plant (rarely a short-lived perennial) growing to 1.5-3.5 m tall with a woody base [3]. The stems are 1-2.5 cm diameter, often but not always branched. The leaves are 10–15 cm long, variable in shape and deeply lobed with 3-7 lobes. Kenaf is a dicotyledonous plant has two distinctive stem regions. The outer portion or bast which is about 34% of the stem by the weight and inner, woody core which is about 66% of the stem by the weight. Fibers from the bast portion of stem are about 2.48 mm in length and resemble softwood fibers while those from the core are shorter, 0.72 mm in length and resemble hardwood fibers. The yield (Dry fibre) per hectare varies considerably. The differences in yield are associated with different Kenaf cultivars, soil type, location, climate and the management practices that could be an important consideration in selecting the best cultivar [4, 5].

There are more than 50 Hibiscus species that occur in the tropical and subtropical environments of every continent but only two of these species, kenaf (*Hibiscus cannabinus* L.) and Roselle (*Hibiscus sabdariffa* L. var. altissima) have economic importance for the production of pulp and paper [6]. In Bangladesh, BJRI has developed 36 varieties of Jute, Tosha, Kenaf and Mesta so far. Among them 5 varieties of Jute, 4 varieties of Tosha, 2 varieties of kenaf named HC-2 (1977) and HC-95 (1995) and varieties of Mesta are now cultivating in farmers field. Moreover BJRI has more than 6000 germplasm of Jute, Kenaf, Tosha and Mesta of both exotic and indigenous origin. The HC-2 variety yields up to 6.8 tons per hectare. In Bangladesh around 30,000 ha. Land is being used under Kenaf cultivation which yields 60-70 tons [7].

Kenaf has a great importance like other fibre crops. Kenaf fibre is widely used in paper industry, construction sector and as raw materials of cosmetics products. It is also utilized as packaging materials for different agricultural and industrial products as well as raw materials for the production of paper and pulp [8]. The other uses of kenaf fibre are in rope, twine, coarse cloth, engineered wood, insulation, clothing-grade cloth, soil-less potting mixes, animal bedding and materials that absorb oil and liquids (similar to that made from Jute). In one words, it has multipurpose uses other than fibre and paper.

The paper made from Kenaf are stronger, brighter and cleaner with less detriment to the environment and less bleaching is required to create a brighter sheet of paper. Due to less lignin content, it needs 20% less energy than tree pulp. Pre-board can be made from Kenaf which is used as base material to make car's interior. The kenaf leaves enriched with protein can be consumed as human and animal diets. Kenaf seeds yield an edible vegetable oil. Kenaf oil is high in omega polyunsaturated fatty acids (PUFA's) which are expected to play a role in cardiovascular health. Its dried stems are also used as fuel, fencing, match sticks and climbing sticks of various vegetables [9].

It can take part in economic development of a country through generating employment opportunities and earning foreign currency. Kenaf as an alternative source of wood pulp, it conserves the forest resources. Kenaf can absorb CO_2 which is 3 to 8 times higher than a tree. In one acre of land, it can absorb 10 tons CO_2 per season. Less pesticides are needed in Kenaf cultivation. Its root can uptake nutrient from deeper soil as it can be cultivated in less fertile soil. It absorbs heavy metals from the soil. Products of Kenaf can be recycled. It enriches biomass content of soil. It has a great contribution to reduction of greenhouse gases and energy savings.

Kenaf can be used as a substitute of Jute having some advantages. Kenaf can be grown on marginal land where Jute cannot be gown. Moreover, it needs less weeding and less care. It can be grown in saline and drought affected areas. Kenaf plants rapidly produce a tremendous amount of biomass, meaning that it has an ample opportunity as an alternative source of raw materials for making paper and pulp [10].

The genetic improvement of any crop is dependent upon the existence of initial genetic variability amongst population. Therefore, knowledge of the initial variability and the degree and direction of correlation amongst yield attributes are necessary for genetic improvement of economic yield through selection approaches in a population of diverse genotype. The yield and quality of Kenaf fibre may varies if variation in environmental factors occurs. Therefore, it is also important to know the genetic, phenotypic and environmental variance for various attributes. These will help to select suitable genotypes which can be used in crop improvement program. In cereal crops, reproductive part is the main concern for improvement while vegetative part (stem bark) which need to be improved in Kenaf.

Fibre yield in Kenaf is a complex character and its improvements is dependent on some yield contributing traits. Existence of genetic variation of various attributes are useful for effective selection. These yield contributing attributes are correlated with fibre yield and also themselves. Path analysis helps to find out the real contribution of this traits to yield and desired genotypes can be traced through diversity analysis.

Kenaf is an important fibre crop in fibre producing countries of the world. Due to increase the environmental consciousness the demand of natural fibre increases rapidly through the world. To meet this increasing demand there is an urgent need to redesign the ongoing breeding strategies to improve both the yield and quality of kenaf. It is therefore, essential to understand the variability and diversity in the available germplasm of kenaf. Increased pressure has been exerted on kenaf scientists to develop varieties with high yield potential and superior grade fibre that meet the demands of the textile industries.

The use of plant genetic resources in breeding research is largely dependent on the available information of their genetic variability.

MATERIALS AND METHODS

The experiment was conducted at the experimental field of JAES, Manikganj during April 2014 to December 2014. Fifty-eight accessions of kenaf were taken for this study. The experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. Seeds were sown in single row of 3m long with spacing of 30, 60 and 10 cm between rows, replications and plants respectively. Standard production technology was adopted to raise a good crop under optimum management. In this study fifty-eight accessions of kenaf germplasm collected from Gene Bank Department of Bangladesh Jute Research Institute were characterized to find out the superior genotypes by using the kenaf descriptor developed by the International Jute Organization (IJO). The seeds were sown on 21 April, 2014. Intercultural operations were done at proper time for ensuring proper growth of the crop. The data on different morphological parameters were recorded from 10 randomly selected plants of each accession from each replication. Observations were recorded on different morphological characters on the basis of descriptor. The collected data on different parameters were statistically analyzed. The statistical software Excel and MSTAT-C computer package program developed by Russell (1986) [11] were used for these analyses.

RESULTS

Morphological characters of Hibiscus cannabinus germplasm

The mean performance of the major yield contributing characters and co-efficient of variation are presented in Figure 1, 2, 3 and Table-1.

The plant height (m/plant): The plant height at harvest (120 days) ranged from 1.98-3.04m (Fig. 1). The highest score of plant height was recorded in variety HC-95 (3.04 m/plant) which was followed by accessions 1653 (3.02 m/plant), 1681 (2.92 m/plant), 1996 (2.92 m/plant), variety HC-2 (2.92 m/plant) and accession 1607 (2.86 m/plant).

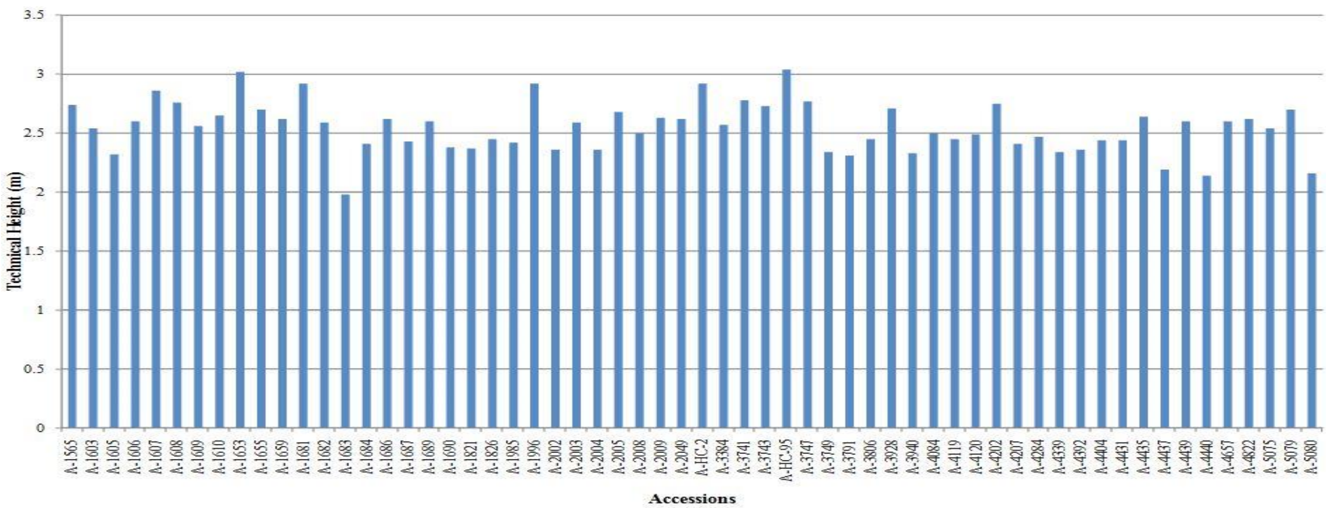

Figure 1: Plant height of fifty-eight accession of kenaf.

Leaf angle (dg): Leaf angle ranged from 70-95˚. The highest leaf angle (95˚) was observed from accession number 4339 while accession number 5080 showed lowest leaf angle (70˚) (Table 1).

Leaf length (cm): Leaf length ranged from 4.18-13.38 cm. Largest leaf length (13.38 cm) was observed from controlled accession number HC-95 while accession number 1681 showed smallest leaf length (4.18 cm) (Table 1).

Leaf width (cm): Leaf width ranged from 4.28-18.88 cm. The highest leaf width (18.88 cm) was observed from controlled accession number HC-95 while accession number 4207 showed lowest leaf width (4.28 cm) (Table 1).

Petiole length (cm): Petiole length was ranged from 6.22-21.16 cm. The largest petiole length (21.16 cm) was observed from controlled accession number HC-95 while accession number 2049 showed smallest petiole length (6.22 cm) (Table 1).

Node No: Number of nodes ranged from 27-113. The highest node number (113) was observed from accession number 3743 while accession number 4439 showed lowest node number (27) (Table 1).

Internode length (cm): Internode length ranged from 2.12-6.90 cm. The highest internode length (6.9 cm) was observed from accession number 5079 while accession number 5075 showed lowest internode length (1.2 cm) (Table 1).

Base diameter (mm): Base diameter was ranged from 13.13-21.91 mm. Largest base diameter (21.91 mm) was observed from accession number 1653 while accession number 1683 showed smallest base diameter (13.13 mm) (Table 1).

Middle diameter (mm): Middle diameter ranged from 7.10-14.44 mm. The largest middle diameter (14.44 mm) was observed from accession number 1826 while accession number 4440 showed smallest middle diameter (7.1 mm) (Table 1).

Top diameter (mm): Top diameter ranged from 3.32-8.82 mm. largest top diameter (8.82 mm) was observed from accession number 2009 while accession number 4440 showed smallest top diameter (3.32mm) (Table 1).

Core diameter (mm): Core diameter ranged from 9.42-19.66 mm. largest core diameter (19.66 mm) was observed from accession number 3384 while accession number 4440 showed smallest core diameter (9.42 mm) (Table 1).

Green weight with leaf (g): Green weight of ten plants with leaf ranged from 120-590g. The highest green weight of ten plants with leaves (590 g) was observed from accession number 1653 while the lowest (120 g) was observed from accession number 4440 (Table 1).

Green weight without leaf(g): Green weight of ten plants without leaf ranged from 100-470g. The highest green weight of ten plants without leaves (470 g) was observed from accession number 1653 while the lowest (100 g) was observed from accession number 4440 (Table 1).

Dry fibre weight (g/plant): Dry fibre weight ranged from 10-38 gm/plant (Fig. 2). It was highest in accession 1653 (38 gm/plant) which was followed by accessions 3384 (35 gm/plant), 3928 (34 gm/plant), 4202 (34 gm/plant), 2009 (33 gm/plant) and 3743 (30 gm/plant) (Fig. 2).

Table 1. Range, mean and co-efficient of variation (CV%) of fifteen characters of fifty eight *Hibiscus cannabinus* germplasm.

Acc.no.	Leaf Angl (dg)	Leaf Lnth (cm)	Leaf width (cm)	Petiol Lnth (cm)	Node No.	Internode Lnth(cm)	Base Dia (mm)	Middle dia (mm)	Top Dia (mm)	Core Dia (mm)	Gwt with Leaf(g)	Gwt without Leaf(g)
1565	90	7.38	12.28	13.14	107	2.88	18.32	11.25	6.94	15.95	367	310
1603	80	10.60	14.90	11.60	89	2.35	18.85	11.76	6.24	15.45	410	355
1605	80	7.46	12.26	13.00	60	2.36	15.90	10.06	5.31	13.57	251	134
1606	85	7.50	5.52	8.30	74	2.86	17.58	11.10	5.61	14.82	360	330
1607	70	8.14	12.36	8.40	94	2.92	19.10	12.42	5.78	16.14	359	307
1608	80	8.30	12.22	9.54	89	2.70	19.41	11.99	5.82	16.42	424	367
1609	90	9.22	16.18	16.12	95	3.26	18.65	11.88	6.43	15.65	423	392
1610	85	7.52	10.12	9.12	88	2.56	16.13	11.25	5.30	14.39	363	324
1653	85	8.36	15.18	13.50	105	3.43	21.91	13.33	6.72	18.38	590	470
1655	75	5.32	6.32	9.30	92	3.10	20.70	13.39	6.40	17.45	470	400
1659	85	6.08	6.10	10.14	81	4.62	17.61	10.64	6.01	14.93	345	310
1681	85	4.18	7.46	9.14	85	3.48	17.85	11.19	5.66	16.31	506	335
1682	75	7.20	6.32	9.94	73	3.12	13.13	9.04	4.48	11.08	185	120
1683	85	6.12	6.06	12.32	45	3.16	14.95	8.56	4.78	12.70	168	110
1684	90	7.30	5.48	8.24	58	2.42	14.99	10.40	4.41	12.87	250	185
1686	95	7.96	17.70	13.12	108	2.24	19.45	12.64	6.18	18.24	496	420
1687	80	6.88	10.86	11.08	82	2.76	17.27	11.16	6.10	15.36	358	310
1689	75	7.08	10.06	10.38	100	2.22	16.94	10.88	6.47	15.60	450	350
1690	70	7.36	11.98	14.34	93	3.42	17.15	12.96	6.57	14.57	370	315
1821	80	7.18	11.28	7.84	88	4.43	18.70	11.89	5.81	16.80	573	310
1826	95	5.62	6.52	7.30	80	2.50	14.23	14.44	4.75	12.50	185	125
1985	90	7.12	13.92	11.52	93	3.60	20.24	13.52	7.52	18.03	541	380
1996	95	7.08	12.90	8.14	74	3.12	18.92	11.96	5.29	16.32	303	192
2002	90	8.30	7.12	7.50	68	5.26	18.22	12.77	5.98	16.53	383	320

Table 1. Contd..

2003	95	7.96	11.50	11.00	66	3.80	19.60	12.71	5.80	16.50	465	340
2004	90	7.82	12.54	9.10	66	5.32	18.27	12.20	6.67	16.00	390	330
2005	85	5.32	8.38	7.10	82	3.52	18.59	11.68	6.11	16.00	393	315
2008	90	7.38	7.56	13.52	70	5.78	18.37	12.45	7.36	17.25	190	150
2009	90	9.06	12.90	11.62	77	4.78	20.98	12.82	8.82	18.52	491	380
2049	80	7.12	8.10	6.22	95	4.62	19.23	11.55	7.36	17.50	446	375
*HC-2	88	13.24	16.52	13.65	95	5.95	17.65	13.83	6.92	17.09	490	405
3384	85	7.28	11.02	9.94	88	5.80	21.83	12.15	6.84	19.66	473	335
3741	80	7.10	10.82	10.80	94	2.75	17.38	11.64	7.46	16.25	390	326
3743	85	7.38	10.84	13.30	113	4.32	21.13	12.23	5.93	18.73	472	330
*HC-95	75	13.38	18.88	21.16	109	4.30	19.80	10.07	5.19	15.94	400	340
3747	75	10.52	16.98	13.38	99	3.78	21.82	12.50	6.82	17.96	566	375
3749	70	8.66	7.70	12.90	84	3.96	17.58	10.70	4.73	14.67	266	167
3791	90	8.12	17.60	18.80	97	3.33	19.10	11.90	6.17	16.17	380	233
3806	80	7.52	8.24	13.20	80	2.68	17.55	10.10	5.29	14.71	400	278
3928	85	6.78	9.90	7.00	75	3.35	19.46	10.66	5.41	15.80	533	340
3940	90	6.68	5.14	8.40	70	2.45	16.98	9.55	4.45	14.32	300	167
4084	90	6.96	10.84	10.40	89	4.28	18.48	11.20	7.64	14.54	450	325
4119	85	9.14	6.34	10.90	75	3.22	17.13	9.80	4.44	13.77	367	230
4120	75	6.72	9.20	9.90	90	5.12	18.53	9.99	5.04	15.36	369	290
4202	70	7.96	11.12	10.44	65	5.58	16.71	10.62	5.67	13.60	300	230
4207	80	7.10	4.28	11.20	90	3.30	17.71	10.64	6.21	15.60	400	295
4284	85	10.86	15.60	18.35	86	2.80	18.21	9.39	3.90	13.71	300	185
4339	95	8.32	7.42	11.28	88	3.42	17.92	9.04	3.70	14.32	367	170
4392	90	6.26	9.16	11.96	95	3.82	14.18	9.00	4.49	12.23	267	150
4404	85	7.80	11.48	8.89	93	3.35	18.75	9.70	4.66	13.76	333	200
4431	70	6.76	7.22	7.82	97	2.50	15.95	9.44	3.94	12.92	267	190
4435	85	6.32	11.46	13.76	76	3.75	16.77	10.22	4.15	14.29	300	235
4437	85	9.28	13.16	16.42	96	3.20	15.42	9.16	5.16	12.95	270	170
4439	90	9.04	13.76	14.10	27	3.32	18.15	11.45	4.83	15.92	366	300
4440	80	11.54	16.86	16.65	73	4.10	17.00	7.10	3.32	9.42	120	100
4657	85	7.94	7.26	7.96	63	3.60	16.12	10.19	3.95	13.05	300	233
4822	75	8.62	11.90	14.44	84	5.65	17.34	9.50	4.11	13.24	267	227
5075	80	8.30	13.12	14.90	47	2.12	16.72	11.29	5.43	14.22	400	335
5079	80	11.82	16.82	14.38	66	6.90	16.37	10.18	5.67	13.56	300	250
5080	70	10.82	15.42	16.68	70	3.40	19.93	10.89	5.45	16.87	400	322
Range	70-95	4.18-13.38	4.28-18.88	6.22-21.16	27-113	2.12-6.90	13.13-21.91	7.10-14.44	3.32-8.82	9.42-19.66	120-590	100-470
Mean	83.3	7.97	10.97	11.58	82.52	3.64	17.98	11.13	5.67	15.27	371.97	279.9
CV%	8.56	22.33	34.05	27.86	19.85	29.94	10.41	13.03	19.93	12.97	28.01	31.87

* Controlled germplasm

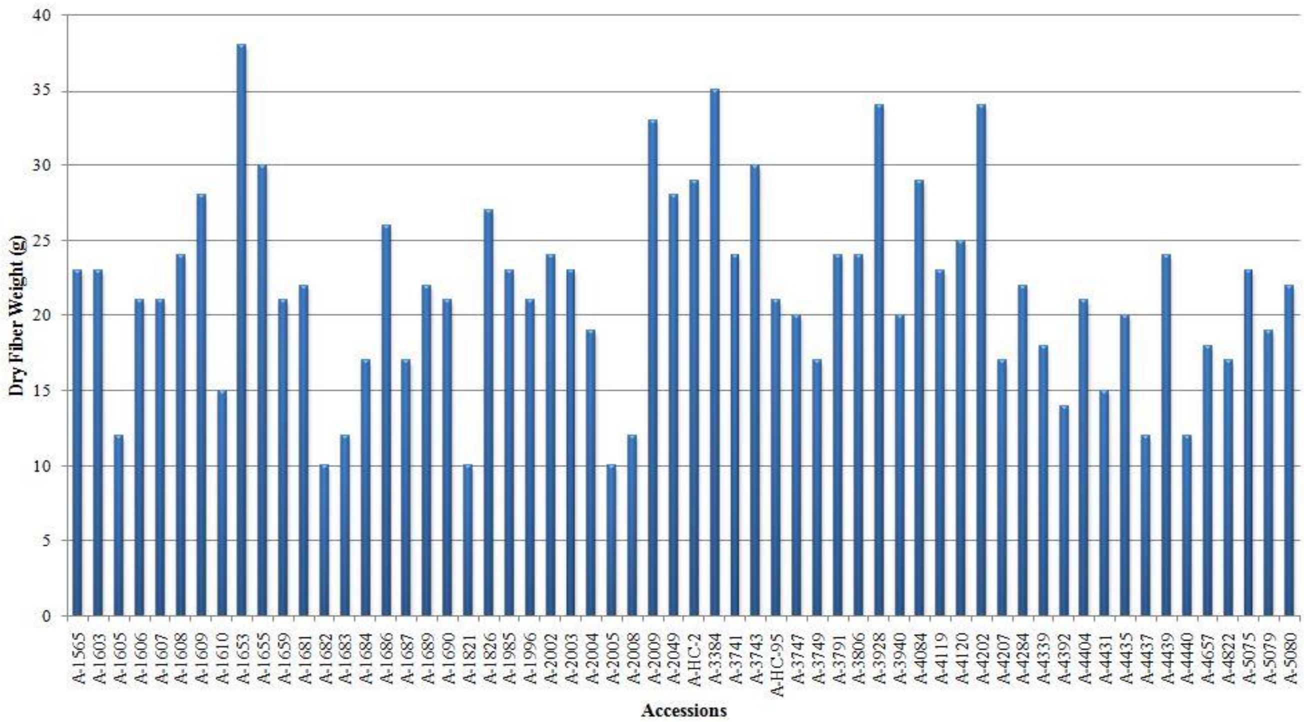

Figure 2: Dry fibre weight of fifty eight accession of kenaf.

Dry core weight (g/plant): Dry core weight ranged from 30-85 g/plant (Fig. 3). The highest dry core weight was recorded in accession 1653 (85 g/plant) which was followed by accessions 1608 (80 g/plant), 1826 (73 g/plant), 3928 (71 g/plant) and 3384 (69 g/plant).

Pigmentation of Hibiscus cannabinus germplasm.

Pigmentation data on stem colour, leaf colour, vein colour, petiol colour, stipule, stipule colour, leaf pubescence, stem pubescence, bud colour and fruit colour are presented in Table 2.

Stem color: Red stem color was found in accession number 1682, 1683. Stem color was green in accession number 1565, 1605, 1653, 1655, 1659, 1681. 1690, 1821, 1985, 1996, 2002, 2003, 2004, 2005, 2008, 2049, HC-2, 3743, HC-95, 3791, 3928, 4207, 4284, 4392, 4404, 4431, 4437, 4439, 4440, 4657, 4822, 5079, 5080. While either reddish green colored stems were shown by rest of the accessions (Table 2).

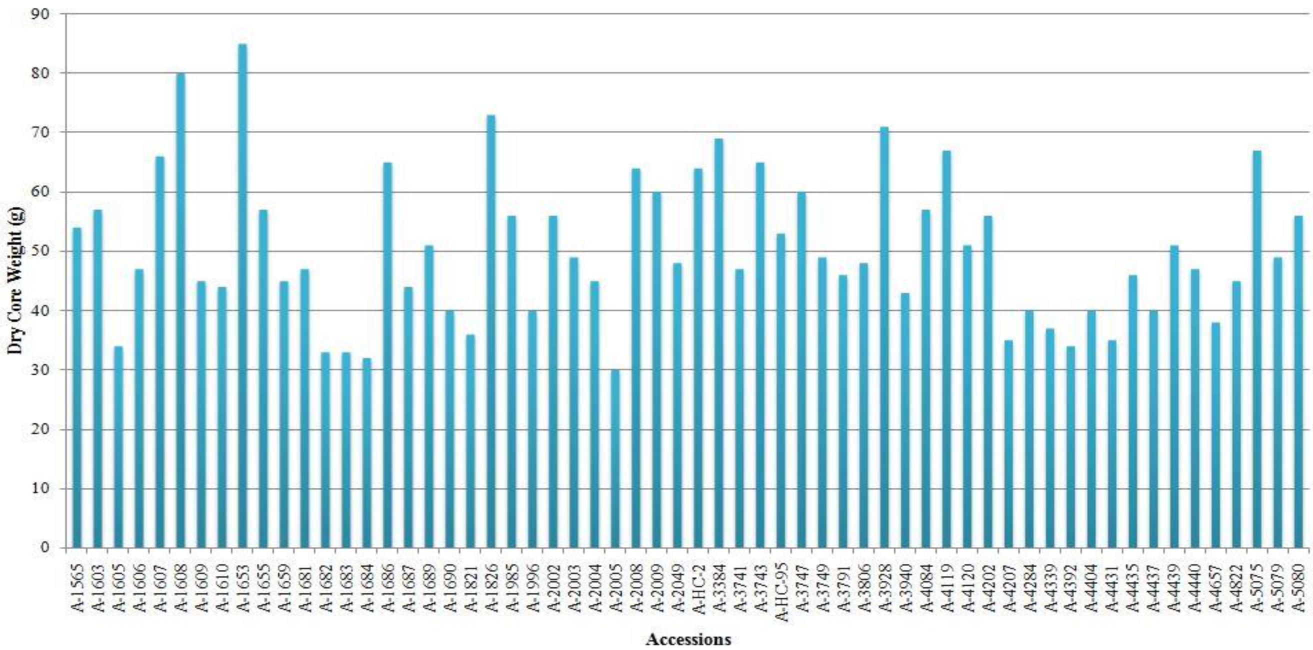

Figure 3: Dry core weight of fifty eight accession of kenaf.

Leaf color: Leaf color was green in all accession except accession number 1683, 1684 in which leaf color were red (Table 2).

Vein Color: Vein color was green in all accession (Table 2).
Petiole color: Red colored petiole was found in accession number 1682, 1683. Petiole color was green in accession number 1565, 1605, 1607, 1653, 1655, 1659, 1681. 1690, 1821, 1985, 1996, 2002, 2003, 2004, 2005, 2008, HC-2, 3743, HC-95, 3791, 4119, 4207, 4284, 4392, 4404, 4431, 4437, 4439, 4440, 4822 and 5079. While reddish green colored petioles were shown by rest of the accessions (Table-2).

Stipule: All of the accessions were stipulated (Table 2).

Stipule color: Stipule color was reddish-green in accession number 1982, 1683, 1689 and 4435. Stipule color was green in rest of the accessions (Table 2).

Leaf pubescence: Among all the accessions no leaf pubescence was observed (Table 2).

Stem pubescence: Pubescence was found in all of the accessions (Table 2).

Bud color: Bud color was green in all accession except accession number 1683, 1684 in which bud color were red (Table 2).

Fruit Color: Fruit Bud color was green in all accession except accession number 1683, 1684 in which fruit color were red (Table 2).

DISCUSSION

As mentioned earlier, one of the major problems hindering effective utilization of kenaf germplasm is the difficulty of identifying its varieties. The situation of kenaf labeling as the same varieties but having different morpho-agronomic characters occurs frequently, which is commonly caused by misidentification, apart from the man-made reasons (e.g. artificial mixture and purposely forging for market benefit) in the seed production and marketing [12]. The misidentification always leads to a great confusion of kenaf varieties in the market. Therefore, breeders and researchers exigently hope to establish an effective method to correctly identify kenaf varieties [13]. In addition, our knowledge on genetic diversity and

relationships of kenaf is still limited, hindering the efficient use and conservation of its germplasm. Therefore, research on genetic divergence in this crop is very important in formulating a successful breeding program for evolving cultivars superior in both yield and quality to cater to the increasing demand of value added jute products in the domestic and international markets.

In this study, most of morpho-agronomic characters showed significant within- and between-variety variation. This in general suggests considerable genetic diversity among the included kenaf varieties. Mean sum of square for plant height was highly significant (Table 1). The highest score of plant height was recorded in variety HC-95 (3.04 m/plant) which was followed by accessions 1653 (3.02 m/plant), 1681 (2.92 m/plant), 1996 (2.92 m/plant), variety HC-2 (2.92 m/plant) and accession 1607 (2.86 m/plant) (Fig. 1). High heritability was found for the plant height was reported by many researchers [14]. Largest base diameter (21.91 mm) was observed from accession number 1653 while accession number 1683 showed smallest base diameter (13.13 mm). The value ranged from 13.13 to 21.91 mm (Table 1). The earlier scientist also reported the highest heritability for base diameter in Tossa Jute [10]. The analysis of variance revealed highly significant differences among the genotypes with respect to number of nodes per plant. Number of nodes ranged from 27-113. The maximum number of node (113) was observed from accession number 3743 while accession number 4439 showed minimum node number (27). Mean node number was 82.52 with 19.85% coefficient of variance (Table 1). Similar findings were reported by many researchers [15, 16]. This value notifies that the character is governed by additive genes and selection will be rewarding for improvement of such trait. Internode length ranged from 2.12-6.90 cm. highly significant differences among the genotypes were observed for internode length. Mean internode length was 29.94 cm with 3.64% coefficient of variance (Table 1). So selection is ineffective without improvement of this character. The earlier scientist observed the same findings in Tossa Jute [17]. The highest green weight of ten plants with leaves (590 g) was observed from accession number 1653 while the lowest (120 g) was observed from accession number 4440. The coefficients of variability at phenotypic level was 28.01 percent (Table 1). Significant differences were observed in green weight without leaves per plant due to diverse genotypes. Green weight of ten plants without leaf ranged from 100-470g. The highest green weight of ten plants without leaves (470 g) was observed from accession number 1653 while the lowest (100 g) was observed from accession number 4440 (Table 1). This character can be selected on the phenotypic basis. Dry fibre weight is the most important yield attributing character for genetic diversity studies. Dry fibre weight ranged from 10-38 gm/plant (Fig. 2). It was highest in accession 1653 (38 gm/plant) which was followed by accessions 3384 (35 gm/plant) and 3928, 4202 (34 gm/plant). Mean fibre weight was 21.6gm with the coefficient of variance 30.05% (Table 1). Hence, selection will be effective on phenotypic basis. This findings was also supported by Many scientist [18, 19] in Kenaf. A wide variation was found among the genotypes for the stick weight or core weight. It varied 30 to 85 gm significantly among the genotypes with an overall mean of 50.37 gm. The coefficient of variance for stick weight was 24.8%. The earlier scientist recorded similar findings in Kenaf [20]. This character is highly efficient for selection.

Different Pigmentation characteristics of *Hibiscus cannabinus* germplasm was also studied and discussed in the manuscript. Red stem color was found in accession number 1682, 1683. While by rest of the accessions stem color was either green or reddish green. Leaf color was green in all accession except accession number 1683, 1684 in which leaf color were red. Stipule color was reddish-green in accession number 1982, 1683, 1689 and 4435. Stipule color was green in rest of the accessions. Among all the accessions no leaf pubescence was observed.

In order to have a good choice of character for selection of desirable genotypes under planned breeding program, the knowledge of nature and magnitude of variation existing in available breeding materials, the association of component characters with fibre yield and their exact contribution through direct and indirect effects are very important. However, the data from this study suggests that morpho-agronomic characters alone still cannot be regarded as critical indicators to identify individual kenaf varieties.

Table 2. Pigmentation of *Hibiscus cannabinus* germplasm along with check varieties HC-2 and HC-95.

Acc.no.	Stem colour	Leaf colour	Vein colour	Petiol colour	Stipule	Stipule colour	Leaf Pubescence	Stem Pubescence	Bud colour	Fruit colour
1565	G	G	G	G	+	G	0	+	G	G
1603	G,R	G	G	G,R	+	G	0	+	G	G
1605	G	G	G	G	+	G	0	+	G	G
1606	G,R	G	G	G,R	+	G	0	+	G	G
1607	G	G	G	G	+	G	0	+	G	G
1608	G,R	G	G	G,R	+	G	0	+	G	G
1609	G,R	G	G	G,R	+	G	0	+	G	G
1610	G,R	G	G	G,R	+	G	0	+	G	G
1653	G	G	G	G	+	G	0	+	G	G
1655	G	G	G	G	+	G	0	+	G	G
1659	G	G	G	G	+	G	0	+	G	G
1681	G	G	G	G	+	G	0	+	G	G
1682	R	G	G	R	+	G,R	0	+	G,R	G,R
1683	R	R	G	R	+	G,R	0	+	G,R	G,R
1684	G,R	R	G	G,R	+	G	0	+	G	G
1686	G,R	G	G	G,R	+	G	0	+	G	G
1687	G,R	G	G	G,R	+	G	0	+	G	G
1689	G,R	G	G	G,R	+	G,R	0	+	G	G
1690	G	R	G	G	+	G	0	+	G	G
1821	G	G	G	G	+	G	0	+	G	G
1826	G,R	G	G	G,R	+	G	0	+	G	G
1985	G	G	G	G	+	G	0	+	G	G
1996	G	G	G	G	+	G	0	+	G	G
2002	G	G	G	G	+	G	0	+	G	G
2003	G	G	G	G	+	G	0	+	G	G
2004	G	G	G	G	+	G	0	+	G	G
2005	G	G	G	G	+	G	0	+	G	G
2008	G	G	G	G	+	G	0	+	G	G
2009	G,R	G	G	G,R	+	G	0	+	G	G
2049	G	G	G	G	+	G	0	+	G	G
HC-2	G	G	G	G	+	G	0	+	G	G
3384	G,R	G	G	G,R	+	G	0	+	G	G
3741	G,R	G	G	G,R	+	G	0	+	G	G
3743	G	G	G	G	+	G	0	+	G	G
HC-95	G	G	G	G	+	G	0	+	G	G
3747	G,R	G	G	G,R	+	G	0	+	G	G
3749	G,R	G	G	G,R	+	G	0	+	G	G
3791	G	G	G	G	+	G	0	+	G	G
3806	G,R	G	G	G,R	+	G	0	+	G	G
3928	G	G	G	G	+	G	0	+	G	G
3940	G,R	G	G	G,R	+	G	0	+	G	G
4084	G,R	G	G	G,R	+	G	0	+	G	G
4119	G,R	G	G	G	+	G	0	+	G	G
4120	G,R	G	G	G,R	+	G	0	+	G	G
4202	G,R	G	G	G,R	+	G	0	+	G	G
4207	G	G	G	G	+	G	0	+	G	G
4284	G	G	G	G	+	G	0	+	G	G
4339	G,R	G	G	G,R	+	G	0	+	G	G
4392	G	G	G	G	+	G	0	+	G	G
4404	G	G	G	G	+	G	0	+	G	G
4431	G	G	G	G	+	G	0	+	G	G
4435	G,R	G	G	G,R	+	G,R	0	+	G	G
4437	G	G	G	G	+	G	0	+	G	G
4439	G	G	G	G	+	G	0	+	G	G
4440	G	G	G	G	+	G	0	+	G	G
4657	G	G	G	G,R	+	G	0	+	G	G
4822	G	G	G	G	+	G	0	+	G	G
5075	G,R	G	G	G,R	+	G	0	+	G	G
5079	G	G	G	G	+	G	0	+	G	G
5080	G	G	G	G,R	+	G	0	+	G	G

G= Green, R= Red, “+”= Present, “0”= Absent

CONCLUSION

Among the accessions characterized four accessions viz. 1653, 3384, 3928 and 4202 performed relatively better than the studied materials and control varieties HC-2 and HC-95. Hence these accessions may be selected for further study.

CONFLICT OF INTEREST

The authors have not declared any conflict of interests.

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