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# Developing agro-morphological descriptors of mesta (*Hibiscus* spp. L.) varieties for germplasm evaluation and characterization as per DUS test guidelines

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**ABSTRACT**

*Mesta (Hibiscus spp. L.) is an important genus of bast fibre crop next to jute crop in the world. The mesta fibre can be obtained from the two species viz., roselle (Hibiscus sabdariffa L.) and kenaf (Hibiscus cannabinus L.) and both of them are being cultured for bast fibre production. A total of seventh varieties (7 varieties of kenaf and 10 varieties of roselle) have been characterized based on expression of thirty seven essential morphological variability and fibre quality traits as per National DUS (Distinctiveness, Uniformity and Stability) test guidelines. Out of thirty seven characters, five characters are monomorphic in nature, twenty characters are dimorphic and twelve characters are polymorphic in nature in the varieties of kenaf (Hibiscus cannabinus L.) whereas eight characters are monomorphic in nature, twenty characters are dimorphic and nine characters are polymorphic in natureamong the varieties of roselle (Hibiscus sabdariffa L.) indicating their potentiality for varietal characterization.*

***Keywords*:** Characterization, distinctiveness, evaluation, germplasm, stability and uniformity

Mesta and Bimli which belong to the *Hibiscus*, family Malvaceae is the most important jute substitute fibres. Mesta is the second important bast fibre crop after jute in India. Mesta fibre obtained from the plant *Hibiscus spp* L. introduced in India from its native habitat, Sudan and cultivated in the same way as jute but thriving well in a wide range of ecological condition. Internationally this crop is known as kenaf but in India it can be grouped into two species of mesta namely roselle (*Hibiscus sabdariffa* L.) and kenaf (*Hibiscus cannabinus* L.) that are being cultivated for bast fibre production. The plant is harder than jute and can withstand drought condition and it can be grown on rockey and lateritic soil. In India the fibres of the *H. cannabinus* are known by different names in different places, e.g., it is called Mesta or kenaf in West Bengal, Bihar, Orissa, Assam and U.P., Gogu or Bimli in Andhra Pradesh and Madras, Bombay Hemp in Bombay, Deccan Hemp in Hyderabad, Channa, Ambadi, Gongkura, Sunkura, and Sunbeeja etc. whereas, *H. sabdariffa* is known as roselle, java jute, Thai jute, Pusa hemp, Tengrapat, Lalambadi, Chukair, Yerrago gu, Palechi and Pundibeeja etc. Outside India, a similar fibre, which is being grown as a serious potential, rival of jute, is known as Kenaf. Besides India the mesta is grown mainly in Argentina, China, Cuba, Egypt, Hewti, Guatamala, Italy, Iran, Indonesia, Mozambique, North Africa, New Guina, Peru, Spain, South Africa, Southern Part of Zimbabwe, Thailand, U.S.A and Russia. In India, mesta is mainly cultivated in Andhra Pradesh, Maharastra, Odisha, West Bengal, Tripura, Assam, Tamil Nadu, Karnataka (Sen and Karmakar, 2014). Of the two species, *H. cannabinus* is a stronger fibre but is more susceptible to plant diseases while *Hibiscus sabdariffa* known as Roselle is of inferior strength but it is easier to grow it and it is relatively free from plant diseases. It is generally grow in harsher environment than jute. This crop takes a longer time of retting i.e. 8 to 12 days more than required by jute. Roselle requires to some extant long duration i.e. 180-210 days for taking flowering and kenaf need 150 days for flowering. Roselle occupies around 80% of the mesta growing area. Mesta fibre is blended with jute fibre and used for making of cordage, rope, twines, hessian, sacking, geotextiles etc (Da-Costa-Rocha *et al*., 2014). In different parts of the world it is known by various vernacular names *viz*. Roselle, Sotelle, La ambadi, Patwa, Jelly okra etc (Morton, 1974). Both the species requires warm humid climate whereas *H. sabdariffa* varieties are better resistant to drought comparatively than *H. cannabinus* varieties. The plant is hermaphrodite, annual, producing large cream colored flowers. The flowers are short lived opening in the early hours of morning before sunrise and closing by noon of the same day. The color of the stem is generally green. However, some types with reddish stem are also found. Both compound and simple leaves may be found on the same plant.

India has enacted the legislation "Protection of Plant Varieties and Farmer's Rights Act (PPV & FRA) in 2001 following *sui generis* system in order to provide protection of new varieties including extant and farmer's varieties. Plant varieties seeking protection need to be registered with PPV and FR Authority, which has come

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into existence under this act and is the apex office responsible for implementation of this act. Being prerequisite for registration, the varieties have to be enrooted through DUS test. The importance of germplasm as a basic tool for crop improvement and preliminary characterization and evaluation are pre-requisites for successful utilization of plant genetic resources. Characterization of crop varieties is also required for their protection under Plant Variety Protection (PVP) legislation because varietal testing for DUS (Distinctiveness, Uniformity and Stability) is the basis for grant of protection of new varieties under Protection of Plant Varieties and Farmer's Rights Act (PPV & FRA) in 2001(PPV & FR Act, 2001). As DUS (Distinctiveness, Uniformity and Stability) test guidelines on jute varieties have been successfully established after thorough agro-morphological characterization and evaluation by taking several varieties for the protection of jute varieties (Shil *et al.,* 2011). With this background, being an allied fibre crop there is a requirement for common and standard characterization and evaluation of mesta that can protect the mesta varieties. Moreover, germplasm evaluation and characterization is very important activity before start of any crop improvement programme. Hence, present investigation has been done to develop common as well as standard agro-morphological descriptors of both the mesta species for proper germplasm evaluation and characterization by following the basis of morphological characters as prescribed in the Revised Official DUS Test Guidelines of Jute (PPV & FRA, 2008). Therefore seven varieties of kenaf (*H. cannabinus*) *viz*., HC-583, AMC-108, MT 150 (Nirmal), JBM-2004-D (Sumit), JRM-3 (Sneha), JBM-81 (Shakti) and JRM-5 (Shrestha) and ten varieties of roselle *viz*., HS-4288, HS-7910 (Ujjal), AMV-1, AMV-2, AMV-3 (Surya), AMV-4 (Kalinga), AMV-5 (Durga), Non Bristle-4 (Jaya), AMV-7(Janardhan) and GR-27 (Madhuri) have been taken to prepare an agro-morphological database along with their passport information.

## MATERIALS AND METHODS

To assess the genetic resources of this crop, a database of 17 high yielding mesta varieties of both the species was prepared. Nucleus and breeder seed was used for the data base preparation in the first year and later seed grown from the original seed was used for further study. Revised Official DUS test guidelines of Jute (PPV & FRA, 2008) were used as a source for preparation of agro-morphological descriptors and descriptors states of mesta. The experimental materials were grown in Randomized Block Design with three replications and the plot size for each genotype was 6.0 m X 1.6m. There were 4 lines of 6.0 m length in each plot. Row to row and plant to plant distances were 40 cm and 7 cm, respectively. Standard package of practices were followed to raise the crop. Net plots were harvested at 125 days of crop age. The experiments was done at Indian Council of Agricultural Research-Central Research Institute for Jute and Allied Fibres (ICAR-CRIJAF), Barrackpore, West Bengal, India during 2012-13, 2013-14 and 2014-15. A total of 37 agro-morphological traits and fibre quality characters were utilized to develop the morphological descriptors and their descriptors states. Among these 37 morphological and fibre quality characters 15 characters were quantitative and 22 characters were qualitative. The proposed descriptors and descriptor states are presented according to guidelines and definitions provided by IPGRI (2003, 2005 and 2007) and National Institute for Agrobiological Resources, Ibaraki, Japan (Nagamine and Takeda, 1999). The botanical terminology regarding plant morphology is based on Jackson (1965), Robinson and Walters (1997) and Nayar and More (1998).

## RESULTS AND DISCUSSION

To establish a standard agro-morphological characterization of both the species of mesta varieties we have studied on seven high fibre and quality yielding varieties of kenaf (*H. cannabinus*) and ten high fibre and quality yielding varieties of roselle (*H. sabdariffa*) by taking 37 agro-morphological as well as quality attributing characters. Among 37 characteristics, 15 characters *viz*., leaf lamina colour, leaf vein colour, leaf petiole colour, presence of leaf stipule and leaf stipule colour, leaf shape, leaf angle, leaf length and width, petiole length, leaf pubescence, stem colour, stem pubescence, late stem colour, stem diameter etc were vegetative in nature, 5 characters *viz*. early plant vigour, plant height, plant bristle, branching habit, number of nodes/plant etc were plant growth characters in nature, 11 characters *viz*., flower colour, time of 50% flowering with at least one open flower, flower bud pigmentation of calyx, outer corolla colour, inner corolla colour, pigmentation of calyx and epicalyx, fruit pubescence, pod dehiscence, seed shape, seed coat colour, thousand seed weight, etc were reproductive in nature, 4 characters *viz*. fibre dry weight, fibre core weight, fibre strength (g $tex^{-1}$), fibre fineness (tex) etc were quality attributing and remaining 2 such as days to maturity and biotic stress susceptibility etc were miscellaneous in nature. In India, while certain diagnostics features for mesta varieties are known and used in seed certification the descriptors by and large are incomplete. The varieties have not so far been extensively described for various heritable morphological traits to enable the identification of these

varieties and for unambiguous ascertain of distinctiveness. The accurate description and identification of mesta varieties are not only pre-requisites for production of pure foundation and certified seeds but are also crucial for DUS testing. The identity of another fibre crop like jute variety has already been established by using a set of morphological characteristics (Shil et al, 2012). These characteristics are also useful to establish distinctiveness, uniformity and stability of the new variety, based on which the variety is given protection.

Among all the characteristics few characters are monomorphic, few are dimorphic and polymorphic in nature. Qualitative morphological characters are mostly monomorphic. Observations on plant height (short, medium and tall) and time of 50% flowering (early, medium and late) were recorded and though quantitative in nature these could be grouped into distinct classes and could be useful for varietal identification and genetic purity testing. Each polymorphic plant characteristic grouped the mesta varieties into different categories based on the number of states of expressions (Table 1, 2). Stem colour was scored for green, regular red and irregular red for kenaf varieties and green, green but nodes are pigmented, red and light red for roselle varieties. These are not for different intensities of colour pigmentation, which is liable to vary due to the effect of the environment within varieties. Out of the 37 morphological characteristics studied in *H. cannabinus* (Table 1), five characters *viz*. leaf petiole colour, flower bud pigmentation of calyx, fruit pigmentation of calyx and epicalyx, seed coat colour and biotic stress susceptibility were found monomorphic in nature whereas twenty characters *viz*. leaf lamina colour, leaf vein colour, leaf stipule colour, presence of leaf stipule, leaf pubescence, stem colour, stem pubescence, late stem colour, plant bristle, flower colour, outer and inner flower corolla colour, fruit pubescence, pod dehiscence, seed shape, seed thousand weight, fibre dry weight and fibre core weight, fibre strength and days to maturity were found to be dimorphic in nature. Twelve traits *viz*. leaf shape, leaf angle, leaf length and width, leaf petiole length, stem diameter, early plant vigour, plant height, branching habit, number of nodes per plant, time of 50% flowering and fibre fineness were established as polymorphic in nature among the varieties indicating their potential for varietal characterization. The polymorphic traits in mesta varieties indicated their potentiality to classify and distinction the varieties from, other varieties and these potentialities have also been established as uniform and stable within the varieties year after year. In case of *H. sabdariffa* (Table 2), eight characters *viz*. leaf lamina colour, leaf vein colour, leaf stipule colour, plant bristle, flower bud pigmentation of calyx, fruit pigmentation of calyx and epicalyx, leaf pubescence and pod dehiscence etc were studied as monomorphic in nature. Twenty characters like leaf petiole colour, presence of leaf stipule, leaf shape, petiole length, stem colour, stem pubescence, late stem colour, branching habit, inner corolla colour, fruit pubescence, seed shape, seed coat colour, fibre dry weight and core weight, number of nodes per plant, flower colour, time of 50% flowering, fibre fineness, days to maturity and and biotic stress susceptibility were found dimorphic in nature whereas nine characters *viz*. leaf angle, leaf length and width, stem diameter, early plant vigour, plant height, seed thousand weight, outer corolla colour and fibre strength were established as polymorphic in nature.

Stem colour was scored for different intensities of colour pigmentation, which is liable to vary depending on the skill of the observer and the effect of the environment within the varieties as well as between varieties. Observations on plant height (short, medium and tall) and days to 50% flowering (early, medium and late) were recorded and though quantitative in nature these could be grouped into distinct classes and could be useful for varietal identification and genetic purity testing. It was very attractive to observed that there was no variation in the detections of three years for these characters, thus approved to be more dependable (stable) for varietal characterization of mesta.

Therefore, it was found that the qualitative characteristics of mesta were stable over years and less cumbersome to record. Hence, these are not only suitable for varietal characterization but are also reliable and reproducible for assessing the genetic purity of varieties and to establish their identity. On the basis of qualitative characteristics identity of few varieties could be established individually and remaining varieties could be classified into two or more groups.

However, jute an important fibre crop that is popularly cultivated throughout the world as an inherited fibre crop material and that's why the descriptors of several jute varieties has already been established for their germplasm evaluation and characterization as per DUS (Distinctiveness, Uniformity and Stability) test guidelines (Shil *et al.*, 2012). But, being an another secondary fibre crop that has immense economic value need to popularize worldwide and for that reason a standard descriptors for agro-morphological characters of the varieties are essential for their establishment required for varietal evaluation and germplasm characterization. This varietal descriptor of mesta were most important from the seed multiplication point of view.

**Table 1: Descriptors for characterization of *H. cannabinus* varieties**

| Descriptor numbers | Descriptor name | Descriptor alphabetic code (ABC) | Growth stage & Duration of recorded data (DAS) | Descriptor state | Descriptor numeric code |
|---|---|---|---|---|---|
| **1. Vegetative characteristics** | | | | | |
| 1.1 | Leaf | | | | |
| 1.1.1 | Lamina color | LF-CLR | 60 DAS at full foliage stage | Green | 1 |
| 1.1 | | | | Red | 2 |
| 1.1.2 | Vein color | LF-V-CLR | 60 DAS at full foliage stage | Green | 1 |
| 1.1 | | | | Red | 2 |
| 1.1.3 | Petiole color | PETL-CLR | 60 DAS at full foliage stage | Green | 1 |
| 1.1 | | | | Red | 2 |
| 1.1.4 | Stipule | STIP | 60 DAS at full foliage stage | Exstipulate (Absent) | 0 |
| 1.1 | | | | Stipulate (Present) | 1 |
| 1.1.5 | Stipule color | STIP-CLR | 60 DAS at full foliage stage | Green | 1 |
| 1.1 | | | | Red | 2 |
| 1.1.6 | Shape | LF-SHP | First bud stage i.e. appearance of first visible flower bud on main stem | Unlobed | 1 |
| 1.1 | | | | Entire | 2 |
| 1.1 | | | | Entire cordate | 3 |
| 1.1 | | | | Palmate deeply lobed | 4 |
| 1.1.7 | Angle | LF-ANG | The angle between the stem and the line connecting the base and the center of midrib of the leaf (6$^{th}$ leaf from top of main stem) in degrees at pre-bud stage (average of 10 leaves) | Erect (0-20) | 1 |
| 1.1 | | | | 21-40$^{o}$ | 2 |
| 1.1 | | | | Intermediate (41-60$^{o}$) | 3 |
| 1.1 | | | | Semi-erect (61-80$^{o}$) | 4 |
| 1.1 | | | | Horizontal (81-100$^{o}$) | 5 |
| 1.1 | | | | 101-120Ú | 6 |
| 1.1 | | | | Descending (121-140$^{o}$) | 7 |
| 1.1 | | | | 141-160$^{o}$ | 8 |
| 1.1 | | | | Drooping (161-180$^{o}$) | 9 |
| 1.1.8 | Length (cm) | LF-LT | Maximum length at pre-bud stage (average of 5 leaves starting from the 6$^{th}$ leaf from top of main stem) | Quantitative | |

*Contd...*

*Table 1 Contd.*

| Descriptor numbers | Descriptor name | Descriptor alphabetic code | Growth stage & Duration of recorded data (DAS) | Descriptor state | Descriptor numeric code |
|---|---|---|---|---|---|
| 1.1.9 | Width (cm) | LF-WD | Maximum length at pre-bud stage (average of 5 leaves starting from the 6th leaf from top of main stem) | Quantitative | |
| 1.1.10 | Petiole length (cm) | PETL-LT | Pre-bud stage (average of 5 leaves used for measuring leaf angle) | Quantitative | |
| 1.1.11 | Pubescence | LF-PUB | As presence of princkles and hairs on upper and lower surface of leaf at first bud stage | Absent | 0 |
| 1.1 | | | | Present | 1 |
| 1.2 | Stem | | | | |
| 1.2.1 | Color | STM-CLR | 60 DAS (visual interpretation of color of whole stem at full vegetative expression) | Green | 1 |
| 1.2 | | | | Regular red | 2 |
| 1.2 | | | | Irregular red | 3 |
| 1.2.2 | Pubescence | STM-PUB | On stem surface at pre-bud stage (after the development of the first flower bud) | Smooth | 1 |
| 1.2 | | | | Hairy | 2 |
| 1.2 | | | | Prickly | 3 |
| 1.2.3 | Late stem color | STM-CLRL | At early fruiting stage before capsule turn brown | Green | 1 |
| 1.2 | | | | Red | 2 |
| 1.2.4 | Diameter (mm) | STM-DM | At midpoint between base to top (at harvesting stage) | Quantitative | |
| **2. Plant growth characteristics** | | | | | |
| 2.1 | Early plant vigour | PLT-VGR | After 25 DAS | Poor | 1 |
| 2.1 | | | | Good | 2 |
| 2.1 | | | | Very good | 3 |
| 2.2 | Plant height (cm) | PLT-HGT | As total plant height from base to top including all flowering nodes at harvesting stage i.e. 140 DAS | Short (<200cm) | 3 |
| 2.2 | | | | Medium (200-300cm) | 5 |
| 2.2 | | | | Tall (>300cm) | 7 |

*Contd...*

*Table 1 Contd.*

| Descriptor numbers | Descriptor name | Descriptor alphabetic code | Growth stage & Duration of recorded data (DAS) | Descriptor state | Descriptor numeric code |
|---|---|---|---|---|---|
| 2.3 | Plant bristle | PLT-BRIST | At 140-150 days after sowing | Absent | 0 |
| 2.3 | | | | Present | 1 |
| 2.4 | Branching habit | BRN-HAB | At pre-bud stage, based on relative development of auxiliary buds buds on main stem | Non-branching | 0 |
| 2.4 | | | | Very weak | 1 |
| 2.4 | | | | Weak | 3 |
| 2.4 | | | | Intermediate | 5 |
| 2.4 | | | | Strong | 7 |
| 2.4 | | | | Very strong | 9 |
| 2.5 | Number of nodes/ plant | NOD-PLT | As total number of nodes on main stem from soil surface to top including flowering nodes at harvesting stage | Low (<60) | 1 |
| 2.5 | | | | Medium (60-80) | 3 |
| 2.5 | | | | High (>80) | 5 |
| **3. Reproductive characteristics** | | | | | |
| 3.1 | Flower | | | | |
| 3.1.1 | Color | FLW-CLR | On appearance of first flower initiation | Yellow | 1 |
| | | | | Lemon yellow | 2 |
| 3.1.1 | Time of 50% flowering with at least one open flower | TM-FLW | As number of days from sowing to 50% of the plant in a row flowered | Early (120 days) | 1 |
| 3.1 | | | | Medium (120-140 days) | 3 |
| 3.1 | | | | Late (140-180 days) | 5 |
| 3.1.2 | Bud:Pigmentation of calyx | CALX-CLR | On appearance of buds on all 10 plants | Green | 1 |
| 3.1 | | | | Red | 2 |
| 3.1.3 | Corolla color (Outer) | OT-COR-CLR | As soon as possible after full opening of flower at mid-flowering stage | Yellow | 1 |
| 3.1 | | | | Purple | 2 |
| 3.1 | | | | Pink | 3 |
| 3.1 | | | | | |
| 3.1.4 | Corolla color (Inner) | IN-COR-CLR | After full flowering stage | Yellow | 1 |

*Contd…*

*Table 1 Contd.*

| Descriptor numbers | Descriptor name | Descriptor alphabetic code | Growth stage & Duration of recorded data (DAS) | Descriptor state | Descriptor numeric code |
|---|---|---|---|---|---|
| 3.1 | | | | Pink | 2 |
| 3.1 | | | | Purple | 3 |
| 3.2 | Fruit | | | | |
| 3.2.1 | Pigmentation (calyx and epicalyx) | FR-PIG | At early fruiting stage before capsule bearing | Green | 1 |
| 3.2 | | | | Red | 2 |
| 3.2.2 | Pubescence | FR-PUB | As presence and type of pubescence on surface of capsule at harvesting stage | Smooth | 1 |
| 3.2 | | | | Hairy | 2 |
| 3.2 | | | | Bristled | 3 |
| 3.3 | Pod | | | | |
| 3.3.1 | Dehiscence | PD-DEH | At near maturity stage | Absent | 0 |
| 3.3 | | | | Present | 1 |
| 3.4 | Seed | | | | |
| 3.4.1 | Shape | SED-SHP | After harvesting, threshing and cleaning of seed | Reniform | 1 |
| 3.4 | | | | Sub-reniform | 2 |
| 3.4 | | | | Angular | 3 |
| 3.4.2 | Coat color | SED-CLR | After harvesting, threshing and cleaning of seed | Brown | 1 |
| 3.4 | | | | Grey | 2 |
| 3.4.3 | Thousand weight (g) | TH-SED-WT | After harvesting, threshing, cleaning and drying of seed to 10% moisture content | Quantitative | |
| **4. Quality attributing characteristics** | | | | | |
| 4.1 | Fibre | | | | |
| 4.1.1 | Dry weight | FIB-DWT | After defoliation, retting, fibre extraction and drying of fibre (average of 5 random plants) | Quantitative | |
| 4.1.2 | Core weight | COR-WT | After defoliation, retting, fibre extraction and drying of fibre (average of 5 random plants) | Quantitative | |

*Contd...*

*Table 1 Contd.*

| Descriptor numbers | Descriptor name | Descriptor alphabetic code | Growth stage & Duration of recorded data (DAS) | Descriptor state | Descriptor numeric code |
|---|---|---|---|---|---|
| 4.1.3 | Strength (g/tex) | FIB-STR | After fibre extraction and drying of fibre (average of 5 random plants); cleaning and combing of individual plants sample and cutting into 12.5 cm length and weighing each sample into 250-350mg. | Very good ( e" 29 g/tex) | 1 |
| | | | | Good (25-28.9 g/tex) | 2 |
| | | | | Fairly good (21-24.9 g/tex) | 3 |
| | | | | Average ( 17-20.9 g/tex) | 5 |
| | | | | Average and weak (<17 g/tex) | 7 |
| 4.1.4 | Fineness (tex) | FIB-FIN | After fibre extraction and drying of fibre (average of 5 random plants); cleaning and combing of individual plants sample and cutting into 10.5 cm length and weighing each sample into 300mg exactly. | Very fine ( d" 3.5 tex) | 1 |
| | | | | Fine ( 3.4-4.2 tex) | 2 |
| | | | | Average and coarse (>4.2 tex) | 4 |
| 5. Miscellaneous characteristics: | | | | | |
| 5.1 | Days to maturity | HARV-DUR | As number of days from sowing to harvest | Quantitative | |
| 5.2 | Biotic stress susceptibility | BSS | Specify the infestation or infection | Very low or no visible sign of susceptibility | 1 |
| 5.2 | | | | Low | 3 |
| 5.2 | | | | Intermediate | 5 |
| 5.2 | | | | Very high | 9 |

**Table 2: Descriptors for characterization of *H. sabdariffa* varieties**

| Descriptor numbers | Descriptor name | Descriptor alphabetic code | Growth stage & Duration of recorded data (DAS) | Descriptor state | Descriptor numeric code |
|---|---|---|---|---|---|
| **1. Vegetative characteristics** | | | | | |
| 1.1 | Leaf | | | | |
| 1.1.1 | Lamina color | LF-CLR | 60 DAS at full foliage stage | Green | 1 |
| 1.1 | | | | Red | 2 |
| 1.1.2 | Vein color | LF-V-CLR | 60 DAS at full foliage stage | Green | 1 |
| 1.1 | | | | Red | 2 |
| 1.1.3 | Petiole color | PETL-CLR | 60 DAS at full foliage stage | Green | 1 |
| 1.1 | | | | Red | 2 |
| 1.1.4 | Stipule | STIP | As presence or absence of leaf stipule after 60 DAS at full foliage stage | Exstipulate (Absent) | 0 |
| 1.1 | | | | Stipulate (Present) | 1 |
| 1.1.5 | Stipule color | STIP-CLR | 60 DAS at full foliage stage | Green | 1 |
| 1.1 | | | | Red | 2 |
| 1.1.6 | Shape | LF-SHP | First bud stage i.e. appearance of first visible flower bud on main stem | Unlobed | 1 |
| 1.1 | | | | Partially lobed | 2 |
| 1.1 | | | | Palmate deeply lobed into three | 3 |
| 1.1 | | | | Palmate deeply lobed into five | 4 |
| 1.1.7 | Angle | LF-ANG | The angle between the stem and the line connecting the base and the center of midrib of the leaf (6$^{th}$ leaf from top of main stem) in degrees at pre-bud stage (average of 10 leaves) | Erect (0-20) | 1 |
| 1.1 | | | | 21-40$^{o}$ | 2 |
| 1.1 | | | | Intermediate (41-60$^{o}$) | 3 |
| 1.1 | | | | Semi-erect (61-80$^{o}$) | 4 |
| 1.1 | | | | Horizontal (81-100$^{o}$) | 5 |
| 1.1 | | | | 101-120Ú | 6 |
| 1.1 | | | | Descending (121-140$^{o}$) | 7 |
| 1.1 | | | | 141-160$^{o}$ | 8 |
| 1.1 | | | | Drooping (161-180$^{o}$) | 9 |
| 1.1.8 | Length (cm) | LF-LT | Maximum length at pre-bud stage (average of 5 leaves starting from the 6$^{th}$ leaf from top of main stem) | Quantitative | |

*Contd...*

*Table 2 Contd.*

| Descriptor numbers | Descriptor name | Descriptor alphabetic code | Growth stage & Duration of recorded data (DAS) | Descriptor state | Descriptor numeric code |
|---|---|---|---|---|---|
| 1.1.9 | Width (cm) | LF-WD | Maximum length at pre-bud stage (average of 5 leaves starting from the 6th leaf from top of main stem) | Quantitative | |
| 1.1.10 | Petiole length (cm) | PETL-LT | Pre-bud stage (average of 5 leaves used for measuring leaf angle) | Quantitative | |
| 1.1.11 | Pubescence | LF-PUB | As presence of princkles and hairs on upper and lower surface of leaf at first bud stage | Absent | 0 |
| 1.1 | | | | Present | 1 |
| 1.2 | Stem | | | | |
| 1.2.1 | Color | STM-CLR | 60 DAS (visual interpretation of color of whole stem at full vegetative expression) | Green | 1 |
| 1.2 | | | | Green but nodes are pigmented | 2 |
| 1.2 | | | | Red | 3 |
| 1.2 | | | | Light red | 4 |
| 1.2.2 | Pubescence | STM-PUB | On stem surface at pre-bud stage (after the development of the first flower bud) | Smooth | 1 |
| 1.2 | | | | Hairy | 2 |
| 1.2 | | | | Prickly | 3 |
| 1.2.3 | Late stem color | STM-CLRL | At early fruiting stage before capsule turn brown | Green | 1 |
| 1.2 | | | | Red | 2 |
| 1.2.4 | Diameter (mm) | STM-DM | At midpoint between base to top (at harvesting stage) | Quantitative | |
| **2. Plant growth characteristics** | | | | | |
| 2.1 | Early plant vigour | PLT-VGR | After 25 DAS | Poor | 1 |
| 2.1 | | | | Good | 2 |
| 2.1 | | | | Very good | 3 |
| 2.2 | Plant height (cm) | PLT-HGT | As total plant height from base to top including all flowering nodes at harvesting stage i.e. 140 DAS | Short (<200cm) | 3 |

*Contd…*

*Table 2 Contd.*

| Descriptor numbers | Descriptor name | Descriptor alphabetic code | Growth stage & Duration of recorded data (DAS) | Descriptor state | Descriptor numeric code |
|---|---|---|---|---|---|
| 2.2 | | | | Medium (200-300cm) | 5 |
| 2.2 | | | | Tall (>300cm) | 7 |
| 2.3 | Plant bristle | PLT-BRIST | At 140-150 Days after sowing | Absent | 0 |
| 2.3 | | | | Present | 1 |
| 2.4 | Branching habit | BRN-HAB | At pre-bud stage, based on relative development of auxiliary buds buds on main stem | Non-branching | 0 |
| 2.4 | | | | Very weak | 1 |
| 2.4 | | | | Weak | 3 |
| 2.4 | | | | Intermediate | 5 |
| 2.4 | | | | Strong | 7 |
| 2.4 | | | | Very strong | 9 |
| 2.5 | Number of nodes/ plant | NOD-PLT | As total number of nodes on main stem from soil surface to top including flowering nodes at harvesting stage | Low (<60) | 1 |
| | | | | Medium (60-80) | 3 |
| | | | | High(>80) | 5 |
| **3. Reproductive characteristics** | | | | | |
| 3.1 | Flower | | | | |
| 3.1.1 | Colour | FLW-CLR | On appearance of first flower initiation | Yellow | 1 |
| 3.1 | | | | Sulfur yellow | 2 |
| 3.1.2 | Time of 50% flowering with at least one open flower | TM-FLW | As number of days from sowing to 50% of the plant in a row flowered | Early (120 days) | 1 |
| 3.1 | | | | Medium (120-140 days) | 3 |
| 3.1 | | | | Late (140-180 days) | 5 |
| 3.1.3 | Bud:Pigmentation of calyx | CALX-CLR | On appearance of buds on all 10 plants | Green | 1 |
| 3.1 | | | | Red | 2 |
| 3.1.4 | Corolla color (Outer) | OT-COR-CLR | As soon as possible after full opening of flower at mid-flowering stage | Yellow | 1 |

*Contd…*

*Table 2 Contd.*

| Descriptor numbers | Descriptor name | Descriptor alphabetic code | Growth stage & Duration of recorded data (DAS) | Descriptor state | Descriptor numeric code |
|---|---|---|---|---|---|
| 3.1 | | | | Purple | 2 |
| 3.1 | | | | Pink | 3 |
| 3.1 | | | | | |
| 3.1.5 | Corolla color (Inner) | IN-COR-CLR | After full flowering stage | Yellow | 1 |
| 3.1 | | | | Pink | 2 |
| 3.1 | | | | Purple | 3 |
| 3.2 | Fruit | | | | |
| 3.2.1 | Pigmentation (calyx and epicalyx) | FR-PIG | At early fruiting stage before capsule bearing | Green | 1 |
| 3.2 | | | | Red | 2 |
| 3.2.2 | Pubescence | FR-PUB | As presence and type of pubescence on surface of capsule at harvesting stage | Smooth | 1 |
| 3.2 | | | | Hairy | 2 |
| 3.2 | | | | Bristled | 3 |
| 3.3 | Pod | | | | |
| 3.3.1 | Dehiscence | PD-DEH | At near maturity stage | Absent | 0 |
| 3.3 | | | | Present | 1 |
| 3.4 | Seed | | | | |
| 3.4.1 | Shape | SED-SHP | After harvesting, threshing and cleaning of seed | Reniform | 1 |
| 3.4 | | | | Sub-reniform | 2 |
| 3.4 | | | | Angular | 3 |
| 3.4.2 | Coat color | SED-CLR | After harvesting, threshing and cleaning of seed | Brown | 1 |
| 3.4 | | | | Grey | 2 |
| 3.4.3 | Thousand weight (g) | TH-SED-WT | After harvesting, threshing, cleaning and drying of seed to 10% moisture content | Quantitative | |
| **4. Quality attributing characteristics:** | | | | | |
| 4.1 | Fibre | | | | |
| 4.1.1 | Dry weight | FIB-DWT | After defoliation, retting, fibre extraction and drying of fibre (average of 5 random plants) | Quantitative | |

*Contd...*

*Table 2 Contd.*

| Descriptor numbers | Descriptor name | Descriptor alphabetic code | Growth stage & Duration of recorded data (DAS) | Descriptor state | Descriptor numeric code |
|---|---|---|---|---|---|
| 4.1.2 | Core weight | COR-WT | After defoliation, retting, fibre extraction and drying of fibre (average of 5 random plants) | Quantitative | |
| 4.1.3 | Strength (g/tex) | FIB-STR | After fibre extraction and drying of fibre (average of 5 random plants); cleaning and combing of individual plants sample and cutting into 12.5 cm length and weighing each sample each sample into 250-350mg. | Very good ( e” 29 g/tex) | 1 |
| | | | | Good (25-28.9 g/tex) | 2 |
| | | | | Fairly good (21-24.9 g/tex) | 3 |
| | | | | Average ( 17-20.9 g/tex) | 5 |
| | | | | Average and weak (<17 g/tex) | 7 |
| 4.1.4 | Fineness (tex) | FIB-FIN | After fibre extraction and drying of fibre (average of 5 random plants); cleaning and combing of individual plants sample and cutting into 12.5 cm length and weighing each sample into 300mg exactly. | Very fine ( d” 3.5 tex) | 1 |
| | | | | Fine ( 3.4-4.2 tex) | 2 |
| | | | | Average and coarse (>4.2 tex) | 4 |
| **5. Miscellaneous characteristics** | | | | | |
| 5.1 | Days to maturity | HARV-DUR | As number of days from sowing to harvest | Quantitative | |
| 5.2 | Biotic stress susceptibility | | BSS | Specify the infestation or infection | Very low or no visible sign of susceptibility 1 |
| 5.2 | | | | Low | 3 |
| 5.2 | | | | Intermediate | 5 |
| 5.2 | | | | Very high | 9 |

**Table 3: Various salient passport information and notified distinct traits of kenaf (*H. cannabinus*) varieties**

| Sl. No. | Name of the variety | Releasing state | Year of notification | Yield (q ha$^{-1}$) | Distinguished characters notified |
|---|---|---|---|---|---|
| 1 | HC-583 | West Bengal | 1963 | 25 | Most popular variety, tolerant to root rot disease |
| 2 | AMC-108 | Andhra Pradesh | 1982 | 20-25 | Resistant to foot and stem rot diseases, tolerant to jassids and spiral borer |
| 3 | MT-150 (Nirmal) | West Bengal | 2005 | 30 | Superior paper pulp quality for newsprint |
| 4 | JBM-2004-D (Sumit) | West Bengal | 2009 | 27 | Resistant to foot and stem rot and tolerant to spiral borer Mealy bug and good fibre quality and strength |
| 5 | JRM-3 (Sneha) | West Bengal | 2010 | 25-38 | Resistant to foot and stem rot and good fibre quality and strength |
| 6 | JRM-5 (Shrestha) | West Bengal | 2010 | 25-28 | Tolerant to jassids and spiral borer and good fibre quality and strength |
| 7 | JBM-81 (Shakti) | West Bengal | 2010 | 25-30 | Resistant to foot and stem rot and tolerant to spiral borer Mealy bug and good fibre quality and strength |

**Table 4: Various salient passport information and notified distinct traits of roselle varieties**

| Sl. No. | Name of the variety | Releasing state | Year of notification | Yield (q ha$^{-1}$) | Distinguished characters notified |
|---|---|---|---|---|---|
| 1 | HS-4288 | West Bengal | 1967 | 25-30 | Stem has bristles, tolerant to major pests and diseases |
| 2 | HS-7910 (Ujjal) | West Bengal | 1977 | 20-30 | Stem has less bristles, resistant to major pests and tolerant to *Phytopthora parasitica* |
| 3 | AMV-1 | Andhra Pradesh | 1966 | 20 | Stem has less bristles, highly susceptible to pests and diseases |
| 4 | AMV-2 | Andhra Pradesh | 1982 | 20 | Stem has less bristles, highly susceptible to pests and diseases |
| 5 | AMV-3 (Surya) | Andhra Pradesh | 1989 | 20 | Stem has less bristles, resistant to foot and stem rot diseases |
| 6 | AMV-4 (Kalinga) | Andhra Pradesh | 1991 | 20 | Stem has less bristles, moderately resistant to jassids and foot and stem rot diseases |
| 7 | AMV-5 (Durga) | Andhra Pradesh | 2006 | 25 | Good fibre quality, higher fibre yield, tolerant to pests and diseases under field conditions |
| 8 | GR-27 (Madhuri) | West Bengal | 2007 | 27-30 | Stem green with red patches only in nodes, tolerant to pests and diseases |
| 9 | Non-Bristle-4 (Jaya) | West Bengal | 2006 | 20-25 | Stem has no or less bristles, moderately resistant to jassids and foot and stem rot diseases |
| 10 | AMV-7 (Janardhan) | Andhra Pradesh | 2010 | 22-25 | Good fibre quality, higher fibre yield, tolerant to pests and diseases under field conditions |

Conclusion may be drawn from the observations made on 37 morphological characteristics, characterization and identity of all the varieties in kenaf (*H. sabdariffa*) and roselle (*H. sabdariffa*) could be established for Germplasm evaluation and characterization. But truly speaking that morphological character alone may not suffice for the DUS (Distinctiveness, Uniformity and Stability) criteria as identification of all mesta varieties. Hence, a massive collaboration through biochemical and molecular characters need to be explored for the delineation of mesta varieties for varietal protection.

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