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Usefulness of morphological characteristics for DUS testing of jute (*Corchorus olitorius* L. and *C. capsularis* L.)

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Abstract

Thirty two jute (*Corchorus olitorius* and *C. capsularis*) varieties, including 25 released/notified and seven of common knowledge, were characterized through distinctness, uniformity and stability (DUS) testing trials for two consecutive years using 17 heritable morphological traits prescribed in the Revised Official DUS Test Guidelines of Jute to enable identification of these varieties and for unambiguous ascertainment of distinctness. Out of 17 traits, 8 were found to be monomorphic, 7 dimorphic and only 2 polymorphic in *C. capsularis*, while 8 traits were dimorphic and 9 polymorphic among *C. olitorius* varieties, indicating their potential for varietal characterization. On the basis of this study no single character could identify all the varieties individually; however, when used in combination, identity and distinctness of almost all the *C. olitorius* varieties and 10 varieties of *C. capsularis* (Padma, JRC-212, Bidhan Pat-2, D-154, KTC-1, KC-1, JRC-80, Bidhan Pat-3, JRC-7447 and JRC-698) could be established individually. The remaining varieties of *C. capsularis* could be classified into two groups: early flowering group (JRC-321, UPC-94) and fine fibre group (JRC-4444, Bidhan Pat-1). Hence, morphological characters alone may not suffice for DUS testing of *C. capsularis* varieties. All the varieties of both species released in India so far albeit professed their uniformity and stability through morphological characterization, but use of biochemical and/or molecular markers along with search for other morphological traits need to be explored for the delineation of *C. capsularis* varieties.

Additional key words: distinctness; stability; uniformity; variety characterization.

Resumen

Utilidad de las características morfológicas de yute (*Corchorus olitorius* L. y *C. capsularis* L.) para el examen DHE (distinción, homogeneidad y estabilidad)

Se caracterizaron durante dos años consecutivos 32 variedades de yute (*Corchorus olitorius* y *C. capsularis*), 25 difundidas o notificadas y siete de conocimiento común (testigo), mediante ensayos para la distinción, homogeneidad y estabilidad (DHE), utilizando 17 caracteres morfológicos hereditarios descritos en la versión revisada de la Guía Oficial del examen DHE de yute para identificar y distinguir inequívocamente estas variedades. De los 17 caracteres, 8 resultaron ser monomórficos, 7 dimorfos y 2 polimórficos en *C. capsularis,* mientras que 8 fueron dimórficos y 9 polimórficos en *C. olitorius,* lo que indica su potencial para la caracterización de variedades. Según este estudio, un solo carácter no pudo identificar todas las variedades por separado, sin embargo, cuando se usan en combinación, casi todas las variedades de *C. olitorius* y 10 variedades de *C. capsularis* (Padma, JRC-212, Bidhan Pat-2, D-154, KTC-1, KC-1, JRC-80, Bidhan Pat-3, JRC-7447 y JRC-698) pudieron distinguirse de forma individual. Las demás variedades de *C. capsularis* pudieron clasificarse en dos grupos: de floración temprana (JRC-321, UPC-94) y el de fibra fina (JRC-4444, Bidhan Pat-1). Por tanto, los caracteres morfológicos por sí solos pueden no ser suficientes para el examen DHE de variedades de *C. capsularis*. Aunque mediante caracterización morfológica todas las variedades de ambas especies difundidas en la India hasta el momento profesan una uniformidad y estabilidad, para la caracterización de variedades de *C. capsularis* deben explorarse el uso de marcadores bioquímicos y/o moleculares, junto con la búsqueda de otras características morfológicas.

Palabras clave adicionales: caracterización de variedades; distinción; estabilidad; uniformidad.

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Abbreviation used: DUS (distinctness, uniformity and stability), PBR (plant breeders' rights), PVP (plant variety protection).

Introduction

Cultivars are defined by the International Convention for the Protection of New Varieties of Plants (UPOV, 1991). For characterization, differentiation and protection of varieties specific descriptors are used in each species. A descriptor is a characteristic that refers to the form, structure or behaviour of an accession in a germplasm collection. Descriptors must satisfy with three technical requisites of distinctness (D), uniformity (U) and stability (S) (UPOV, 2002). Distinctness is the capability of a descriptor that demonstrates clear differences in inter-varietal variation. Uniformity is the intra-varietal homogeneity, and stability is the absence of temporal or spatial variation. DUS testing of cultivars is one of the requirements for granting Plant Breeders' Rights (PBR) and it is conducted according to the national guidelines prepared on the basis of UPOV guidelines. Plant morphological characters have been recognized to constitute universally undisputed descriptors for DUS testing and varietal characterization of crop species. Use of morphological descriptors in sequential fashion is useful and convenient to distinguish different varieties.

The best way of determining whether descriptors comply with the above mentioned prerequisites is by evaluation of characteristics in field trials in which various varieties are grown under identical conditions. The analysis of descriptive variables by flow chart will determine the validity of the descriptors for discriminating the varieties under study.

The "Protection of Plant Varieties and Farmers' Rights Act, 2001" (PPV&FR Act, 2001) of India provides the opportunities for registration of new/extant varieties of agricultural crops including jute (*Corchorus olitorius* L. and *C. capsularis* L.) if it conforms to the criteria of DUS. The Revised Official DUS Test Guidelines of Jute have been published by Protection of Plant Varieties and Farmers' Rights Authority (PPV&FR Authority) of India in 2008. The test guidelines make use of 17 simply observable and stable morphological characters of stem, leaf, flower, fruit and seed to distinguish jute varieties from one another.

In India 25 jute varieties have been released since 1966 and their number is expected to increase in future. Both the species of jute (*Corchorus olitorius* L. and *C. capsularis* L.) are predominantly self-pollinated crops. Cross-pollination of *C. olitorius* is 6.1-12.87% and that of *C. capsularis* is 8.9% (Ghose and Dasgupta, 1945). Jute varieties attain acceptance when the farmers get genetically pure seeds of high standards as well as for their fibre yield performance. For this purpose, each jute variety should be properly defined with suitable descriptors so as to maintain its identity during seed production through field inspection and certification. It is to be mentioned here that 9 m isolation distance should be maintained for *C. olitorius* (Datta *et al*., 1982), while it is 6 m in case of *C. capsularis* (Maiti *et al*., 1983). Apart from this, characterization of jute varieties is also required for their protection under Plant Variety Protection (PVP) legislation, because varietal testing for DUS is the basis for grant of protection of new plant varieties under PPV&FR Act, 2001. The Act has the provision to compare the novel candidate variety with the varieties of common knowledge on a set of relevant characteristics prescribed in the Revised Official DUS Test Guidelines of Jute (PPV&FR Authority, 2008) and commonly accepted for this purpose at the time of filling of application.

Since jute has been domesticated only around 200 years ago and many mutants have not yet been accumulated in jute population due to lack of human selection pressure for longer time (Mukherjee and Kumar, 2002), qualitative morphological characters of jute are mostly monomorphic and few are dimorphic and polymorphic. In India, while certain diagnostic features for released or notified jute varieties are known and used in seed certification (Kumar *et al*., 2005) the descriptors by and large are incomplete. The jute varieties have not so far been extensively described for various heritable morphological traits to enable the identification of these varieties and for unambiguous ascertainment of distinctness.

In the present study the extant and common knowledge varieties of both species of jute in India were evaluated for establishing the usefulness of 17 morphological characteristics as descriptors for carrying out the DUS test in jute varieties.

Material and methods

A total of 25 varieties of both species (*Corchorus olitorius* L. and *C. capsularis* L.) of jute released or notified in India and 7 varieties of common knowledge were studied for 17 morphological characters. These characters are: premature flowering resistance, leaf lamina colour, leaf vein colour, leaf petiole colour, stipule colour, stem colour, leaf shape, plant height, fibre fineness, fibre strength, pigmentation of calyx, time

of 50% flowering, basal stem root primordia, pod pigmentation, pod dehiscence, seed size and seed colour with different character states as per the Revised Official DUS Test Guidelines of Jute (PPV&FR Authority, 2008).

Nine of the varieties were developed by pureline selection (JRO-632, JRO-620, Chinsurah Green, JRO-36E, JRO-2345, JRC-212, JRC-321, KTC-1 and D-154), 16 by hybridization (JRO-3690, TJ-40, JRO-66, JRO-524, JRO-7835, JRO-878, JRO-8432, JRO-128, S-19, Padma, JRC-4444, UPC-94, JRC-698, Bidhan Pat-2, Bidhan Pat-3 and JRC-80), five by mutation breeding (KOM-62, Bidhan Rupali, JRC-7447, Bidhan Pat-1 and KC-1), and two varieties (Sudan Green and Tanganyika-1) were direct introductions (Table 1).

Nucleus or breeder seed of each variety derived from the germplasm pool of Central Research Institute for Jute and Allied Fibres, Barrackpore, West Bengal, India was taken for the study. The DUS testing trials were conducted for two years during rainy season of 2006-07 and 2007-08 at two designated DUS testing centers of jute, viz. Central Research Institute for Jute and Allied Fibres (CRIJAF), Barrackpore, West Bengal, India (latitude and longitude of 22° 45' N and 88° 26' E, respectively) and Central Seed Research Station for Jute and Allied Fibres (CSRSJAF), Budbud, Burdwan, West Bengal, India (latitude and longitude of 22° 30' N and 88° 26' E, respectively) in randomized complete block design with three replications. Each replication consisted of four rows of 6 m length with 40 cm row to row and 7 cm plant to plant spacing.

The observations were recorded on 10 randomly selected plants in each replication at specified stages of crop growth period when the characters under study had full expression. Premature flowering resistance was observed after 35 days of sowing. Number of off types was recorded in each plot of each variety at both the locations in each year. A total number of 847 to 984 plants were maintained in each plot measuring 57 m^2 (19 m × 3 m) area. Five characters (leaf lamina colour, leaf vein colour, leaf petiole colour, stipule colour and stem colour) were observed at fully expanded foliage after 60 days of sowing. Two characters (leaf shape and plant height) were observed at pre-bud stage before development of first flower. Two fibre quality characters (fibre fineness and fibre strength) were observed after harvesting, retting and drying of fibre. Fibre fineness is the diameter of the filament expressed in tex, while fibre strength (unit is g/tex) is calculated as the breaking load of the fibre sample divided by the linear density of the unstrained fibre which is referred to as its tenacity. This trait was measured from the replicated samples by airflow method which is broadly followed everywhere for assessing fibre fineness in natural fibres. On the contrary, fibre strength was determined by fibre bundle strength tester which gives an average value of fibre strength of different fibre samples. The detail procedure for measurement of these two characters has been discussed in the Revised Official DUS Test Guidelines of Jute (PPV&FR Authority, 2008). Pigmentation of calyx was observed at the time of appearance of flower buds. The character time of 50% flowering was noted when 50% of the plants had at least one open flower. This trait envisages the resistance to premature flowering. If a jute variety sown before middle of April does not flower prematurely in seedling stage and flowers at least after 100 days, the variety is known as premature flowering resistant variety. The presence or absence of basal stem root primordia was noted at half-way stage of flower opening. Pod pigmentation and pod dehiscence were observed at early fruiting stage and near pod maturity, respectively. Lastly, seed characters like seed size and seed colour (visual observation) were observed at harvest. Attempts had been made through flow chart (Figs. 1 and 2) to establish distinctness of the dummy candidate variety from all other varieties and also among extant varieties of both species separately.

Results

In the present study, 17 morphological characteristics listed in the Revised Official DUS Test Guidelines of Jute (PPV&FR Authority, 2008), the most important from the seed production point of view, were explored for varietal distinctness of jute. Out of 17 morphological characteristics studied, in *C. capsularis* 8 traits (premature flowering resistance, leaf lamina colour, leaf vein colour, stipule colour, leaf shape, basal stem root primordia, pod dehiscence and seed colour) were found to be monomorphic, 7 traits (leaf petiole colour, stem colour, plant height, pigmentation of calyx, time of 50% flowering, pod pigmentation and seed size) were dimorphic and only 2 traits (fibre fineness and fibre strength) were polymorphic. In *C. olitorius* no trait was monomorphic, 8 traits (premature flowering resistance, leaf lamina colour, leaf shape, pigmentation of calyx, time of 50% flowering, basal stem root primordia, pod dehiscence and seed size) were dimorphic

Table 1. Qualitative characterization of released and common knowledge jute varieties based on morphological characters included in Official DUS Test Guidelines

Variety	Pedigree	PFR	LLC	LVC	LPC	SC	StC	LS	PC	BSRP	PP	PD	SdC
C. olitorius: Notified varieties													
JRO-632	Pureline selection from an indigenous germplasm	1	2	2	2	2	2	2	2	1	2	9	3
JRO-3690	Selection from tobacco leaf×long internode	1	2	2	2	2	2	2	2	1	2	9	3
KOM-62	JRO-878 treated with 40 Kr gamma ray	1	2	2	3	3	3	2	2	1	3	9	3
TJ-40	Selection from a cross between mutants of JRO-632	1	2	2	2	2	2	2	2	1	2	9	1
JRO-66	Selection from a multiple cross	1	2	2	2	2	2	2	2	1	2	1	3
JRO-524	Selection from Sudan Green×JRO-632	9	2	2	2	2	2	2	2	1	2	1	4
JRO-7835	Selection from JRO-632×Sudan Green	9	2	2	2	2	2	2	2	9	2	1	4
JRO-878	Selection from JRO-620×Sudan Green	9	2	3	3	3	3	2	2	1	3	1	4
JRO-8432	Selection from IC-15901×Tanganyika-1	9	2	2	2	2	2	2	2	1	2	1	4
JRO-128	Selection from TJ-40×Tanganyika-1	9	2	2	2	2	2	2	2	1	2	1	4
S-19	Selection from (JRO-620×Sudan Green)×Tanganyika-1	9	2	3	3	3	4	2	2	1	3	1	3
Bidhan Rupali	X-ray induced mutant of JRO-632	1	1	1	1	1	1	2	1	1	1	9	3
C. olitorius: Varieties of common knowledge													
JRO-620	Selection from local type	1	2	3	3	3	3	3	2	1	3	9	3
Chinsurah Green	Selection from a local strain in Chinsurah	1	2	2	2	2	2	2	2	1	2	9	1
Sudan Green	Introduction from Sudan, Africa	9	2	2	2	2	2	2	2	1	2	1	1
Tanganyika-1	Introduction from Tanganyika	9	2	2	2	2	2	2	2	1	2	1	1
JRO-36E	Selection from Tanganyika-1	9	2	2	2	2	2	3	2	1	2	1	3
JRO-2345	Selection from KEN/SM/024C	9	2	2	2	2	2	2	2	1	2	1	1
C. capsularis: Notified varieties													
JRC-212	Selection from an indigenous germplasm	9	2	2	2	2	2	2	2	1	2	1	2
JRC-7447	X-ray derivative of JRC-212	9	2	2	2	2	2	2	2	1	2	1	2
JRC-321	Selection from an indigenous germplasm 'Hewti'	9	2	2	3	2	5	2	3	1	3	1	2
Padma	Selection from JRC-6165×JRC-412	9	2	2	3	2	5	2	3	1	3	1	2
JRC-4444	Selection from JRC-212×D-154	9	2	2	2	2	2	2	2	1	2	1	2
UPC-94	Selection from JRC-321×JRC-212	9	2	2	3	2	5	2	3	1	3	1	2
JRC-698	Selection from a multiple cross	9	2	2	2	2	2	2	2	1	2	1	2
Bidhan Pat-1	Gamma ray derivative of D-154	9	2	2	2	2	2	2	2	1	2	1	2
Bidhan Pat-2	Selection from D-154×D-18 (mutant)	9	2	2	2	2	2	2	2	1	2	1	2
Bidhan Pat-3	Selection from D-154×D-18	9	2	2	2	2	2	2	2	1	2	1	2
JRC-80	Selection from CIN -114×JRC-321	9	2	2	2	2	2	2	2	1	2	1	2
KC-1	Gamma ray derivative of JRC-4444	9	2	2	2	2	2	2	2	1	2	1	2
KTC-1	Selection from IC-30730 collected from Tripura	9	2	2	2	2	2	2	2	1	2	1	2
C. capsularis: Variety of common knowledge													
D-154	Selection from Kakya Bombai	9	2	2	3	2	2	2	3	1	3	1	2
Rating of characteristics according to Official DUS Test Guidelines of Jute		1. Absent 9. Present	1. Pale green 2. Green	1. Pale green 2. Green 3. Red	1. Pale green 2. Green 3. Red	1. Pale green 2. Green 3. Red	1.Pale green 2. Green 3. Purple 4. Red 5. Coppery red	2. Ovate-lanceolate 3. Lance-olate	1. Pale green 2. Green 3. Red	1. Absent 9. Present	1. Pale green 2. Green 3. Red	1. Absent 9. Present	1. Green 2. Chocolate brown 3. Steel grey 4. Black

PFR: premature flowering resistance. LLC: leaf lamina colour. LVC: leaf vein colour. LPC: leaf petiole colour. SC: stipule colour. StC: stem colour. LS: leaf shape. PC: pigmentation of calyx. BSRP: basal stem root primordia. PP: pod pigmentation. PD: pod dehiscence. SdC: seed colour.

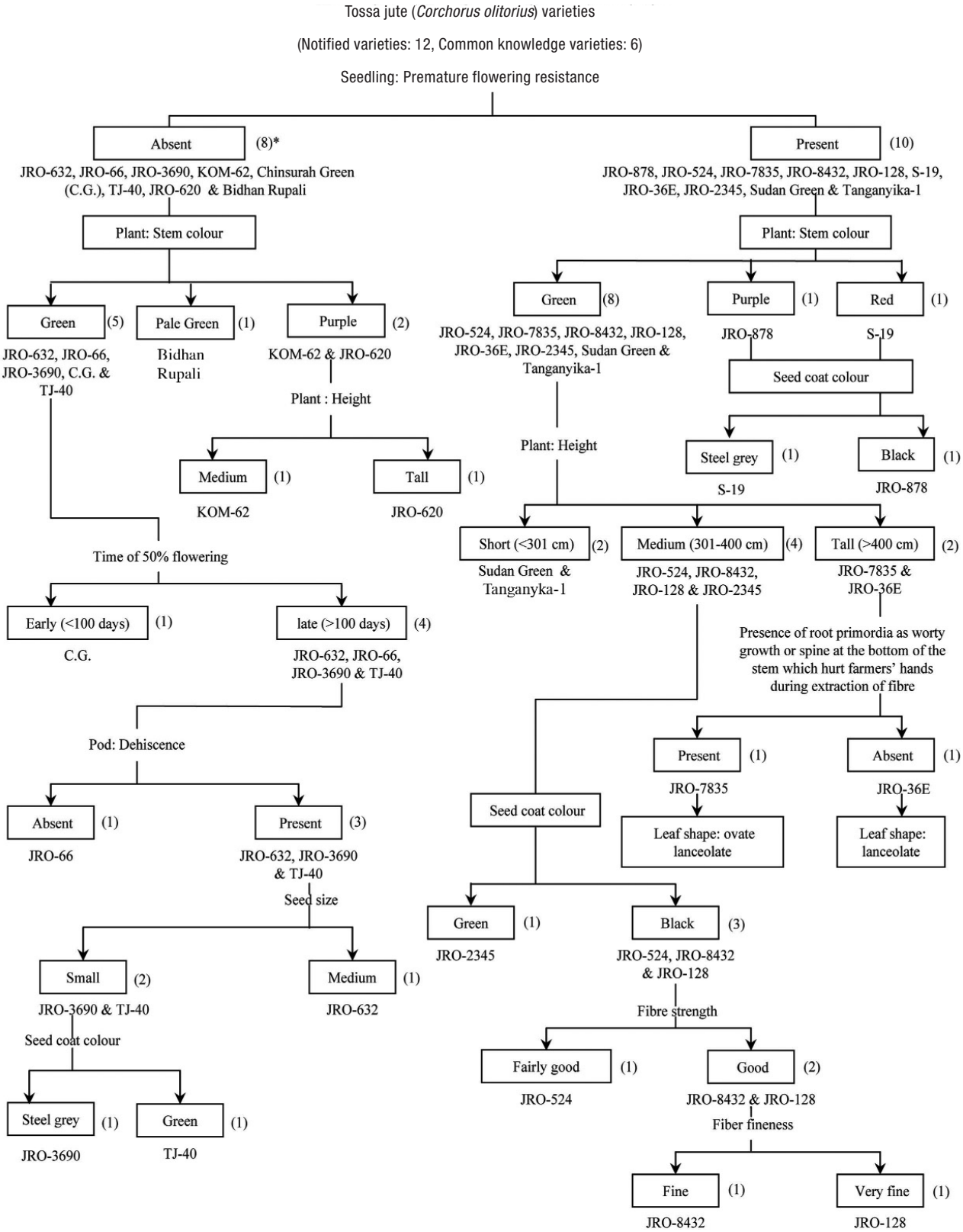

Figure 1. Results of DUS testing of jute with dummy candidate variety, Bidhan Rupali. *: Figures in parentheses indicate number of varieties present in the concerned state of characteristics.

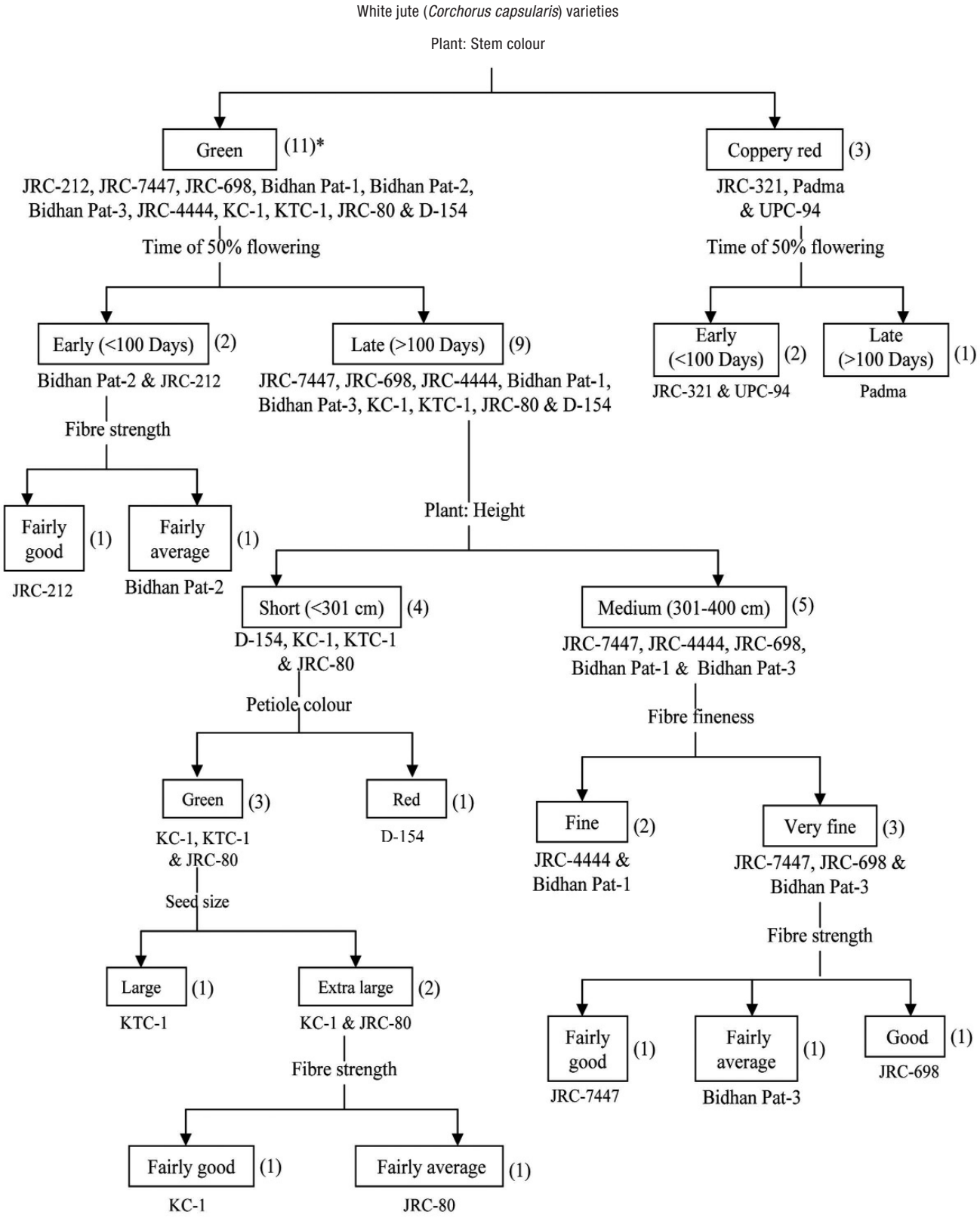

Figure 2. Results of DUS testing of jute with dummy candidate variety, D154. *: Figures in parentheses indicate number of varieties present in the concerned state of characteristics.

and 9 traits (leaf vein colour, leaf petiole colour, stipule colour, stem colour, plant height, fibre fineness, fibre strength, pod pigmentation and seed colour) were polymorphic among varieties indicating their potential for varietal characterization (Tables 1 and 2).

The seed morphological characters such as seed size and seed colour were easy to detect and could classify jute varieties into few broad categories in *C. olitorius* but seed size (category-large) and seed colour (category-chocolate brown) were similar for all the varieties in *C. capsularis*. Seed size categorized the *C. olitorius* varieties into two groups (small and medium) with 14 and 4 varieties, respectively (Table 2). In *C. olitorius* three categories of seed colour (green, steel grey and black) were observed, while all *C. capsularis* varieties were chocolate brown seeded (Table 1).

Out of 18 *C. olitorius* varieties, distinctness could be established for 16 varieties by using the 17 morphological characteristics. Interestingly, Sudan Green and Tanganyika-1 belonged to the same group, indicating their proximity. Identity and distinctness of 10 *C. capsularis* varieties (Padma, JRC-212, Bidhan Pat-2, D-154, KTC-1, KC-1, JRC-80, Bidhan Pat-3, JRC-7447 and JRC-698, Fig. 2) could be established individually and remaining varieties of *C. capsularis* could be classified into two groups: early flowering group (JRC-321 and UPC-94) and fine fibre group (JRC-4444 and Bidhan Pat-1). However, the dummy candidate varieties, Bidhan Rupali in *C. olitorius* and D-154 in *C. capsularis* were distinct from all other *C. olitorius* and *C. capsularis* varieties, respectively.

No intra-varietal variation was observed for any of the characteristic and the expression of each character in all varieties was similar for two consecutive years in both locations. Number of off-type plants recorded in each DUS plot across location over both the years oscillated from 1 to 4, *i.e.* 0.11% to 0.41% for *C. olitorius*, while the range of variation was 0-3, *i.e.* 0.00% to 0.12% for *C. capsularis* (Table 3) professing uniformity and stability of all the varieties.

Discussion

In jute, long duration and premature flowering trait make the varieties unsuitable for multiple cropping systems. Premature flowering resistance character permits the jute varieties for early sowing, offers high yielding potentiality and renders them to fit in crop rotation with transplanted "wet season" paddy. Being a short day crop it is possible to sow tossa jute (*C. olitorius*) after mid-April. To fit paddy after jute in multiple cropping systems three varieties viz. JRO-878, JRO-7835, JRO-524 (Chakraborty and Ghosh, 1969; Ghosh, 1983) were bred during seventies, incorporating premature flowering resistance from 'Sudan Green', an exotic germplasm from Africa, permitting their sowing in mid-March. This character had been found to be very useful for delineating *C. olitorius* jute varieties. Based on this character *C. olitorius* varieties were grouped into two categories (present and absent) comprising 10 and 8 varieties, respectively (Tables 1 and 2). Contrary to it, in *C. capsularis* all the varieties were resistant to premature flowering.

Each polymorphic plant characteristic grouped the jute varieties into different categories based on the numbers of states of expression (Tables 1 and 2). Stem colour was scored for categories like pale green, green, purple, red, or coppery red and not for different intensities of colour pigmentation, which is liable to vary with advancement of growth stage due to environmental effect.

Observations on plant height (short, medium, tall) and time of 50% flowering (early, 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.

As already mentioned 18 *C. olitorius* varieties could be grouped into two distinct classes in respect of premature flowering resistance (Table 1). Resistance was present in 10 varieties and was absent in 8 varieties (Fig. 1). Out of 10 *C. olitorius* varieties with premature flowering resistance, 8 varieties (JRO-524, JRO-7835, JRO-8432, JRO-128, JRO-2345, JRO-36E, Sudan Green and Tanganyika-1) had green stem colour, while JRO-878 had purple and S-19 red stem colour. The seed coat colour of the red pigmented premature flowering resistant variety, S-19, was steel grey and that was black for JRO-878. Among 8 varieties evincing premature flowering resistance and green stem colour, 2 [Sudan Green (299.43 cm) and Tanganyika-1 (298.78 cm)] were short, 4 [JRO-524 (339.23 cm), JRO-8432 (325.34 cm), JRO-128 (326.18 cm) and JRO-2345 (315.03 cm)] were medium and 2 [JRO-7835 (403.83 cm) and JRO-36E (413.72 cm)] were tall with regard to plant height. Sudan Green was similar to Tanganyika-1. Seed coat colour of JRO-2345 was green and that of JRO-524, JRO-8432 and JRO-128 were black. The fibre strength of JRO-524 was fairly good (26.40 g/tex) and was distinct from JRO-8432 (27.10 g/tex) and

Table 2. Quantitative characterization of released and common knowledge jute varieties based on morphological characters included in Official DUS Test Guidelines

Variety	Plant height (cm)	Fibre fineness (tex)	Fibre strength (g/tex)	Time of 50% flowering (days)	Seed size (g)
C. oliotorius: Notified varieties					
JRO-632	7 (401.17 ± 2.016)	5 (3.06 ± 0.029)	5 (25.50 ± 0.249)	5 (110.41 ± 0.733)	5 (2.16 ± 0.023)
JRO-3690	7 (411.33 ± 2.514)	7 (2.63 ± 0.032)	1 (20.34 ± 0.246)	5 (120.42 ± 1.276)	3 (1.93 ± 0.024)
KOM-62	5 (333.98 ± 4.760)	7 (2.58 ± 0.273)	1 (16.33 ± 0.094)	5 (130.56 ± 0.852)	3 (1.96 ± 0.020)
TJ-40	7 (404.17 ± 2.070)	7 (2.53 ± 0.047)	1 (14.69 ± 0.072)	5 (135.22 ± 1.670)	3 (1.96 ± 0.021)
JRO-66	7 (411.57 ± 2.159)	5 (3.10 ± 0.030)	7 (26.60 ± 0.102)	5 (143.33 ± 1.410)	3 (1.95 ± 0.013)
JRO-524	5 (339.23 ± 5.370)	3 (3.40 ± 0.024)	5 (26.40 ± 0.064)	5 (162.17 ± 4.310)	3 (1.91 ± 0.009)
JRO-7835	7 (403.83 ± 2.040)	3 (3.50 ± 0.030)	7 (26.90 ± 0.061)	5 (159.25 ± 4.120)	3 (1.90 ± 0.026)
JRO-878	7 (410.06 ± 2.827)	7 (2.60 ± 0.016)	5 (26.10 ± 0.092)	5 (152.67 ± 3.230)	3 (1.83 ± 0.015)
JRO-8432	5 (325.34 ± 0.477)	5 (2.80 ± 0.022)	7 (27.10 ± 0.104)	5 (156.92 ± 3.830)	5 (2.04 ± 0.020)
JRO-128	5 (326.18 ± 4.947)	7 (2.60 ± 0.025)	7 (27.50 ± 0.045)	5 (157.67 ± 4.290)	3 (1.86 ± 0.016)
S-19	7 (417.97 ± 2.397)	7 (2.70 ± 0.007)	5 (25.95 ± 0.096)	5 (152.42 ± 4.990)	3 (1.95 ± 0.020)
Bidhan Rupali	5 (316.45 ± 3.741)	7 (2.58 ± 0.026)	1 (18.36 ± 0.057)	5 (139.22 ± 1.510)	3 (1.87 ± 0.023)
C. olitorius: Varieties of common knowledge					
JRO-620	7 (407.13 ± 10.822)	7 (2.50 ± 0.033)	5 (26.14 ± 0.073)	5 (132.88 ± 0.720)	3 (1.96 ± 0.023)
Chinsurah Green	3 (290.11 ± 2.860)	7 (2.52 ± 0.035)	3 (18.76 ± 0.031)	3 (96.44 ± 1.160)	5 (2.01 ± 0.003)
Sudan Green	3 (299.43 ± 3.240)	5 (2.80 ± 0.027)	5 (23.68 ± 0.046)	5 (111.33 ± 1.860)	5 (2.00 ± 0.022)
Tanganyika-1	3 (298.78 ± 4.734)	5 (2.86 ± 0.033)	5 (24.11 ± 0.078)	5 (112.67 ± 1.202)	3 (1.86 ± 0.015)
JRO-36E	7 (413.72 ± 2.666)	5 (3.02 ± 0.028)	9 (29.70 ± 0.019)	5 (161.08 ± 3.060)	3 (1.84 ± 0.010)
JRO-2345	5 (315.03 ± 5.190)	7 (2.50 ± 0.032)	5 (23.80 ± 0.047)	5 (159.42 ± 4.010)	3 (1.95 ± 0.023)
C. capsularis: Notified varieties					
JRC-212	5 (323.59 ± 2.166)	7 (1.61 ± 0.023)	5 (23.97 ± 0.079)	3 (94.17 ± 0.780)	7 (3.36 ± 0.021)
JRC-7447	5 (336.60 ± 4.755)	7 (1.71 ± 0.034)	5 (23.00 ± 0.044)	5 (132.75 ± 3.110)	7 (3.27 ± 0.019)
JRC-321	5 (309.98 ± 1.977)	7 (1.50 ± 0.040)	5 (22.07 ± 0.045)	3 (95.45 ± 1.360)	9 (3.54 ± 0.017)
Padma	5 (311.04 ± 2.665)	3 (2.50 ± 0.039)	7 (24.00 ± 0.058)	5 (124.83 ± 5.030)	7 (3.28 ± 0.035)
JRC-4444	5 (319.42 ± 1.924)	5 (1.90 ± 0.035)	5 (22.10 ± 0.026)	5 (139.42 ± 3.570)	7 (3.38 ± 0.017)
UPC-94	5 (315.17 ± 3.535)	7 (1.50 ± 0.039)	5 (23.00 ± 0.050)	3 (95.25 ± 0.990)	9 (3.53 ± 0.021)
JRC-698	5 (313.31 ± 2.869)	7 (1.80 ± 0.038)	7 (25.71 ± 0.061)	5 (136.17 ± 3.590)	7 (3.35 ± 0.018)
Bidhan Pat-1	5 (305.72 ± 4.850)	5 (2.09 ± 0.048)	5 (21.81 ± 0.045)	5 (107.92 ± 4.250)	7 (3.26 ± 0.016)
Bidhan Pat-2	5 (326.67 ± 1.933)	7 (1.67 ± 0.038)	3 (18.35 ± 0.053)	3 (77.42 ± 3.740)	7 (3.44 ± 0.021)
Bidhan Pat-3	5 (315.42 ± 2.854)	7 (1.80 ± 0.023)	3 (19.20 ± 0.040)	5 (111.25 ± 0.690)	7 (3.14 ± 0.021)
JRC-80	3 (295.72 ± 3.938)	7 (1.25 ± 0.037)	3 (19.42 ± 0.063)	5 (150.5 ± 2.710)	9 (3.52 ± 0.017)
KC-1	3 (296.78 ± 4.267)	7 (1.75 ± 0.022)	5 (22.24 ± 0.037)	5 (144.75 ± 1.120)	9 (3.58 ± 0.037)
KTC-1	3 (291.83 ± 5.187)	5 (2.18 ± 0.020)	5 (21.01 ± 0.076)	5 (138.67 ± 1.860)	7 (3.37 ± 0.099)
C. capsularis: Variety of common knowledge					
D-154	3 (267.00 ± 2.494)	3 (2.50 ± 0.034)	5 (21.81 ± 0.096)	5 (125.50 ± 3.790)	7 (3.16 ± 0.040)
Rating of characteristics according to Official DUS Test Guidelines of Jute	3. Short (< 301 cm) 5. Medium (301-400 cm) 7. Tall (> 400 cm)	3. Coarse (*C. olitorius*: > 3.2 tex, *C. capsularis*: > 2.4 tex) 5. Fine (*C. olitorius*: 3.2 -2.8 tex, *C. capsularis*: 2.4-1.9 tex) 7. Very fine (*C. olitorius*: < 2.8 tex, *C. capsularis*: < 1.9 tex)	1. Average & weak (*C. olitorius*: 20.4 g/tex & below *C. capsularis*: 17.9 g/tex & below) 3. Fairly average (*C. olitorius*: 20.5-23.4 g/tex, *C. capsularis*: 18.0-20.9 g/tex) 5. Fairly good (*C. olitorius*: 23.5-26.4 g/tex, *C. capsularis*: 21.0-23.9 g/tex) 7. Good (*C. olitorius*: 26.5-29.4 g/tex, *C. capsularis*: 24.0-2.9 g/tex) 9. Very good: (*C. olitorius*: 29.5 g/tex & above *C. capsularis*: 27.0 g/tex & above)	3. Early (< 100 days) 5. Late (> 100 days)	3. Small (< 2 g) 5. Medium (2-3 g) 7. Large (3.1-3.5 g) 9. Extra large (> 3.5 g)

Table 3. Number of off-type plants recorded in DUS plots of jute across location over two years

	2006-07		2007-08	
	Barrackpore	**Budbud**	**Barrackpore**	**Budbud**
C. olitorius: Notified varieties				
JRO-632	1 (0.11)	2 (0.21)	4 (0.40)	3 (0.31)
JRO-3690	3 (0.31)	1 (0.11)	1 (0.11)	3 (0.32)
KOM-62	1 (0.11)	1 (0.11)	2 (0.21)	2 (0.21)
TJ-40	2 (0.22)	2 (0.21)	3 (0.31)	1 (0.11)
JRO-66	1 (0.11)	4 (0.41)	2 (0.21)	2 (0.21)
JRO-524	2 (0.21)	2 (0.22)	2 (0.21)	1 (0.11)
JRO-7835	1 (0.12)	3 (0.32)	3 (0.31)	2 (0.21)
JRO-878	1 (0.11)	1 (0.11)	1 (0.11)	1 (0.11)
JRO-8432	3 (0.31)	1 (0.11)	3 (0.31)	1 (0.12)
JRO-128	2 (0.23)	2 (0.21)	2 (0.21)	1 (0.12)
S-19	3 (0.31)	1 (0.11)	2 (0.21)	3 (0.33)
Bidhan Rupali	2 (0.22)	2 (0.21)	2 (0.21)	2 (0.22)
C. olitorius: Varieties of common knowledge				
JRO-620	4 (0.41)	3 (0.31)	3 (0.31)	2 (0.21)
Chinsurah Green	3 (0.32)	2 (0.21)	2 (0.21)	2 (0.22)
Sudan Green	2 (0.22)	1 (0.11)	1 (0.11)	1(0.11)
Tanganyika-1	3 (0.31)	4 (0.41)	4 (0.41)	2 (0.21)
JRO-36E	2 (0.21)	1 (0.11)	1 (0.11)	1 (0.11)
JRO-2345	3 (0.31)	3 (0.32)	2 (0.10)	3 (0.31)
C. capsularis: Notified varieties				
JRC-212	0 (0.00)	1 (0.11)	0 (0.11)	2 (0.21)
JRC-7447	2 (0.21)	2 (0.21)	1 (0.11)	1 (0.11)
JRC-321	1 (0.12)	0 (0.00)	1 (0.12)	1 (0.12)
Padma	1 (0.11)	1 (0.12)	0 (0.00)	0 (0.00)
JRC-4444	2 (0.21)	1 (0.11)	1 (0.11)	1 (0.11)
UPC-94	0 (0.00)	2 (0.22)	2 (0.22)	1 (0.11)
JRC-698	2 (0.21)	3 (0.31)	1 (0.11)	2 (0.22)
Bidhan Pat-1	1 (0.11)	0 (0.00)	0 (0.11)	3 (0.32)
Bidhan Pat-2	2 (0.21)	1(0.31)	3 (0.31)	2 (0.21)
Bidhan Pat-3	0 (0.00)	1 (0.11)	2 (0.22)	1 (0.12)
JRC-80	1 (0.12)	2 (0.22)	1 (0.12)	1 (0.12)
KC-1	2 (0.23)	0 (0.00)	1 (0.11)	2 (0.22)
KTC-1	1 (0.11)	1 (0.11)	1 (0.11)	0 (0.00)
C. capsularis: Variety of common knowledge				
D-154	2 (0.22)	2 (0.21)	1 (0.11)	2 (0.21)

Figures in parenthesis indicate % of off-types. Plot size = 19 m × 3 m = 57 m^2.

JRO-128 (27.50 g/tex) whose fibre strength was good. But the fibre fineness of JRO-128 was of very high order (2.60 tex) and was distinct from JRO-8432 whose fibre fineness was of high order (2.80 tex). Out of 2 tall *C. olitorius* varieties, JRO-7835 had unique character, root primordia modified as spine like outgrowth at the base of the stem that was not found in any other *C. olitorius* variety and this character distinguished JRO-7835 from JRO-36E.

Out of 8 *C. olitorius* varieties showing premature flowering susceptibility, 5 (JRO-632, JRO-3690, TJ-40, JRO-66 and Chinsurah Green) had green stem colour, 2 (KOM-62 and JRO-620) had red stem colour and only one variety, Bidhan Rupali, had pale green stem colour. Bidhan Rupali was distinct from all other *C. olitorius* varieties for pale green stem colour. Among 2 premature flowering susceptible with red stem varieties, KOM-62 was medium (333.98 cm) and JRO-620

was tall (407.13 cm) with regard to plant height and they were distinct for this character.

Out of 5 varieties with green stem, Chinsurah Green was early flowering (96.44 days) and was distinct, JRO-66 had non-dehiscent pod, JRO-632 had medium seed size (2.16 g), JRO-3690 has steel grey seed coat, whereas the seed coat is green for TJ-40 and they were distinct from each other.

Though polymorphic characters were less among *C. capsularis* varieties, three varieties, viz. JRC-321, Padma and UPC-94 had coppery red stem and all others had green stem (Fig. 2). JRC-321 (95.45 days) and UPC-94 (95.25 days) were early flowering type, whereas Padma (124.83 days) was late flowering type. Padma was distinct from all other *C. capsularis* varieties but JRC-321 was similar to UPC-94. Out of 11 varieties with green stem colour, Bidhan Pat-2 (77.42 days) and JRC-212 (94.17 days) were early with regard to time of 50% flowering, whereas the other 9 varieties were late. These two early flowering varieties exhibited their distinctness with regard to fibre strength. JRC-212 had fairly good fibre strength (23.97 g/tex); while Bidhan Pat-2 (18.35 g/tex) exhibited fairly average fibre strength. Out of 9 late flowering varieties, 4 varieties viz. D-154 (267.00 cm), KC-1 (296.78 cm), KTC-1 (291.83 cm) and JRC-80 (295.72 cm) were short with regard to plant height. Of them D-154 was with red petiole and was distinct from all other three short height varieties which were green petiole coloured. Out of these, 3 varieties (KC-1, KTC-1 and JRC-80) having green petiole colour, KTC-1 had large seed (3.37 g) and was distinct for the other two extra large seeded varieties viz. KC-1 (3.58 g) and JRC-80 (3.52 g). On the other hand, among 5 (JRC-7447, JRC-4444, JRC-698, Bidhan Pat-1 and Bidhan Pat-3) medium height varieties JRC-4444 (1.90 tex) and Bidhan Pat-1 (2.09 tex) had fine fibre, while the remaining 3 varieties viz. JRC-7447 (1.41 tex), JRC-698 (1.80 tex) and Bidhan Pat-3 (1.80 tex) had very fine fibre. Out of these 3 varieties JRC-7447 had fairly good fibre strength (23.00 g/tex), Bidhan Pat-3 had fairly average fibre strength (19.20 g/tex) and JRC-698 (25.71 g/tex) was with good fibre strength. These 3 varieties were distinct from the remaining 2 varieties viz. JRC 4444 and Bidhan Pat-3.

Therefore, using 17 morphological characteristics, distinctness of almost all *C. olitorius* varieties and few *C. capsularis* varieties could be established individually and two groupings could be done for the remaining *C. capsularis* varieties. It may be mentioned here that Kumar *et al*. (2006) could establish distinctness of only few varieties in both species by using 16 morphological characters prescribed in the Draft National Test Guidelines of Jute (Kumar and Mahapatra, 2004) but distinctness of almost all the varieties of *C. olitorius* and 10 varieties of *C. capsularis* could be established by using 17 characters of the Revised Official DUS Test Guidelines of Jute (PPV&FR Authority, 2008). Similar attempts for establishment of distinctness were made in soybean (Ravikumar and Naraayanswamy, 1999), oat (Kumar *et al*., 2002), rapeseed-mustard (Gupta *et al.,* 2003; Yadav, 2004), pearl millet (Kumar *et al*., 2004), rice (Joshi *et al*., 2007; Patra *et al*., 2010), jute (Kumar *et al.*, 2008) and maize (Yadav and Singh, 2010).

All the morphological DUS descriptors did not show any variation in their states of expression over two years study. Further less number of off-types was observed in both locations in two consecutive years. As revised per Official DUS Test Guidelines of Jute (PPV&FR Authority, 2008) to fulfill the criteria of uniformity, the number of off-types should not exceed 4 in 400, *i.e.* 1.0% and if a variety exhibits its uniformity for two consecutive years, the variety is considered as stable. In our present study the percentage of off-types recorded in each plot across location over both years varied from 0.11% to 0.41% for *C. olitorius* and 0.00% to 0.12% for *C. capsularis* (Table 3) which is less than the percentage of permissible off-types professing the uniformity of the varieties. Expression of each characteristic was also found to be stable in both years for the respective varieties affirming their consistency and stability. Therefore, it may be inferred that all these 32 varieties were uniform and stable. The morphological characteristics studied are stable due to a low genotype-environment interaction in the expression and are controlled by single or two genes with simple dominant or recessive inheritance. Apart from this, during the development of varieties, jute breeders have purposefully emphasized on the stability and uniformity of these morphological characteristics. Though some jute varieties were released long back, those are stable even now with regard to these morphological characteristics. The present result corroborates the findings of Kumar *et al.* (2006).

It may be concluded that morphological DUS descriptors can be used effectively for identification and grouping of the jute varieties and varieties satisfying the DUS criteria for these descriptors could be registered under the PPV&FR Act for obtaining Plant

Breeders and Farmers' Rights. However, morphological descriptors used in the present study alone may be limiting for the DUS criteria for establishment of distinctness of *C. capsularis* varieties. Hence, some other markers/descriptors may be considered for complementing the morphological DUS descriptors to establish distinctness of closely related varieties.

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