Plant Introduction : Achievements and Opportunities in Jute and Allied Fibre Crops in India

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Collection and introduction of jute and allied fibre crops germplasm through different modes like institute efforts, correspondence, joining in National and International programmes from early twentieth century to recent time have been chronologically narrated. Variablities in different traits within the collected germplasm have been studied and short listed accessions are under use as base material in breeding programmes for crop improvement. Role of these valuable germplasm in developing different suitable varieties is enumerated. Their impacts on national productivity and in various industrial sectors have been dealt with. Further need and scope in collecting germplasm for developing varieties, required for diversified products for sustainability of these crops from competition with the synthetic fibres are indicated.

Key words: Jute, Mesta, Germplasm collection, Variability, Utilization

The genus *Corchorus* belongs to the family Tiliaceae and its two annual species viz., *C. capsularis* (White jute) and *C. olitorius* (Tossa jute) yield fibre from bark of the stem after being retted in water and termed as jute. Other two species, *Hibiscus cannabinus* (Kenaf / H.C. mesta) and *H. sabdariffa* var. *altissima* (Roselle / H.S. mesta) of family Malvaceae also produce similar fibre; and thus known as allied fibre. Fibres of all these four species, known as raw jute in trade and commerce are used in the jute industry either alone or in combination. There are several other non-cotton fibre plants cultivated in India, termed as allied fibres, such as ramie (*Boehemeria nivea*), sunnhemp (*Crotalaria juncea*), flax (*Linum usitatissimum*) and sisal (*Agave sisalana*). In all these plants, fibre is extacted from the bark of the stem except sisal where extraction is from the leaf.

Asian countries like Bangladesh, China, India, and Thailand are major producers of jute. World area under these crops varies from 4.3 to 4.6 million hectares with an average annual production of 3.43 million tons. About 0.8 million hectares and 0.2 million hectares of land are covered annually with jute and mesta respectively with an average annual production of little more than 1.7 million tons of fibres (Anonymous, 1998).

Cultivation of jute, kenaf and roselle is of high socio-economic significance since livelihood of more than 12 million small and marginal farm families in developing countries like India, China, Bangladesh, Thailand and Nepal depend very much on these crops. Moreover, thousands of other workers are employed in the jute industry, trade and commerce. An increasing competition from synthetic substitutes is causing a serious threat to this industry. The land area under jute and allied fibres is declining and these crops are gradually being pushed to the poor marginal land, which in turn reduces productivity. The productivity has remained low and static over the years. National and international efforts are being made to introduce germplasm from diverse agro-ecological and diversity rich areas from abroad as elucidated in earlier studies (Mahapatra and Saha, 1995; Saha *et al.*, 2004). Utilization of elite germplasm in breeding programme is the headway to enhance productivity along with judicious crop husbandry practices.

Germplasm Introduction

National Programme

To build up a rich and diverse genepool of these bast fibre crops, introduction of germplasm and utilization for selection for improvement of jute and kenaf started in early 20th century (Patel and Ghosh, 1940). But the approach was sporadic and the plant breeders engaged in the crop improvement programme had to work with narrow gene pool of about 300 accessions of jute and 200 accessions of locally collected kenaf and roselle till early seventies.

The systematic approach for collection of jute and allied fibres germplasm was initiated during 1977. Distribution of all the *Corchorus* species found in India and their diagnostic features were studied in detail for strengthening germplasm collection programme either through direct exploration or through correspondence (Mahapatra *et al.*, 1998). Following information collected

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from literature survey, study of herbarium specimen, and areas of diversity, different collection teams were sent to different regions. The scientists of Central Research Institute for Jute and Allied Fibres (CRIJAF) made majority of the collections between 1977 to 1985. Later on, National Bureau of Plant Genetic Resources (NBPGR) organized such collection missions in collaboration with CRIJAF.

After evaluation, such collections were found to display diversity, which could meet requirements of the breeders partially. Thereafter, germplasm collections were made under International programme during 1987-1993 which have been elucidated separately. From 1999-2004, under the aegis of National Agricultural Technology Project (NATP) on Conservation of Agro-biodiversity (Plant Genetic Resources), 14 exploration missions were undertaken for collection of trait specific germplasm in some target areas following fine grid method. Six hundred and fifty-five accessions were collected including landraces and wild relatives from different agro-climatic regions viz., Jharkhand, North Bengal including Tarai region, Bengal-Orissa border region, north-eastern and south-eastern Rajasthan, Gujarat, north-eastern Orissa, drier parts of Bengal, parts of Tamil Nadu, Kerala, Karnataka, Maharashtra and different islands of Sundarban Biosphere Reserve in West Bengal.

International Collection Efforts

With the initiative of International Jute Organization (IJO), intensive germplasm-collection programmes were undertaken in countries having rich genetic diversity. Although richest genetic diversity occurs in Republic of South Africa, IJO identified two East African countries like Kenya and Tanzania for direct exploration. Five germplasm collection missions were executed these countries with the logistic support from International Board on Plant Genetic Resources (IBPGR), now known as Bioversity International, regional office for Sub-Saharan Africa in Nairobi. Two scientists from each of the IJO project participating countires (India, Bangladesh, China, Nepal, Thailand) formed five collecting teams to explore the target area during 1987-1988 and collected 790 accessions. Further, IJO provided financial support to the countries like China, Indonesia, Thailand and Nepal during 1988-1990 for collection of jute and mesta germplasm from their own countries and acquired 927 accessions. IJO, later, funded a special mission in Pakistan for exploration in September-October 1990, which collected a total of 251 accessions. It also networked the agencies like USDA, CSIRO, IBPGR and CENERGEN to share the crop germ pool and the information generated.

Thus IJO acquired a total of 2,300 accessions from all sources and conserved these at the gene bank of Bangladesh Jute Research Institute (BJRI), as the IJO's Centralized Germplasm Repository. Germplasm thus acquired was distributed among member countries and India (CRIJAF) also received its due share. Duplicate base collection centre was built up with CSIRO Gene Bank in Canberra, Australia (Denton, 1992).

The total germplasm accessions collected by CRIJAF under different species through correspondence, national and international programmes are given in the Table 1. Crop specific explorations were undertaken for sunnhemp, flax, ramie and sisal germplasm.

Diversity in Jute and Mesta Gene Pool

Yield Parameters: For assessment of total variability and identification of desirable traits in the collected germplasm, the whole set of jute germplasm were grown over two environments and data were recorded on fibre yield and its contributing parameters. The observed range of variability is presented in Table 2. The range for each of the parameters was considerably wide in both the species of jute. For fibre yield range was 0.5-9.2 g per plant in white jute whereas the range was 1.0-10.5 g per plant in tossa jute. Plant height showed the strong correlation with fibre yield and varied between 70-360 cm and 60-420 cm in white and tossa jute respectively (Mahapatra and Saha, 1995).

Table 1. Germplasm holding of jute and allied fibre crops at CRIJAF

Species	No. of accessions
Corchorus capsularis	939
C. olitorius	1,647
Corchorus sp. (wild)	313
Hibiscus cannabinus	705
H. sabdariffa	605
Hibiscus sp. (wild)	125
Crotalaria juncea	149
Crotalaria sp. (wild)	75
Linum usitatissimum	64
Boehmeria nivea	52
Boehmeria utilis	2
Boehmeria sp. (wild)	1
Agave sp. (wild)	45
Agave hybrid	1
Total	**4,723**

Table 2. Range of variability in yield and yield contribution characters of jute

Characters	Range of variations	
	C. capsularis	*C. olitorius*
Plant height (cm)	70 to 360	60 to 420
Basal diameter (cm)	0.4 to 2.4	0.5 to 2.7
Number of nodes	25 to 84	34 to 102
Days to 50% flowering	41 to 186	29 to 175
Dry fibre yield (gm)	0.5 to 9.2	1.0 to 10.5

Early Flowering Resistance: Jute fibre is the product of vegetative growth and a prolonged growth period is essential before the crop enters into reproductive phase. Hence, resistance to early flowering is much sought after parameter. *C. olitorius* germplasm, collected from equatorial region of East Africa under the aegis of IJO were specially evaluated for resistance to early flowering. Eighty such germplasm lines/accessions were sown at four different dates (middle of February, early March, middle of March and early April). Number of days taken to bloom the first flower was recorded and mean values determined. All the accessions over all the dates of sowing were then classified into several groups on number of days to flowering Table 3.

Variability range for early flowering resistance was 48.7-130.4 days in the mid-February sowing. Nine genotypes, which were clubbed under group 1 for this date of sowing are the most desirable genotypes (Anonymous, 1987-89).

Growth Attributes: Investigation on genotypic variability in growth attributes of jute (*Corchorus capsularis* L.) was undertaken to elucidate the extent of genotypic variability of some physiological parameters of growth and yield viz., production of total dry matter, Relative Growth Rate (RGR), Net Assimilation Rate (NAR), Harvest Index (HI), and Leaf Area Index (LAI). Twenty-five jute genotypes representing wild, semi wild, elite types, and recommended commercial varieties were studied. Existence of significant genotypic variability could be observed for all the above-mentioned direct and derived attributes over the stages of growth except for RGR (Table 4).

Range of variability for dry weight ($\log_e W$) during 16th week (harvesting stage) was 5.45-6.26. HI ranged from 14.76-20.26% on the basis of whole aerial biomass. The NAR ranged from 0.141-0.926 g / cm^2 per week during 10th week, the peak time of vegetative growth. LAI during the same week varied between 1.68-3.37 (Saha, 1998).

Abiotic Stress Tolerance

Moisture Deficit : Moisture stress in the early growth phase is prevalent in the areas where jute is grown as rainfed crop. Fifteen representative white jute accessions of exotic and indigenous origin were evaluated for moisture stress tolerance. Parameters like relative turgidity and chlorophyll disintegration (CD) were used for such evaluation. Relative turgidity of the genotypes varied between 37-90% over control and CD varied between 0.03 mg-0.85 mg (Table 5). These 15 genotypes could be classified into susceptible, moderately susceptible and moderately tolerant types. Moderately tolerant types were JRC 212, and Cordate leaf and susceptible types were EC 41337 and Branca (Gupta and Saha, 1987).

Fifteen tossa jute accessions of exotic and indigenous origin were also evaluated for moisture stress tolerance using the same parameters as in case of white jute. Relative turgidity was observed to vary between

Table 3. African jute (*C. olitorius*) germplasm showing various degrees of resistance to early flowering

Group of germplasm	No. of accs. identified in each group	Mean number of days to flower			
		1st sowing (Mid-Feb.)	2nd sowing (Early March)	3rd sowing (Mid-March)	4th sowing (Early April)
Group I	9	130.4	128.8	181.2	171.4
Group II	12	65.9	113.8	181.8	180.3
Group III	38	59.2	50.2	188.4	181.7
Group IV	06	48.7	40.7	46.4	68.2
Control	03	54.2	51.9	191.2	172.2

Table 4. Diversity in physiological attributes of growth and yield in white jute

Growth stages week	Total dry weight $\text{Log}_e W$	Relative growth rate g / g / week	Net assimilation rate g/ cm^2 / week	Leaf area index	Harvest index %
12th	4.863 – 5.700	0.043 – 0.240	0.080 – 0.303	1.37 – 3.17	14.91 – 22.74
14th	5.227 – 5.894	0.015 – 0.210	0.045 – 0.581	1.28 – 3.60	15.51 – 20.66
16th	5.451 – 6.263	0.035 – 0.252	0.128 – 0.836	1.21 – 3.48	14.76 – 20.26

Table 5. Diversity range for moisture stress tolerance in white and tossa jute

Crops	Relative turgidity (%)	Chlorophyll disintegration (mg)
White Jute	37 – 90	0.03 – 0.85
Tossa Jute	45 – 85	0.33 – 1.60

45%-85% over control and CD varied between 0.33 mg to 1.60 mg (Table 5). Genotypes like Palmate leaf, Salyout and JRO 524 were identified as tolerant to moisture stress condition and long narrow leaf was susceptible to such situation (Gupta and Saha, 1984).

***Moisture Excess*:** Crop loss due to water inundation is noticed during pre-harvest stage particularly in low-lying areas of white jute belt. CRIJAF took initiative to assess the variability for tolerance to water inundation. Twenty accessions each of white and tossa jute and 6 wild species represented by one accession each were evaluated under inundated condition (30 cm water depth) from 60 days crop age. All the genotypes succumbed to the stress as evidenced by profuse growth of adventitious roots, stunted stem growth and early senescence of leaves. But *Corchorus trilocularis* showed no such symptoms and identified as only tolerant genotype.

Biotic Stress Tolerance

***Fungal Diseases*:** The pests, which are ubiquitous, infest jute crop every year and cause crop loss to the tune of 10-20%. There are as many as 14 diseases of jute caused by 6 fungal pathogens. The major diseases, which reduce the yield of jute, as well as fibre quality are, stem rot, root rot, collar rot and seedling blight. All these 4 maladies are caused by *Macrophomina phaseolina* (Tassi) Goid. syn. *M. phaseoli* (Maubl) Ashby.

A preliminary field evaluation of entire gene pool of white jute (*C. capsularis*) and tossa jute (*C. olitorius*) was carried out to find out the range of diversity with regard to natural incidence of diseases. The scale used in assessing the resistance/ susceptibility of an accession was : 0% infection – resistant, 0.1-5.0% infection moderately resistant, 5.1-10.0% infection moderately susceptible, 10.1- 20.0% infection susceptible and above 20% infection-highly susceptible. A summary of the observations is presented in Table 6 (Mahapatra *et al.*, 1994 and Saha *et al.*, 1994).

In mesta the major diseases are foot and stem rot, sclerotial rot and phoma leaf spot. Foot and stem rot is caused by *Phytopthora parasitica* Dast. Causal organism of sclerotial rot is *Sclerotium rolfsii* Sacc. and *Phoma* sp. causes *Phoma* leaf spot. The scale used in this case was same as mentioned for jute. But for *Phoma* leaf spot the % leaf area affected by the spots was considered for assessing resistance or susceptibility of a type. Thus the scale used was: no spot – resistant, 5.0% of leaf area affected – moderately resistant, 5.1-10.0% leaf area affected – moderately susceptible, 10.1-20.0% area affected – susceptible and above 20.0% area affected – highly susceptible. Observations have been presented in Table 7 (Mandal *et al.*, 1995 a, and 1995 b). Above observations primarily identified potential donor germplasm in respect of resistance to major fungal diseases. The short listed germplasm has formed the base material for resistance breeding in jute and mesta.

Table 6. Natural incidence of stem and root rot in white and tossa jute germplasm caused by *Macrophomina phaseolina*

Crops species	Diseases reaction	No. of accessions
C. capsularis (White jute)	Resistant	205
	Moderately resistant	437
	Moderately susceptible	116
	Susceptible	57
	Highly susceptible	6
C. olitorius (Tossa jute)	Resistant	182
	Moderately resistant	665
	Moderately susceptible	414
	Susceptible	177
	Highly susceptible	35

Table 7. Natural incidence of foot and stem rot, sclerotial rot and *Phoma* leaf spot in HC and HS mesta

Crop species	Disease reaction	Foot and stem rot	Sclerotial rot	*Phoma* leaf spot
H. cannabinus (HC Mesta)	Resistant	419	501	34
	Moderately resistant	107	27	446
	Moderately susceptible	2	Nil	28
	Susceptible	Nil	Nil	Nil
	Highly susceptible	Nil	Nil	Nil
H. sabdariffa (HS mesta)	Resistant	335	373	271
	Moderately resistant	70	41	147
	Moderately susceptible	13	4	4
	Susceptible	4	4	Nil
	Highly susceptible	Nil	Nil	Nil

Insect Pests: Insect pests, which cause substantial damage to jute crop, are *Apion corchori* Marshall (stem weevil), *Anomis sabulifera* Guen (jute semilooper), *Polyphagotersonemus latus* Bank (yellow mite) and *Diacrisia obliqua* Walker (hairy caterpillar). Three more pests cause serious damage but are localized and appear sporadically. These are *Spodoptera exigua* Hbn. (Indigo caterpillar), *Nupsera bicolor* (stem girdler) and *Barachytripes achatinus* Stoll (field cricket). Minor pests of jute are *Myllocerus discolor* Boheman (grey weevil) and *Oligonychus coffeae* Nietner (red mite). Besides these, 6 very minor pests also exist.

Both tossa and white jute germplasm have been evaluated for the three major insect pests of jute like yellow mite, semilooper and stem weevil in the field conditions. Wide range of diversity could be observed in tossa jute germplasm for susceptibility /tolerance to these insect pests (Table 8). Percentage of infestation varied between 5.36 (JRO 524) to 63.71 (OIJ 137) for yellow mite. Majority of germplasm showed infestation between 20-30%. No accession showed resistant reaction. Percent infestation for semilooper ranged between 21.00 (OIJ 203) to 39.14 (OIN 189). Most of the accessions showed infestation around 30%. For stem weevil, diversity range for infestation was between 12.68 (OIM 028) – 39.47 (OIN 857) and majority showed around 20% infestation (Pradhan, 1987-89; 1993-95).

In case of white jute yellow mite, infestation percent varied from 6.20 (CIN 362) to 16.96 (CIN 189). No resistant genotype could be identified in the studied materials. Percent infestation for semilooper varied between 15.43 (CIN 003) to 48.99 (CIM 084). Majority of the accessions showed around 40% infestation. Accessions of white jute showed stem weevil around 22% infestation with range between 18.28% (CIM 036)-33.36% (CIN 360) as shown in Table 8 (Pradhan, 1990-92).

Nematodes: The nematodes that attack roots of jute crop with consequential pathological symptoms are *Meloidogyne incognita* (Kofoid and White) Chitwood and *M. javanica* (Treub) Chitwood. Five hundred and seven accessions of white jute were screened against root knot nematode by growing them in the sick field having record of *M. incognita* infestation. Infestation was classified in 0-5 scale on the basis of gall intensity and extent of root damage (Mishra and Chakraborty, 1987).

Table 8. Diversity range of infestation (%) for three major insect pests in tossa and white jute germplasm

Crops	Insect pests	Diversity range of infestation (%)
C. capsularis (White jute)	Yellow mite	6.20 – 16.96
	Semilooper	15.43 – 48.99
	Stem weevil	18.28 – 32.36
C. olitorius (Tossa jute)	Yellow mite	5.36 – 63.71
	Semilooper	21.00 – 39.14
	Stem weevil	12.68 – 39.47

Eighteen genotypes were tolerant with index value upto 1.5%. Three hundred and fifty eight genotypes with index value between 1.6-3.5 were moderately susceptible. Highly susceptible group comprised 132 accessions with index value more than 3.5 (Table 9).

One hundred and eighty three genotypes of *Hibiscus cannabinus* (H.C. mesta) were screened against *M. incognita* under pot culture and results have been presented in Table 9. Nineteen genotypes with index value up to 1.5 were grouped as tolerant types. Moderately susceptible group consisted of 147 accessions with index value between 1.6-3.5. Seventeen types showed more than 3.5 index value and grouped as highly susceptible (Mishra, 1987-89).

***Fibre Quality Parameters*:** Fibre quality parameters particularly bundle strength and fineness are of immense importance for production of value added diversified products. Two hundred germplasm of white jute and 300 germplasm of tossa jute were assessed for these two parameters and wide range of variability could be observed in both the species (Table 10). In white jute, observed range for bundle strength was 16.5-29.9 g per tex against check variety JRC 212 with 25 g per tex. This parameter for tossa jute varied between 15.2-32.1 g per tex and the check variety JRO 524 exhibited 26.4 g per tex of strength.

Table 9. Level of nematode infestation in gene pool of white jute and HC mesta

Crops	Gall index value	Category of infestation	No. of accession under each class
C. capsularis (White jute)	Upto 1.5	Tolerant	18
	1.6 – 3.5	Moderately susceptible	358
	3.5 and above	Highly susceptible	132
H. cannabinus (HC mesta)	Upto 1.5	Tolerant	19
	1.6 – 3.5	Moderately susceptible	147
	3.5 and above	Highly susceptible	17

Fibre fineness in white jute ranged between 1.3-2.4 tex while check variety JRC 321 showed 1.5 tex of fineness. In tossa jute this parameter varied from 2.07-3.89 tex whereas check variety JRO 878 exhibited 2.90 tex fineness; (Anonymous, 1998) Lower the "tex" value, finer is the fibre.

Table 10. Range of variability in fibre quality parameters of jute

Crops	Fibre fineness (tex)	Bundle strength (g / tex)
Tossa jute	2.07 – 3.89	15.2 – 32.1
Check variety	2.90 (JRO 878)	26.4 (JRO 524)
White jute	1.3 – 2.4	16.5 – 29.9
Check variety	1.50 (JRC 321)	25 (JRC 212)

Utilization of Germplasm in Varietal Improvement of Jute and Mesta

Systematic jute breeding started in the year 1904 by RS Finlow, appointed by the then Bengal Government as fibre expert. With sustained efforts a number of jute and mesta varieties have been developed to suit different objectives. Thus tossa varieties for early sowing and multiple cropping sequence, for late sowing in rainfed situation, for quality fibre, and for specific locations have been developed. Also in case of white jute, varieties for early sowing in low lying situations, for late sowing in mid and high land situations, responsive to high fertility level, for quality fibre, for specific locations and photo-insensitive varieties have been developed (Chaudhury *et al.*, 2004). Mesta varieties for semi-arid situations, for pulp and paper and with bristle free stem are also available in the varietal pool (Sinha, 2002).

The genetic base of released varieties is very narrow for all the major and minor crops which is a global trend and bast fibre crops are no exception. However, pedigree of all the released varieties of jute and mesta are presented in Tables 11, 12 and 13 which revealed that only 14 accessions parented all the 12 released varieties of tossa jute whereas only 24 accessions were involved in developing all the 13 released varieties of white jute. Nine varieties of mesta involved only 9 different parental accessions.

Realizing the danger of narrow genetic base CRIJAF has made attempts to reverse the trend. Thus JRO 66 and JRC 698, two recently released varieties of jute have been developed involving more number of new genotypes as shown in the Tables 11 and 12.

A paradigm shift in jute cultivation was brought by developing early flowering resistant varieties like

Table 11. Released varieties of tossa jute (*C. olitorius*) and their pedigree

Name of variety	Popular name	Pedigree	Year of release
JRO 632	Baisakhi Tossa	Selection from indigenous type	1954
JRO 878	Chaitali Tossa	JRO 620 x Sudan green	1967
JRO 7835	Basudev	JRO 632 x Sudan green	1971
JRO 524	Navin	Sudan green x JRO 632	1977
TJ 40	Mahadev	Selection from inter-mutant cross	1983
JRO 3690	Savitri	Tobacco leaf x Short internode	1985
KOM 62	Rebati	Gamma-ray derivative of JRO 878	1992
JRO 66	Golden Jubilee Tossa	Selection from multiple cross involving CG, TM, JRO 524, Peking, Bangkok and Tanganyika 1 exotic parents	1977
JRO 8432	Shakti Tossa	IC 15901 x Tanganyika – 1	1999
JRO 128	Surya Tossa	TJ 6 x Tanganyika – 1	2002
Bidhan Rupali		Selection from yellow mutant, x-ray derivative of JRO 632	2002
S 19	Subala	JRO 620 x Sudan green x Tanganyika - 1	2004

Table 12. Released varieties of white jute (*C. capsularis*) and their pedigree

Name of variety	Popular name	Pedigree	Year of release
JRC 321	Sonali	Selection from Hewti	1954
JRC 212	Spnikspma	Selection from an indigenous type	1954
JRC 7447	Sujata	X-ray derivative of JRC 212	1971
JRC 4444	Baldev	JRC 212 x D 154	1980
UPC 94	Reshma	JRC 321 x JRC 212	1983
Hybrid C	Padma	JRC 6165 x JRC 412	1983
KC 1	Jaydev	Gamma-ray derivative of JRC 4444	1992
KTC 1	Rajendra	Selection from an indigenous germplasm IC 30740	1994
JRC 698	Shrabanti	Selection from a multiple cross involving JRC 321, Tripura cap, JRC 212, JRC 918, Cordate leaf, Chinese 1, Egypt S5, EC 41336, EC 101572, Cap. Main land China, Japanese green, Cap. Non-branching and EC 117161.	1999
Bidhan Pat 3		D 154 x D 18 (photo insensitive mutant)	2000
Bidhan Pat 1		Gamma-ray derivative of D 154	2001
Bidhan Pat 2		D 154 x D 18 (photo insensitive mutant)	2001
JRC 80	Mitali	CIM 114 x JRC 321	2004

Table 13. Released varieties of mesta (*H. cannabinus* and *H. sabdariffa*) and their pedigree

Name of variety	Popular name	Pedigree	Year of release
HC 583		Selection from an exotic germplasm from Nigeria	1975
AMC 108	Bhimla	Pure line selection from indigenous germplasm	1982
MT 150	Nirmal	Selection from an exotic germplasm from Nigeria	2004
HS 4288		Selected from a cross between RT 1 x RT 2	
HS 7910	Ujjal	Selected from a cross between HS 4288 x RT 1	
AMV 1		Pure line selection from indigenous germplasm	1966
AMV 2		Pure line selection from indigenous germplasm	1982
AMV 3	Surya	Evolved by backcross method from the cross AMV 1 x AS 163	1989
AMV 4	Kalinga	Selection from a cross between AMV 1 x AS 163	1991
AMV 5	Durga	Selected from a cross between HS 4288 x AS 163	2005

JRO 878, JRO 7835 and JRO 524 during early seventies. In all these three varieties the early flowering resistant gene was contributed by an African accession 'Sudan green'. But the varieties developed during 9th plan period involved a different source for the same early flowering gene i.e. Tanganyika-1.

Utilization of Wild and Weedy Relatives

One hundred and seventy names of the species of *Corchorus* are given in the 'Index Kewensis'. But experts believe that the precise number of 'good species' is around 50 to 60. However, 10 *Corchorus* species including two cultivated ones are found distributed in India. Wild species available with CRIJAF are *C. aestuans* (India and Africa), *C. tridens* (India and Africa), *C. trilocularis* (India and Africa), *C. fascicularis* (India and Africa), *C. urticifolius* (India and Africa), *C. depressus* (India), *C. pseudo-olitorius* (India and Africa), *C. pseudo-capsularis* (Africa).

Potentialities of wild and weedy relatives of *Corchorus* have been assessed for biotic stress tolerance/resistance and fibre quality parameters, *C. pseudo-olitorius* showed immune reaction to fungal diseases like stem rot, root rot, black band, soft rot and anthracnose under conditions of natural infection. Similarly, *C. urticifolius* showed resistant reaction to all diseases but soft rot. *C. pseudo-capsularis* exhibited resistant reaction to all diseases but anthracnose (Palve *et al.*, 2004). Incidentally all the three species utilised were introduced from East Africa. Later on *C. urticifolius* and *C. pseudo-olitorius* were also collected from India. Identification of wild accessions resistant to fungal diseases is of immense value in preventing crop loss due to diseases *vis-à-vis* degradation of fibre quality.

Pre-breeding studies of quality parameters with 5 wild species of *Corchorus* revealed that all the materials produced very weak fibre and bundle strength varied between 5.63 g/tex for *C. trilocularis* to 8.40 g/tex for *C. aestuans* as against 28-32 g/tex for *C. olitorius* and 26-28 g/tex for *C. capsularis* (Table 14). But *C. pseudo-capsularis* produced the finest fibre (0.20 tex) followed by *C. urticifolius* (0.30 tex), *C. aestuans* (0.51 tex), *C. trilocularis* (0.77 tex) and *C. pseudo-olitorius* (0.95 tex) respectively (Palve *et al.*, 2004). Successful inter-specific cross between *C. pseudo-olitorius* and *C. capsularis* showed only 10% pollen fertility. F_2 seeds harvested were small and shriveled.

Table 14. Variability of fibre quality parameters in wild *Corchorus*

Corchorus species	Fibre fineness (tex)	Bundle strength (g/tex)
C. aestuans	0.51	8.40
C. trilocularis	0.77	5.63
C. pseudo-capsularis	0.20	5.67
C. pseudo-olitorius	0.95	7.27
C. urticifolius	0.30	5.50

Impact Assessment

Improvement of varietal status through utilization of introduced germplasm particularly of exotic origin has created significant impact in productivity of jute. During post partition days productivity was a little more than 11 q/ha and at present national productivity has reached 22 q/ha mark. Raw jute produced in the country very well saturates the demand of jute industry comprising 78 jute mills in organized sector and around 1,150 jute diversified units in unorganized sector.

Earlier, field duration of jute was 135-150 days. But at present this is a crop of moderate duration (110-120 days) with increased capacity to harvest more of solar energy. Roselle (H.S. mesta) was originally a long duration crop of 180 days. Reduction of field duration by 30 days has been possible with increased capacity of fibre production. All these have been possible due to employment of new donor parents in crop improvement programme from India and abroad. Curtailment of field duration coupled with advancement of sowing date by about 30 days has made jute crop suitable for multiple cropping. Crop rotations like jute-paddy-wheat/paddy/pulses/vegetables has made the crop sustainable with increased income of the farmers.

In the fibre quality front, exotic germplasm has left a footmark. The finest quality fibre producing white jute variety JRC 321 was selected from an exotic germplasm 'Hewti'. This variety is in high demand in speciality product development sector. Employing 'Sudan green' and JRO 620 from Africa and India respectively, the finest fibre yielding tossa jute variety JRO 878 was developed. Impact has been felt in marketed fibre grades over plan periods. Supply of grade 5 fibre (the bench mark grade for which minimum support price is declared every year by Agricultural Price Commission) has increased from 34.9% during 6^{th} plan to 40.2% during 8^{th} plan. On the contrary, supply of grade 6 fibre in the market has reduced from 23.7% to 14.8% during the same plan periods (Anonymous, 2005). There is no denying that improved crop husbandry played a role in up-gradation of marketed fibre but intrinsic property built through crop improvement programme had also collaborative role.

Unexploited Potentials of Jute and Mesta

Textile Sector: Jute has ruled the packaging sector for over one and a half century. But the golden era of golden fibre started down slide from sixties and more conspicuously from seventies mainly due to immense pressure from synthetics. Thus new growth areas of jute products became inevitable and technologists have projected various applications of jute fibre.

Manufacture of technical textiles is one of the important areas where jute can be used profitably. The technical textiles are classified into 12 application areas like Agro-tech., Build-tech., Geo-tech., Mobil-tech. etc. where jute can play a major role. Non-wovens and jute composites are also future growth areas. At present 3% of the global production of technical textiles is based on jute, 10% and 85% are based on cotton and man made fibres respectively. World market size has been projected to be US $ 60-70 billion by 2005.

Phytomedicine : A fresh look on the ultimate end uses of fibre as well as the plant as a whole revealed very fascinating information. Jute, mesta and their wild relatives are rich sources of many pharmacodynamic compounds like erysimosol, strophanthidin, helveticoside, β-sitosterol, ursolic acid etc. These compounds are used for drug preparation for cardiac, urological, gastroenteric and other health problems (Hazra *et al.*, 2003; 2004; Bandyopadhyay *et al.*, 2004).

Seed Oil: Jute and mesta seeds are rich sources of oil (jute seed contains 11-12% and mesta seed contains 21-22% oil) which can find their uses in industries. Fatty acid composition, saponification and iodine values of these oils are very close to edible oil like ground nut, soybean and rape. Mesta seed oil in particular can be made edible after purification (Bhaduri *et al.*, 1985; Gadgil *et al.*, 1988).

Pulp and Paper: Forest has been the main source of raw material for making pulp and paper till date. Rampant deforestation for pulp and paper production has a telling effect on ecology and forest bio-diversity. During 2000-01 share of agro-based materials for pulp making was 37.2% which consisted of cereal straw, bagasse and grasses. Jute and mesta can very well be used as replacement of forest based raw material (wood) whose share is now 53.2% (Hazra and Singh, 1997).

Wood Substitute: Global production of wood was around 8.5 billion cubic meter during the year 2000. Contribution of India was around 2% of global production amounting to 22 million cubic meter. Denundation of forest cover for production of timber is increasing at a faster rate and its impact on environment is being felt.

Jute and mesta being ligno-cellulosic material like wood has emerged as substitute of wood. These fibres can be processed for semi-rigid board by incorporating adhesive chemicals. Packaging of mango, orange, apple and grape in boxes made of 0.6-0.8mm thick sheet has been found suitable and transport worthy. Rigid jute composite board of various thicknesses (3 mm to 20 mm) can be produced and maybe used as wood substitute. The swelling behaviors, nailing and polishing properties of such boards are comparable to good quality timber (Mitra, 1996). Jute stick alone can be used to produce low-density composite board or particleboard using adhesive. Such board can be used for erecting room divider, sound proof lining and false ceiling (Mahapatra and Saha, 1999).

Energy Source: Jute and mesta waste after appropriate conversion can liberate profuse energy. It has been proved experimentally that one kg. jute waste liberates 3,300 K cal. of heat as against 5,200 K cal. from coal and 10,000 K cal. from mineral oil. If jute and mesta are grown in non-conventional areas and the whole plant is used for energy conversion, rural sector can be immensely benefited (Anonymous, 2002).

Information presented in the foregoing paragraphs amply indicate that jute and mesta along with their wild relatives are potential candidates for research to develop various diversified products other than those attempted so long.

Gaps in Germplasm Collection and Future Need

For such wide range of applications of jute and mesta, a diverse gene pool requires to be built up. Germplasm collected so far are mainly from India, East African countries, Nepal, Thailand, Indonesia and China. Collections from USA and Australia are also available with CRIJAF. It can be stated in general terms that East African germplasm are more variable for fibre yield and early flowering resistance, while Indian germplasm are more variable for fibre quality particularly fibre fineness. Wild species from east Africa are endowed with biotic stress tolerance as well as fibre fineness. It is indicative that trait wise variability has got regional distribution. Thus it is necessary to make endeavour to collect jute and mesta germplam from the areas / countries which have not been explored so far. Republic of South Africa is one among such countries with richest diversity of jute and mesta. However, trait specific germplasm are also available in other countries.

Conclusion

Collection and utilization of germplasm has made a phenomenal increase in productivity, but with the advent of synthetic materials, jute faces serious competition in traditional packaging products. Strong promotional efforts and price competitiveness have abated further erosion of the market of jute. To create demand in market, cost of production of jute fibre has to be reduced substantially. Weeding operation consumes about 35% of production cost and apart from crop loss due to diseases and pest, some efficient producing areas lie in flood and drought prone zones. Hence, introduction of trait specific germplasm has become a compulsion. Further, germplasm have to be assessed for desirable traits. Although preliminary evaluation for whole set of germplasm have been carried out for yield potential, diseases and pests resistance, specific evaluation were done only on some representative accessions for early flowering resistance, moisture stress tolerance, leaf area index, relative growth rate, harvest index etc. Whole set of germplasm needs to be evaluated to identify potential donor parents for breeding.

On the other hand, to make the crops suitable for other value added diversified products, evaluation for fibre quality parameters, total biomass production, pulp and paper, wood substitute, and pharmaceutical qualities are needed. Though some valuable traits have been identified in some wild relatives of jute and allied fibre crops germplasm, this could not be utilized due to their inter-specific incompatibility. Applications of modern tools of biotechnology are the need of the hour. CRIJAF has started activities in such areas. Apart from bio-diversity management, global trends towards sustainable development have brought to light the natural renewable, reuseable and biodegradable materials like jute and allied fibres. Consorted research and development efforts will help to regain country's monopoly in exports of this golden fibre. Collection of diversity and its utilization is the answer to these issues.

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