Compiled By

Dr. A.K. Bhattacharjee
Dr. H.S. Sen
Dr. Sitangshu Sarkar
Dr. Anirban Roy
Mr. P. Nayak

Improved Production Technology for Mesta

Published By

Dr. H.S. Sen
Director
Central Research Institute for Jute and Allied Fibres (ICAR)
Barrackpore, Kolkata – 700 120

Improved Production Technology for Mesta

Compiled By

Dr. A.K. Bhattacharjee
Principal Scientist

Dr. H.S. Sen
Principal Scientist and Director

Dr. Sitangshu Sarkar
Senior Scientist

Dr. Anirban Roy
Scientist (Senior Scale)

Mr. P. Nayak
Principal Scientist

Published By

Dr. H.S. Sen
Director
Central Research Institute for Jute and Allied Fibres (ICAR)
Barrackpore, Kolkata – 700 120, India
http://www.crijaf.org

Technical Bulletin Series: 3 A

First published

July, 2007

Published by

Director
Central Research Institute for Jute and Allied Fibres (ICAR)
Barrackpore, Kolkata – 700 120, India
Phone: +91-33-25356124; Fax: +91-33-25350415
Email: crijaf@wb.nic.in ; Web: http://www.crijaf.org

Cover design

Dr. Sitangshu Sarkar

ISBN

Price
Rs. 50 (for individual from India, Nepal and Bangladesh)
Rs. 100 (for institutions within India)
US $ 5 (for others)

Printed at
Graphique International, 12/1B, Madhab Chatterjee Lane, Kolkata – 700 020, India
Phone: +91-33-24749245/ 7268

FOREWORD

The global importance of mesta as a potential substitute for jute, particularly under increasingly drought conditions needs no emphasis. Search for an updated referred documentation on the crop was overdue to cater the growing needs of the research workers, entrepreneurs and the farming community in the wake of rapid diversification and global demand of jute (including mesta) products. Being a global leader both in acreage and production of mesta fibres, the primary responsibility of this sub-continent in enhancing the productivity of the crop consistent with quality can not be overlooked. This document embodies precisely the improved technologies generated so far to improve the productivity of its fibre and the pulping material in particular.

(H.S. Sen)
Director
Central Research Institute for Jute and Allied Fibres (ICAR)
Barrackpore, Kolkata – 700 120

CONTENTS

Introduction

Mesta, a herbaceous annual plant (ligno-cellulosic bast fibre crop like jute) believed to be originated from Afro- Asian countries, ranks next to jute in importance (sharing 15% of raw jute-cum-mesta fibre production) and comprises of two major distinct cultivated species – *Hibiscus cannabinus* (Kenaf, 2n = 36) and *H. sabdariffa* (Roselle, 2n = 72) belonging to cotton family Malvaceae, order: Malvales). Mesta is more adaptive than jute under diverse conditions of climate and soil and it is also very resistant to drought. It is tougher and stronger than jute fibre but is somewhat coarser and less supple. It, however, equals in quality to the medium grades of jute (Berger, 1969). Mesta has proved as a major substitute for jute and is successfully being grown in tropical and subtropical regions of both the hemispheres (Annexure I). The principal producing countries are India, China, Thailand, Egypt, Sudan, Brazil and Australia. In India (2004-05), area under mesta (Annexure II) is around 1.5 lakh ha with an average fibre production of 10.16 q/ha (Mitra *et.al*., 2006). The majority of the area (36%) is concentrated in Andhra Pradesh (A.P.) accommodating roselle which shares 51% of estimated fibre production. In A.P., mesta is concentrated in Srikakulam and Vizianagaram districts accounting for 98.7% area of total area in the State (Sreelatha and Kanaka Raju, 2004). The productivity of mesta is, however, highest (17.12 q/ha) in West Bengal followed by Andhra Pradesh (14.17 q/ha) and Tripura (13.95 q/ha). Mesta area is likely to be enhanced gradually even in non traditional areas due to increasing frequency of droughts. Of late, even traditional jute growing belts are gradually shifting towards mesta cultivation. In a recent communication of 22nd May, 2007 from the concerned Agricultural Development Officers of Kumarganj and Hili blocks of south Dinajpur, West Bengal, it has been learnt that around 40% of the jute area has already been replaced by mesta primarily due to shortage of adequate rainfall, low input requirement and lesser weed problems. All the existing types of of *H. sabdariffa* (roselle) are characterized by slow growth rate and require a longer vegetative period of 180 to 237 days when sown in the optimum period (mid March to mid May) and do not flower before the second week of November, irrespective of sowing dates (Chakravarty, 1974). *H. cannabinus* (kenaf) varieties, on the other hand, are quick growing in nature and exhibit considerable variation in their maturity behaviour. In spite of the slow growth rate of roselle resulting in lesser productivity per unit area per unit time, poor harvest index due to lesser fibre recovery % and inferior fibre quality (Table 1), it is preferred under rainfed conditions of India (covering more than 80% area) since it is more hardy and resistant to drought and can also stand incessant rainfall provided there is no stagnation of water. There are, however, two distinct cultivated forms in roselle. The tall non-branching types cultivated for fibre purpose are designated as *H. sabdariffa* var. altissima Hort. while the bushy and wild types grown mainly for their fleshy edible calyces on their flower buds (Chakravarty, 1974). In southern India, pickles prepared out of these are most popular (Singh, 1997). Mesta seed contains 16-22% of oil and 32% of protein, due to which it is used in cooking. Besides, it has unsaturated fatty acid in low proportion which is used in the elaboration of margarine. After the extraction of the oil, the residue contains approximately 32% of protein and is used as livestock feed. The seedlings, leaves and fruits are used to make sauces, jellies and wines (Wilson and Menzel, 1964 and 1967). Of late, mesta is receiving increasing global attentions as a source of good quality paper pulp due to increasing shortage of hard wood.

Table 1. Important production and quality aspects of kenaf and roselle

Aspects	Kenaf	Roselle	Source
Growth rate	Fast	Slow	
Growth period	Short	Long	
Productivity per unit area per unit time	More	Less	
Resistance to drought	Less	More	
Susceptibility to pests	More	Less	
Susceptibility to diseases	Susceptible to root knot nematode	Resistant to root knot nematode	Pandit and Pathak, 2000
Fibre recovery (%)	5.46-7.39	4.09-5.97	Chakravarty, 1974
Fibre quality	Better	Inferior	Maiti, 1997
Wood	Soft	Hard	Maiti, 1997
Average seed yield (q/ha)	12	7-8	Singh, 1997
Seed weight	Higher	Lower	
Seed oil (%)	18.6 - 28.4	18.1- 22	Gadgil *et.al.,* 1988
Iodine value	101.5 ± 2.6	107.8 ± 3.6	Gadgil *et.al.,* 1988
Saponification value	169.5 ± 3.0	172.0 ± 3.5	Gadgil *et.al.,* 1988
Seed protein	18.4-21.6	16.5-20.7	Gadgil *et.al.,* 1988

Climate

Mesta, especially *H. sabdariffa* has been found more promising than jute under conditions of water stress. It is adapted to diverse climatic conditions from the tropical monsoons of northeastern Thailand up to the Mediterranean regions of the former Soviet Union (Wood and Angus, 1974). Both species require a tropical or sub-tropical climate and, therefore, their cultivation is extended to tropical and sub-tropical regions of both the hemispheres. Their rainfall requirements generally vary from 500 to 700 mm. Long-term rainfall pattern (1996-2006) of Mesta Research Station, Amadalavalasa, Andhra Pradesh (Fig 1) reveals that rainfall available during the major growing period of mesta (June to October) is quite satisfactory for mesta cultivation. The mean temperature during the period was observed to be around 29^{0}C (Fig.2). Long light periods during April-July prolong the vegetative period and plants begin flowering with the advent of short days in September, irrespective of the sowing time (Maiti, 1997). Roselle can stand a warmer and more humid climate than kenaf but it has been found more susceptible to damage due to frost and foggy weather. Neither of them can, however, stand waterlogging (Maiti, 1997; Berger, 1969).

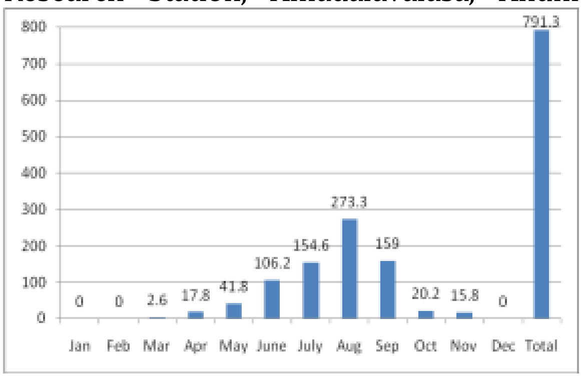

Fig 1. Long term average rainfall pattern at Amadalavalasa, Andhra Pradesh

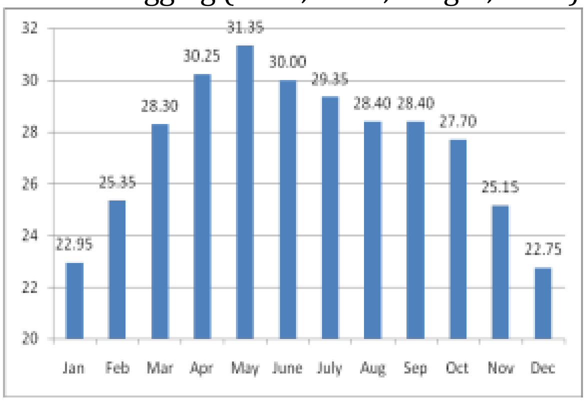

Fig 2. Long term mean temperature at Amadalavalasa, Andhra Pradesh

Soil

Both the species adapt to diverse soil types but for a good growth and development of the crop, soils should be well drained, shallow and of a light sandy loam texture with good quantity of organic material. The crops can also grow in acid soils with a pH of 6.0 to 6.8 (Maiti, 1997). Salinity, however, affects the vegetative growth and fibre yield of mesta (Francois *et.al.*,1992), particularly in case of roselle which has been observed to be affected with chlorosis due to iron deficiency when pH is above 7 (Handbook of Agriculture, 5th edn., Indian Council of Agricultural Research, pp.1044).

Crop improvement

For improvement in fibre yield in a predominantly self pollinated crop like mesta, the distinction in growth pattern and adaptation of two species (*Hibiscus cannabinus* and *H. sabdariffa*) need to be kept in view and successful crossing of the two will be of immense value for developing varieties with rapid growth, higher harvest index, more uniform stem diameter and stress management for varied soil and climatic conditions.

Kenaf (HC 583)

Roselle (GR 27)

Roselle (AMV 4)

Roselle (HS 4288)

As in jute, plant height and basal diameter have been noted to be the effective criteria in the selection of the plant for high yield as they are found to be significantly and positively correlated with the fibre yield (r= +0.8549) (Datta *et. al.*, 1955; Sasmal and Chakravarty, 1977).

The improved varieties evolved in India for the cultivation of mesta for different agro-ecological situations are summarized hereunder (Table 2).

Table 2. Improved mesta varieties of India

Variety	Developing Institute (year of release)	Potential yield (q/ha)	Significant attributes	Area recommended
Roselle (***H. sabdariffa***)				
HS 4288	CRIJAF (1967)	20-22	Stem bristled	West Bengal, Bihar, Assam and Tripura
HS 7910 (Ujjal)	CRIJAF (1977)	18-20	Stem non- bristled	West Bengal, Bihar, Assam and Tripura
AMV 1	MRS (1962)	15-16	Stem bristled	Andhra Pradesh, Orissa and Tamil Nadu
AMV 2	MRS (1982)	16-18	Stem less bristled, tolerant to jassids and mealy bugs	Andhra Pradesh, Orissa and Tamil Nadu
AMV 3 (Surya)	MRS (1989)	18-20	Stem less bristled, resistant to foot and stem rot disease	Andhra Pradesh, Orissa and Tamil Nadu
AMV 4 (Kalinga)	MRS (1991)	20-22	Stem less bristled	Andhra Pradesh, Orissa and Tamil Nadu
AMV-5 (Durga)	MRS (2006)	25-28	Pubescence is present, Leaf and stem pink in colour	Andhra Pradesh, Orissa and Tamil Nadu
GR 27 (Madhuri)	CRIJAF (2007)	27-30	Green stem with red patch in nodes only	Andhra Pradesh, Orissa, Tamil Nadu and West Bengal
Kenaf (***H. cannabinus)***				
HC 583	CRIJAF (1967)	25-30	Moderately resistant to foot and stem rot	West Bengal, Assam and Orissa
AMC 108 (Bhimli)	CRIJAF (1982)	25-30	Resistant to foot and stem rot disease, tolerant to spiral borer and jassids	Southern India, Bihar and Orissa
MT 150 (Nirmal)	CRIJAF (2005)	256 q/ha (Green biomass)	Superior paper pulp quality for newsprints	Entire mesta growing belt

Note: CRIJAF- Central Research Institute for Jute and Allied Fibres, MRS- Mesta Research Station

Cultural practices

Sowing

Seed is the basic and most vital input for optimizing productivity and quality of any crop and, therefore, only certified seed from a reputed agency should be procured for sowing. Line sowing proves superior to traditional broadcasting in both the species as the former facilitates better and timely crop management with reduced cost resulting in comparatively uniform plant stand, better crop growth and higher fibre productivity. Roselle is grown under two situations - as a rainfed kharif crop during May-June to September-October and as a rabi crop during February-March to August in places receiving both the monsoons (South-west and north-east). In other areas, sowing needs to be completed as early as possible, preferably by mid-April to harness higher productivity with reduced pest and disease incidence. Saha and Sengupta (1965) observed that time of sowing and photoperiod exerted significant effect on the growth and development of *cannabinus* mesta. It has been observed that crop sown between March to July flowered by mid or end of September as in case of jute while the vegetative and flowering periods were short with late sowings and yielded lesser. Experimental data suggest that a seed rate of 12.5 kg/ha in case of roselle and 15 kg/ha for kenaf is optimum to achieve the desired plant population of around 4 lakh per ha (Sreelatha and Kanaka Raju, 2004). In drier areas with reduced organic matter content, intra-row spacing of 30 cm is generally adopted while this can advantageously be reduced to 25 cm to accommodate more plants per unit area to enhance fibre productivity consistent with quality, particularly in areas with higher rainfall and soil organic matter content. Besides, plants with reduced diameter provide significantly higher fibre content and dry matter than those with stems of greater diameter (Maiti, 1997).

Cropping system

Multiple cropping

Since *cannabinus* mesta is grown under identical conditions of jute and is harvested simultaneously with jute, jute based cropping systems can advantageously and profitably be followed in case of kenaf also. However, roselle being a longer duration dry region crop, growing of legumes following mesta will prove beneficial both in terms of yield and soil enrichment through atmospheric fixation of nitrogen and enhanced microbial activity. The findings of Mesta Research Station, Amadalavalasa [AICRP Annual Reports of Project No. CP (SA) 13.4 for1987-89] also lent support to this observation and both blackgram (cv. LBG-20) and horsegram (cv. RHG-185) were found promising as succeeding crops due to their very low water requirement. However, an ideal plant will be that which is fast growing, attaining a considerable height within a short period of its maturity associated with high cambial activity adding more fibre per unit of time and such a plant type can be adjusted easily with greater flexibility in a multiple cropping programme (Chakravarty, 1974).

Intercropping

Like jute, mesta is a narrowly spaced fibre crop limiting the scope of intercropping within the rows due to competition effects. In a three year study (1983-85) at Central Research Institute, Barrackpore with roselle cv. HS-4288, it has, however, been observed that intercropping single rows of groundnut (cv.TMV-7, low canopy, 120 days), soyabean (cv. Bragg, low canopy, 90 days) or blackgram (cv.T-9, low canopy, 85 days) between paired or triple roselle rows spaced 15 cm apart is commercially more viable than a roselle crop alone, particularly if the intercrops are sown 15 days after the roselle and groundnut proves to be the most suitable intercrop (Roy *et.al.*, 1990). At Mesta Research Station, Amadalavalasa, intercropping of blackgram with roselle (1:1) has been proved promising (Mitra *et. al*., 2006).

Nutrient management

A uniform and optimum plant stand can exhibit its maximum yield potential only if it is properly nourished and managed thereafter. Soil fertility and its health govern the productivity of any crop while the index of these two vital components is determined by its organic matter content. Mesta is generally grown as rainfed with low levels of nutrients. The recommended dose of fertilizers in Andrah Pradesh for mesta is N_{25} P_{20} K_{20} of which N_{15} P_{20} K_{20} is given as basal and the remaining quantity of N_{10} is provided as top-dress during 25-30 days after sowing. However, trials at Mesta Research Station, Amadalavalasa have revealed that combined application of manure (1 ton poultry manure per ha) and 75% recommended fertilizer dose enhanced roselle productivity (Sreelatha and Kanaka Raju, 2004). The response of assimilation of N on the rate of production of fibre has been found to be smaller in *cannabinus* varieties (AMC-108 and HC-583) as compared with *sabdariffa* varieties (AMV-5 and AS-7). The application of N at 40 kg per ha, however, was found to be optimum for both the species (Laksminarayana *et.al*., 1980). In a light loamy soil, poor in nitrogen but rich in phosphorus and potassium, increase in roselle fibre yield (cv.R.T.2), has been noted with increasing levels of nitrogen application (up to 90 kg/ha) during normal seasons while phosphate application elicited only a minor response as in jute. Potash application has, however, been found to depress the fibre yield of roselle (Jain *et. al*., 1965) and the magnitude of adverse effect of potassium increased with increasing levels of nitrogen (Table 3).

Table 3. Fibre yield (q/ha) of roselle as influenced by nitrogen, phosphate and potash (pooled data for 3 years)

Nutrient Level (kg/ha)		Levels of N (kg/ha) 0	45	90	Average
		Normal crop			
P_2O_5	0	10.11	12.37	13.22	11.90
	45	10.14	12.57	14.15	12.29
K_2O	0	10.58	12.62	14.53	12.58
	28	9.67	12.31	12.83	11.60
Average		10.12	12.47	13.68	

In an alluvium soil (pH 7.35, low in organic carbon and N, medium in P and high in K) on the growth and nutrition of kenaf (cv. HC-583), it has been revealed that there was no significant effect of fertilizers on fibre production during early stages of growth while at later stages (75 days and beyond), addition of N increased the fibre production compared with wood production. Application of N decreased both the fibre tenacity and fibre fineness thus producing weaker and coarser fibre while P and K improved both quality parameters (Sinha and Saha, 1980). In the coarse textured soils of Kendrapara (Orissa), poor in organic matter and nitrogen, it has been noted (AINP Annual Report of NP (MA) 1.4 for 2006-07) that substitution of recommended nitrogenous fertilizer dose (N_{40} P_{20} K_{20}) by 50% through organics, roselle fibre yield improved significantly (Table 4).

Table 4. Effect of integrated nutrient management on fibre yield of mesta at Kendrapara, Orissa

Treatments	Fibre yield (q/ha)
Recommended dose (RD)	23.45
75% RD + 25% N through organic source	25.63
75% RD	20.95
50% RD + 50% N through organic source	27.20
50% RD	16.25
Farmers' practice	11.53
CD 5%	1.92

Fertilizer trials with kenaf (cv. HC-583) conducted at Jute Agricultural Research Institute, Barrackpore (Patel *et.al.*, 1968) during 1964-66 in a light loamy soil (pH 6.5-7.4), deficient in N, rich in phosphate and moderately well supplied with potash revealed that kenaf responded linearly to the application of nitrogen up to 60 kg N/ha. Under limiting soil moisture conditions, it has been found that nitrogen can be fed through foliar spray of urea (up to 5% concentration) using low volume sprayers (Handbook of Agriculture, 5^{th} edn., Indian Council of Agricultural Research, pp.1044)

Weed management

Being primarily a monsoon crop, weeds pose a serious problem in mesta as in jute accounting for around 40% of its cultivation cost towards weeding-cum-thinning alone. In a 2-year study (1982-83), Bhattacharjee *et. al*. (1988) observed that post-emergence application of monosodium methane arsonate (MSMA) @ 5.60 kg/ha was effective in controlling the weeds of roselle (cv. HS 4288) grown in both heavy and light soils. On heavier soils, MSMA also significantly influenced the growth and yield attributes of roselle and registered the highest herbicidal efficiency index (HEI, 0.673) and net profit (58.20%). In a comparatively light soil supporting remarkably higher weed growth, it proved phytotoxic to the crop resulting in the lowest HEI (-0.047) and net return (24.92%) whereas fluchloralin at 1 kg/ha as pre-plant application though found beneficial but could not control nutsedges. The recommended practice of manual weeding twice was found significantly superior in suppressing weed growth in the light soil but proved economically unfavourable in both the soil types because of escalating cost of the hired labour. In comparatively drier regions of Amadalavalasa (A.P.), application of preplant herbicides like Fluchloralin and Pendemethalin exerted phytotoxic effects (AICRP Annual Report of CP (SA) 13.3a for 1987-89) as evidenced by gappy and delayed emergence of roselle (cv. AS-73-CP-304). It has, however, been found that these herbicides were capable of doing away with the first manual weeding at 21 days after sowing. Identical findings were achieved at Coimbatore centre, Tamil Nadu (AICRP Annual Report of 1988 and 1989).

Table 5. Impact of weed management practices in roselle at Mesta Research Station, Amadalavalasa (pooled data for 1987-89)

	Treatments	Fibre yield (q/ha)
T_1	Fluazifop butyl at 400 g/ha as Post emergence (21 DAS)	14.97
T_2	Fluazifop butyl at 600 g/ha as Post emergence (21 DAS)	15.65
T_3	Fluazifop butyl at 400 g/ha Post emergence (21 DAS) + One HW (35 DAS)	17.97
T_4	Fluazifop butyl at 600 g/ha as Post emergence (21 DAS) + One HW (35 DAS)	16.32
T_5	Two hand weeding at 21 and 35 DAS	20.78
T_6	Fluchloralin at 1 kg/ha as Pre-emergence (3 DBS)	16.66
T_7	Fluchloralin at 1 kg/ha as Pre-emergence (7 DBS)	16.45
T_8	Fluchloralin at 1 kg/ha as Pre-emergence (3 DBS) + One HW (35 DAS)	19.45
T_9	Fluchloralin at 1 kg/ha as Pre-emergence (7 DBS) + One HW (35 DAS)	19.34
T_{10}	Pendimethalin at 750 g/ha as Pre-emergence	15.87
T_{11}	Pendimethalin at 750 g/ha as Pre-emergence +one HW (35 DAS)	18.39
T_{12}	Control (weedy check)	13.19
	CD 5%	1.92

Note: HW – Hand weeding, DAS – Days after sowing and DBS – Days before sowing

Weed management technologies evolved for jute is likely to be equally effective in general for mesta crop also. However, under drier conditions with poor soil organic matter content, due cautions need to be undertaken while opting for herbicides, particularly pre-plant and pre-emergent ones (fluchloralin, pendimethalin, triflurain, metolachlor, etc.) due to their phytotoxic effects. In the United States (Lane, Oklahoma), metolachlor, however, proved more promising than trifluralin in a fine sandy loam soil primarily due to its reduced toxicity even at a higher dose of 2.24 kg/ha (Webber, 1992). With increasing environmental consciousness, systematic attempts need to be diverted for managing the weeds preferably through eco-friendly measures as far as practicable considering the harmful role of the herbicides in soil-plant-water system. Further, weeds are important components of biota and are potential source of nutrients. These should not be treated as absolute pests; rather these should preferably be conserved as source of organic compost following manual weeding and their growth needs to be regulated judiciously, preferably through quick growing legume cover crops with low water requirement.

Water management

Being quick growing in nature, mesta is generally grown as a rainfed crop. Kenaf thrives better under partially irrigated conditions, particularly in areas receiving low rainfall (Burger, 1969). The early and late maturing varieties of kenaf responded differently to the levels of irrigation. In Sudan, the early maturing lines produced greater yield when the irrigation was applied every 12 days at early crop growth stages and every 10 days in late stages while the late maturing varieties yielded better when the irrigation was from 10-12 days at early stages and 8 days at later stages (Farah, 1981). During drought, application of fertilizers becomes prohibitive and nitrogen can directly be fed to the crop through foliar spray (up to 5% concentration) of urea. Besides, CRIJAF bast fibre extractor can save up to 80% water requirement and two-third of time for extraction of both jute and mesta during the post-harvest drought spell.

Crop protection

Flea beetle (*Nisotra orbiculata* Mots.), Jassids (*Amrasca bigutulla* bigutulla Ishida), mealy bug (*Maconellicoccus hirsutus* G.), semilooper (*Cosmophilus hirsutus* H.), spiral borer (*Agrillus acutus* Th.), etc. are considered as the major pests of mesta. In general, clean cultivation practices, suitable cropping system, use of bioagents like entomogenous fungus, bacteria and other biopesticides are recommended for effective management of insect pests in mesta without disturbing the environment. Under rainfed conditions, early sowing during April should be avoided in case of spiral borer. Inclusion of a cereal in mesta based cropping system has been found effective in restricting the incidence of nematodes in kenaf. Roselle has however, been found resistant to nematode infection. Besides, foliar spray with neem oil at 5 ml/l of water proved beneficial for the control of semilooper, grey weevil and hairy caterpillars. Flea bettle attacking the mesta seedlings can successfully be controlled by *Beauveria bassiana*, a bio-agent (Pandit and Pathak, 2000). The pest incidence can, however, be effectively controlled using foliar spray with endosulphan 35% EC @ 0.05% or chloropyriphos @2.5 ml/l of water. The incidence and severity of different diseases on the two species of mesta were worked out under natural disease pressure and it has been observed that roselle varieties were more susceptible to foot and stem rot (FSR) (*Phytophthora parasitica*) whereas, the kenaf varieties were found more susceptible to collar rot (CR) (*Scelorotium rolfsii).* The highest foot-cum-stem rot and collar rot were recorded with HS-7910 (53.08%) and MT-150 (46.30%) respectively (CRIJAF Annual Report of JM4.15 for 2005-06, pp.72).

Leaf curl disease of mesta

A comprehensive package accommodating both cultural and chemical approaches is more effective in managing the diseases below the threshold level. Sowing early during first week of April (except in case of spiral borer endemic regions), soil reclamation in acidic soils, suitable crop rotation involving at least one cereal, seed treatment with mancozeb (3g/kg)/ copper oxychloride (5 g/kg) /*Trichoderma viridi* (10 g/kg) and growing of tolerant varieties (AMV-3 for roselle and AMC-108 for kenaf) is recommended. However, pre-sowing chemical seed treatments with copper oxychloride (Blitox 50) and mancozeb (Bavistin) were found most effective against FSR and collar rot respectively (CRIJAF Annual Report for 2005-06, pp. 73-75). Mesta crop suffers from many viral diseases of which yellow vein mosaic and leaf curl disease are most common in the recent years and appear in a devastating manner in eastern and northern India (Chatterjee *et al.*, 2005, Ghosh *et al.*, 2007, Paul *et al.*, 2006). Yellow vein mosaic disease is characterized by yellowing of veins and veinlets and complete chlorosis of the leaves of affected plants followed by defoliation and yield reduction at an advanced stage.

Yellow vein mosaic disease of mesta

If the plants are infected by the virus at the early stage of growth, they do not flower even. The infected plants, in general, show stunted growth with reduced leaf size. Leaf curl disease infected plants showed curly leaves at early stages and then gradually become distorted and puckered. The infected plants, in general, showed stunted growth with reduced leaf size. Both these diseases are transmitted by whitefly (*Bemisia tabaci*). Molecular detection and characterization revealed that a new recombinant *Begomovirus* is associated with these diseases. Foliar spraying of Imidacloprid 20 SL (0.5 ml/l) and Thiomethoaxm 25 WG at 1 g/l of water has been noted to provide appreciable control against whitefly.

Harvesting and retting

Harvesting and retting methods for mesta fibre are similar to that in jute. For paper pulp production, the method is, however, differentas the latter does not involve retting. The harvested bundles are stacked vertically for sun-drying until they attain a moisture content of around 10%. The top 30cm is removed and the dried stems are rebundled for transport to the mills (Wood, 1978). In order to achieve higher fibre yield, roselle crop is generally harvested at pod formation stage as this does not interfere with the recommended mesta based cropping system accommodating a winter crop with low water requirement (generally horsegram or blackgram). In mesta-rice agro-ecosystem, mesta should be harvested by mid-August as in jute and in that case kenaf should be preferred to harness higher mesta equivalent yield. Since water is a scarce commodity during the retting period in majority of mesta growing belts of India, bast fibre extractor developed by the Institute can advantageously be utilized for the purpose to economize on water (up to 80%) and retting time (two-third). Improvement in fibre quality will be an added advantage with this mechanical option.

Productivity

The duration from sowing to flowering is an important determinant of the fibre yield of mesta as majority of the crop is harvested at flowering stage. In 20 varieties of kenaf, it has been observed (Maiti, 1980) that optimum period of growth occurred between 56 and 98 days of the crop age and the vertical growth caused by the apical meristem ceased because of flower initiation after 98 days in majority of the cultivars. Besides, plant height and basal diameter, fibre recovery percentage plays a significant role in influencing the dry fibre yield. The harvest index was found to be more in kenaf than in roselle primarily due to its quicker growth rate and fibre recovery percentage (5.46-7.39% in kenaf cf. with 4.09-5.97% in roselle) as recorded by Chakravarty, 1974. The poor current average productivity of mesta in India (around 12 q/ha) can primarily be attributed to its concentration in marginal soils grown under rainfed conditions and extreme paucity of retting water. Under optimum agro-climatic conditions, *cannabinus* mesta is endowed with the potential of harnessing comparable yield as in jute.

Fibre quality

Mesta fibre quality is inferior to jute in respect to fineness, luster and colour. Among the two species of mesta, the quality of fibre in roselle is inferior to that of kenaf due to non uniform retting, particularly of the basal region. In case of kenaf, basal regions get properly retted thereby giving much better quality of fibre due to lower basal diameter and top diameter ratio and the wood being softer (Maiti, 1997).

Diversification of mesta

Paper pulp

With the growing domestic and global demand of pulping material for newsprints and papers and increasing shortage of hard woods, the role of management practices on pulp production and its quality was estimated for elite bast fibre varieties. In a 2-year study (1982-83) to evaluate the role of rainfed kenaf as the source of raw material for newsprints, Bhattacharjee *et.al* (1987) observed that HC-583 was significantly superior to all other varieties like AC-21-2, AMC 108, AC 7447 and HC 615 except HC 269 in respect of growth components and production of total biomass. Increasing the level of N from 40 to 60 kg per ha and deferring the stage of harvesting from 90 to 110 days also exerted beneficial impact on fibre yield. Green mesta whole plants of 90 and 110 days' maturity have been observed to yield mechanical pulp suitable for blending with chemical pulp to make standard newsprints. Differences in variety and stage of harvest had no appreciable impact on pulp characteristics. The pulp yield was, however, found directly related to total biomass production and therefore, quick growing high yielding varieties like HC-583 and HC-269 were found preferable as source of raw materials for newsprints (Table 6).

Table 6. Influence of varieties, fertilizer levels and stages of harvest on biomass production of mesta

Treatments	**Total green biomass (t/ha)**		
Variety	*1982*	*1983*	*Pooled*
AC 21-2	34.13	41.52	37.85
AMC 108	33.79	41.79	37.79
AC 74-47	34.50	41.44	37.97
HC 269	35.02	53.14	44.08
HC 615	31.47	42.60	37.04
HC 583	35.81	55.21	45.51
CD 5%	1.82	3.46	6.91
Fertilizer			
N_{40} P_{20} K_{20}	31.66	44.51	38.08
N_{60} P_{20} K_{20}	33.12	49.08	41.10
CD 5%	1.05	2.00	NS
Stage of harvest			
90 Days after sowing	31.66	40.35	36.04
110 Days after sowing	33.11	53.23	43.18
CD 5%	1.05	2.00	3.99

The influence of seed rates (10, 12.5 and 15 kg/ha)-cum-nitrogen levels (25, 50 and 75 kg per ha)-cum-stage of harvesting (90, 110 and 130 days after sowing) on the production of roselle (cv. AMV-2) biomass for newsprints was studied at Mesta Research Station, Amadalavalasa during 1987-1989 and the results suggest that mesta biomass production enhanced significantly with advancing stages of harvesting and increasing levels of seed rates and nitrogen indicating a synergistic role of all the factors (AICRP Annual Reports of CP(MA)13.2(a) for 1987-89). In a recent All India Network study (AINP Annual Report of NP (MA) 3.1 for 2006-07, pp. 69) at Mesta Research Station, Amadalavalasa (A.P.) and Aduthurai (Tamil Nadu) on the performance of mesta varieties (AMV-5, AHS-103, and MT-150) for biomass production potential under different nitrogen levels (40, 60 and 80 kg per ha), it has been noted that the variety AMV-5 significantly out yielded the rest in both the centres and the green biomass production improved with increasing nitrogen levels at Amadalavalasa. At Aduthurai, biomass production was significantly highest at N_{60} (Table 7).

Table 7. Green biomass production potential of mesta varieties under different nitrogen levels

Treatments	**Green biomass (q/ha)**	
Variety	*Amadalavalasa*	*Aduthurai*
AMV 5	314.6	550.0
AHS 103	272.9	553.3
MT 150	129.9	426.7
CD 5%	8.1	24.5
N Levels		
No fertilizer	131.8	513.3
N 40 kg/ha	199.3	527.8
N 60 kg/ha	280.1	566.7
N 80 kg/ha	345.5	405.6
CD 5%	14.08	28.32

Kenaf (MT 150)

Amongst bast fibre crops, it has been observed (AICRP Annual Reports of CP (BFA) 8.6 for 1987 - 89) that sunnhemp (cv. K12 yellow) yielded maximum green biomass (excluding leaves) closely followed by kenaf (cv. MT 150). Production of green biomass for making paper pulps enhanced progressively until flower initiation in case of both sunnhemp and *olitorius* jute but in kenaf, particularly with MT 150 cultivar, this continued up to seed formation stage. In an attempt (Sinha *et.al.,* 1985 and Sinha and Sen, 2004) to make newsprint paper from kenaf, whole mesta plants harvested at 50% flowering stage were used and it was observed that MT-150 excelled over the rest in general and produced newsprints pulp of superior quality (even better than Russian and Canadian ones), particularly in terms of Fold and Burst factors (Tables 8 and 9).

Table 8. Mechanical and chemical pulping of mesta whole plants

Cultivars	Mechanical pulp				Chemical pulp			
	Pulp yield (%)	BLM	Fold	BF	Pulp yield (%)	BLM	Fold	BF
MT 150	88.0	2565	10-12	12	78.0	4669	20-22	16
Everglade 71	89.0	1832	1-2	4	76.0	2113	10-20	6
MT 889 x MT 183	87.0	1828	2-3	5	75.4	2089	13-14	8
HC 613	82.0	1884	2-3	4	74.0	2930	10-15	6
MT 183	87.0	2340	4-6	6	76.0	2980	14-16	8
AC 212	83.0	1866	2-3	-	75.0	3020	10-15	-
AMC 108	82.5	1960	2-3	-	75.0	3020	10-15	-
AMC 7447	83.0	1900	2-4	-	75.5	2980	10-15	-
HC 269	81.5	1990	2-4	-	75.0	3000	12-18	-
HC 615	81.5	2020	2-4	-	74.0	3050	12-18	-

Note: BLM: Breaking length/metre; BF: Burst factor

Table 9. Comparison of mesta whole plant newsprint with imported newsprint

Sources	Tensile (BLM)	Fold	Burst factor
Mesta (MT 150)	4669	20-22	16
Russian	4700	18	8
Canadian	4500	12	8

Besides, it has been revealed from the extensive studies undertaken in jute/mesta producing countries that most conventional pulping techniques are also suitable for jute/kenaf pulping. Using whole jute/mesta plant, bleachable grade pulp with yield of 48% can be obtained in both the chemical process (Soda-AQ and kraft process). The bark (unretted fibre) and core (wood/stick) fractions can be used to produce pulp with properties comparable to those produced from wood. Kraft and writing papers can be produced in kraft process using existing chippers (pallmann) and stationery digester and the overall quality of kraft and writing papers were found better than those paper produced from wood (Mohiuddin *et.al*., 2004). Besides, mesta can easily compete with wood as a source of pulp due to the fact that mesta pulping involves lesser energy (up to 25%) and chemical inputs (Taylor and Kugler, 1992).

Edible calyces

Wild forms of *sabdariffa* (dwarf, branched and bushy) have been found to bear fleshy calyces on their flower buds and for culinary purposes (jam, jelly, sauce, pickle, etc.) these can successfully be grown during end-May to October for fleshy calyces in a variety of soils (pH 4.4-7.8) using a wider row spacing of 40 cm and 15-20 cm between plants with a marginal fertilizer dose of N_{20} P_{20} K_{10} to yield up to 30 q/ha of calyces. Calyces harvested before opening of the flowers were, however, found to be of superior quality (Singh, 1997).

Bibiliography

Berger, Josef. (1969). The world's major fibre crops - their cultivation and manuring. *Centre D'etude De L'azote 6 Zurich*, pp.294

Bhattacharjee, A. K., Mukherjee, Nirmalendu, Dutta, A. N. and Goswami, K. K. (1987). Suitability of rained kenaf (*Hibiscus Canabinus*) as the source of raw materials for newsprints. *Jute Development Journal* **7 (2)**: 27-29.

Bhattacharjee, A. K.; Mukerjee, Nirmalendu and Saraswat, V.N. (1988). Weed management in roselle (*Hibiscus Sabdariffa* var. altissima (Hort.) grown in different soil types. *Indian Journal of Agricultural Sciences* **58(5)** : 368-73.

Chakravarty, K. (1974). Breeding for high fibre yield in mesta. *Indian Journal of Genetics and Plant Breeding* **34A**: 937-944

Chatterjee, A., Roy, A., Padmalatha, K.V., Malathi, V.G. and Ghosh, S.K. 2005. Occurrence of a Begomovirus with yellow vein mosaic disease of mesta (*Hibiscus cannabinus* L. and *H. sabdariffa* L.). *Australasian Plant Pathology* **34:** 609-610.

Datta, A.N., Sanyal, P. and Kundu, B.C. 1955. Preliminary studies on the effect of different dates of sowing in mesta and roselle. *Proceedings of Indian Science Congress* **1**:258

Farah, S.M. 1981. Irrigation of kenaf (*H. cannabinus*) in the Sudan. *Journal of Agricultural Sciences* **96(3**): 569-578.

Francois, L.E.., Donovan, T.J., and Mass, E.V. 1992. Yield, vegetative growth and fibre length of kenaf on saline soil. *Agronomy Journal* **84(4**); 592-598.

Gadgil, J.D., Mitra, R., Sinha, M.K. and Guha Roy, M.K. (1988). Proximate chemical composition of seeds of *H. cannabinus* and *H. sabdariffa*. *Jute Development Journal* **8(3**):28-30

Ghosh, R., Paul, S., Roy, A**.**, Mir, J. I., Ghosh, S. K., Srivastava, R. K., and Yadav, U. S. 2007. Occurrence of begomovirus associated with yellow vein mosaic disease of kenaf (*Hibiscus cannabinus*) in northern India. *Online Plant Health Progress doi*10. 1094/PHP-2007-0508-01-RS.

Jain, N.K., Gupta, B.N., Sasmal, P.K. and Dutta,, A.N. (1965). Fertility trials with roselle (H. sabdariffa L. var. altissima Hort.), *Tropical Agriculture* **42**:87-92.

Lakshminarayana, A.R., Krishna, M., Rama Rao, M. and Appa Rao, P. 1980. Efficiency of nitrogen utilization by roselle (*Hibiscus sabdariffa*) and kenaf (*Hibiscus cannabinus*). *Indian Journal of Agricultural Sciences* **50(3**): 244-248.

Maiti, R. 1980. Plant Fibres. *Bishen Singh Mahendra Pal Singh, Dehra Dun*, *India,* pp.299.

Maiti, R. 1997. World Fibre Crops. Science *Publishers Inc., Enfield Distribution Co., Post Office Box 699/May Street, Enfield, New Hampshire 03748, United States of America,* pp.208.

Mitra, S., Sinha, M. K., Maiti, S.N. and Sarkar, S. 2006. Recommendations for jute and allied fibre crops - an endeavour of All India Network Project. In: *Central Research Institute for Jute and Allied Fibres Technical Bulletin* 3/2006, Barrackpore 700 120, pp. 28.

Mohiuddin, G., Rashid, M. Rahaman, M., Abul Hasib, Sk.and Razzaque, A. (2004). Pulp and paper from jute and allied fibre crops. In: *Book of papers and proceedings of National Seminar on 'Diversified used of jute and allied fibre crops' (edited by S.K.Hazra and P.G.Karmakar) held at CRIJAF, Barrackpore, India during January 8th and 9th*, pp.1-10.

Pandit, N.C. and Pathak, S. (2000). Management of insect pests in mesta. *Technical Bulletin, Central Research Institute for Jute and Allied Fibres*, pp. 39.

Patel, C.S., Pandey, S.N. and Dargan, K.S. 1968. Mesta responds well to nitrogen. *Fertiliser News* **13(3**): 37-38.

Paul, S., Ghosh, R., Roy, A., Mir, J. I. and Ghosh, S. K. 2006. Occurrence of a DNA -containing begomovirus associated with leaf curl disease of kenaf (*Hibiscus cannabinus* L.) in India. *Australasian Plant Disease Notes*. **1** : 29–30.

Roy, A. R., Sasmal B.C. and Bhattacharjee, A.K.(1990). Effect of intercropping oilseeds and pulses in roselle (*Hibiscus sabdariffa). Experimental Agriculture* **26**: 407-411.

Saha, J.R. and Sengupta, J.C. 1965. Effect of sowing time and photoperiods on the growth and development of *Hibiscus cannabinus*. *Bulletin Botanical Society of Bengal* **19**:3-9.

Sasmal, B.C., and Chakravarty, K.K. 1977. Variability in quantitative characters in mesta (*H. cannabinus* L.). *Acta Agronomica* **26**: 278-282

Singh, D.P. 1997. Mesta (*Hibiscus cannabinus* and *H. sabdariffa*). *Technical Bulletin Series No. 3, Central Research Institute for Jute and Allied Fibres, Barrackpore-743101*, *West Bengal*, pp. 46.

Sinha, A.K. and Saha, S. 1980. Growth and nutrition of *Hibiscus cannabinus* L. *Journal of Agricultural. Sciences* **94**:575-582

Sinha, M.K., Guha Roy, M.K., Chakrabartti, N.K. and Dey, A. 1985.-86. *Annual Report of Project No.JB6.20, Jute Agricultural Research Institute (ICAR), Barrackpore*, pp.6-7.

Sinha, M.K. and Sen, H.S. 2004. High pulp yielding genotypes vis-à-vis paper qualities in jute and allied fibres. In: *Book of papers and proceedings of National Seminar on 'Diversified used of jute and allied fibre crops' (edited by S.K.Hazra and P.G.Karmakar) held at CRIJAF, Barrackpore, India during January 8th and 9th*, pp.17-20.

Sreelatha, T. and Kanaka Raju A. 2004. Latest development for enhancing productivity and improving quality of mesta in Andhra Pradesh. In: *Proceedings of "National seminar on raw jute" organized by CRIJAF and Directorate of Jute Development during April 16-17*, pp.87-92.

Taylor, C.S. and Kugler, D.E. 1992. Kenaf: Annual fibre crop products generate a growing response from industry. In: *New crops, new uses, new markets*. *1992 Yearbook of Agriculture, US Govt. Printing Office, Washington, D.C.*

Webber, C.l. II.1992. The influence of metolachlor and trifluralin on kenaf (*Hibiscus cannabinus* L.) yield components. *Industrial Crops and Products* **I (1):**17-20.

Wilson, F.D. and Menzel, M.Y. 1964. Kenaf (*Hibiscus cannabinus*), roselle *(H. sabdariffa*). *Economic Botany* **18**:80-91.

Wilson, F.D. and Menzel, M.Y. 1967. Kenaf Breeding. *Proceedings of First Conference Kenaf for pulp., USDA Northern Utilization Research and Development Division*, *Illinois,* pp.11-12(Abst.).

Wood, I. M. 1978. Preliminary experiments on the growth of kenaf (*Hibiscus cannabinus*) for paper pulp production in the Ord Irrigation Area, Western Australia. *Australian Experiment on Animal Husbandry* **18**: 97-106.

Wood, I.M. and Angus, J.F. 1974. A review of prospective crops for the ord irrigation area. II. Fibre Crops. *Australian Diversified Land Use Research Technical Paper* **36** : 1-27.

Annexure 1

Global Area and Production of Mesta

Country	Area 000 ha	Fibre (1000 MT)	Stick (1000 MT)
World		430.80	1292
India		200.5	601.5
China		136	408
Thailand		29.5	88
Rest of the World		64.8	194.5

Source: FAO, jute, kenaf and allied fibres, June 2002, CCP: JU/HF/ST/2002/1

Annexure-II

State-wide area, production and productivity of mesta in India

	2002-03	2003-04	2004-05	2002-03	2003-04	2004-05	2002-03	2003-04	2004-05
A. Pradesh	81.0	59.0	54.0	613.0	470.0	425.0	1362	1434	1417
Assam	5.0	5.4	6.0	25.0	26.8	30.0	900	893	900
Bihar	20.0	18.9	15.0	120.3	145.6	105.0	1083	1387	1260
Karnataka	3.1	4.1	4.2	4.2	6.1	6.5	244	268	279
M. Pradesh	0.6	0.9	1.8	1.1	1.8	5.5	330	360	550
Maharashtra	20.0	19.0	27.0	30.0	27.0	47.0	270	256	313
Meghalaya	4.5	4.5	4.6	20.6	20.5	20.6	824	820	806
Nagaland	–	–	–	–	–	–	–	–	–
Orissa	25.4	26.6	24.5	96.9	109.0	102.0	687	738	749
Tripura	1.7	1.4	1.2	12.1	11.2	9.3	1281	1440	1395
U. Pradesh	–	–	–	–	–	–	–	–	–
W. Bengal	8.2	9.7	8.6	72.6	98.8	81.8	1594	1833	1712
Others	1.3	2.6	2.0	5.9	11.5	8.0	817	796	720
All India	**170.8**	**152.1**	**148.9**	**1001.7**	**928.3**	**840.7**	**1056**	**1099**	**1016**

Source: Directorate of Jute Development, Nizam Palace, Kolkata