Vision 2050

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Vision 2050

Central Research Institute for Jute and Allied Fibres
(Indian Council of Agricultural Research)
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West Bengal, India
## Contents

<table>
<thead>
<tr>
<th>No.</th>
<th>Section</th>
<th>Page No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Message from the Minister of Agriculture</em></td>
<td>i</td>
</tr>
<tr>
<td>2.</td>
<td><em>Foreword</em></td>
<td>ii</td>
</tr>
<tr>
<td>3.</td>
<td><em>Preface</em></td>
<td>iii</td>
</tr>
<tr>
<td>4.</td>
<td>Context</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>Goals and Targets</td>
<td>4</td>
</tr>
<tr>
<td>6.</td>
<td>Operating Environment</td>
<td>6</td>
</tr>
<tr>
<td>7.</td>
<td>Challenges</td>
<td>8</td>
</tr>
<tr>
<td>8.</td>
<td>New Opportunities</td>
<td>12</td>
</tr>
<tr>
<td>9.</td>
<td>Strategy</td>
<td>14</td>
</tr>
<tr>
<td>10.</td>
<td>Way Forward</td>
<td>20</td>
</tr>
</tbody>
</table>
MESSAGE

The scientific and technological inputs have been major drivers of growth and development in agriculture and allied sectors that have enabled us to achieve self reliant food security with a reasonable degree of resilience even in times of natural calamities, in recent years. In the present times, agricultural development is faced with several challenges relating to state of natural resources, climate change, fragmentation and diversion of agricultural land to non-agricultural uses, factor productivity, global trade and IPR regime. Some of these developments are taking place at much faster pace than ever before. In order to address these changes impacting agriculture and to remain globally competent, it is essential that our R&D institutions are able to foresee the challenges and formulate prioritised research programmes so that our agriculture is not constrained for want of technological interventions.

It is a pleasure to see that Central Research Institute for Jute and Allied Fibres (CRIJAF), Kolkata, a constituent institution of the Indian Council of Agricultural Research (ICAR) has prepared Vision-2050 document. The document embodies a pragmatic assessment of the agricultural production and food demand scenario by the year 2050. Taking due cognizance of the rapidly evolving national and international agriculture, the institute, has drawn up its Strategic Framework, clearly identifying Goals and Approach.

I wish CRIJAF all success in realisation of the Vision-2050.

(SHARAD PAWAR)
The Indian Council of Agricultural Research, since inception in the year 1929, is spearheading science and technology led development in agriculture in the country. This is being accomplished through agricultural research, higher education and frontline extension undertaken by a network of research institutes, agricultural universities and Krishi Vigyan Kendras. Besides developing and disseminating new technologies, ICAR has also been developing competent human resources to address the present and future requirements of agriculture in the country. Committed and dedicated efforts of ICAR have led to appreciable enhancement in productivity and production of different crops and commodities, which has enabled the country to raise food production at a faster rate than the growth in demand. This has enabled the country to become self-sufficient in food and emerge as a net food exporter. However, agriculture is now facing several challenges that are expected to become even more diverse and stiffer. Natural resources (both physical and biological) are deteriorating and getting depleted; risks associated with climate change are rising, new forms of biotic and abiotic stress are emerging, production is becoming more energy intensive, and biosafety concerns are growing. Intellectual property rights and trade regulations impacting technology acquisition and transfer, declining preference for farm work, shrinking farm size and changes in dietary preferences are formidable challenges.

These challenges call for a paradigm shift in our research approach to harness the potential of modern science, innovations in technology generation and delivery, and enabling policy and investment support. Some of the critical areas as genomics, molecular breeding, diagnostics and vaccines, nanotechnology, secondary agriculture, farm mechanization, energy efficiency, agri-incubators and technology dissemination need to be given priority. Multi-disciplinary and multi-institutional research will be of paramount importance, given the fact that technology generation is increasingly getting knowledge and capital intensive.

It is an opportune time that the formulation of ‘Vision-2050’ by ICAR institutions coincides with the launch of the national 12th Five Year Plan. In this Plan period, the ICAR has proposed to take several new initiatives in research, education and frontline extension. These include creation of consortia research platforms in key areas, wherein besides the ICAR institutions, other science and development organizations would be participating; short term and focused research project through scheme of extramural grants; Agri-Innovation fund; Agri-incubation fund and Agri-tech Foresight Centres (ATFC) for research and technology generation. The innovative programme of the Council, ‘Farmer FIRST’ (Farmer’s farm, Innovations, Resources, Science and Technology) will focus on enriching knowledge and integrating technologies in the farmer’s conditions through enhanced farmer-scientist interface. The ‘Student READY’ (Rural Entrepreneurship and Awareness Development Yojana) and ‘ARYA’ (Attracting and Retaining Youth in Agriculture) are aimed to make agricultural education comprehensive for enhanced entrepreneurial skills of the agricultural graduates.

I am happy to note that the ‘Vision-2050’ document of Central Research Institute for Jute and Allied Fibres, Kolkata has been prepared, based on the assessment of present situation, trends in various factors and changes in operating environment around agriculture to visualize the agricultural scenario about 40 years hence and chalk out a demand-driven research agenda for science-led development of agriculture for food, nutrition, livelihood and environmental security, with a human touch.

I am sure that the ‘Vision-2050’ would be valuable in guiding our efforts in agricultural R&D to provide food and nutritional security to the billion plus population of the country for all times to come.

Dated the 20th June, 2013
New Delhi
preface

Jute is the second most important fibre yielding annual plant, next to cotton, cultivated in tropical regions of the world. It is mainly grown in the South-East Asian countries like India, Bangladesh, Nepal, China, Indonesia, Thailand, Myanmar and some South American countries. The lower gangetic delta contributes more than 80% of total production of jute in the world. Beyond its traditional uses, jute has gained importance in production of diversified value added products which earn more than Rs 2400 crores per annum and the trend is increasing.

Most of the raw jute consisting of jute and mesta in the country has been used traditionally as a source of raw material for the packaging industry. Hence, emphasis so far was given mainly on the production of more fibre irrespective of quality. However, recently finer fibres with higher strength are of great demand for producing value added products. Whole plant of mesta can be used as raw material for pulp and paper industry. High α-cellulose content of sunnhemp fibre and its degree of polymerization make it suitable for production of high quality paper. Ramie fibre can be successfully utilized for manufacturing fabrics, apparels, bio-composites etc. Sisal fibre due to its strength and durability has potential for making cordage, industrial fabrics, geotextiles, bio-composites, etc. while flax fibre can be used for manufacturing high quality fabrics and paper. In view of their growing demand from industry, production of these allied fibres needs to be augmented.

Jute and allied fibre sector today is facing stiff competition from synthetics, changing climatic conditions, shortage of farm labour, non-availability of quality seeds/planting materials and other inputs, and is in the lookout for overcoming these hurdles. Diversified uses of jute and allied fibres crops are however proving more remunerative, but they require different kinds of production and processing technologies. To meet the new challenges, CRIJAF envisions employing new and emerging disciplines of sciences like nanotechnology and advanced research methodologies over the next two decades. Designing of small machines for various operations of JAF farming and production of quality seeds/planting materials will hugely contribute to boost the production of these fibres. Jute and allied fibres and their by-products can be highly economical, renewable, natural sources of bio-energy and important means for mitigating global warming.

The genetic base of cultivated jute and allied fibre crops is narrow which may result in vulnerability to biotic and abiotic stresses. Broadening of genetic base by using new germplasm as well as different wild species having wider adaptation, higher resistance to major pest and diseases is necessary. Jute is a labour intensive crop and weeding accounts for about 35% of the total cost of cultivation. With the ever decreasing supply of agricultural labourer, alternative approach of weed management in jute with eco-friendly means is inevitable. Jute is mainly a rainfed crop. Owing to the erratic nature of rainfall over space, time and quantity, the crop is often subjected to phasic drought spells especially in the early growth stage. However, the crop is equally sensitive to
water logging in the field. Therefore, effective water management techniques for jute crop are required to be developed.

The ability of CO₂ sequestration by jute crop may be handy to reduce the concentration of CO₂ in the air, an inevitable effect of climate change, by further increasing the biomass of the jute plant. By jute cultivation, currently India reduces about 12 million tonnes of CO₂ gas from atmosphere per annum which has been valued at Rs 1080 crores. Estimated revenue from CER (certified emission reduction) of jute cultivation is about Rs 16,000/- per hectare. Benefits of carbon credit of jute farming need to be harnessed in the coming decades.

Large volume of fresh water is necessary for retting to obtain good quality jute fibres. Efforts towards reduction in water volume with ensured fibre quality are needed. Efficient retting microbes need to be identified for further improvement in the fibre quality with significant reduction in duration of retting.

I have the confidence that this vision document will serve as a valuable guide and give necessary roadmap to the researchers and policy makers to achieve the targeted fibre production (raw jute) of 250 lakh bales by 2050. All the scientists of CRIJAF have contributed their intellectual inputs to prepare the document in the present form. Assistance of Dr. Bijan Majumdar, Dr. Kunal Mandal, Dr. Tamina Begum and Mr. Nilanjan Paul in compilation of materials is acknowledged. Constant encouragement and support received from Dr. S. Ayyappan, Hon’ble Director General, Prof. S. K. Datta, Deputy Director General (Crop Science), Dr. N. Gopalakrishnan, Assistant Director General (Commercial Crops), Indian Council of Agricultural Research, New Delhi and Prof. B. S. Mahapatra, former Director, CRIJAF, Barrackpore is gratefully acknowledged. It is hoped that the document would be subjected to periodic reviews to accommodate imminent changes in future so that the perspective plan continues to be close to our target.

July, 2013
Barrackpore

(S. Satpathy)
Acting Director, CRIJAF
Context

As we progress through the twenty first century, challenges will confront us with wide range of changes in diversified areas. Major changes are expected in terms of climatic conditions, atmospheric $O_2/CO_2$ and $H_2O$ levels, depletion of ozone layer, chemical load in agri-ecosystem, and population dynamics. On the other hand, demand for food and feed likely to soar which has to be met with from minimal resources. Hence, existence of mankind in the future world will largely depend on how best we modify our agriculture to achieve futuristic goals. Apart from food and feed crops, demand for natural fibres is ought to increase with the changing lifestyle of the consumers.

Jute and allied fibres (mesta, sunnhemp, ramie, sisal and flax) play an important role in Indian economy. Raw jute (jute and mesta) supports about 4 million farm families and provides employment to the tune of 10.0 million man days in the rural sector. Moreover, about 0.25 million industrial workers and 0.50 million traders get employment in jute sector. Thus, raw jute farming, industry and trade provide livelihood support to about 5 million people though it occupies only 0.47% of the gross cropped area of the country. India is the single largest producer of jute goods in the world, contributing about 60% of the global production. The domestic market continues to be the mainstay of industry consuming about 87% of the total production. At the same time, our export market share is estimated at around 30% of the global market and it is showing an increasing trend. India today earns about Rs 2095 crores per annum through jute good export as against Rs 233 crores in early sixties. This clearly shows that despite stiff competition from cheaper synthetic fibres, jute and allied fibres have made significant progress and have a very bright future.

In the changing climatic scenario, the crop is more likely to be exposed to increased biotic and abiotic stresses. The uneven distribution of rainfall may pose jute to early season drought, while the shrinkage in the natural water resources may affect fibre quality as large volume of clean and slow moving water is required for quality retting. Moreover, the crops may face a wider range of pest and diseases with the elevated temperature, some of which is already making their presence visible. Jute and allied fibre production under the present system of cultivation is labour intensive and costly, which need to be reduced significantly to make it competitive with the cheaper synthetic fibres.

The Central Research Institute for Jute and Allied Fibres (CRIJAF), a premier crop research institute of the Indian Council of Agricultural Research (ICAR), is mandated to develop technologies to improve yield and quality of jute and allied fibres. It remains vigilant and responsive to changing scenario through development of novel technologies and by promoting problem-solving knowledge products. Jute varieties and production technologies developed by CRIJAF have contributed a lot to achieve the landmark production of raw jute over 110 lakh bales/annum. Efforts for exploiting potentials of allied fibre crops such as sunnhemp, sisal, ramie and flax have been relatively little. Though ramie and sisal are much costlier and qualitatively superior to jute fibre, there is stagnation in the area, production and productivity of these crops in
India. Similarly, fibre production potential of sunnhemp and flax have largely remained unexploited in India.

The productivity of jute and mesta has increased by two folds since independence which may be treated as a significant achievement. This was made possible through introduction of high yielding varieties supported by location-specific production and protection technologies. Besides, the *tossa* jute varieties having pre-mature flowering resistance enabled crop to be fitted in the intensive rice based cropping sequence of the eastern and north-eastern part of the country.

At present, jute is cultivated over an area of 8.5 lakh ha in the country with an average productivity of 25.3 q/ha, while mesta (kenaf and roselle) is cultivated in an area of about 1.5 lakh ha and the average national productivity of the crop is around 11 q/ha. Moreover, couple of varieties of finer fibre quality (fineness less than 2.5 tex) have been developed in *tossa* jute, which can cater to the need of industry for producing value added diversified products.

![Graph](image.png)

**Fig. 1: Trend in area and production of raw jute**

CRIJAF envisions challenges that jute and allied fibre sector is facing, especially the competition from synthetics, changing climatic conditions, shortage of farm labour, non-availability of quality seeds/planting materials and other inputs to the farmers, and is in the lookout for emerging domestic and global opportunities. Jute and allied fibre crops and their by-products can be highly economical, renewable, natural sources of bio-energy and important crops for environmental cleaning. The carbon sequestration potential of jute and allied fibre crops are estimated to be much higher than many tree species. Diversified uses of jute and allied fibres crops are proving more remunerative, but they require different kinds of production and processing technologies. It is now realized that jute and allied fibre sector would have to face
several challenges and threats, along with the opportunities that are emanating from both supply and demand perspectives. An effective natural fibres invention and innovation continuum would play a crucial role in addressing a number of supply-side obstructions and in harnessing numerous demand-side opportunities. The pre-conditions for making jute and allied fibre sector more remunerative and sustainable would be to evolve effective mechanisms for technology delivery and to enhance capacity of all stakeholders in the invention-innovation continuum.

‘CRIJAF Vision 2050’ document narrates key challenges and opportunities in the jute and allied fibre sector in the next four decades for developing an appropriate strategy and gives a roadmap to articulate role of the Central Research Institute for Jute and Allied Fibres in shaping the future of the jute and allied fibre crops research for growth, development and equity.
Goals and Targets

1. Increasing yield/meeting market demand for adequate supply of fibre
   • Characterization of germplasm of jute& allied fibre crops both at morphological and molecular level, genetic divergence analysis, evaluation for economically important characters, documentation and registration of identified germplasm and their enhanced utilization through pre-breeding.
   • Development of improved varieties of jute& allied fibres through conventional method integrating marker assisted selection and other biotechnological tools.
   • Development of plant ideotype for increasing fibre yield in jute and allied fibres.
   • Exploitation of hybrid vigour through development/identification of male sterility of jute for productivity improvement.
   • Development of transgenic in jute for resistance to biotic and abiotic stresses and better quality parameters for diversified uses.
   • Standardization of integrated pest and disease management tactics to reduce the losses in yield and quality of fibres caused by biotic stresses.

2. Improving quality to meet industrial requirement
   • Genetic manipulation of lignin biosynthesis for achieving improved fibre fineness in jute, and of pectin biosynthesis for reducing gum content in ramie. Use of nano-technology for improvement of lignocellulosic biopolymers.
   • Determination of anatomical parameters responsible for fibre development in jute and mesta.

3. Less dependent on human labour, water and other inputs
   • Development of cost-effective and user friendly machines for sowing/planting, weeding and application of fertilizer and pesticides in jute and allied fibre crops.
   • Development of harvester-cum-ribboner machines for jute and mesta.
   • Design of cost-effective, user friendly and portable machines for extraction of fibres of jute and allied fibre crops.
   • Up-scaling of jute retting microbial consortia; development and delivery of consortia formulations to the end users.
   • Management of soil fertility with special emphasis on use of locally available organics and biofertilizers, recycling of crop residues under different agro-climatic conditions.
   • Optimizing irrigation schedules for jute and allied fibre crops under different agro-climatic conditions.
4. Jute for protection/conservation/cleaning of environment

- Development of photo- and thermo-insensitive varieties.
- Exploring the potentials of jute (with high carbon sequestration capacity) in mitigating global warming and harnessing the benefits of CER (certified emission reduction) revenue from jute cultivation.
- Simulation studies on weather-growth relationship of jute and allied fibre crops.

5. Exploitation of alternate/diversified/multiple uses of jute and allied fibres

- Exploring potentials of the jute & allied fibre biomass as fodder, bio-fuel and paper pulps
- Promoting use of jute as leafy vegetables.
- Extraction of edible healthy oil with high linoleic acid from seeds of jute & allied fibres.
- Cultivation of jute & allied fibre crops for ameliorating problem soils/ waste lands.

6. Promotion of public private partnership for development of jute and allied fibre

- Public-private partnership in production of quality seeds and planting materials.
- Establishment of accelerated research-extension-farmer-market linkages.
- Availability of farm machines for mechanisation in jute and allied fibre.

7. Capacity building for advance research and extension

- Advance laboratory for frontier research.
- Advance training in emerging field of research.
- Utilization of innovative and progressive farmers as para-professionals for extension.
- Dissemination of technologies through electronic media/e-extension, training of trainers and farmers in improved fibre production technologies; farmer to farmer approach through farm schools and utilization of innovative and progressive farmers as para-professionals for extension.
Operating Environment

CRIJAF is responsible for carrying out and coordinating systematic research on jute and allied fibres in India. At present, CRIJAF has four regional stations mandated with research on allied fibre crops and seed. Three crop research station viz. Ramie Research Station, Sisal Research Station, and Sunnhemp Research Station were established at Sarbhog (Assam), Bamra (Odisha) and Pratapgarh (UP), for conducting research work on ramie, sisal and sunnhemp, respectively. Central Seed Research Station for Jute and Allied Fibres (CSRSJAF) was established at Bubud in Burdwan district of West Bengal to conduct research on seed of jute and allied fibre crops. The institute has fourteen collaborative centres for multi-locational testing and revalidation of the technologies under All India Coordinated Research Project on Jute and Allied Fibres (AICRPJAF), started in 1967 and presently functioning as All India Network Project on Jute and Allied Fibres (AINPJAF). In order to give thrust on jute research, technology, fibre products and marketing, Technology Mission on Jute was sanctioned by the Govt. of India in 2006. CRIJAF is the nodal agency for research component (MM I) with 13 collaborating units in SAUs, Traditional Universities and ICAR Institutes located all over the country. CRIJAF is also an active partner in MM II (extension related programmes).

CRIJAF has well equipped laboratories and field facilities for basic, applied and field oriented research in various disciplines of agriculture. The institute is organized into three Divisions, viz. Crop Improvement, Crop Production and Crop Protection and Agricultural Extension & AINPJAF on JAF Section supported by Farm, Workshop, Library, AKMU Cell, PME Cell, ITMU, Administration and Accounts.

Apart from CRIJAF, there are other national and international organizations and bodies which are working in the area of jute and allied fibres with diversified mandates:

<table>
<thead>
<tr>
<th>Organization</th>
<th>Areas of activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIRJAFT, Kolkata</td>
<td>Development of technologies for processing of fibres for industrial use</td>
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<tr>
<td>Department of Agriculture &amp; Cooperation, Govt. of India</td>
<td>Facilitating the production of breeder seed of HYVs</td>
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<tr>
<td>Directorate of Jute Development, Govt. of India</td>
<td>Quick dissemination of improved technologies among the farmers and capacity building of farmers.</td>
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<tr>
<td>SAUs and Institutes</td>
<td>Research and development on jute and allied fibres</td>
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<tr>
<td>Office of the Jute Commissioner, Government of India</td>
<td>Deals with policy decision about jute and allied fibre crops.</td>
</tr>
<tr>
<td>Jute Corporation of India, Kolkata</td>
<td>Policy determination for fixation of minimum support price (MSP) and facilitate the procurement of jute &amp;mesta from growers and funds support for research and promotion</td>
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<tr>
<td>Indian Jute Industries Research Association (IJIRA), Kolkata Jute Industries</td>
<td>Research on industrial processing of jute and allied fibres.</td>
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<td>Product development</td>
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<tr>
<td>National Jute Board</td>
<td>Policy for marketing jute product and funding for research and development</td>
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<tr>
<td>State Agriculture Department</td>
<td>Development and dissemination of improved technologies among the farmers and capacity building of farmers.</td>
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<tr>
<td>KVKs</td>
<td>Training and demonstration of different improved technologies for dissemination among the farmers</td>
</tr>
<tr>
<td>PPV&amp;FRA, Ministry of Agri., Govt. of India</td>
<td>Registration of varieties under PPV &amp; FR act and facilitate DUS testing of jute varieties.</td>
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Apart from these, a number of institutes in different countries (Bangladesh Jute Research Institute, Institute of Bast Fibre Crops, China) along with international bodies like International Jute Study Group (IJSG), Dhaka are also involved in research and development in jute and allied fibres sector.
Challenges

- Population pressure will shrink arable land and primary emphasis will be given to the food/feed crops. The population pressure is expected to cause 11% increase in average per capita calorie consumption between 2003 and 2050 as estimated by Food and Agriculture Organization of the United Nations. Meeting those demands would require 175 - 220 million hectares of additional cropland. Limited availability of additional arable land and water resources, nutrient mining by exhaustive cropping systems and the declining trend in crop yields globally make fibre availability a major challenge. To restore our environment, sequestration of half a billion tonnes of carbon in the tropics per year (equivalent to 1.8 billion tonnes of carbon dioxide) would require between 50 - 150 million hectares of vegetation. In the coming decades, bast and leaf fibre crops will face a very stiff competition for land with food crops, and may also face new competitors in the area product consumption (environment friendly polymers, alternate packaging materials). With a modest assumption of 50% increase in demand of bast fibre by 2050 (analogous to 50% increase in demand for food production), India has to increase jute productivity to 4.7 t/ha from present 2.35 t/ha if land under jute cultivation remains same. With a projected decrease in available area by 10 – 20%, average productivity should be increased to 5.5 t/ha by 2050.

- As we progress through the twenty first century, major changes are expected in terms of climatic conditions, atmospheric O₂/CO₂ and H₂O levels, depletion of ozone layer, chemical load in agri-ecosystem, population dynamics and associated demand for food, fibres and fuels. For Indian subcontinent, the IPCC has projected 0.88–3.16°C by 2050 depending on the pace in future development scenario. On the other hand, the concentration of atmospheric CO₂ may increase upto 445-640 ppm by 2050. These changes may deplete the SOC pool and structural stability, disrupt the cycle of C, N, S and other cycles and cause adverse impacts on biomass productivity and environment. Climate change with changing water regimes, ground and air temperatures will have potential devastating effect in production. Increased incidence of biotic and abiotic stresses will have adverse impact on fiber productivity of jute and allied fibre crops.

- Under changing climate, abiotic stresses are expected to be major limiting factors for crop improvement and new pests and diseases are expected to break up in the changing climate scenario. A study has proposed that land degradation, climate change, water scarcity and pest problems could reduce up to 25% of world food production in this century.

- Although research for crop improvement has developed number of high-yielding varieties of jute and allied fibre crops, it has measurably failed to develop interspecific crosses to exploit heterosis. Even the extent of heterosis among the interspecific progenies is not remarkable which hinders considerably the harnessing of the benefit of cis genetic research. Development of jute hybrids...
remains a challenge before the scientists. Development of perennial jute varieties capable of yielding seasonal cuts of biomass would be another challenge before the jute breeders.

• Jute crop may serve as carbon sequester. It is already reported that the tap root of C. capsularis grows to a length of 20 to 28 inches, that of C. olitorius 25 to 32 inches with well-developed and more deeply penetrating secondary roots. An integrated approach is needed towards development of jute cultivars with deeper and thicker root systems and strategies that enhance the quantity and recalcitrance of belowground C inputs and management practices that slowdown the decomposition of SOC and its loss to the atmosphere.

• Lack of retting water, in some years, due to rainfall deficit during jute harvesting period has also led to a severe problem of quality retting which dictates its market price. Jute is a rain-fed crop and the important post-harvest operation that is affected seriously by the deficit rainfall or shortage of freshwater is the retting. The normal rainfall or availability of freshwater during retting period is a million dollar question. The trend of last few years clearly indicates that the total rainfall as well as rainfall during retting period is decreasing gradually.

• Under the present mode of fibre extraction from ramie, fibre recovery is only 3-4% of the aboveground biomass (fresh weight basis) which is quite low. Challenges before the scientists are to fabricate a fibre extraction machine which will give at least 12-15% fibre recovery as that will significantly increase the productivity and profitability of ramie farming.

• The fibre of Indian ramie genotypes have 28-30% gum (weight basis) which need to be lowered for production of apparel quality textile fabric. Breeding/development of low gum varieties of ramie is a challenge before the researchers. Then, microbial degumming is preferred over chemical degumming as it is eco-friendly. The microbial consortia are usually used for degumming in liquid condition. The entire handling (storage, transfer, application, etc.) of the consortia is difficult and time consuming. For large scale operations, the culture has to be kept in large sterile containers which are costly and also occupy lot of space. On the other hand, if the inoculum is prepared in solid carriers (beads, powders, etc.), it can be preserved in small containers (poly packets, jars, etc.) for longer periods. Moreover, the repetitive use of the same consortium will reduce the cost of degumming.

• For apparel industries, the fineness of ramie fibre needs to be less than 0.4 tex which at present is imported exclusively from China. Besides, coarser fibre is also imported from China which is used for manufacturing different diversified products. It is therefore, imperative to focus on developing ramie varieties having fibre fineness <=0.4 tex.

• Import of sisal fibre in India increased at least seven times within twelve years period and the same will rise to 23,000 tonnes in 2050 at the present rate of...
population and industrial growth. The import value will be as high as 44 million US Dollar in 2050. Day by day, the price of imported sisal fibre is increasing, so a hefty amount of valuable foreign exchange may be drained from India. Therefore, India has to be self-sufficient for sisal fibre by increasing the production through horizontal and vertical expansion and must have a goal to grasp at least part of the export market also. The projected import of 23,000 tonnes of sisal fibre can be met from domestic production from an area of 15,000 ha with a productivity of 1500 kg/ha. So, the present area of sisal (±3000 ha) need to be expanded and the productivity of sisal fibre required to be increased to 1500 kg/ha (present world average productivity is 865 kg/ha).

- Weed management is important component of jute and allied fibre production as the magnitude of loss due to weed infestation varies between 52 and 70% and weeding alone contributes to about 35% of the total cost of cultivation as it is primarily done manually in majority of the jute growing areas. Due to industrialization and welfare programmes of the government, agriculture sector is facing labour shortage. According to some estimates, by the year 2050, nearly 60 per cent of the population would be living in urban areas, creating unprecedented shortage of labour force in agriculture. Therefore, in future, management of weeds through mechano-chemical means continue to be very important. The potential of herbicide contaminating the ground water has gained considerable attention nowadays. There are indications that few herbicides not only damage the microbial population but crops too when applied in succession. Notwithstanding these apprehensions, herbicides would remain as one of the major tools in weed management as it offers huge benefits to the farmers and as herbicide use is likely to increase substantially in the future but their judicious use is of utmost importance. Develop integrated weed management practices with particular references to i) new safer herbicide molecules ii) improved mechanical weeding tools iii) screening suitable smother crops to increase net return from jute husbandry.

- In the context of probable changing spectrum and increasing loss from biotic stresses due to gradual shift in climatic conditions, edaphic factors and cropping sequence, there will be urgent need to develop ecological modelling for accurate pest and disease forecast for enhancing the efficiency of pest management tactics though precise scheduling of low-volume, persistent pesticides with improved application technologies.

- Diversified/alternative/multiple uses of jute and allied fibre crops hold the key to make their production profitable. Use of jute and mesta biomass in paper pulp production, mesta seeds for biofuel production, sisal leaves and pulps for extraction of vegetable wax and chemicals with pharmaceutical values, mesta/roselle calyx as raw material for producing food items like jelly, herbal tea, etc. jute and mesta leaves as anti-oxidant rich vegetable/ herbal drink, jute leaves and sisal leaf residues as ingredient for making organic manures need
promotion. Mesta fibre usually gives poor remuneration to the farmers but it can be augmented by producing mesta fibre-cum-seed crops which will produce mesta fibre along with mesta seed (22-24% oil). Development of jute and allied fibre crop varieties capable of yielding multiple products of economic value will hold the future of their production.

- There is also need for mechanization in the jute growing areas because labour is becoming scarce and costly which led to higher cost of cultivation.

- Whatever amount of research for development and refinement of technologies are attained may be futile if not reached to the end users (say jute and allied fibre growers) in time. By middle of this century, the quality and quantity of natural resources will further decline. In this scenario, agricultural extension section of the institute will come forward to inculcate the coping strategy among the jute and allied fibre growers.
New Opportunities

1. Since genes controlling some vital characters of jute and allied fibres are scattered among various species/varieties of same species and could not be dragged into a one stock through conventional breeding, it was a serious setback to harness the benefit of available variation in respect of various characters. New frontier areas of science offer opportunities to deploy cutting-edge technologies like biotechnology, nanotechnology and convergence of conventional breeding with modern cell technological approaches for improvement of jute and allied fibre crops.

2. To restore our environment, sequestration of half a billion tonnes of carbon in the tropics per year (equivalent to 1.8 billion tonnes of carbon dioxide) would require between 50 - 150 million hectares land. Jute, during its growth adds about 15 tonnes green leaves to the soil and the root of both the species that penetrated upto 60cm soil depth or more with lateral roots may act as potential carbon sequesters and restorer of soil fertility. As potential for C sequestration in deeper soil layers is large, jute having deeper roots and quick and heavy biomass production characteristics will present greater opportunities for C sequestration. Through jute cultivation in 0.80 million hectare area, India reduces about 12 million tonnes of carbon-dioxide from atmosphere every year which has been valued at Rs 1080 crores. Estimated CER (certified emission reduction) revenue per hectare of jute cultivation is about Rs 16,000/-. Benefits of carbon credit of jute cultivation has not yet been explored and need to be realised in the coming decades.

3. Diversified and alternative uses would be the key to survival of jute and allied fibre crops. In future, bast fibre composites are expected to be good supplement of wood due to high strength and durability in paper pulp industry. Increase in textile demand also opens up opportunity for jute blended textiles and increased use of ramie-cotton blends. Besides, other alternative uses including identification of key botanical compounds from jute and mesta are expected to be developed. Mesta fibre usually gives poor remuneration to the farmers but it can be augmented by producing fibre-cum-seed crops which will produce mesta fibre along with mesta seed containing 22-24% oil. Additional return from mesta seed oil/bio diesel and oil cakes (feed or costly concentrated manures) will add to the net return of mesta husbandry by adding its return to that of fibre. The International Energy Agency has set targets and roadmaps to replace 27% of the transport fuel by biofuel within 2050, which would also reduce carbon di-oxide emission by 2.1 gigatonnes. Today, about one third of the USA’s maize harvest is channelled for biofuel production. Kenaf, roselle, jute and other lignocellulosic fibre crops thus have high opportunity in this area.

4. Mixed and/or intercropping of jute with other short-duration vegetable, pulse, oilseed crops offer opportunities of insurance against drought, control of weed pressure, conservation of soil moisture and additional income to the farmers.
5. Sisal-based composites offer the highest flexural stiffness (16150 MPa) compared to other composites and they will be preferred in future for characteristics like bending and impact in the building and construction industries. With the substantial cuts in the expenditure in defence and aerospace programmes throughout the present world, number of multinational companies are reorienting their product range from high cost and high performance composites towards more environment friendly, less energy-intensive and lower cost plant fibre reinforced specifically sisal based composites.

6. Analysis of India’s import figure of sisal fibre revealed that the demand increased at least 7 times within 12 years period and the same will rise to 23,000 tonnes in 2050 at the present rate of population and industrial growth. Projection of import value will goes as high as 44 million US Dollar in 2050. Countries with higher length of coast line (India ±26,000 km) and preference of maritime transportation certainly require more sisal fibre for meeting the demand either by producing or by importing. Day by day the price of imported sisal fibre is increasing, so the hefty amount of valuable foreign exchange is exhausted from India. Therefore, India has to be self-sufficient for sisal fibre by increasing the production through horizontal and vertical expansion and must have a goal to gain at least part of the export market also.

7. Weed management is important component of jute and allied fibre production as the magnitude of loss due to weed infestation varies between 52 and 70%. Weeding alone contributes to about 35% of the total cost of cultivation as it is primarily done manually in majority of the jute growing areas. Projected shortage of labour in agriculture sector offers opportunity to the researchers to develop energy-efficient farm machines and identify environment-safe chemicals for weed control, other intercultural operations, harvesting, and fibre extraction.

8. Present energy/input (water, nutrient, etc.) use efficiency in jute and allied fibre production in India is so low that their improvement alone can make this sector economically attractive. Advancement in micro-irrigation technology, development of high-analysis, controlled-release fertilizer formulations and their applicators, invention of improved seed drill, herbicide/pesticide applicator offer new opportunities for improving energy use efficiency in jute and allied fibre production.

9. Growing shortage of fresh water for retting has proved to be a serious constraint for cultivation of jute and mesta. This offers new opportunities for development of moist and/or dry retting technologies with introduction of efficient retting microbes, use of sewage and drainage water of cities/towns for retting, and identification of some safe chemicals for spray to achieve quick retting.
Strategy

In the coming decades, bast and leaf fibre crops will face a very stiff competition for land with food and horticultural crops, they may also face new competitors in the area of product consumption like environment friendly polymers, alternate packaging materials, etc. With a modest assumption of 50% increase in demand of bast fibre by 2050 (analogous to 50% increase in demand for food production), India has to increase jute productivity to 4.7 t/ha from the present 2.35 t/ha if land under jute cultivation remains same. With a projected decrease in available area by 10 – 20%, average productivity should be increased to 5.5 t/ha by 2050. To meet the challenges ahead, we may have to achieve following targets

**Improvement of jute and allied fibre crops to suit the changing environment /requirement**

- Development of short duration varieties of jute and mesta (preferably 80 - 90 days) maintaining high productivity by modifying fibre biosynthesis pathway to obtain higher fibre accumulation per day between 20 – 90 days.
- Development of genetic technologies for deferring at later stage
- Development of bast fibre crop ideotypes with higher bark:core and stem:leaf biomass ratio.
- Development of male sterility and/or apomixis based hybrid jute production technology.
- Development of perennial/semi-perennial types of jute and mesta suitable for multi-cut.
- Development of jute, mesta, sunnhemp and flax varieties suitable for growing as intercrop/mixed crop for better, sustainable land utilization and increased net return.
- Development of ramie ideotypes with higher fibre bundle number and minimal gum content.
- Genetic intervention in sisal for increasing growth rate and number of harvestable leaves per year.
- Development of field based sensor systems for prediction of fibre yield and development of nanotechnology and microprocessor based methods for assessing fibre quality in situ.

**Value addition of jute and allied fibres for diversified use and increasing profitability**

- Modification of fibre biosynthesis pathway to minimize meshiness for better spinnability of jute and mesta fibres.
- Development of plant types with smooth periphery and regular shape fibre bundles with higher fibre bundle density per fibre wedge in jute and mesta.
• Pharmacogenetics of valuable chemical compounds from jute and allied fibres and development of technologies and varieties for large scale bioprospecting of valuable chemicals.

• Development of varieties suitable for biofuel production from jute and allied fibres.

• Development of photo-thermo insensitive varieties of jute and mesta for continuous biomass supply to meet the prospective demand from paper pulp industries.

• Evaluation of jute species and varieties for vegetables with higher edible antioxidants like β-carotene, vitamin-C, and various minerals.

• Assessment of medicinal properties of mesta leaves (to exploit as herbal tea) and roselle flowers (for exploiting calyx extract for making delicious jelly) for utilization in food processing industries.

• Extraction of vegetable wax for commercial use and evaluation of the pulp of sisal leaves for pharmaceutical values.

• Identification of fast growing, photo-insensitive species/varieties of jute and mesta for exploitation of their biomass as pulp in paper industries.

• Assessment of oil content and properties of jute and mesta seeds for use in food, fuel and pharmaceutical industries.

Application of biotechnology/ genetic engineering tools for improvement of jute and allied fibre crops

1. Genomics of cellulose-hemicelluloses network(s) in jute and kenaf: targeted manipulation of the hemicelluloses and their interactions with cellulose in bast fibre using comparative genomics and/or reverse genetics:

a) Identifying genes that encode hemicellulose synthase to modulate fibre hemicelluloses content, with a special reference to Golgi-resident hemicelluloses biosynthesis genes including cellulose synthase (Ces)-like (Csl) genes that belong to the CesA super-family.

b) Modifying the interactions of cellulose with non-cellulosic polysaccharides using non-catalytic carbohydrate binding modules (CBMs), polysaccharide-binding proteins.

c) Development of low-hemicellulose jute and kenaf with increased fibre strength and improved bast fibre characteristics, especially fibre fineness.

2. Genomics of lignin metabolic grid in jute and kenaf: targeted manipulation of the phenylpropanoid pathway in bast fibre by metabolic engineering and/or reverse genetics:
a) Development of lignin-free bast fibre in jute and kenaf, without affecting the wood (secondary xylem) lignin content that provides mechanical support to the plant stand.

3. Nanobiotechnology:
   a) Identification and development of jute-derived biopolymers for industrial and biomedical applications.
   b) Design and development of nanocatalysts for conversion of jute wastes to biodegradable industrial solvents and bio-based fuels.
   c) Development of jute and kenaf fibre thermoplastic alloys.

4. Genomics of photoperiodic regulation of flowering and bast fibre biogenesis in jute based on comparative genomics and/or reverse genetics:
   a) Identification and characterization of candidate genes controlling flowering time and bast fibre biogenesis in jute.
   b) Development of day-neutral (photoperiod insensitive), short-duration jute for diverse cropping systems and seed production across spatio-temporal environmental conditions without compromising fibre quality and yield.

5. Genomics of biological retting of bast fibre in jute and kenaf based on transgenics:
   a) Development of auto-retting jute and kenaf in plant by developing transgenics expressing microbial genes that are involved in biological retting process and their pyramiding.

6. Designer jute and kenaf:
   a) Tailor-made crop canopy to maximize nutrient use efficiency and marketable bast fibre yield so as to enable the farmers to custom-design their own optimum crop canopy for their specific growing conditions and needs.

7. Development of jute and kenaf varieties with fibres of lower ‘linear density’ that would allow yarns of lower count to be spun resulting in the production of light-weight fabrics.

Controlling increased incidence of diseases and pests in jute and allied fibre crops

- **Improved ecological modelling for pest and disease forecast**: Development of degree-day models, coupling this with crop modelling will serve to predict insect and pathogen incidence better than empirical relations and these model works based on the accumulation of heat units over stage-specific thresholds of development. This will help to assess impact of climate change on pest dynamics as well as crop-pest interactions which would act as a guide for adaptation measures.

- **Nano-pheromone technology**: Designing of nano-fibre based composite formulations of semiochemical/pheromone for management of Bihar hairy
caterpillar, jute semilooper, mesta hairy caterpillar and sunnhemp hairy caterpillar for enhancing the photo- and thermo-stability. Development of nano-sensor, to detect the release of pheromones at the least concentration which will be a forewarning system for the pest infestation.

- **Nano-formulations of bio-control agents and pesticides:** Nano-encapsulation of pesticides will help in producing formulation of pesticides which will offer effective control of insect pests and pathogens while preventing residue in soil of major insect pests of jute and allied fibres.

- **Nanodipstick technology:** Development of quick and accurate test kit for identification of plant viral, bacterial and phytoplasmal diseases in jute and allied fibre crops to provide the farmers low cost pathogen detection technology.

- **Biotechnological interventions:** Development of transgenic jute with Bt gene against Bihar hairy caterpillar, stem weevil and semilooper will certainly reduce the pest pressure and pesticides use in jute. Using RNAi silencing specific gene which is responsible for host plant-insect interactions may be used for management of sucking pests in jute and allied fibres. Development of pathogen derived resistant transgenic against viral diseases in jute and mesta.

- **Application of genomics:** Better understanding of pathogen and insect pest at the genomic level will open new door for development of disease resistant varieties which will be core component for integrated disease management of jute and allied fibre crops. Management of pests and diseases will be easier as we understand host-pest/pathogen interactions at the molecular level. Such strategies would be more eco-friendly, effective and durable.

- **Bio-intensive disease management:** In the backdrop of increased population build-up of pests and augmented inoculums load of pathogens, no single approach will be effective enough to manage the future pest and diseases. Rather, a combination of approaches spanning from bio-agents (PGPR, endophyte, bio-control agent) to new generation chemicals (including phytochemicals), broad horizontal resistance based host genotypes would be appropriate to tackle the pest scenario.

- **Plant defence activation/ plant immunization/cross protection:** Understanding of practical aspect and mechanism of induced systemic resistance (ISR) and systemic acquired resistance (SAR) mediated through biotic and abiotic plant defence activator which will play important role for eco-friendly disease management of jute and allied fibre crops.

**Integrated weed control measures in jute and allied fibres**

- Shifting of weed species and their life cycles in changed atmosphere/ecosystem will require close monitoring.

- Screening of new herbicides for the control of changing weed dynamics in Jute and allied fibre crops will be needed. Identification of new molecules/ herbicide...
having less or almost no harmful impact on eco-system will be of utmost requirement.

- Mechanical and cultural methods (plant residue management, growing intercrops, cover crops and green manure crops) of weed control will gain importance for generating additional income from the inter/smother crops and simultaneous maintenance of soil fertility.

**Mechanization of jute and allied fibre crops cultivation in view of shortage of labour and cost-effectiveness**

- Development of power-operated seeder/planter, weeder and harvester for jute, mesta, sunnhemp, ramie, sisal, flax and other fibre crops

- Development of automatic jute/ mesta ribboner with an extraction capacity of two quintal dry fibre/hr.

- Development of automatic sunnhemp, ramie and sisal ribboners with an extraction capacity of one quintal dry fibre/hr.

- Development of automatic flax ribboner with an extraction capacity of 50 kg dry fibre/hr.

**Retting of jute and allied fibres with low volume of water and/or with waste water**

- Development of moist retting (5-10% moisture) technology with the introduction of highly efficient retting microbe(s) without degradation in fibre quality.

- Development of dry retting technology with the introduction of highly efficient aerobic retting microbe(s) preferably bacteria may be cloned/genetically engineered without degradation in fibre quality.

- Development of varieties with pectin and xylan degrading gene screened out from the pectin and xylan degrading microbes, in such a way that at 100-120 days of crop growth these genes will show their expression and auto degradation of pectin and xylan will start and the dependency of retting on water will be very less.

- The use of sewage and drainage water of cities/towns for retting may be another probable option which can be tested.

- Possibility of spraying of harmless chemicals for quick retting may be another option.

- Besides these, community retting facilities may be created, where repeated retting can be carried out in stagnant water by maintaining the BOD.

**Development of improved production technologies for perennial fibre crops of Ramie and Sisal**

- Development of ramie varieties with finer fibres (fineness <= 0.4 tex)
• Development of ramie transgenics with diverse genes, singly or in combination, governing tolerance to various biotic and abiotic stresses, which may be tailored into existing germplasm to make them tolerant with enhanced productivity.

• Development of fibre extraction machine for ramie that can give fibre recovery of at least 12 – 15%.

• Development of efficient, cost-effective and easy-to-handle delivery system for microbial degumming consortia in ramie with better shelf-life suitable for repetitive use.

Effective dissemination of jute and allied fibre production technologies

• Establishment of ‘Information Kiosks’ at the village level for speedy and timely dissemination of market/credit/business development information (linked with website).

• Empowerment of jute and allied fibre growers at the grass-root level through network connectivity via mobile applications especially smart phone.

• Maintenance of information data bank in local linguistics for transfer of customised technology cluster to individual jute and allied fibre grower through village resource centres.

• Focus on market led extension and organization of commodity interest groups at village level for improving the profitability of jute and allied fibre cultivation.

• Technology transfer for the jute and allied fibre growers at village/block/district level through organizing “virtual class rooms”

• Launching of expert centres for jute and allied fibre growers at research centre so that jute and allied fibre growers can have face to face interaction with the experts.
Way Forward

For accomplishing the vision and the goals of the Central Research Institute for Jute and Allied Fibres and for enhancing efficiency and effectiveness of the research resources, the following 6-point strategy would be adopted.

1. Balancing futuristic and problem solving research
   - Strengthening of multi-disciplinary basic and strategic research to meet the challenges of climate change on jute and allied fibre crops
   - Orientation of research to harness the benefits of alternate/diversified/multi uses of jute and allied fibre crops for making them competitive with synthetics

2. Modernization of infrastructure/ facilities for conducting upstream research
   - Establishment of well-equipped and centralised laboratories pertaining to genomics, phenomics, biotechnology, biochemistry, fibre quality, physiology, soil science, plant protection and agricultural chemicals
   - Development of new and renovation of old equipment/buildings/workshop, farm office, fibre extraction unit and storage facilities
   - Establishment of greenhouse/polyhouse/glasshouse and creation of phytotron facilities for initiating simulation studies on impact of climate change on jute and allied fibre production
   - Modernization of library facilities through digitization, e-resources and utilization of relevant electronic journals through network (national and international level) in secured manner
   - Creation of crop- and/or region-specific research stations/centres to concentrate on focused research activity

3. Strengthening and development of human and financial resources
   - Increasing cadre strength for focused in-depth research and allocating human resources in different crops in tune with relative importance
   - Mobilizing fund from various sources through motivating scientific staffs for submission of winning proposals in vital scientific fields relevant to jute and allied fibre crops
   - Training and visit of scientists in state-of-the-art laboratories for exposure to the advanced research methodologies
   - Promotion of e-governance (paperless administration) in office

4. Thrust on R&D through collaborative/partnership/network mode
   - Organization of network research projects to meet location specific requirements and refinement/validation of technologies
• Implementation of externally funded and inter-institutional/collaborative research projects

• Strengthening of Public Private Partnership mode of R&D in jute and allied fibre sector

5. **Faster dissemination of technologies by adopting innovative methods of extension and impact assessment**

• Novel methods of technology dissemination of jute and allied fibres

• Modernization of KVKs with adoption of more villages and accommodation of more stakeholders

• Establishment of seed village for boosting quality seed production and farm income

• Development of ATIC with creation of e-extension channel to benefit large number of clientele

6. **Commercialisation of technologies and research outputs in IPR regime**

• Protection of plant varieties in allied fibre crops and motivating researchers through incentives and recognition

• Patenting of inventions/ novel output of research

• Marketing/ commercialization of research innovations (seeds, machines, etc.) through private firms
Agrisearch with a human touch