The Breeding and Development of Kenaf in China

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The Institute of Bast Fiber Crops (IBFC), CAAS, was founded in Yuanjiang, in 1958, was moved to Changsha, Hunan province in 2001.
About 180 staffs, engaged in kenaf, jute, ramie, flax, hemp and other bast fiber crops.
Outline

• Introduction of kenaf
• Brief history of kenaf in China
• Progress of Hybrid Kenaf Breeding
• Characteristic in Tropics (MY)
• Multiple applications of Kenaf & potential markets
• Conclusion

From IBFC kenaf team
Photoinsensitive Super kenaf, over 6 m, 9, November 2012, China.
Introduction of kenaf

- **Kenaf**, Malvaceae, *Hibiscus cannabinus L*, an annual fiber crop, wide adaptability, photosensitive to shortday, $2n=36$
- **Hybrid kenaf**, a high heterosis, Fast growing
- **Leaves**, a high-protein animal food
- **The bark**, long bast fibers
- **The core**, short woody fibers.
- **The kenaf stem**, an ideal blend of long and short fibers for paper and paperboard products, high biomass....
1. Brief history of Kenaf in China

History, Area, Production

• History: started in 1908
• About 100,000 ha in the early 1950’s.
• From 1970's to 1990, area fluctuated around 400,000 ha, peak, > 900,000 ha in 1985

• Since 1990, affected by cheaper synthetical fibers

Fortunately, larger in recent years for kenaf multi-uses.
The changes of retted fiber yield:

1.5T/ha (1970’s, 7.5T dry stem/ha)

2.5--3.0T/ha (1980’s/1990’s, 12.5—15T DS/ha) in 120-150 d

4.5—5.2T/ha (2000's, 18—25T DS/ha), high fiber yield, 150 d.
2. Major agro-ecological kenaf growing regions in China

• (1) The South China Kenaf Belt

• (2) The Yangtze River Kenaf Belt

• (3) The Yellow and Huaihe River Kenaf Belt

• (4) The North China Kenaf Belt (Northwest and Northeast)
**Main kenaf varieties released in China**

Since 1970, there are more than 40 varieties of kenaf were bred and released in production level, promote the development of kenaf production in China.

IBFC(20):

- 722 (1972*), 7804 (1982), Hongyin 135 (1996),

Hybrid Kenaf:

- H005 (1979), H116 (1991), H305 (2005),
GDAAS(3):
Yue74-3 (1986), Xuan No.1 (1992), Xuan No.2 (1992)
ZAAS(3):
FAAS(5):
Furong Hongma 369 (1994), Ming Hong 298, Ming Hong 82/34
FAFU(10):
Fu Hong No.2 (1992), Fu Hong No.3 (2003), Fu Hong 951 (2001),
Fu Hong 952 (2001), Fu Hong 991 (2003), Fu Hong 992 (2007),
Fu Hong 9913 (2007), Fuhong JInuguang NO1 (2007) ...
GXAAS(2):
Guangxi Hongpi (1960), Nanxuan (1963)
Guangxi Univ. (3):
Hongyou No 1 (2007) ...
Introduced from Vietnam (1):
QiPi No.3 (1963)
3. Kenaf Breeding Activities

• (i). Breeding new varieties of anthracnose resistance and high-yield
• (ii) Studies and utilization of hybrid kenaf
(i). Breeding new varieties of anthracnose resistance and high-yield

- The initial breeding program to incorporate anthracnose resistance into kenaf involved straight selection in the variety ‘Madras Red Stem’. Two moderately resistant varieties, ‘Plant protection 506’ and ‘Guangxi Red Skin’, were then selected. Combined with fungicide treatment, these two varieties helped China to recover much of kenaf hectarage previously lost due to anthracnose. A turning point appeared when three kenaf lines were introduced from Vietnam in 1963. Qingpi 3’ (Q3) showed very good resistance to anthracnose
In the 1970s another two resistant varieties ‘722’ (entire leaf) and ‘Xiong-hong 1’ (palmate leaf), were selected by IBFC from the heterogeneous introduction ‘Africa Divided leaf’.
• In 1984, the first Chinese kenaf variety ‘7804’ developed through inter-varietal hybridization. It showed excellent resistance to the all three races of *C. hibisci* Poll. medium maturity, more 18% retted fiber than ‘Q3’ , because of high bark core ratio.

• produce mature seed in the YRB region. But this variety has less lodging resistance.
Later, some new varieties with high yield and good resistance and later mature, such as Hongying135, Chinakenaf10 (KB2), Chinakenaf11 (KB11), Chinakenaf12 and 13, have been bred and released by IBFC in the 1990s and 2000s.

Some provincial agricultural research agencies also established their own kenaf breeding programs, particularly in Guangdong, Zhejiang and Fujian province. Some good varieties released by them were ‘743’, ‘433’, ‘8310’, ‘821’, ‘298’ and ‘8831’, Fuhong series “95-1”, “95-2”, 991, 992 etc.
Main Factors on Fiber yield

• Biomass yield
  final available plants, plant height, stem diameter, growth period......

• Fiber Percentage (Fiber rate to Fresh stem, to dry stem, bast)
  Fiber rate to Fresh stem from low 4.5% to high 6—7%
(ii) Studies and utilization of hybrid kenaf

- The hybrid kenaf breeding program in IBFC started in 1978. The commercial herbicide, “DalaponNa” (CH3CCL3CCNa) was identified as a selective gametocide for hybrid seed production. This finding led to the development of a dedicated hybrid seed production protocol. On commercial scale, about 750kg seed/ha. with more 90% purity of hybrid seeds can be produced by applying this chemosterilent followed by hand pollination.
• In 1980s, from more than 150 crosses, two superior crosses, named as ‘H005’ and ‘H116’, were successfully identified. ‘H005’ and ‘H116’ demonstrated 24.5% and 30.1%, respectively, fiber yield superiority over the standard variety ‘Q3’. Impressively, the F2 generation of the hybrid variety ‘H116’ still showed 18.3% more yield than ‘Q3’.

• In recent years, Super hybrid H305 (2005)、H316 and H318(2007) had been bred successfully ,H305 for using both F1 and F2, its F2 show 30% higher than CK ‘Q3’ in fiber and stalk yield.
Report on kenaf male sterility

Earliest Report on kenaf male sterility, in 1958 by Pate, J.B, but no further report

Cytoplasmic genetic male sterility in kenaf, in 1976 by Ugale, S.P (India), but no further report and uses

The discovery of kenaf male sterility in China,


A series of improved kenaf male sterile lines (Cytoplasmic or cytoplasmic & nucleolus interaction genetic male sterility) were used for breeding hybrid kenaf
Fibre yields of kenaf lines & hybrids in national regional trial
(2004—2006, kg/ha)

<table>
<thead>
<tr>
<th>Place</th>
<th>H318</th>
<th>H316</th>
<th>LC 0301</th>
<th>Fuhong 992</th>
<th>Fuhong 9913</th>
<th>ZH—01</th>
<th>K03—2</th>
<th>CK (KB2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PuTian FJ</td>
<td>5114.10</td>
<td>5015.83</td>
<td>4473.33</td>
<td>5226.67</td>
<td>5075.83</td>
<td>3425.83</td>
<td>5120.00</td>
<td>4282.50</td>
</tr>
<tr>
<td>Nanning GX</td>
<td>3874.20</td>
<td>3401.67</td>
<td>3476.67</td>
<td>3045.83</td>
<td>2792.50</td>
<td>1963.33</td>
<td>3048.33</td>
<td>3038.33</td>
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<tr>
<td>YingTan JX</td>
<td>5242.50</td>
<td>5030.81</td>
<td>5316.67</td>
<td>4874.17</td>
<td>4741.67</td>
<td>4342.50</td>
<td>4807.50</td>
<td>4350.83</td>
</tr>
<tr>
<td>Changsha HN</td>
<td>5050.05</td>
<td>4805.50</td>
<td>4928.33</td>
<td>4287.50</td>
<td>4200.83</td>
<td>3683.33</td>
<td>4184.17</td>
<td>4200.83</td>
</tr>
<tr>
<td>XiaoSha JZ</td>
<td>3447.45</td>
<td>3395.83</td>
<td>3445.00</td>
<td>3250.00</td>
<td>3285.83</td>
<td>3260.00</td>
<td>3146.67</td>
<td>3016.67</td>
</tr>
<tr>
<td>LiuAn AH</td>
<td>3830.85</td>
<td>3571.67</td>
<td>3968.33</td>
<td>3387.50</td>
<td>3198.33</td>
<td>2998.33</td>
<td>3690.00</td>
<td>3064.17</td>
</tr>
<tr>
<td>XinYang Henan</td>
<td>4322.55</td>
<td>3978.33</td>
<td>4150.83</td>
<td>3705.83</td>
<td>3599.17</td>
<td>3165.83</td>
<td>3582.00</td>
<td>3620.00</td>
</tr>
<tr>
<td>Average</td>
<td>4411.65</td>
<td>4171.31</td>
<td>4251.31</td>
<td>3968.21</td>
<td>3867.38</td>
<td>3262.74</td>
<td>3939.88</td>
<td>3653.33</td>
</tr>
<tr>
<td>Over CK (%)</td>
<td>20.75</td>
<td>14.18</td>
<td>16.37</td>
<td>8.62</td>
<td>5.86</td>
<td>-10.69</td>
<td>-0.69</td>
<td>-0.69</td>
</tr>
</tbody>
</table>

① ② ③ ④ ⑤ ⑥ ⑦ ⑧
Spraying gametocide for chemical emasculation of kenaf in winter of Hainan in early years (from 1978-2003)
The kenaf male sterility （cytoplasmic and cell nucleus sterility）
Comparison of different flowers
Artificial pollination for producing hybrid kenaf seeds in Hainan during winter
Sterility Genetic ways of interaction cytoplasmic and nucleus

Cytoplasmic gene:  
F: fertilizable.  
S: sterility

Nucleus gene:  
MSMS: fertilizable,  
MSms: fertilizable,  
msms: sterility

(1). gene type of male sterile line:  S (msms)  
(2). gene type of male sterile keeping line:  F (msms)  
(3). gene type of renewing line:  F/S (MSMS)
High fiber yield male sterile line “100A”, at 21 Oct. 2009 in Yuangjiang, Hunan.
Super Hybrid kenaf H318
MARDI kenaf expert visit field of IBFC
Modern Agriculture on hybrid kenaf
Sown by large machinery in Xinjiang (Northwest of China)
Kenaf raw material basis in Xinjiang
Reaching Aim of 22—25 Ton dry stem/ha.

Require:

• Under the suitable condition of cultivation (soil, fertilizer, water, control insects & disease)

• 5—6 months growing period, plant height 5m, final available effective plants 150,000—180,000pl/ha,

• Good resistance & suitablity to disease&envir.
Super hybrid kenaf H318 fiber yield record: 7500kg/ha by a farmer technician in Honghu county of Hubei province in 2009.
Super hybrid kenaf H318 fiber yield record: 7500kg/ha
The raw bast were separated from fresh stem with small machinery in field.
Kenaf material storege square in Tunhe pulp mill in Xinjiang
Hybrid Kenaf H305 in Tunisa
Tunisia Kenaf Project
Kenaf Utilization
1. For Textile materials:

Applied widely in many products.

Typical Example:

Jiangsu Redbud Dyeing Technology Co., Ltd., produce good jute and kenaf fiber “MBARY” utilizing modern textile techniques to apply in many products development in commercial level ……
2. Eco-friendly Products and Wall cloth

Geotextiles:

Applied widely basic construction areas, such as control water and soil erosion, freeway slope preserving, dam slope preserving, etc.

Bast fiber mulch film: (Developed by IBFC)

Degradating without pollution; air and moisture conditioning bi-directionally
Wall cloth: more comfortable, showed some good qualities, such as natural color, texture and dampproof.

(By Zhejiang Zhicheng Kenaf Wall Cloth Co., Ltd)

Bio-degumming

Fiber after making up
Kenaf fiber for wall cloth

Wall-cloth from Kenaf
Bast fiber mulch film applied in field

Samples of bast fiber mulch film

Bast fiber mulch film applied in field
3. **Pulp and Paper**

**Advantages:**

- Good quality: kenaf pulp take on soft, high strength, high absorptivity, low sulphur-containing substance and bacteriostatic.
- High -yield pulping: pulping rate >48%(whole stalk), >55%(bast fiber).
- Low cost: simple equipments, no need (or less) bleaching, cheap raw materials.
- New varieties: new varieties ensure the raw materials quality and supply.

**Disadvantages:**

- Low price discourage peasants to plant kenaf
- Harvest in a fixed time leading to some storage problems
- Existing equipments do not suit to kenaf pulp making
- Higher transportation cost
Multi-uses of kenaf
4. Kenaf core for construction board

Particle board (exploited by Demao New High-tech Ltd. Changde, Hunan & Tianma group company, Chaoyang, Liaoning):

Characters: strong moisture proof; lightweight; high static bending strength

Market prospects: promising.
Flame- Retarding Board

Developed by FAFU

Characters:

Water content 6〜14%
Static bending strength ≥31.85MPa
Density ≤0.52g·cm⁻³
Rate of heat release ≤80 kW ·min·m⁻²
Horizontal combustion test: up to standard GB2408-80/Ⅰ-Ⅱ
Vertical combustion test: up to FV-0
5. Absorbing Materials

Kenaf core can be carbonized in 250~500°C for lipophilic absorbent.
6. Kenaf seed oil

Edible oil possessing attractive color, savory, good taste, rich nutrition and health care.
Bastfibre processing
Suggestion for Future New Kenaf Pulp Mills

- Selecting **Right Places**
- At **Right Period**
- Using **Right Technology**
- With **Right Management**

**Success**
The prospect

The kenaf market for traditional textile showed declining, but the tendency is becoming better and better for kenaf as low carbon and marginal friendly crop, multiple uses for return to nature and meet the crisis of petroleum oil.

The potential of super hybrid kenaf in fiber and stem yield is marvelous large. How to producing enough qualified seeds with suitable cost will be a key problem to meet the need for market. The prospect of hybrid kenaf is very bright in future production.
Super Hybrid Kenaf H328 near 7 m, released in 2013

Highest dry stem yield, over 30T/ha
The kenaf market for traditional textile showed declining, but the tendency is becoming better and better for kenaf as low carbon and marginal friendly crop, multiple uses for return to nature and meet the crisis of petroleum oil.

The potential of super hybrid kenaf in fiber yield is marvelous large. How to producing enough qualified seeds with suitable cost will be a key problem to meet the need for market. The prospect of hybrid kenaf is very bright in future production.
Thanks for Your Attention!
谢谢！
Ramie (*Boehmeria nivea* L.) and Its Advancement of Breeding in China

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Contents

• 1. Introduction
• 2. Crop and fiber yields
• 3. Ramie germplasm resources
• 4. The main ramie varieties bred in recent years
• 5. The relevant studies with ramie breeding
1. Introduction

Ramie--a hardy perennial bast fiber crops
The useful crop life ranges from 6 to 20 years
the gardon of ramie
Distribution of ramie in China

Ramie planting area

Yangtze river
varieties of home textile

Grass cloth, as a traditional product

ramie textiles
Propagation of ramie

It is generally propagated vegetatively, using rhizome or stem cuttings.

ramie sprout of stem cuttings
The biological traits of ramie

The most suitable climate for ramie is one which is warm and humid with an annual rainfall (or irrigation) of at least 1000 mm, evenly spread over the year.

It is tolerant of a range of soil types.

It can tolerate low temperature in the range of $-8$ to $-10^\circ C$ degrees in winter.

It prefers slightly acid soil conditions with pH in the range of 5.5 to 6.5.
yields

The dry weight of harvested stem from both tropical and temperate crops ranges from about 3.4 to 7.5 t/ha/year; a 7.5 tonne crop yields about 3,400 kg/ha/year of dry undegummed fiber. Yield of degummed fiber of about 1,200 kg/ha/year.
yields of different region

High yield and multi-purpose

**Ramie** yield for multi-purpose

<table>
<thead>
<tr>
<th>Region</th>
<th>Raw Fiber</th>
<th>Tender Shoots</th>
<th>Core</th>
<th>Biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunan</td>
<td>5,190</td>
<td>8,415</td>
<td>16,425</td>
<td>30,030</td>
</tr>
<tr>
<td>Hubei</td>
<td>5,265</td>
<td>9,645</td>
<td>13,695</td>
<td>28,605</td>
</tr>
<tr>
<td>Jiangxi</td>
<td>4,920</td>
<td>9,285</td>
<td>13,635</td>
<td>27,825</td>
</tr>
</tbody>
</table>

- **Textile**
  - 15% higher than farmer’s highest level
- **Feed**
- **Culture medium for mushroom**
- **Residues**
  - More than 80% of the total biomass
  - Rich of CP and other nutrients
More feed gotten by Four cuts (Plant)

Highest profits in Jiangxi for the lowest cost during production (Process)

• We had done researches on optimizing the farming management to gain a higher yield and profit.

Highest yield in Hunan for the most efficient soil management (Soil)
New machine for ramie harvest
Ramie germplasm resources

- The National Field Genebank for Ramie was established in 2001.
- There are 2052 ramie accessions which subject to 19 species and 8 varieties collected and conserved in The National Field Genebank. Among them there are 1901 cultivar accessions and 151 wild species accessions.
- We have exchanged ramie germplasm and information with more than 20 foreign countries or regions.
The main ramie varieties bred in recent years

- Fiber-Zhongzhu NO.1
- Multi-purpose-Zhongzhu NO.3
- Dual-purpose-Zhongzhu NO.2
Zhongsizhu NO.1-It is the first ramie variety used as forage in the world.
Huazhu NO.5
Chuanzhu NO.11
The relevant studies with ramie breeding

- (1) The genetic diversity of 9 main ramie varieties

Fig. 2 Dendrogram generated based on SSR markers for the nine Ramie varieties used in this study.
(2) Study on Glutamine Synthetase Genes Cloning and Over-expression of Ramie

- Glutamine synthetase (GS) plays fundamental roles in higher plants nitrogen primary assimilation.
- GS isoenzymes have essential effects to the nitrogen absorption, assimilation and use efficiency.
- The focus of our study was first isolation and characterization of ramie GS gene families, and comparatively analyzed of GS gene families sequences, GS gene families expression pattern at different tissues and development stages.
• The over-expression plant vector of ramie BnGS1-2 gene was constructed according to homologous recombination technology and transgenic tobacco was obtained by “leaf-disk” transformation method.

• The investigation of the effects of BnGS1-2 over-expression in improving the nitrogen absorption, assimilation and use efficiency provided theoretical basis at molecular level for ramie GS function and nitrogen assimilation pathway, and material basis for utilization of ramie GS genes.
Thanks for your attention!