The Study Situation and Sustainable Development of the Hemp in China

Wang Yu Fu

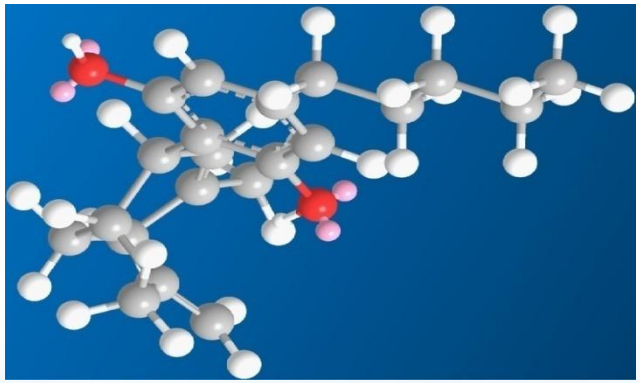
Institute of Bast Fiber Crops(IBFC),

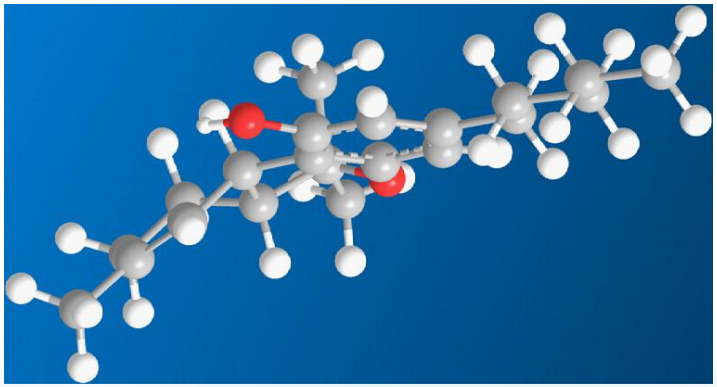
Chinese Academy of Agricultural Sciences(CAAS).
Changsha, China.

E-mail: wangyufu@caas.cn Tel. 0086-731-88998550

contents

- Ⅰ. The general situation of hemp
- Ⅱ. The study situation
- Ⅲ. The sustainable development





Ⅰ. The situation of hemp in China

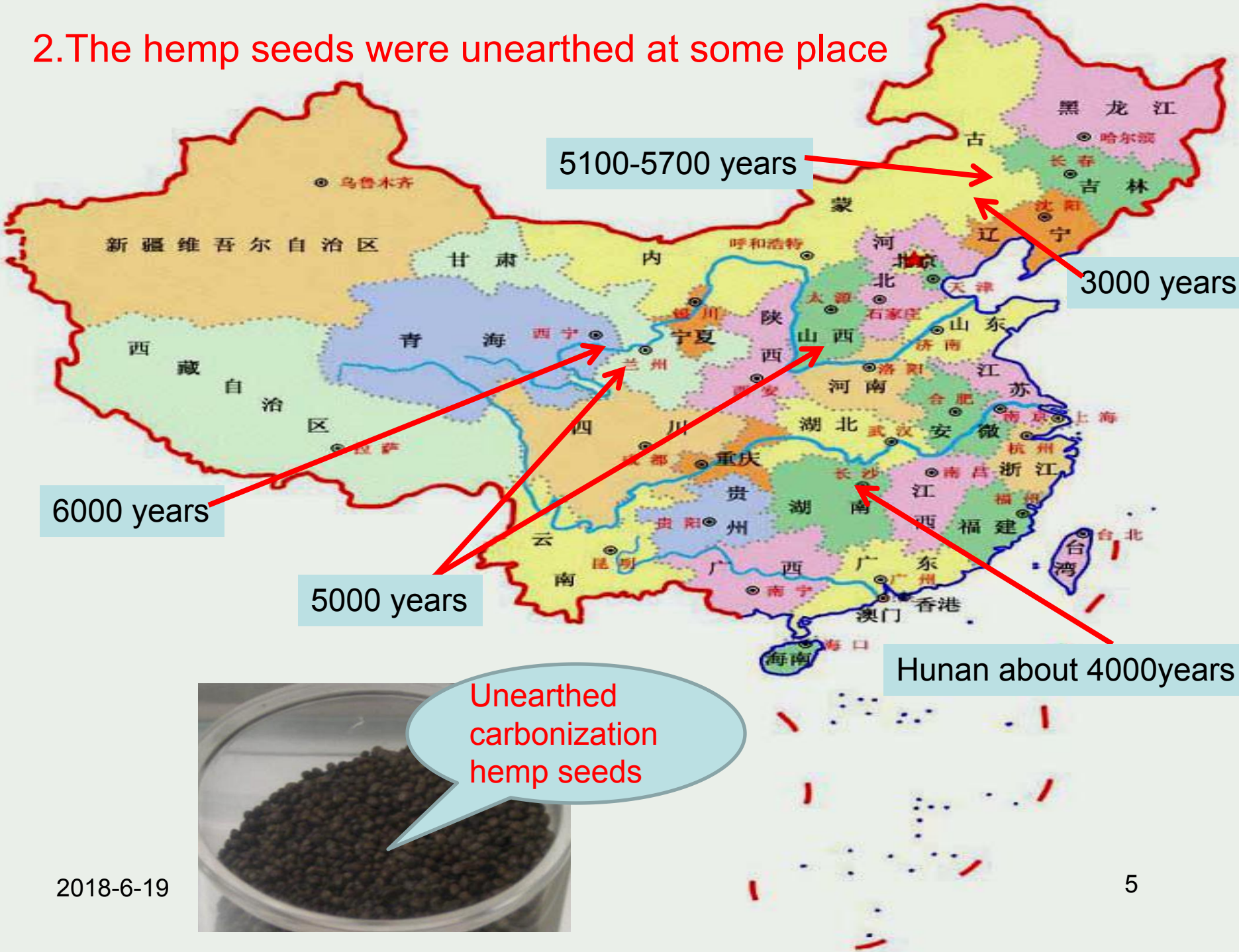
1. Origin and dissemination

- Hemp (*Cannabis sativa*L.) is one of the oldest crops in China and the world.
- Hemp may have been harvested by the Chinese at 8500 years* ago, and it has probably been grown at least 6000 years
- A hemp record of the 3rd century B.C. was found in China.

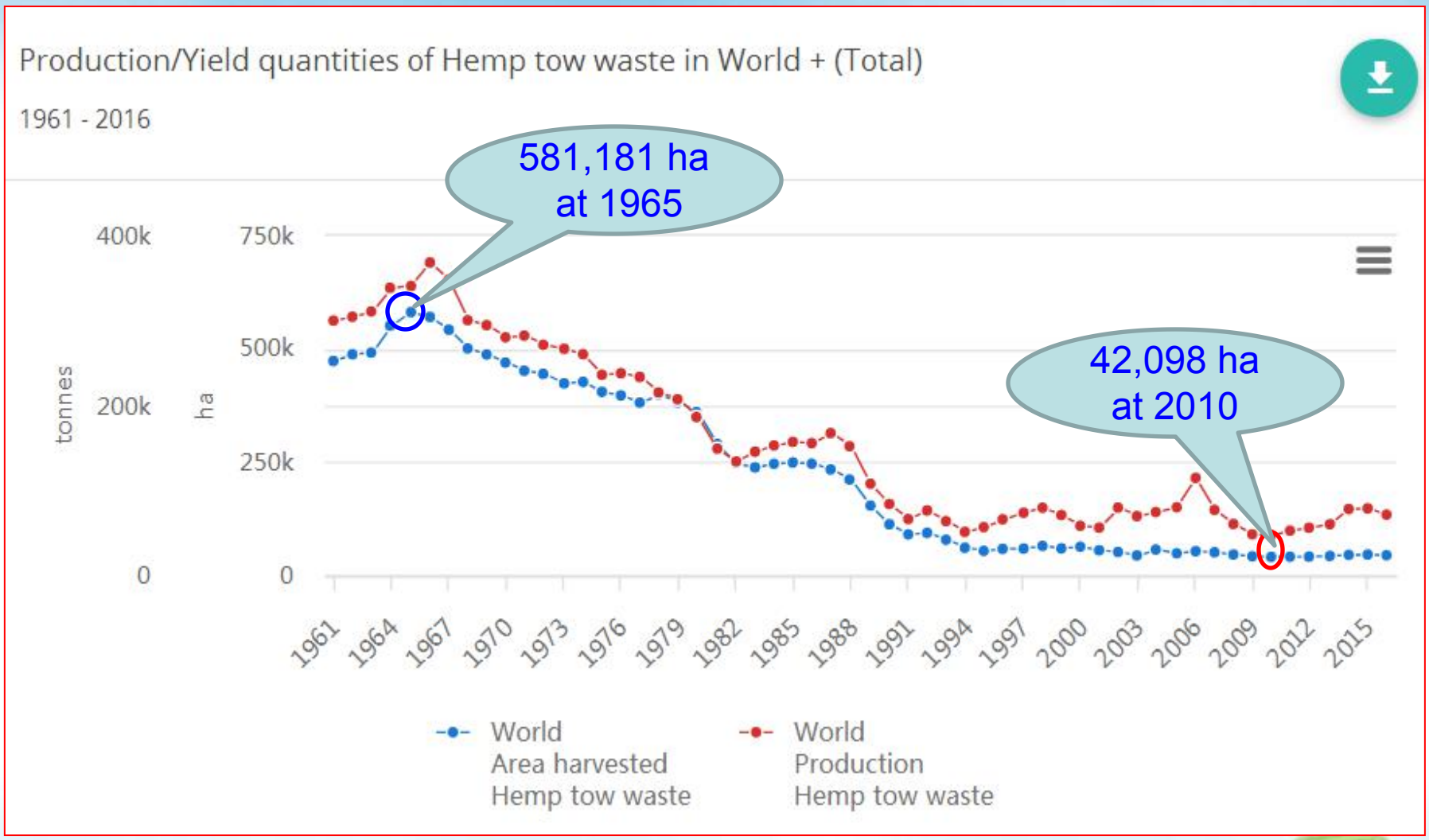
*From: Ernest Small. Evolution and Classification of Cannabis sativa (Marijuana, Hemp) in Relation to Human Utilization. Bot. Rev. (2015) 81:189–294

- Hemp grown for fiber was introduced to western Asia and Egypt, and then to Europe somewhere between 1000 and 2000 B.C.
- Cultivation of hemp in Europe became wide spread after 500 AD.
- Hemp was first grown in South America in 1545 (in Chile), and in North America in Port Royal, Acadia in 1606.The hemp industry flourished in the U.S., particularly in Kentucky. Hemp was widely grown in North America until the early part of the 20th century.

2.The hemp seeds were unearthed at some place



3. Fiber hemp plant area in the word(From FAOSTAT)

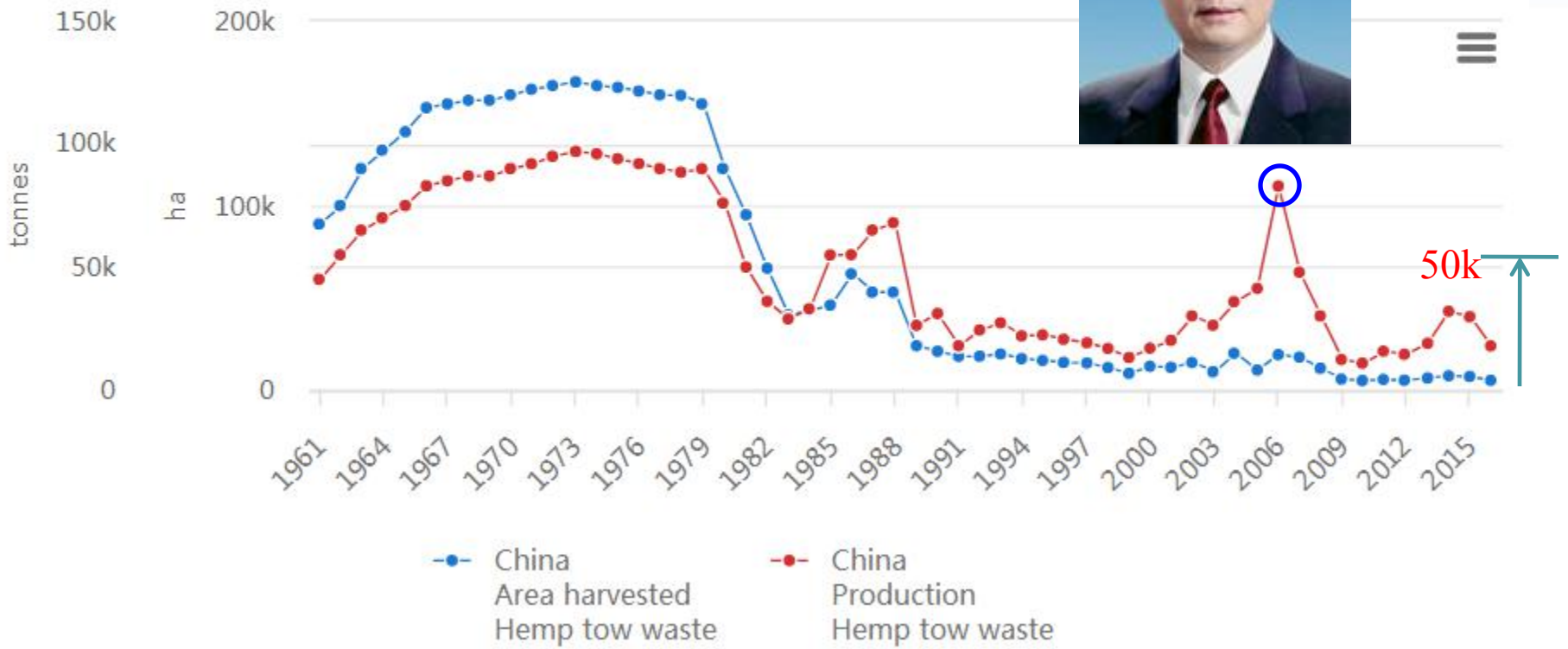


4. Fiber hemp plant area in China (From FAOSTAT)

- The situation of hemp was same in China, but its decrease is postponed slightly. However, the people renewed interest in hemp recent years. The hemp plant area begun to increase in the 21 century.

Production/Yield quantities of Hemp tow waste in China

1961 - 2016



There are about 40,000-50,000 ha hemp in China now.
(including seed hemp and fiber hemp)

The distribution of hemp cultivation in China

Ⅱ. The Study Situation of hemp in China

1. Hemp germplasm

- The studies on hemp germplasm are including: collection, identification and evaluation, preservation, utilization, diversity analysis, etc.
- There are about 500～600 hemp collection in china.
- They were collected at Ynnan, Guizhou, Guangxi, Sichuan, Anhui, Shandong, Shanxi, Henan, Hebei, Heilongjiang, Jinlin, Lianning, Inner Mongolia, Xinjiang, Gansu 15 Province.
- About 200 germplasm have been identified and restored in the National Gene Bank.

The hemp germplasm were collected from 15 provinces all over the China

The place of hemp germplasm

To distinguish the chemotype of hemp germplasm，23 hemp germplasm (69 single plants) from different areas of China were analyzed. The average content of THC was 0.56% ranging from 0.01%～2.45%． The average content of CBD was 0.53% ranging from 0～2.24% .

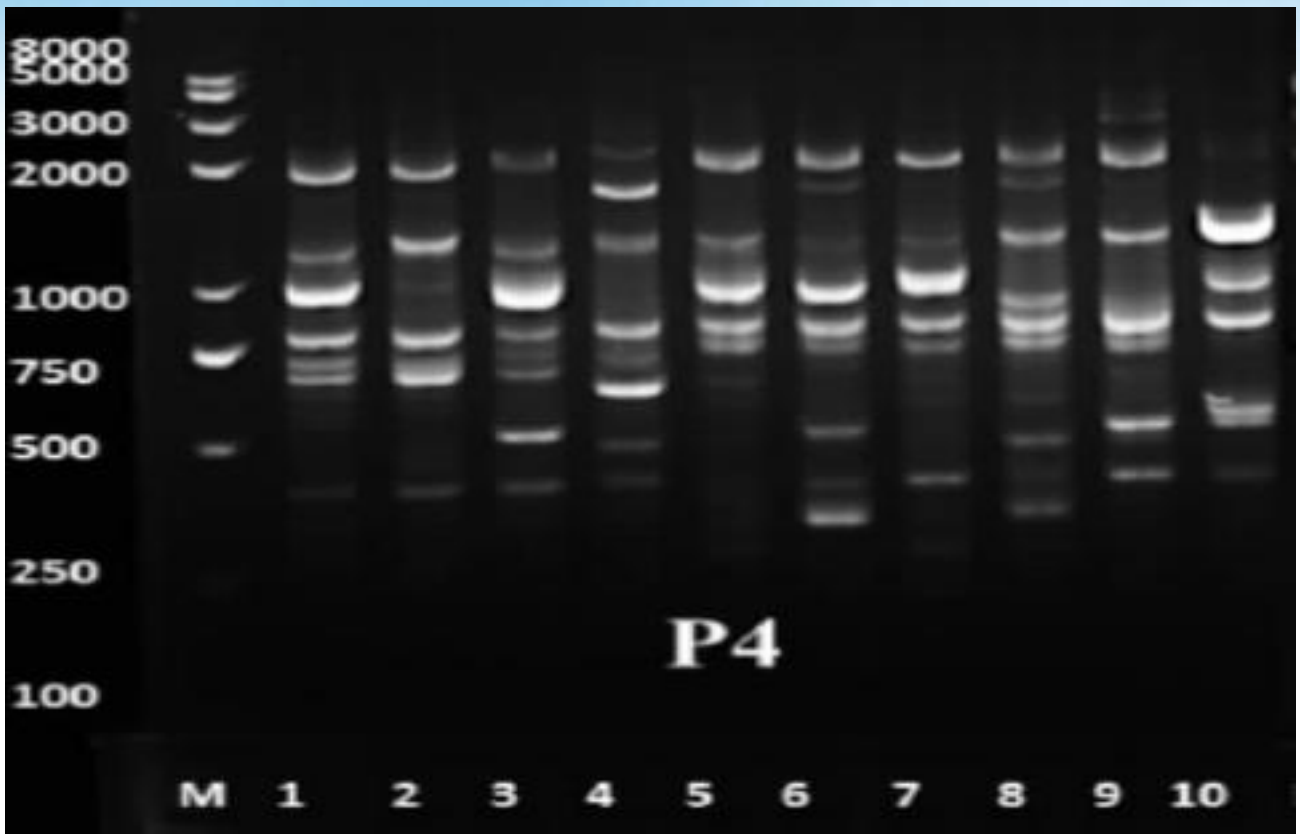
The 21 hemp plants of a landrace from southern Yunnan was studied. The THC content are from 0.07%～1.35%; CBD content are 0～0.58%.

The results shown us that the genetic diversity are not only in the diffirent germplasm, but also in the diffirent plants of one landrace.

The distribution of wild hemp in China

The wild hemp are distributed at the Ynnan, Tibet, Shandong, Inner Mongolia, Hebei, Liaoning, Jilin, Heilongjiang and so on.

The genetic diversity in wild hemp are abundant, and the difference of 11 morphological characters in all germplasms was significant ($P<0.001$). The thousand-grain weight had highest variation, resistance to drought are different too.



10 wild plants from wild population same place in Liaoning province.

But the genetic basis is different. The wild population has Genetic Diversity

2. Hemp breeding

- **2.1 The base situation**
- The objectives of hemp breeding are high fiber or seeds yield, high fiber content, low THC and high CBD content, and so on.
- Currently，there are more than 10 institutions studing on industrial hemp in china.
- IBFC,CAAS--Institute of Bast Fiber Crops, Chinese Academy of Agricultural Sciences;
- IIC,YAAS--Institute of Industrial Crops, Yunnan Academy of Agricultural Science;
- Daqing Branch, HAS- -Daqing Branch of Heilongjiang Academy of Sciences;
- IIC,HAAS--Institute of Industrial Crops, Heilongjiang Academy of Agricultural Sciences;
- Daqing Branch, HAAS--Daqing Branch of Heilongjiang Academy of Agricultural Sciences;
- IIC,SAAS-- Institute of Industrial Crops, Shanxi Academy of Agricultural Sciences;
- IIC,GAAS-- Institute of Industrial Crops, Guangxi Academy of Agricultural Sciences;
- Lu'an Institute of Agricultural Sciences

- About 25 hemp varieties (including hybrids) were registered in China until now.
- My institute have bred 5 hemp varieties, and we have bred some new lines which CBD content is more than 1.8%. Its THC is lower than 0.2%.
- We have some new lines which CBD is more than 4%～5%.

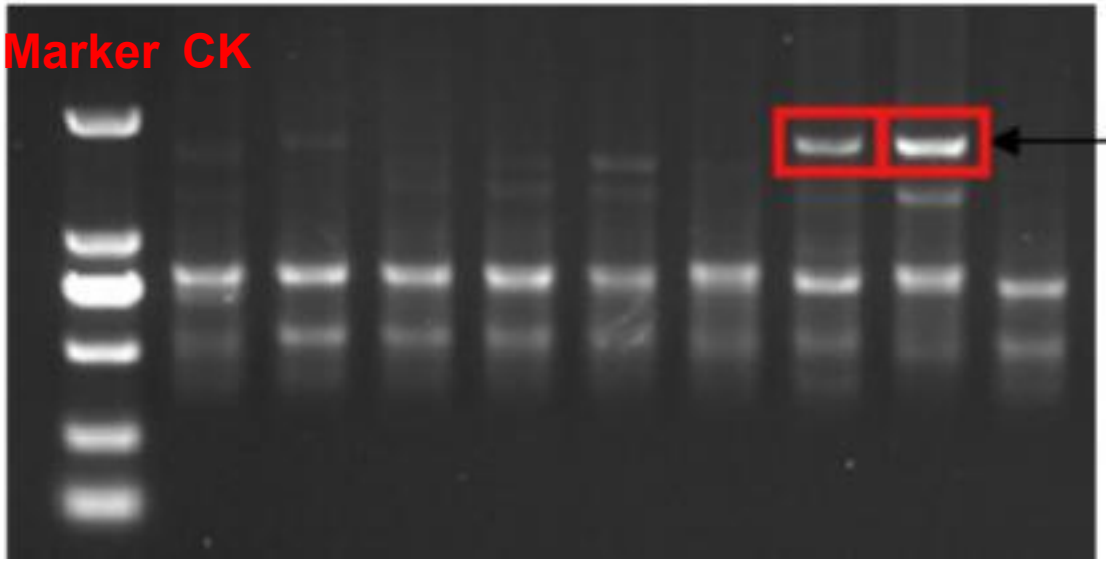
Some varieties were listed in the table. They were bred by Cross or System selection.

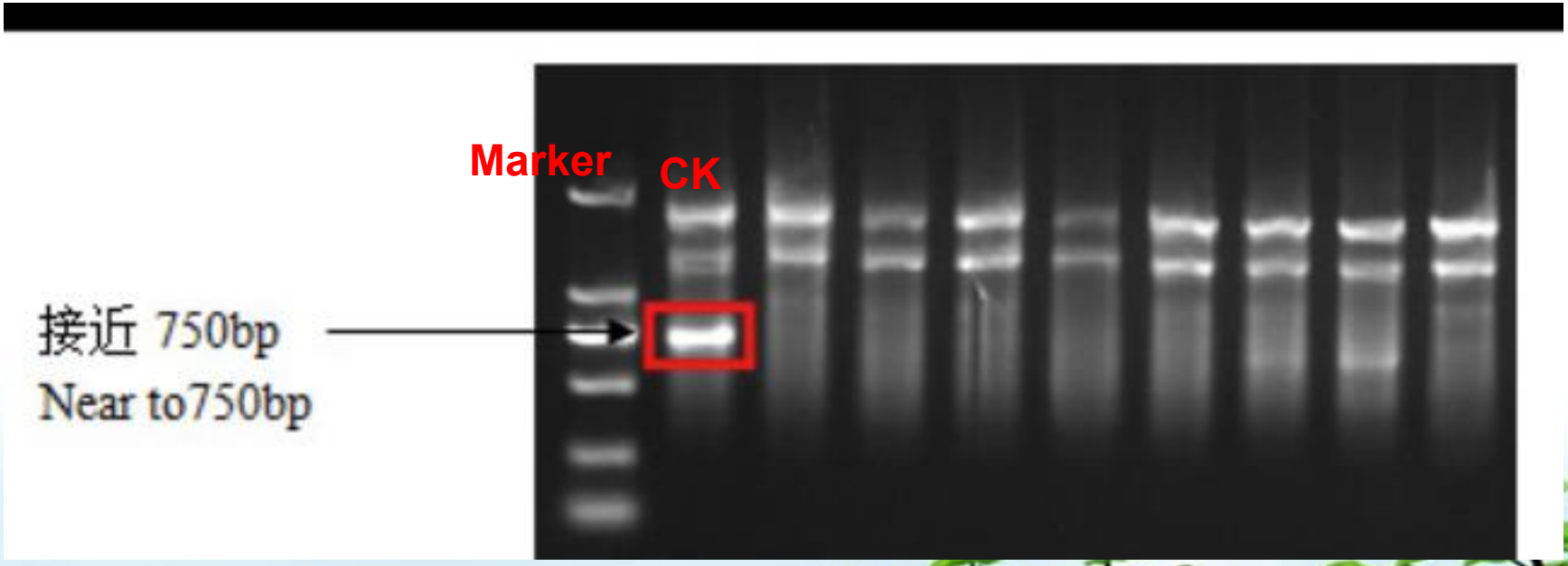
Varieties	**Institution**	**parent**	**Fiber kg /ha**	Seeds **kg /ha**	**method**
QingDama No.1	Daqing branch of HAAS	Qingyuan108 X Днепновская одн	1763.7	/	cross
Fenma No.3	IIC,SAAS	Yangqu hemp	/	1325.5	System
Longdama No.1	IIC,HAAS	LumaNo.1 X Wuchang40	1638.3	/	Cross
Yunma No.2	IIC,YAAS	Early hemp X F1 (Yun Wild X Yunma 1)	/	1545	Cross
Yunma No.3	IIC,YAAS	Yuanan Landreace X W1	1905	1560	Cross
Wandam No.1	L I.A.S	Liuan Hanma	3258	1041	System
Wandam No.2	L I.A.S	Liuan Huoma	2446	1265	System
China Hemp No.5	IBFC,CAAS	Taian Hemp	2743		System

2.2 mutation breeding

- Soak the seeds in to 1.5%～2% EMS（Ethylmethylsulfone）for 6～8h is better methods for hemp mutation. The effect will depend on the different varieties or germplasm.
- 150Gy is suitable dose to treat hemp seeds by Co^{60}-γ ray.

mutants


Marker CK
接近 2000bp
Near to 2000bp


Marker
CK
接近 750bp
Near to750bp

2.3 tissue culture

(1) The first green regeneration plants obtained from stem tissue culture at 1982. Improved MS medium (add KT 1.5, 6-AB1.5, 2,4-D 0.4, NAA 0.1, IAA 0.1mg/L) was used.

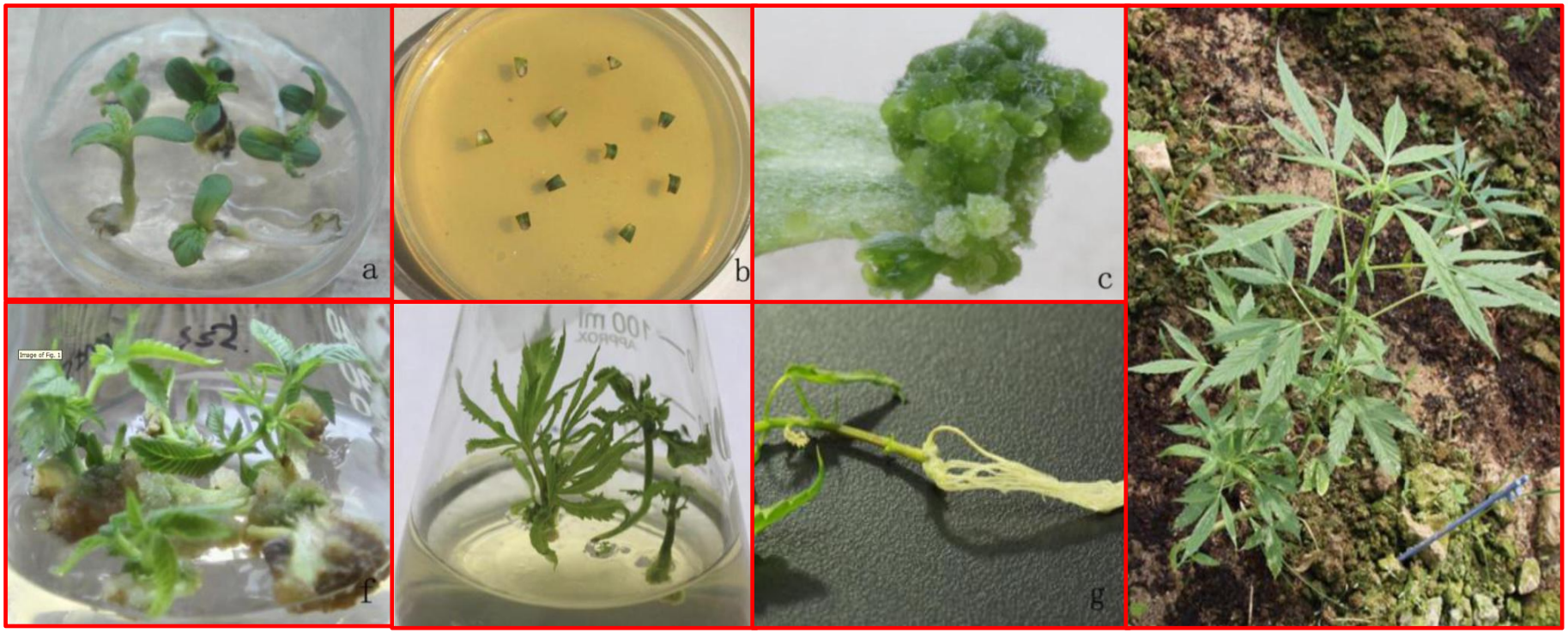
(2) 13 days old hypocotyl were used as explants, when MS +ZT 1.1mg/l +IAA 1.1mg/l , rate of callus is 87.0%; And then move them to MS+ ZT 0.6mg/l +IAA 1.1mg/l , 82.3% callus can form the buds(2012).

(3) 10 days seedling stems were used explants, when MS +1.0 mg/L 6-BA + 0.5 mg/L NAA, rate of callus is 88.3%; And then move them to MS+ 1.0 mg/L KT +0.5 mg/L NAA, 65.0% callus can form the buds(2015).

(4) The cotyledons can be regenerated too. MS + 0.4 mg/LTDZ + 0.2 mg/L NAA , 51.7% induction frequency and 3.0 shoots per explant. When shoots grew to the height of 1.5～2 cm in 3～4 weeks , about 80% of the shoots can root well in 1/2 Ms medium + 0.5～2 mg /L BA for 4～5 weeks.

So，The young stem, hypocotyls, and cotyledons can be used as explants for tissue culture. The regeneration system of hemp was established and it being studied now.

The regeneration system of hemp



3. Cultivation technologies study

- **3,1 the planting**
- The effective sowing number of seeds is 450 grains/m^2. The sowing date is May 1^{th} to 20^{th} , compound fertilizer 25%(N：P_2O_5 ： K_2O = 1: 1: 1) 450kg/ha, stem yield is 12 800kg/ha, long fiber yield is1600kg/ha. Total fiber is about 2000kg/ha.(Northeast)
- Bama hemp 9 plants/m^2，1050 kg/ha compound fertilizer（N-P-K=17-17-17）, sowing date at August, seeds yield is 1352 kg/ha. If hemp interplant with corn, sowing corn at last part of Feb. to first part of March, harvest at middle part of July, hemp sowing at May 20～25, and harvest at Nov. middle part, the hemp seeds yield can reach 3252 kg/ha.(Guangxi)

- To optimize seed and stem dual-type of cultivation， the 76.16～83.84 cm line space, 80.8～83.8 kg/ha nitrogen(N)，33.3～41.7kg/ha phosphorus (P_2O_5) and 54.2～65.7 kg/ha potassium（K_2O) were tested． Using the optimized method，the seed and stem yield could reached 1,500 and 12,750 kg/ha at same time (Yunnan) .

experiment

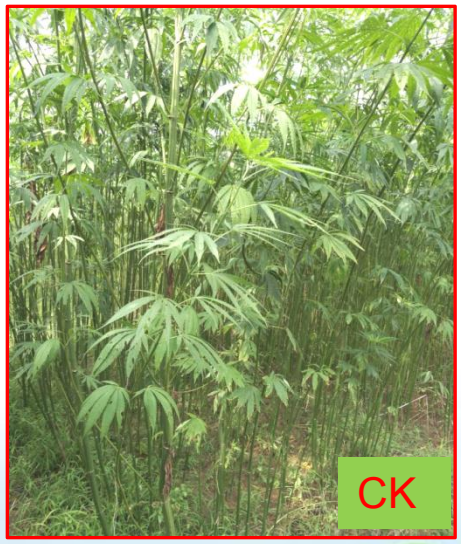

production

- **3.2 crop rotation**
- The rhizosphere soil water extract，0.001，0.005 and 0.010 g /ml to treat the seeds of 3 kinds plants. The extract can not effect hemp germination and growth, but it can effected other plants. So, hemp and *Angelica sinensis* rotation should be used in production to dislodge continuous cropping obstacle caused by autointoxication.
- hemp is an excellent break crop. Subsequent crops have less weed pressure, and yield increases of 10%～20% have been shown in winter wheat crops grown after hemp.

4.Physiological regulation

4.1 The defoliant regulation:

Spray defoliant at 2～3 weeks before harvest, after 2 weeks the rate of falling leaves was 85%～100%. The effect of falling leaves was stable and had no damage to fiber, which was beneficial to machine harvest and the retting of hemp.



4.2 sex regulation of hemp

GA3 promote the male differentiation; 6-BA promote the female differentiation.

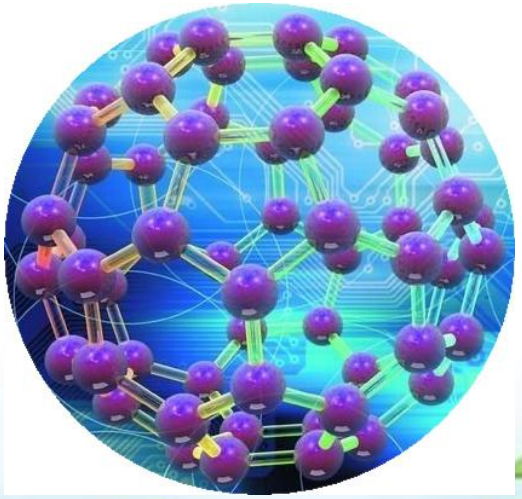
IAA could promote the male differentiation when treated with low concentration(30 mg/L), but when treated with high concentration(60, 120 mg/L), It can promote the female differentiation.

Short day treatment (8 h) had no influence on sex differentiation, but long day treatment (16 h) promote the male differentiation.

Hormone	plants	female plants	male plants	female%
6BA	100	89	11	89
3AA	100	82	18	82
IAA	100	72	28	72
NAA	100	65	35	65
CK	100	55	45	55
2.4-D	100	45	55	45
GA	100	43	57	43
ZEN	100	40	60	40

4.3 THC and CBD regulation

- The content of THC in three-layer shading, overdose nitrogen fertilizer and serious drought were decreased by 68.6%, 51.6% and 51.3%, respectively.
- THC accumulation is related to geographic latitude. High latitude will lead to high THC content.
- CBD can higher then control 8 times by regulating agent



5 Study on weed control

- When weed is 1～4 leaves, spray 56% of MCPA-Na WP 300 g + 120 g/L clethodim EC 195 mL + water 600 kg/ha, could be a good control of annual weeds in the hemp field, efficacy was more than 95% after 30 and 50 days.
- After sowing the hemp, spray 50% acetochlor 2.25kg/ha + water 600 kg/ha on the soil.

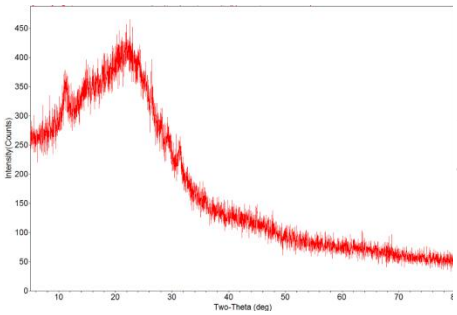
- Black Nightshade (*Solanum nigrum) extract as a herbicidal substance.* The results indicated that the inhibition of *Solanum nigrum extract was not notable for hemp seed at the* 1 g/L concentration . So, it is suitable to develop soil finishing agent in the production of hemp to control the weed. It is studying now.

6. phytoremediation

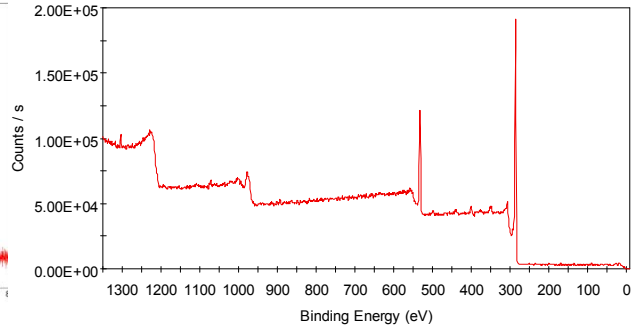
- Cd could be strongly absorbed and accumulated by hemp.
- Zn，Pb，Cu and Cd 4 types of heavy metals with low concentration(<30mg/L) could promote seed germination. And could increase the plant height and dry weight of hemp.
- The seed germination of hemp was highly resistant to this 4 types of heavy metals, and resistant could be ranked as Pb^{2+} (500mg/L)＞ Zn^{2+} (500mg/L) + ＞Cd^{2+} (125mg/L) ＞ Cu^{2+} (125mg/L).
- So, hemp is very good for phytoremediation of contaminated soil by heavy metals.

- Pb^{2+} did not affect the normal growth of the plant under 600 mg /kg ，and Pb^{2+} was mainly accumulated in root with 109. 05 , stem 44. 72,leaf 34.4,fiber 31.5, seeds 2.5, male follower 2.66 mg/kg respectively. Concentration coefficient and the transfer coefficient <1
- Cu^{2+} was mainly concentrated in root>stem>leaf>seed >male flowers > fiber.
- Cd^{2+} content was 150 mg /kg. It was accumulated in root>stem>leaf > fiber，the bioconcentration factors (BCF) were very high (＞1) ，especially in the root and fiber of male plants (＞2) . And its Cd^{2+} content are more then the critical value of the super accumulation plant(100mg/kg)
- The hemp is resistance to Pb^{2+} and accumulate Cd^{2+} .

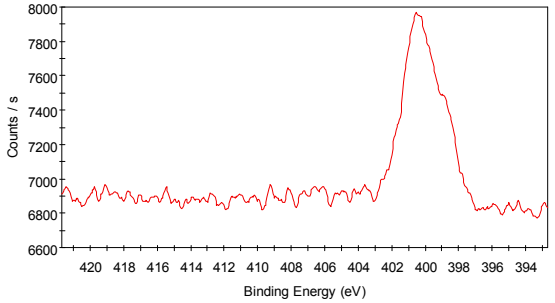
The utilization of hemp plants grown in Cd-contaminated soil



XRD



XPS全波段扫描光谱



Cd3d XPS图谱

Magnetic polyglutamic acid cellulose

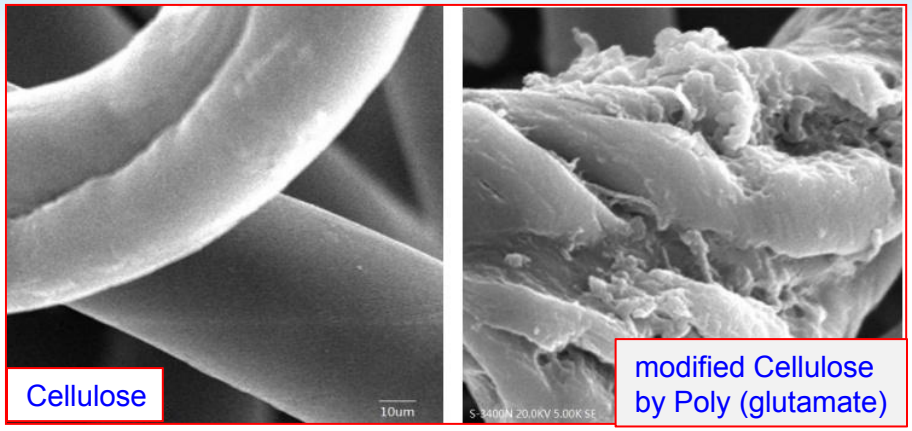
Waste biomass of hemp

Cellulose extraction

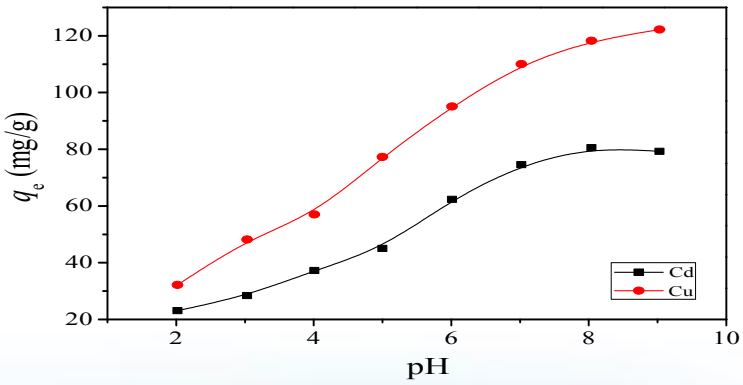
Polyglutamic acid

polyglutamic acid cellulose

Magnetic polyglutamic acid cellulose

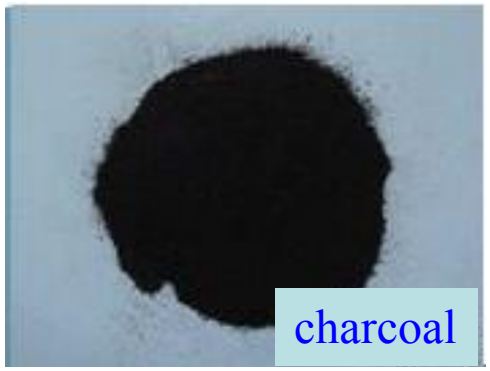


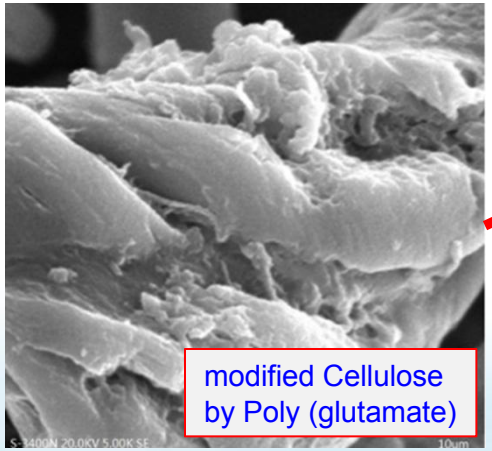
Electron microscopic picture



Removal effect of Magnetic Cellulose / Poly (glutamic Acid) on Cd^{2+} and Cu^{2+} in solution

The charcoal and magnetic polyglutamic acid cellulose can be used to industrial waste water treatment





7. Seeds utilization

- Hemp it is food and oil crop. Its seeds yield is about 1500～2200kg/ha, which can be used to food, oil, and cosmetics.
- The oil content of different hemp seeds is different, The range of changes is 30.1%～36.1% , average is 32.8%.
- Fatty acid ratio is different too.

hemp varieties	palmic acid	stearic acid	oleinic acid	linolic acid	γ-linolenic acid	α-linolenic acid
D10	8.84	1.91	15.44	57.72	14.55	0
D11	7.52	2.94	14.49	51.89	0.68	20.92
D12	0	0	0.85	70.37	0.52	27.05
D13	6.68	2.83	14.75	52.06	0.67	21.47

Effect of microwave pretreatment of hemp seed on THC content and quality of hemp seed oil

- The conditions of microwave time 15 min and microwave power 1,000 W，the THC content in crude hemp seed oil can decrease from 122.6 mg /kg to 57.3 mg /kg，oxidation induction time increased from 2.28 h to 3.02 h，and residual oil rate of hemp seed cake can decrease from 14.36% to 9.98%，respectively.

Removal technology of THC from hemp kernel oil

- The best removal conditions were obtained as follows:

  The volume ratio of ethanol to isopropanol is 2:1, deactivation time 1 h. The steam distillation combined with ultrasound treatment conditions are: oil temperature 170℃, pressure 0.55 kPa, steam flux 40 g /(h·kg) , distillation time 2 h, ultrasonic power 180 W, ultrasonic time 30 min, interval time 15 min. Under these conditions, THC content in hemp kernel oil can decrease to 4 mg/kg. Compared with hemp seed oil obtained by direct pressing, the removal rate reached 92%.

8. The function of CBD

Institution	animal	symptoms	Methods	function
Changzheng Hospital, Second Military Medical University	adult male SD rats	nonalcoholic steatohepatitis	fed with CBD and Injection， 2mg/kg/d	Relieve symptom，
Shanxi Medical University	adult male SD rats	Myocardial ischemia / reperfusion injury	intravenous injection 50 μg /kg CBD at 2、12、24、48 h	Protect myocardium
Anhui Medical University	adult male mice	Acute cerebral hemorrhage	20 mg / kg CBD was injected intraperitoneally for 48 h.	Nerve protection
Shanghai Institute of Pharmaceceutical Industry	adult male SD rats	rheumatoid arthritis	10-20 mg CBD drench	Relieve symptom
Southern Medical University	mice	Spinal Cord Injury	30mg /kg CBD was injected intraperitoneally	inhibit inflammation

- Hemp is medicinal crops. Its inflorescence and fresh leaves yield is about 2000 kg/ha. Which content more than 100 individual cannabinoids. And which can be used to produce CBD or cosmetics
- the hemp leaf extract is not harmful for skin. In addition, the hemp extract also had a good stability in solution with changing pH, cold, heat and light. The 95% ethanol extract of hemp leaves (160 days plants) had the potential to be used as a functional plant additive for anti-UV(ultraviolet rays) cosmetics

.

- Some studies were introduced above.
- Medical hemp variety breeding, molecular marker development and selection, genetic diversity analysis , construction of fingerprinting, gene clone and transformation, are studying too now. but there are not so much progress or important results.

Ⅲ. The Sustainable Development of hemp

1. The problems about hemp in China

- The hemp study, planting and production develop rapidly in recent years in China. But there are some problems which impact the development of hemp industry.
- 1.1 The machines are deficiency. Harvest machine are not high efficiency, and there are not turning machine， balling(or Bundling) machine, pick up machine.
- 1.2There are about 20~30 companies have been registered for CBD production, but there are not so many raw material. And the CBD content is lower.

- 1.3 There are about 40,000ha hemp in China now, at same time some province intend to develop the hemp. for example: *Three-year Special Action Plan for Hemp Industry in Heilongjiang Province (2018～2020).* By 2020 *Heilongjiang* will be the largest base of hemp industry in China. Processing of 70,000 tons hemp bark，10,000 tons of hemp seeds and 10,000 tons of leaves and flowers，and 300,000tons stem core. But quality is not good enough for textile now.
- 1.4 The hemp variety and planting technologies are not good enough for large-scale planting.

- 1.5 One important problem is that hemp relate to marijuana. So, the THC and CBD content will be discussed.

  There are two province have local code and regulation, and another province will have it. But there is not national rule or law. And many other province have not rules about hemp.

2. The suggestions about sustainable development of the hemp

- 2.1 Moderate scale development of hemp cultivation.

  Can not plant too much hemp, can not more than 100,000ha untill 2020 in China.

- 2.2 law-making is urgent need

  Not only CBD can be used as medicine, but also THC. The study shown that THC can be used to medicine , and THC + CBD can reduced astrogliosis, microgliosis, and inflammatory, and it is better than with either THC or CBD alone. According to the study of the function, I suggest to relax restrictions of THC content of medicinal hemp.

- 2.3 Strengthen the research of machinery

  Machines can reduce costs and improve quality.
- 2.4 Breeding of High quality hemp varieties, fiber and medical dual-purpose hemp varieties. pay attention to seeds multiplication.
- 2.5 High quality cultivation technique study.

- 2.6 Multipurpose utilization
- Hemp can be used to textile, food, medicine, construction, energy, soil remediation, waste water(effluent) treatment, cosmetics, etc.
- So, if all the parts of hemp plant can be utilized, it can increase benefit of the planting and processing, and promote sustainable development of hemp industry.


THANK YOU
FOR YOUR ATTENTION !!
E-mail: wangyufu@caas.cn
17-6-25 12:40