



# China Biochar Story: From crop straw to biomass industry

Genxing Pan

Biomass and Biochar Green Technology Center,  
Nanjing Agricultural University

Mail: [pangenxing@aliyun.com](mailto:pangenxing@aliyun.com); [gxpanl@hotmail.com](mailto:gxpanl@hotmail.com)



# Why biochar: SOM depleting lands...



# Why biochar: straw unrecycled as pollution

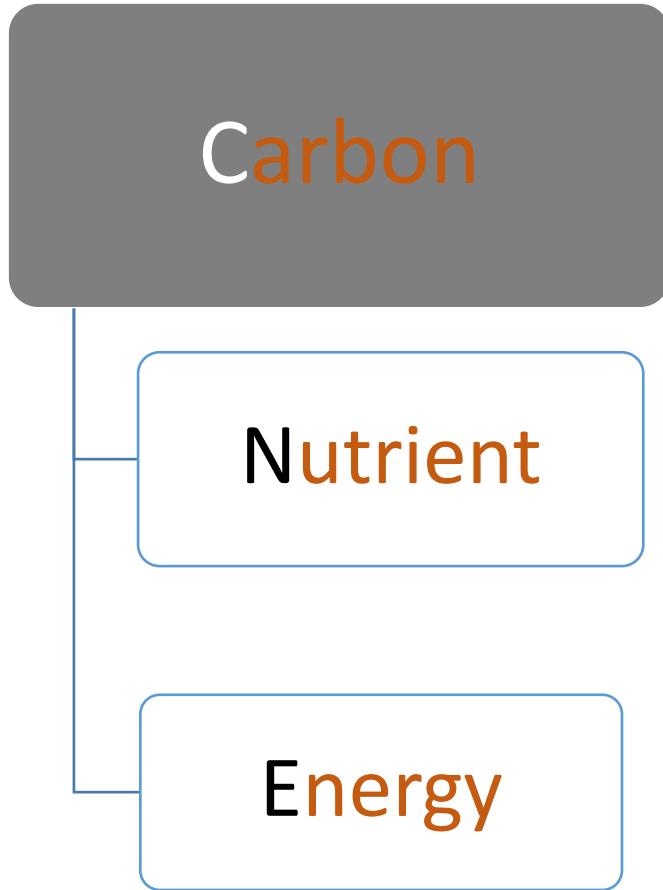


Totally 1 Gt, half in northern China

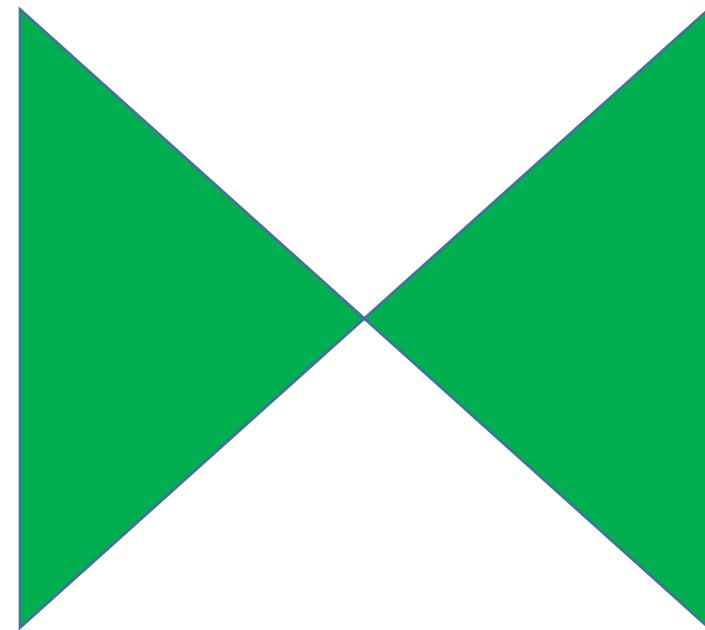


# Why biochar: safe recycling in agriculture

Partitioning to maximize capital



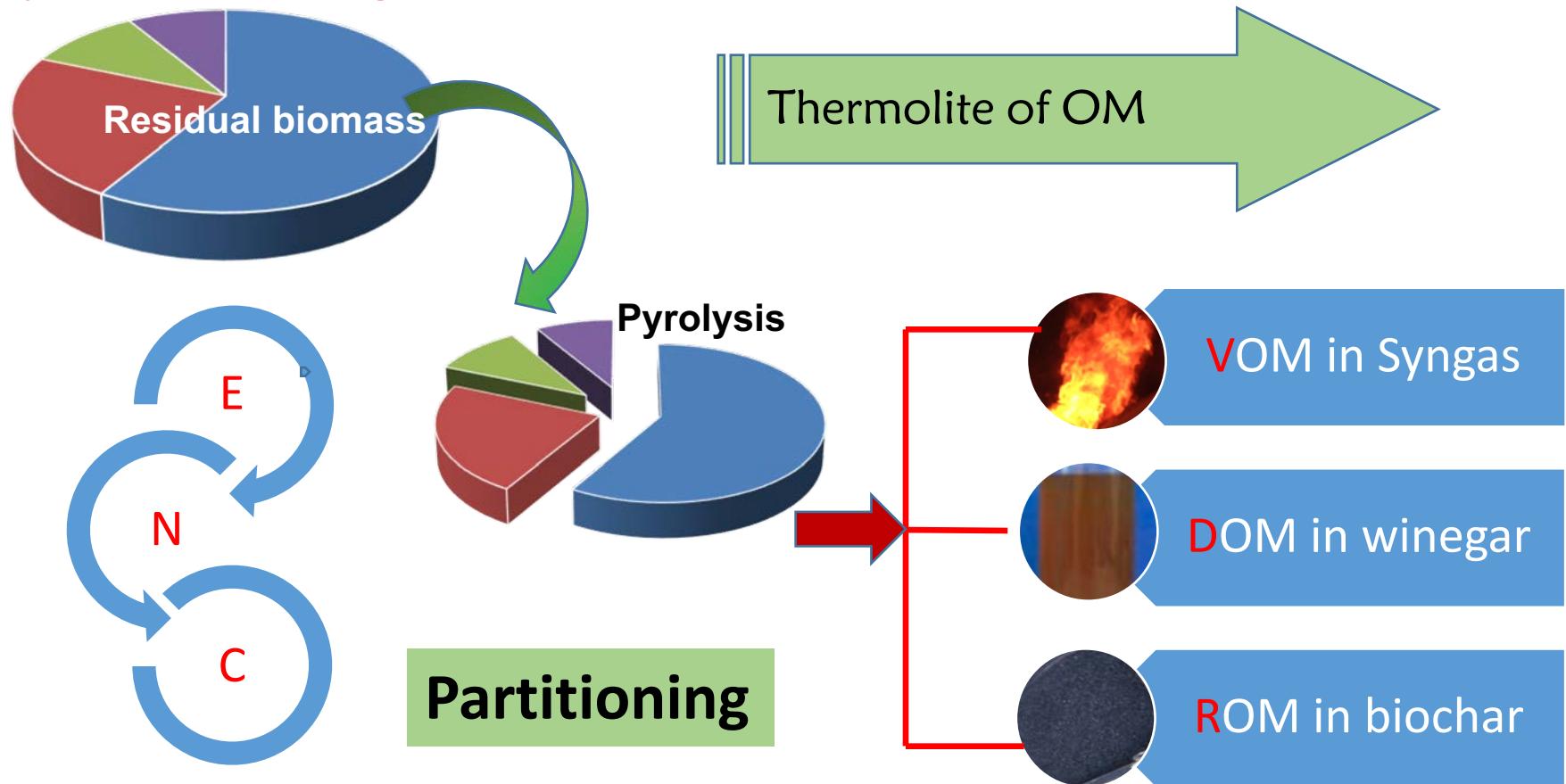
Deform, transform, reform



Transforming to minimize E-risk



# How biochar: Engineering pyrolysis system for agriculture and..



Differentiated pyrolysis, designed products and distributed system of biochar production, 3D approach

# Crop straw pyrolyzer, continuous rotatory kiln

30 thousand ton per year feedstock



Developed by Beijing Sanju in cooperation with NJAU

# Co-Pyrolyzer: mixed feedstock

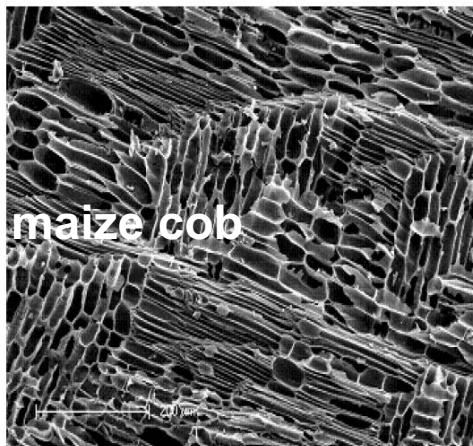




# Designed biochar: single or combined use



Biochar particles



maize cob

SA of biochar derived from( $\text{m}^2/\text{g}$ )

Wheat straw : 16.66

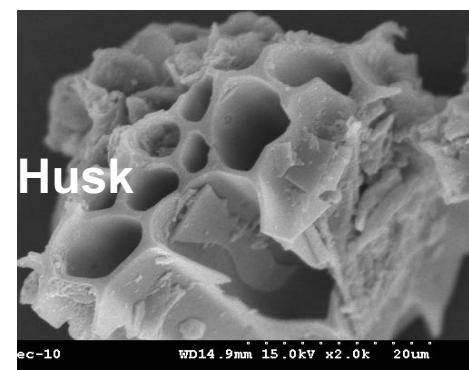
Maize straw: 4.49

Peanut husk: 11.08

Municipal waste: 3.83



Biochar particles



Husk

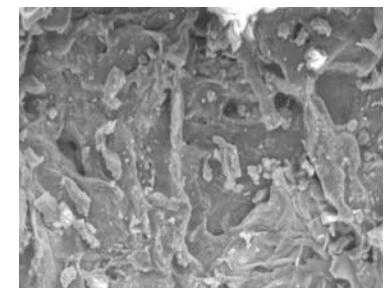
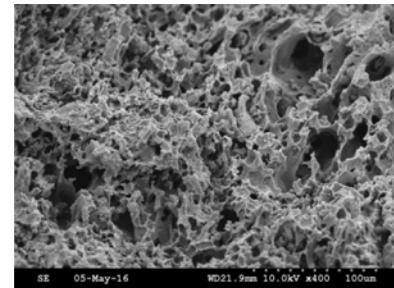
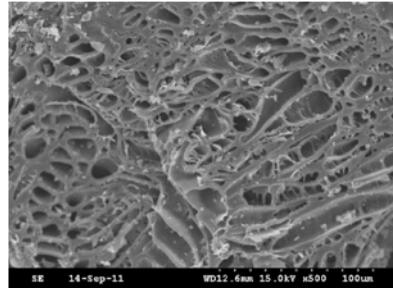
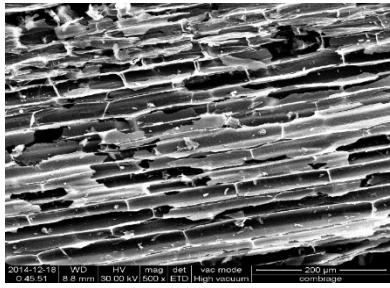
创新生物质材料：

肥料炭载体、饲料炭载体、吸附剂、钝化剂、食品加工佐剂

创新生物质产品：

纳米盾、炭基肥、土壤改良剂、园艺基质及融雪剂

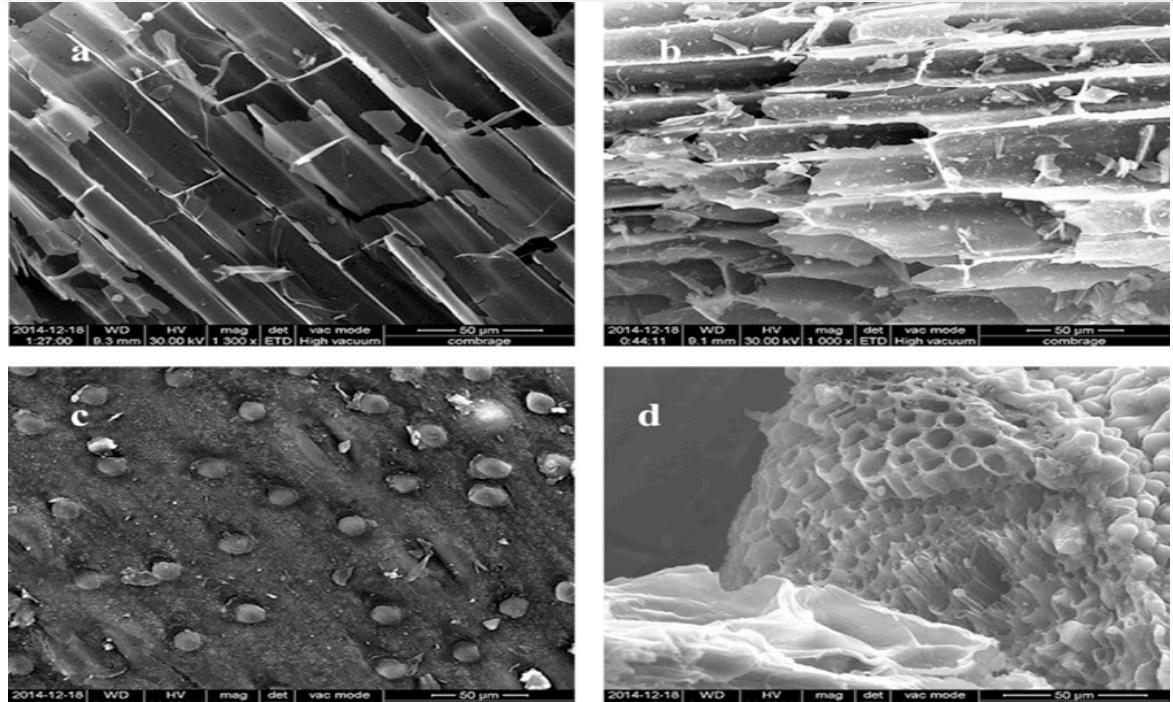
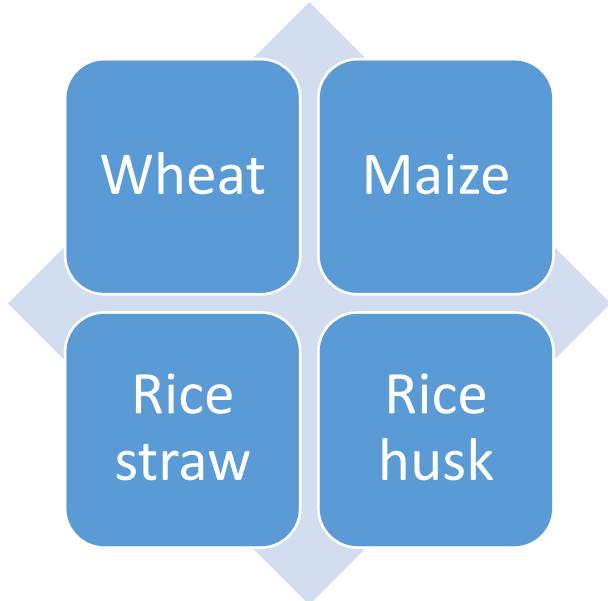
# Designed biochar: from combined feedstocks to combined biochar material



Extraction, modification, formulation and granulation...

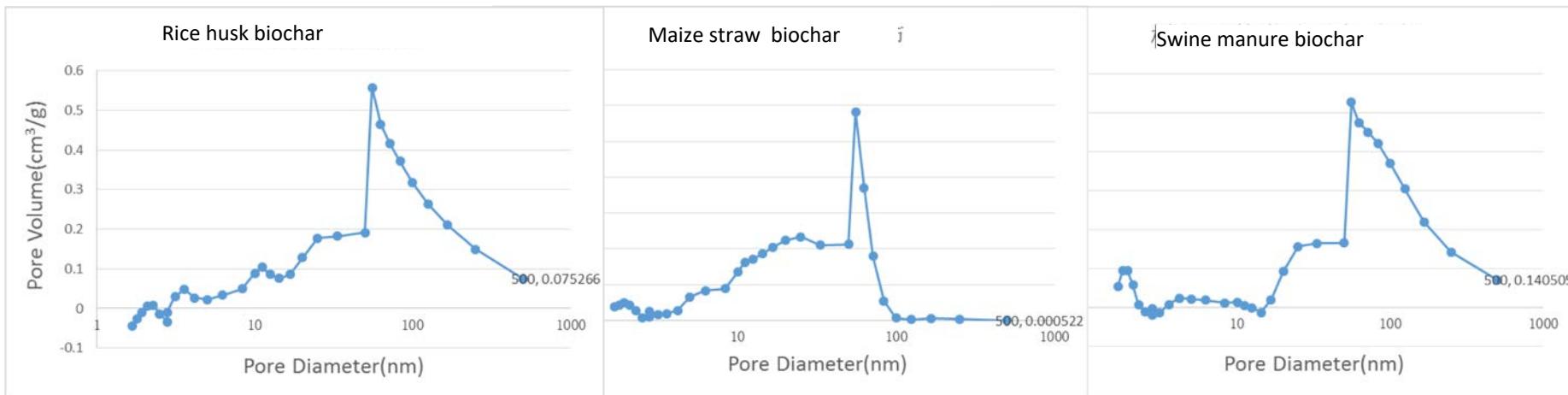
# Main feedstock: straw resource available

Properties concerned:  
CEC, SA, pH;  
VOMs, porosity;  
Ash, ....



# Porosity as a key factor: Cryo-porometry

| Feedstock       | Total<br>(cm <sup>3</sup> /g) | Median<br>pore size (nm) | Minimum<br>size(nm) | Size in 95% CI<br>(nm) |
|-----------------|-------------------------------|--------------------------|---------------------|------------------------|
| Rice husk       | 0.41                          | 80.0                     | 2.0                 | 3.5~250                |
| Maize straw     | 0.55                          | 50.1                     | 1.2                 | 2-83                   |
| Swine<br>manure | 0.72                          | 80.0                     | 2.0                 | 15-500                 |



# Designed biochar: VOM molecules in

~300 species

DOM 4%,

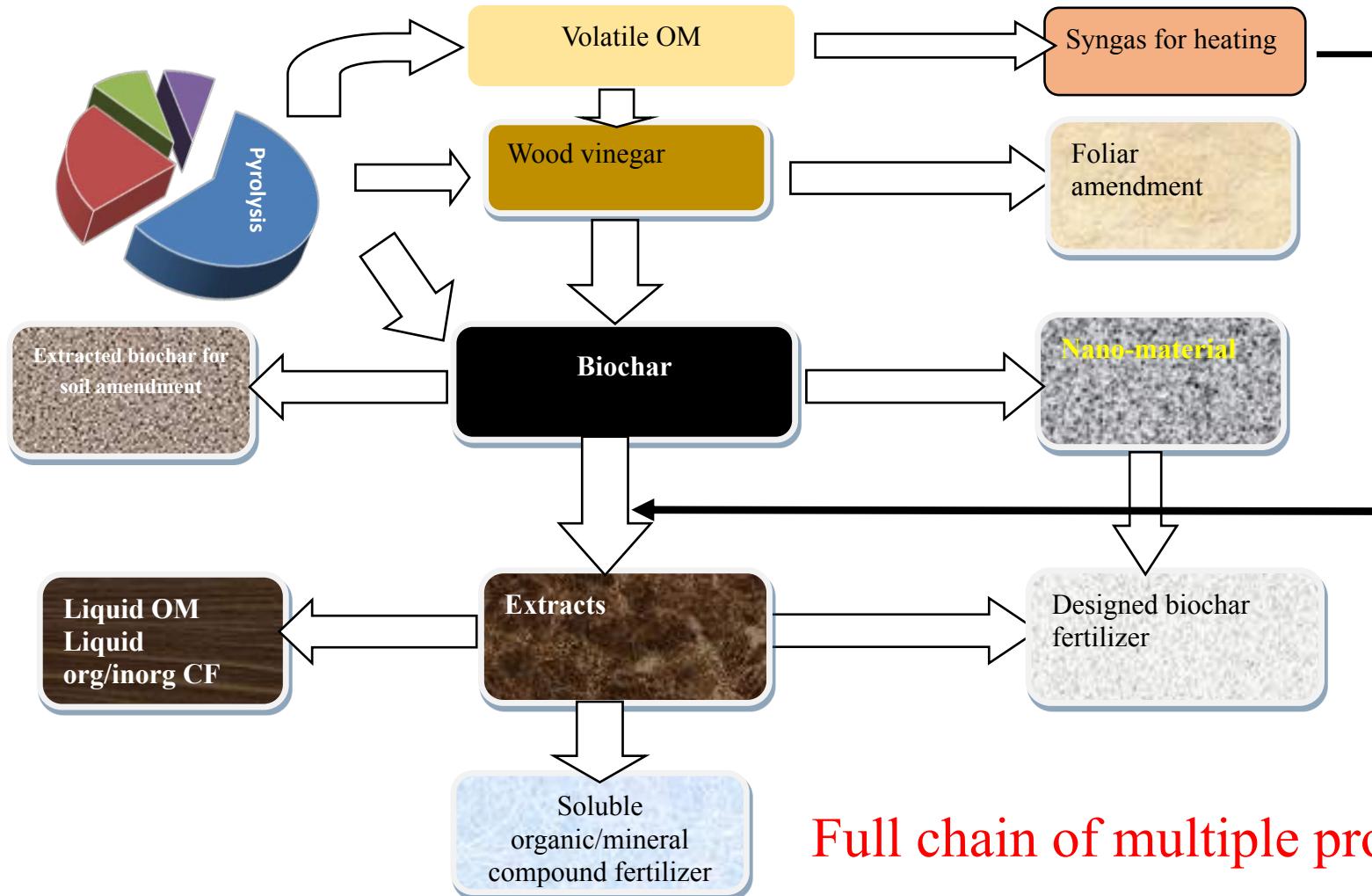
Liquid OM

|  | <b>biochar Compounds</b>                     | <b>Wheat SL</b> | <b>Maize SL</b> | <b>Peanut husk</b> | <b>Wheat LH</b> | <b>Rice husk LH</b> | <b>Rice husk YJ</b> | <b>Maize SX</b> | <b>Wheat TY</b> |
|--|--|-----------------|-----------------|--------------------|-----------------|---------------------|---------------------|-----------------|-----------------|
|  | 2-Butenoic acid                              | Y               | —               | Y                  | Y               | Y                   | Y                   | Y               | Y               |
|  | Triethyl phosphate                           | Y               | Y               | Y                  | Y               | Y                   | —                   | —               | —               |
|  | Benzene propanoic acid                       | —               | Y               | Y                  | —               | —                   | —                   | —               | —               |
|  | Benzoic acid                                 | Y               | Y               | —                  | Y               | Y                   | Y                   | Y               | —               |
|  | 1-pentene                                    | Y               | —               | —                  | —               | —                   | —                   | —               | —               |
|  | Phenol                                       | Y               | Y               | —                  | Y               | Y                   | Y                   | Y               | Y               |
|  | Cyclopentene                                 | Y               | —               | —                  | —               | —                   | —                   | —               | —               |
|  | Formica acid                                 | —               | —               | Y                  | —               | —                   | —                   | —               | —               |
|  | Valeric acid                                 | Y               | Y               | —                  | Y               | Y                   | —                   | Y               | —               |
|  | Phthalic acid                                | Y               | Y               | Y                  | —               | Y                   | Y                   | Y               | Y               |
|  | 1,2-Benzendicarboxylic acid                  | Y               | —               | —                  | —               | —                   | —                   | —               | —               |
|  | 9,12,15-octadecatrienoic acid                | Y               | —               | —                  | Y               | Y                   | Y                   | —               | —               |
|  | 2-propenoic acid                             | —               | —               | —                  | —               | Y                   | Y                   | Y               | —               |
|  | Fumaric acid                                 | —               | Y               | —                  | —               | —                   | —                   | Y               | Y               |
|  | n-Hexadecanoic acid                          | Y               | —               | —                  | Y               | —                   | —                   | —               | —               |
|  | Erucic acid                                  | —               | —               | —                  | Y               | Y                   | —                   | —               | —               |
|  | Nicotinic acid                               | —               | —               | —                  | —               | —                   | —                   | Y               | —               |
|  | N-Methynicotinic acid                        | —               | Y               | —                  | —               | —                   | —                   | Y               | —               |
|  | Heptadecanoic acid                           | Y               | —               | —                  | —               | —                   | —                   | Y               | Y               |
|  | Glycerol                                     | Y               | —               | Y                  | Y               | Y                   | Y                   | —               | —               |
|  | Ribitol                                      | —               | —               | Y                  | —               | —                   | —                   | —               | —               |
|  | 1-Hexadecanol                                | —               | —               | —                  | —               | —                   | —                   | Y               | —               |
|  | Behenic alcohol                              | Y               | —               | —                  | —               | —                   | —                   | Y               | —               |
|  | Oleyl alcohol                                | —               | —               | —                  | Y               | —                   | —                   | —               | —               |
|  | Isoquinoline                                 | —               | —               | —                  | —               | Y                   | Y                   | —               | —               |
|  | Naphthalene                                  | —               | —               | —                  | —               | —                   | —                   | —               | Y               |
|  | Urea   | —               | —               | —                  | —               | —                   | —                   | Y               | —               |
|  | 1-Monolinoleoylglycerol trimethylsilyl ether | Y               | —               | —                  | —               | —                   | —                   | Y               | Y               |



# Biochar industry:

## Co-production and full use of pyrolysis products



Full chain of multiple products

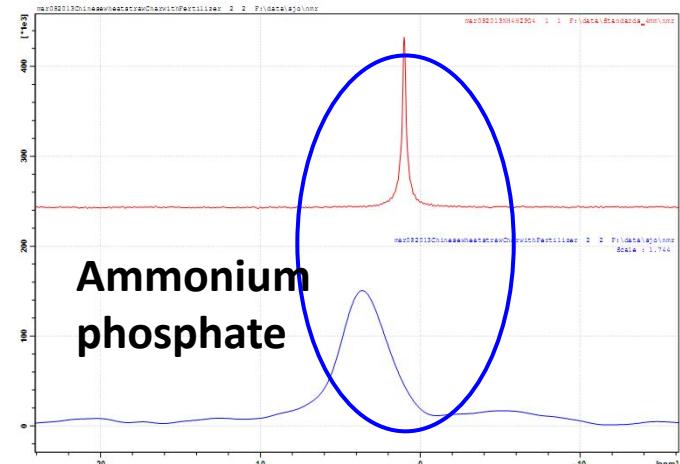
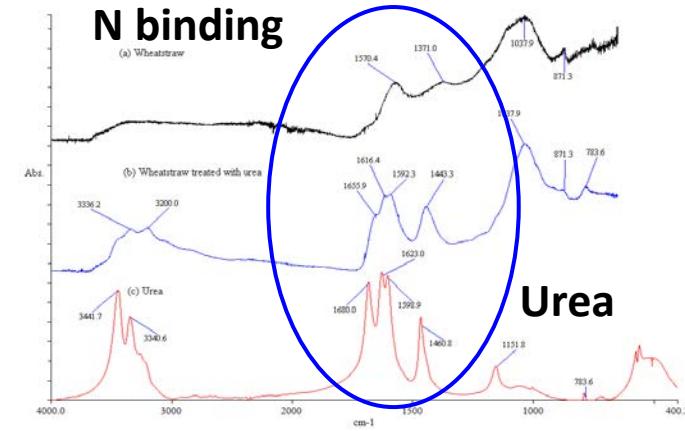
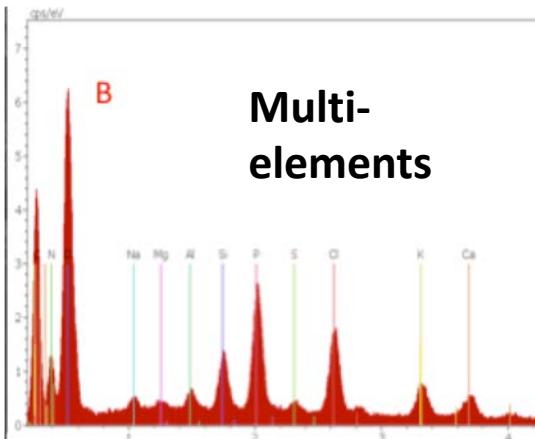
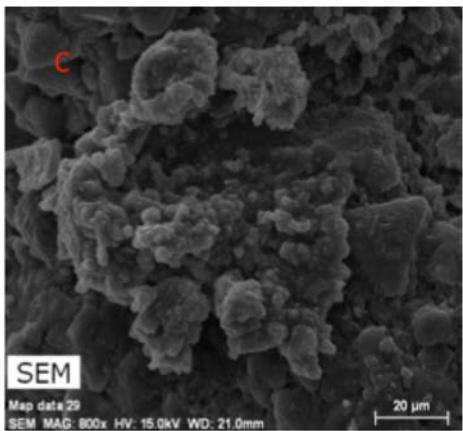
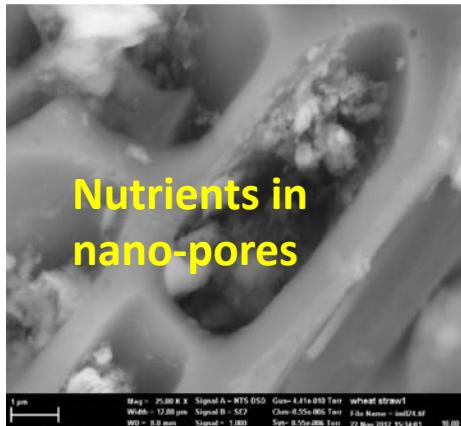
# Core product:

## Blended biochar compound fertilizer (BCF)

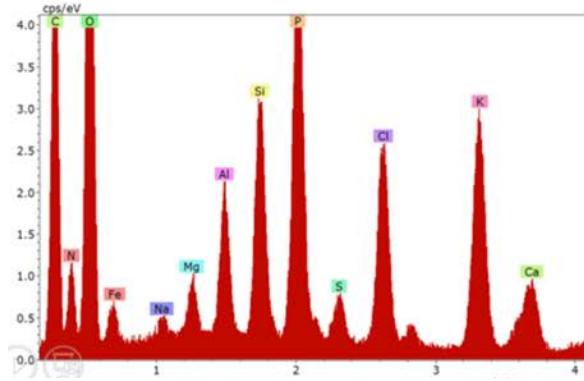
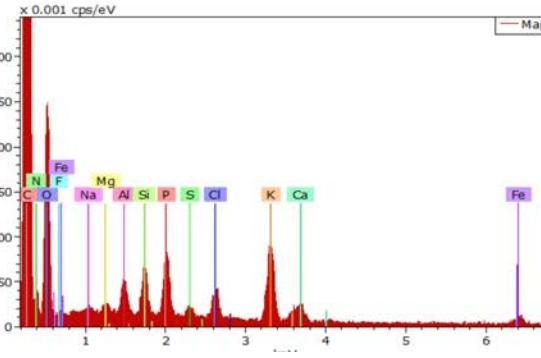
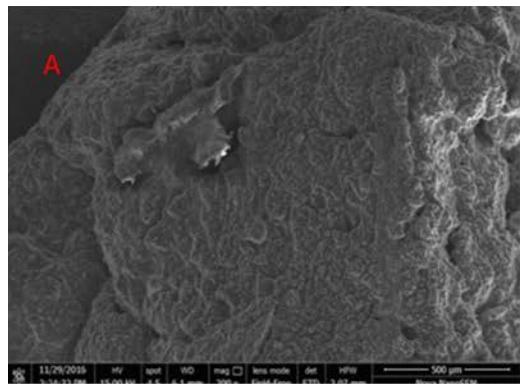
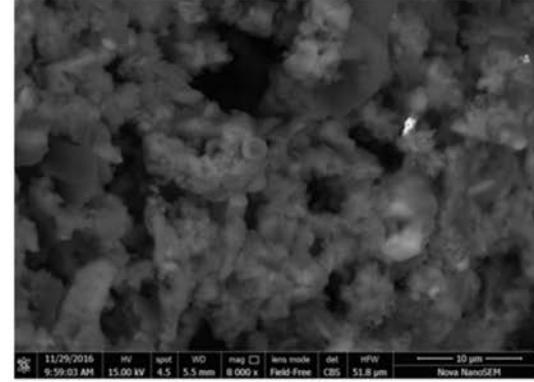
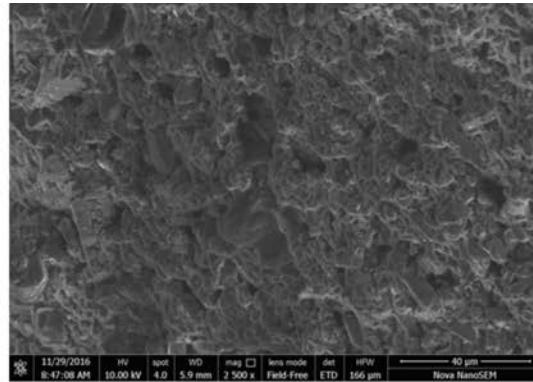
-N-P<sub>2</sub>O<sub>5</sub>-K<sub>2</sub>O, 15-15-10, 40%



organic/inorganic, active Vs structure OM, Habitat and nutrients, macro and micro

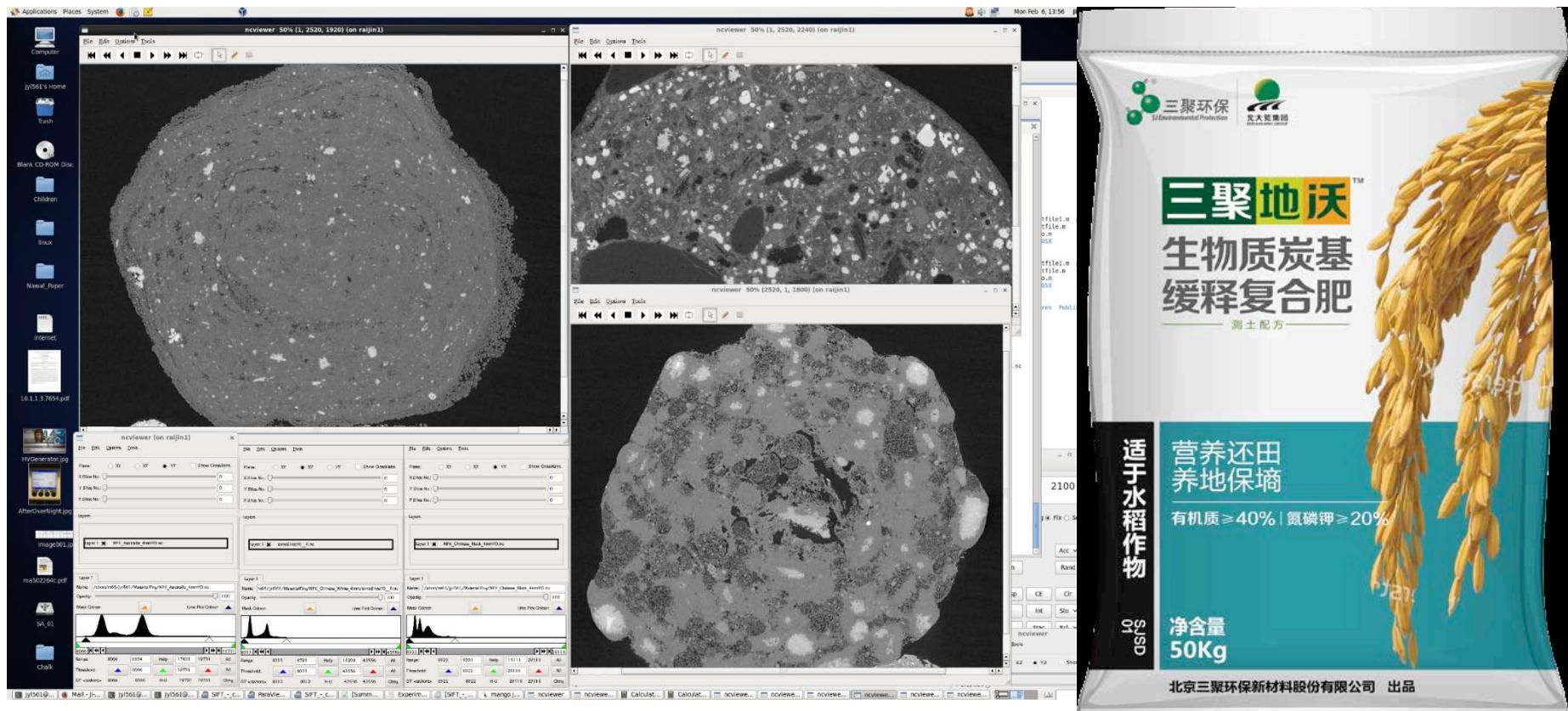


# BCF 2<sup>nd</sup> Generation: balance between org/inorg, N-P-K, major/micro, active /structured OM, quick/slow pool



Simulating aggregates: not only for plants!

# 2<sup>nd</sup> BCF: Aggregate-like Compound mineral organo nano-fertilizer



# 2nd Generation BCF: specifications

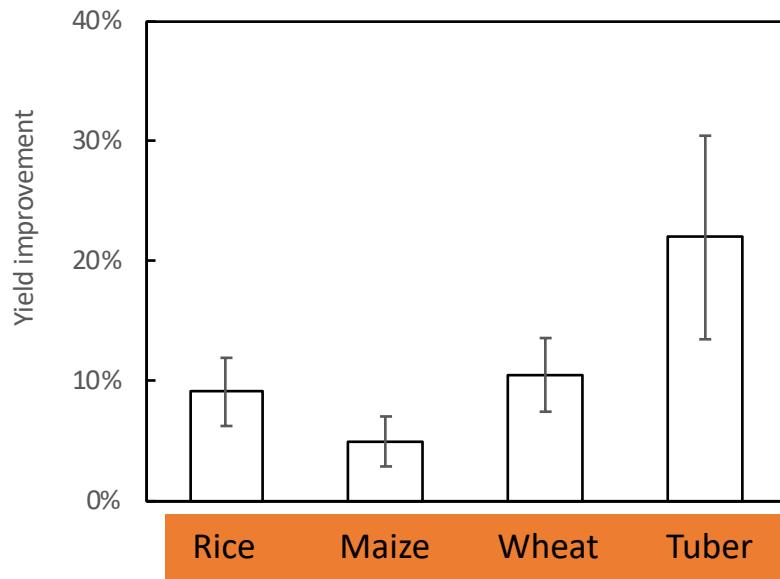
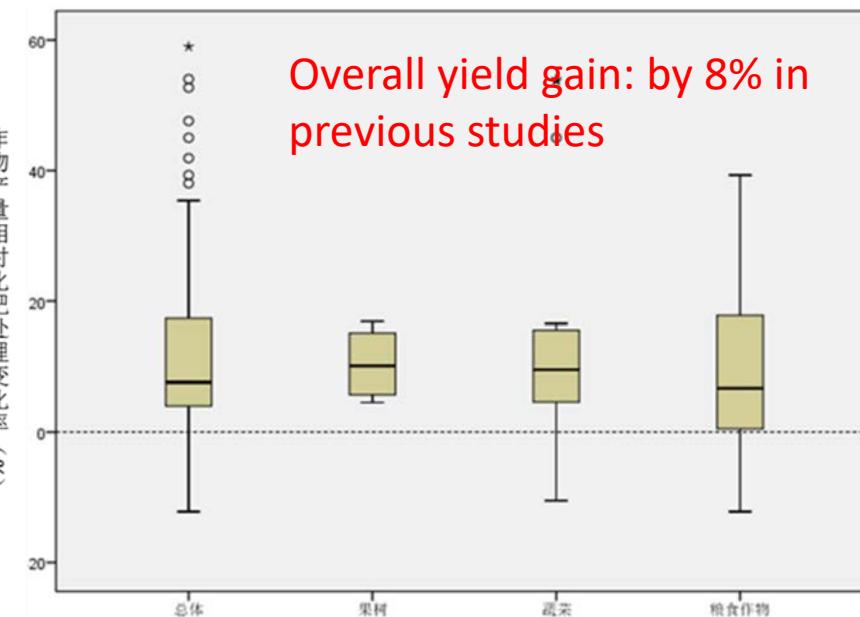
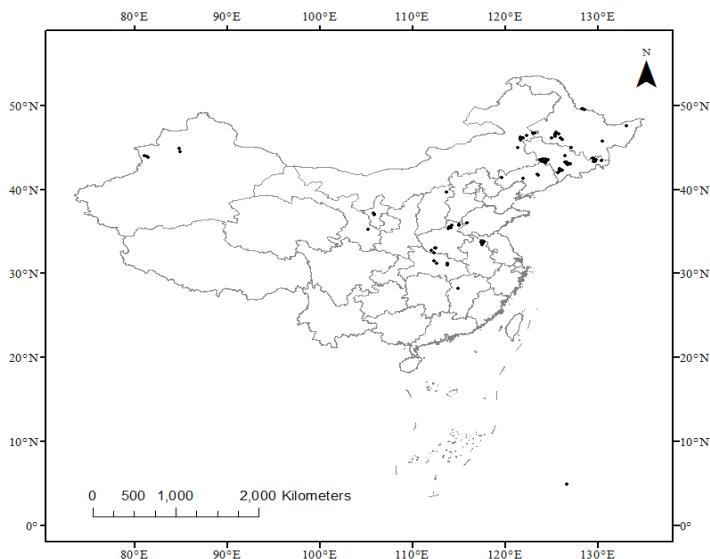
Biochar blended compound fertilizers, crop specific



Biochar and liquid combined seedling promotor

Biochar based amendment

# Field demonstration in 2017



Overall yield gain: by 8% in previous studies

Mean yield increase by biochar fertilizer

(95% confidence interval)

Rice:  $9.1 \pm 1.1\%$ ; 2<sup>nd</sup> BCF

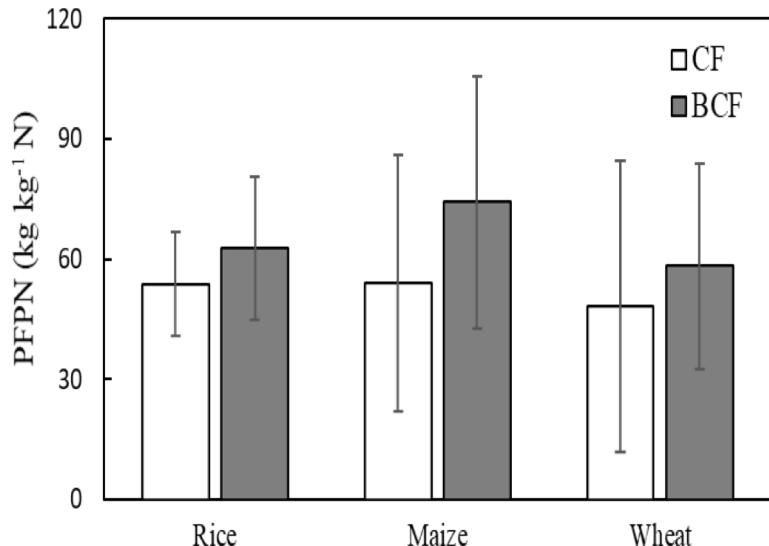
Maize:  $5.0 \pm 6.2\%$ ;

Wheat:  $10.5 \pm 4.3\%$ ;

Potato:  $22.0 \pm 11.5\%$

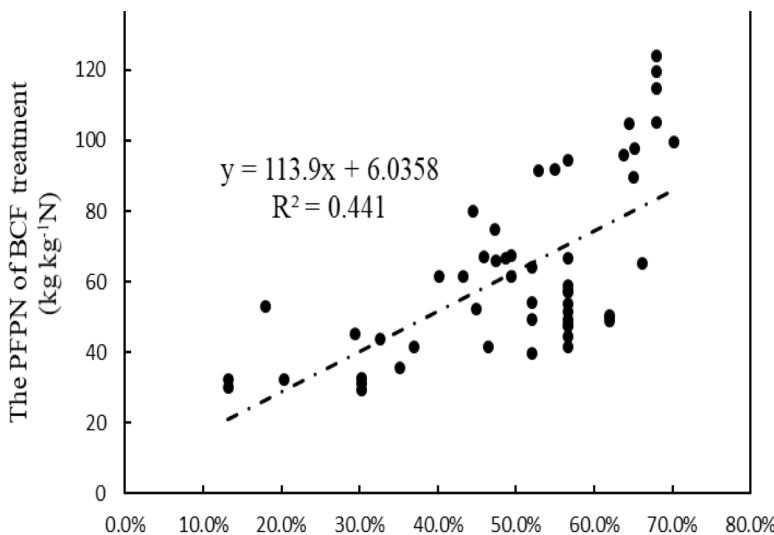
compared to 11% (Jeffery et al., 2011 soil amendment 20t/ha)

# Agronomic use efficiency



Improvement of PFPN ( 95% confidence interval )

- Rice:  $13.6 \pm 3.8\%$  ;
- Maize:  $47.7 \pm 10.8\%$  ;
- Wheat:  $47.3 \pm 80.9\%$ . ;



Increase in PFPN correlated to biochar portion in the fertilizer

# Table grape at mature



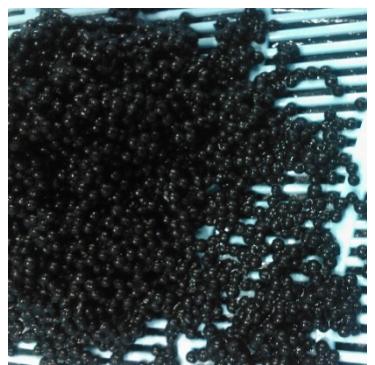
14-08-18

# Quality changes (Table grape)

| Fertilizer | SPAD        | Fruit size<br>(mm) | Sugar<br>(%) | Soluble Prot<br>(mg/g) | Vc<br>(mg/100g) | Acidity<br>(%) | Sugar to<br>acid |
|------------|-------------|--------------------|--------------|------------------------|-----------------|----------------|------------------|
| CF         | 38.88±3.40b | 21.05±1.22b        | 17.52±0.13b  | 56.91±1.18b            | 3.29±0.12b      | 0.95±0.02a     | 18.48±0.31b      |
| BCF1       | 40.48±2.85b | 24.06±1.26a        | 18.50±0.12a  | 60.27±1.52a            | 4.37±0.35a      | 0.86±0.03b     | 21.54±0.82a      |
| BCF2       | 43.66±2.72a | 23.10±1.27a        | 18.62±0.04a  | 60.67±1.08a            | 4.24±0.19ab     | 0.87±0.01b     | 21.34±0.21a      |

Improvement: 2-3mm size; 10% sugar content but 30% for Vc, others improved by 15-20% !

# Main product: Biochar soil conditioner



Combination, formulation and configuration

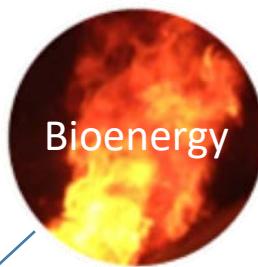




# Distributed biomass industry



Pyrolysis



Bioenergy

- Heating
- Vapors
- drying



Biochar-

- solid
- liquid



Nano-  
material

- Soil-water
- Food/forage
- Municipal use

**Thermolite, transform and segment only**

**No amendment, no synthesis and no  
release of chemicals**

# Distributed system of Biomass-Biochar Industry



Village level



County  
level



Individual farmers, cooperative farmer groups, feedstock company..



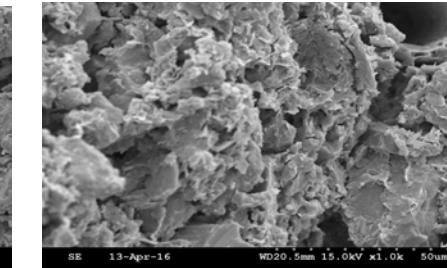
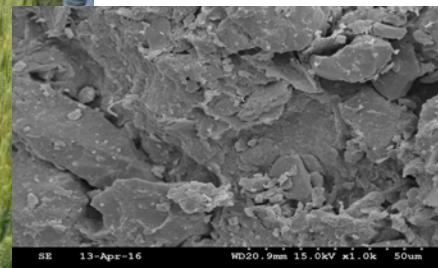
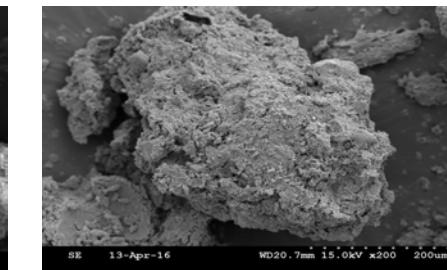
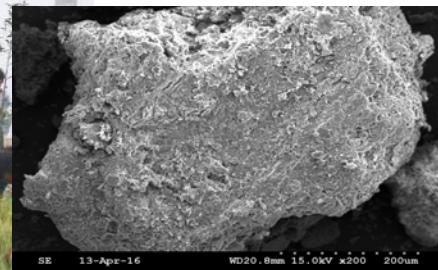
Feedstock: local collection and processing, sealing to biochar plant via logistics







Government appraised, recognized by extension agency..



# Being state policy supported

## 秸秆炭化还田技术受到国家部委认可

三聚绿能

Low carbon key tech, CRD

“秸秆炭化还田——土壤改良技术”，被国家发改委列入国家重点推广的低碳技术目录。



2014年9月



2017年4月

“秸—炭—肥还田改土模式”被农业部列入“秸秆农用十大模式”

Recommended as 10 top technique of resource recycling, MoA

Cutting edge tech, National Chemical Association

“农作物秸秆炭化还田—土壤改良技术开发与应用”被中国石油与化学工业联合会组织专家委员会鉴定为国际领先水平



2017年8月



2018年8月

秸秆炭化制肥项目被国家生态环境部列为“废弃资源综合利用业”

Appraised as comprehensive resource cycling industry, MEP

项目背景——符合国家政策方针

三聚绿能

# China's state policies regarded to biochar in agriculture

- 2012: Demonstration project
- 2013: Key technologies of Local governments
- 2015: Extension project by MoA
- 2017-05: Top 10 Key technologies
- 2017-07: BCF standard issued
- 2017-11: Co-production of biochar by State Council, State Energy Bureau, MoA
- 2018-07: Biochar technology planed by MoA;
- 2018-08: Straw to biochar featured in MEEP,
- more to come up...

The image shows six rectangular documents arranged in a 3x2 grid, each with a red header and black text. The documents are:

- 国家发展和改革委员会文件** (National Development and Reform Commission Document)  
农 业 环 境 保 护 部  
文 件  
发改环资〔2012〕300 号  
关于加强农作物秸秆综合利用  
和禁烧工作的通知
- 国家发展和改革委员会办公厅文件** (National Development and Reform Commission Office Document)  
农 业 部 办 公 室 文 件  
国 家 能 源 局 综 合 司  
发改环资〔2017〕2143 号  
关于开展秸秆气化清洁能源利用  
工程建设的指导意见
- 农业农村部文件** (Ministry of Agriculture and Rural Affairs Document)  
农农发〔2018〕3 号  
农业农村部关于印发《农业绿色发展技术导则  
(2018—2030年)》的通知
- 国家发展和改革委员会文件** (National Development and Reform Commission Document)  
财 农 政 环 保 部  
文 件  
发改环资〔2015〕2651 号  
关于进一步加快推进农作物秸秆综合利用  
和禁烧工作的通知
- 中华人民共和国农业农村部文件** (Ministry of Agriculture and Rural Affairs Document)  
农农发〔2018〕3 号  
对十三届全国人大一次会议  
第 4200 号建议的答复
- 国家能源局文件** (Ministry of Energy Document)  
环 保 部  
文 件  
发改能源〔2017〕211 号  
国家能源局 环境保护部关于开展  
燃煤耦合生物质发电技改试点工作的通知

# Technical advises and services provided for project

## 三聚炭肥示范田建设

三聚绿能  
Triple Poly Environmental Protection Technology Co., Ltd.

### 示范田分布情况

三聚地沃炭基肥示范田



- 示范田328块。**(2018)**
- 第三方权威机构试验报告146份。
- 编制《2017年生物质炭基肥料示范田报告汇编》及《示范田建设与管理手册》。



北京三聚绿能科技有限公司

# Product standards, operation guideline and quality control protocol available

## 企业产品标准

三聚绿能

三聚绿能就生物质综合利用技术获得的专利，制定了一系列生物质炭基肥料等产品的企业标准。

The image displays three main documents related to product standards:

- 实用新型专利证书 (Utility Model Patent Certificate):** Shows a certificate from the State Intellectual Property Office (SIIPO) with a red circular stamp. It includes the title "一种生物质炭化助燃设备" (A biomass charcoal combustion aid device), the date of application (2017.04.19), and the date of grant (2017.11.28). It also lists the patent holder as Beijing Sijilu Energy Technology Co., Ltd.
- 北京三聚绿能科技有限公司企业标准 (Q/SJLN 10102-2017):** A document titled "生物质炭基肥料" (Biomass Charcoal-based Fertilizer). It includes sections for "Q/SJLN 10102-2017", "03-2017", "0104-2017", and "0101-2017". It specifies "发布" (Issued) dates of 2017-08-01 and "实施" (Implemented) dates of 2017-08-15 for different parts.
- 其他标准文件:** Several other standard documents are shown, each with a red circular stamp and a title like "Q/SJLN 10103-2017" or "Q/SJLN 10104-2017".

# Biochar industry: Linked to local economy development: County



# BCF for special rice in Wuchang County





# Biochar industry: linked to Re-vitalization (poverty reduction) in remote rural area



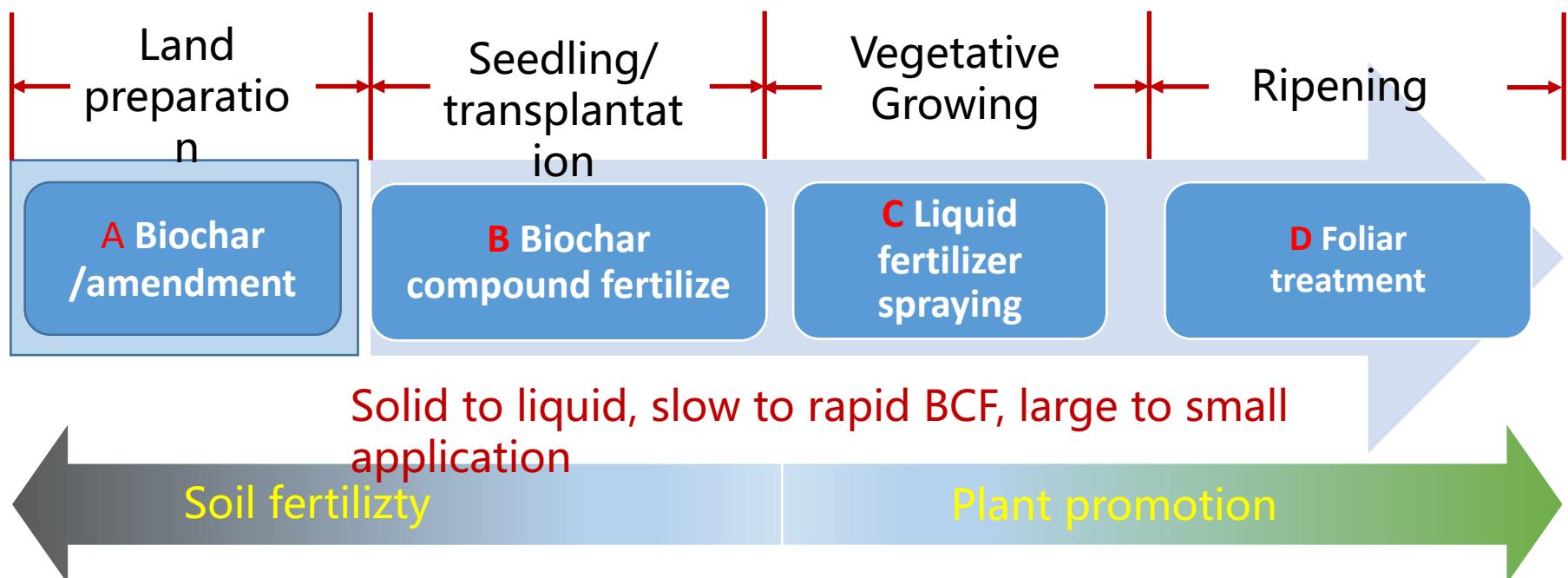
From waste to wealth as from straw to biochar-based agriculture, as in Jianping Liaoning, China

Quality to value



From waste management to food and health improvement!

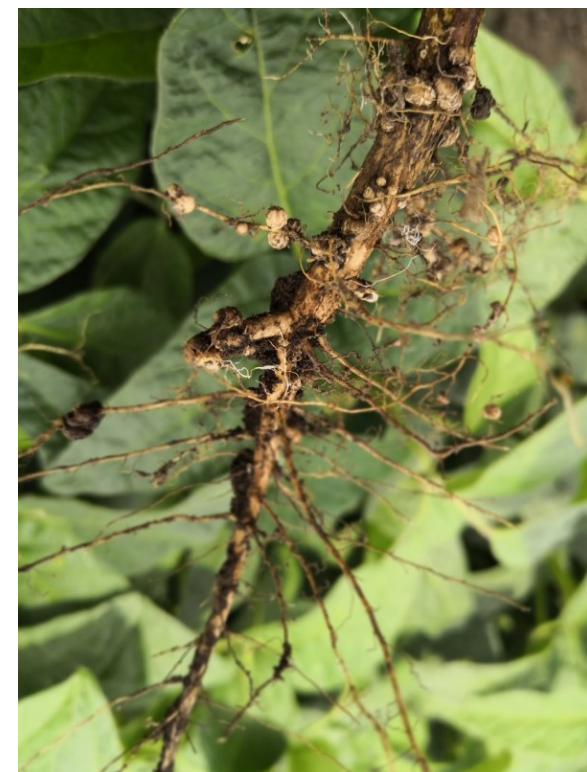
# Integrated soil-plant manipulation technologies under development



Biochar fertilizer based high quality agro-products for special sector: **grain for wine**



# Biochar fertilizer for soybean for food: high yield and quality soybean under testing



# Biochar agriculture: cobenefits should not be ignored

On site

- Carbon sequestration
- Grain production
- Household farmers
- Poverty reduction

Off site

- Environmental risks
- Food and health
- Consumers
- Rural vitalization

# Biochar for new green agriculture

Government, academic, extension and business in close cooperation

