



Potential Application of Juncao Technology for Smallholders' Livelihood Improvement

Dr. Dongmei Lin

China National Engineering Research Center of Juncao Technology
Fujian Agriculture & Forestry University

11 April, 2022

1. Juncao Technology & Juncao Industry

What is Juncao Technology?

Jun



真菌、菌菇
mushrooms or fungi

cao



草本植物
grass or herbaceous plant



Research on Juncao technology 'using grass to replace wood' to grow edible and medicinal mushrooms started in 1983 by Prof. Lin Zhanxi, and firstly succeeded in 1986.

A new **research field** that crossing fungi & herbaceous plant.

A new **category** of grasses.

A new **resource**.

Juncao technical system > **60** patents

Juncao: Herbaceous plants that can be used as the culture substrate for cultivation of edible and medicinal fungi.

** 49 species of Juncao (herbaceous plant) have been screened and bred to cultivate 56 species of edible and medicinal mushrooms.*

Juncao Technology: A comprehensive technology that utilizes Juncao to cultivate edible mushroom, medicinal mushroom, produce feed and fertilizer, etc.

Juncao Industry: A sustainable industry formed by application of Juncao technology and other interrelated techniques.

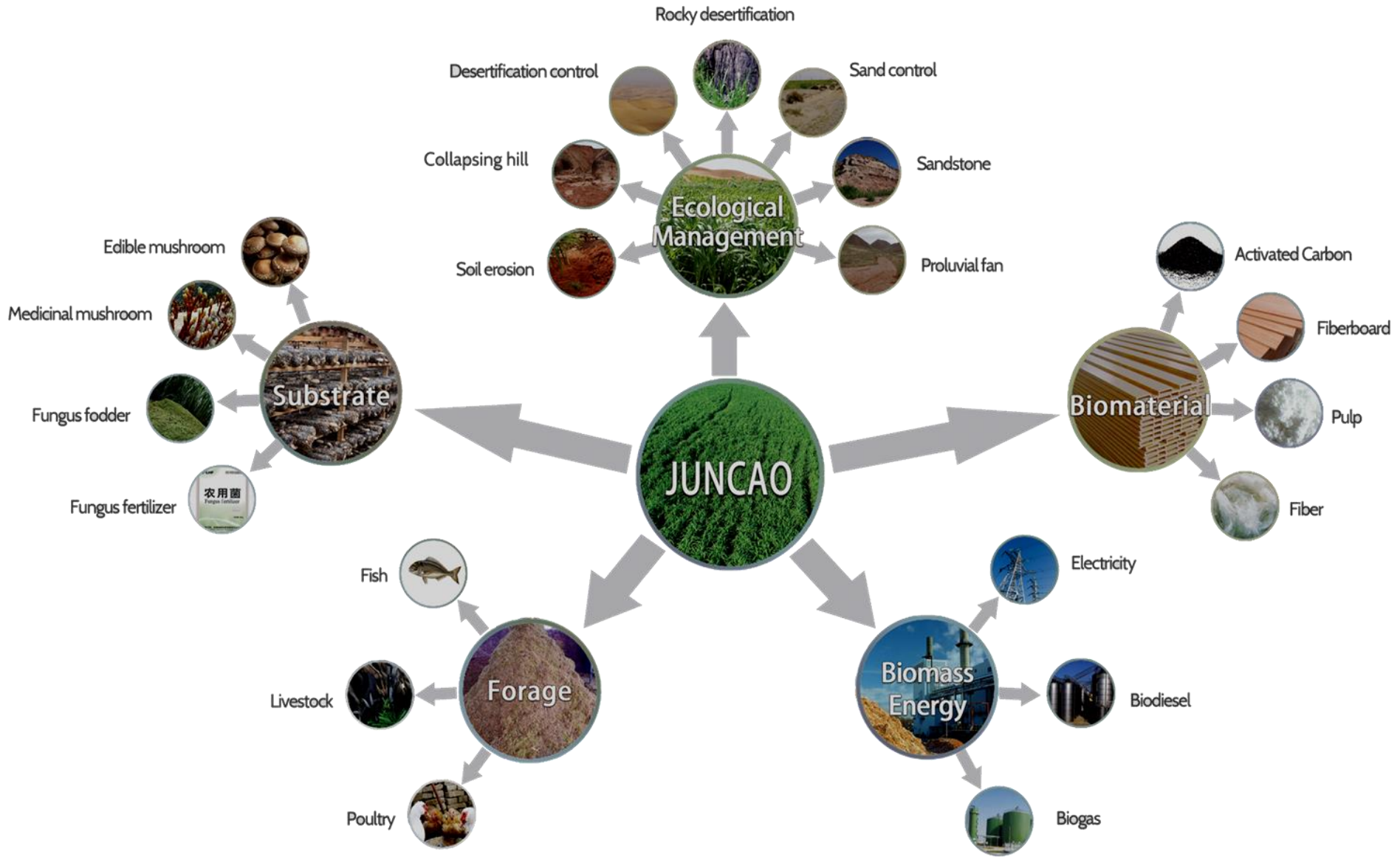
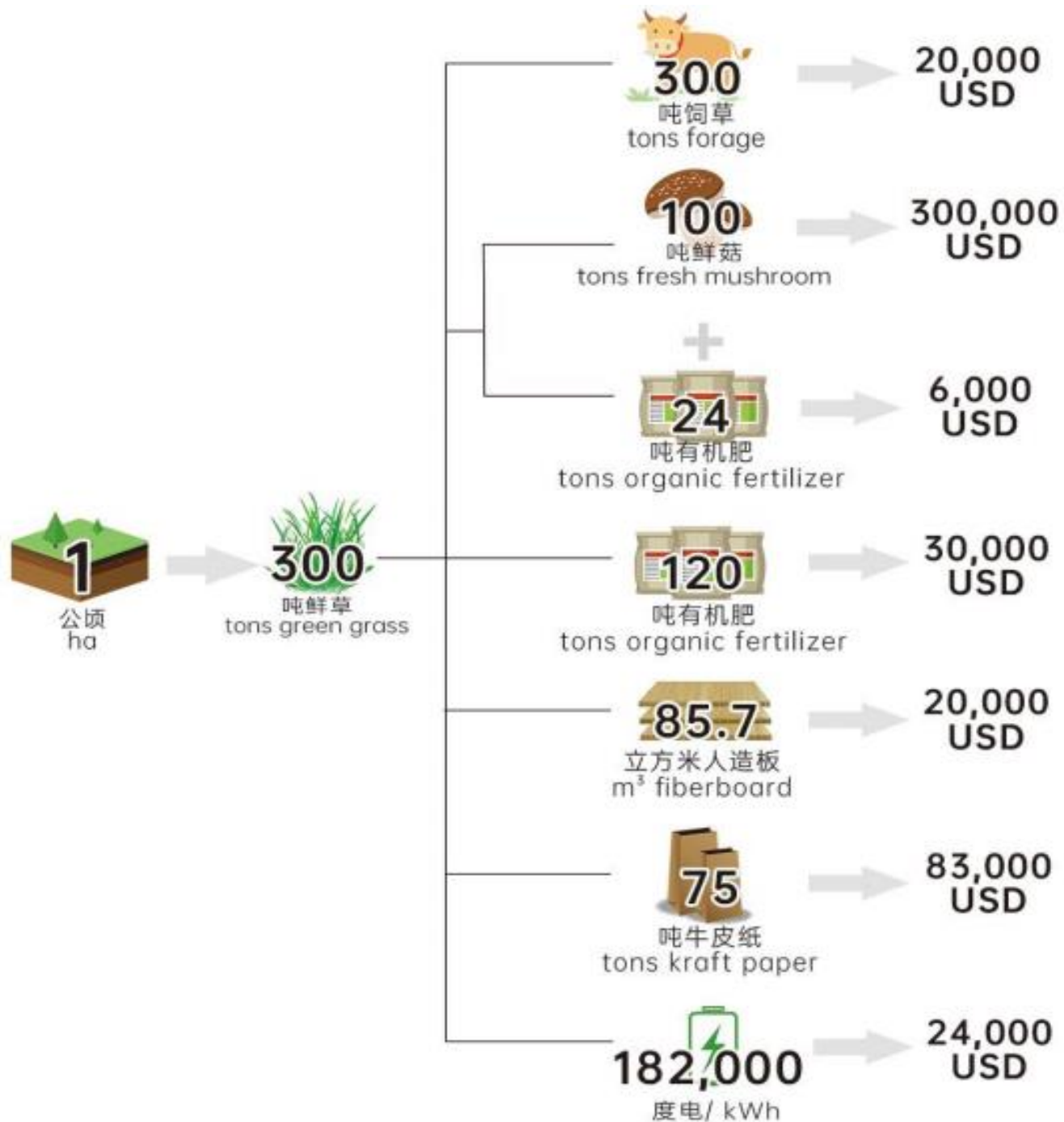


DIAGRAM OF JUNCAO INDUSTRY

Economic value



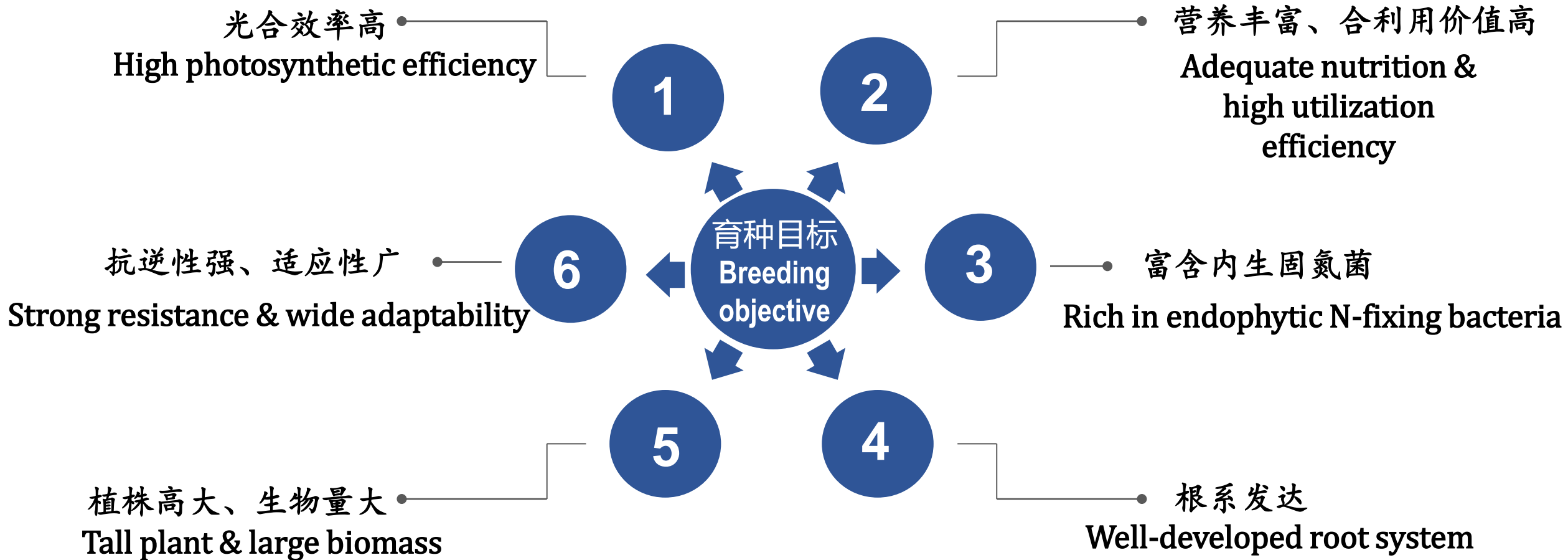
1-1 Screening and breeding of Juncao grass

In the 1980s: wild grasses, agricultural byproducts

Since the 1990s: Juncao grass species adapted to different climate conditions and planted at a large scale



Criteria for screening and breeding of Juncao grass

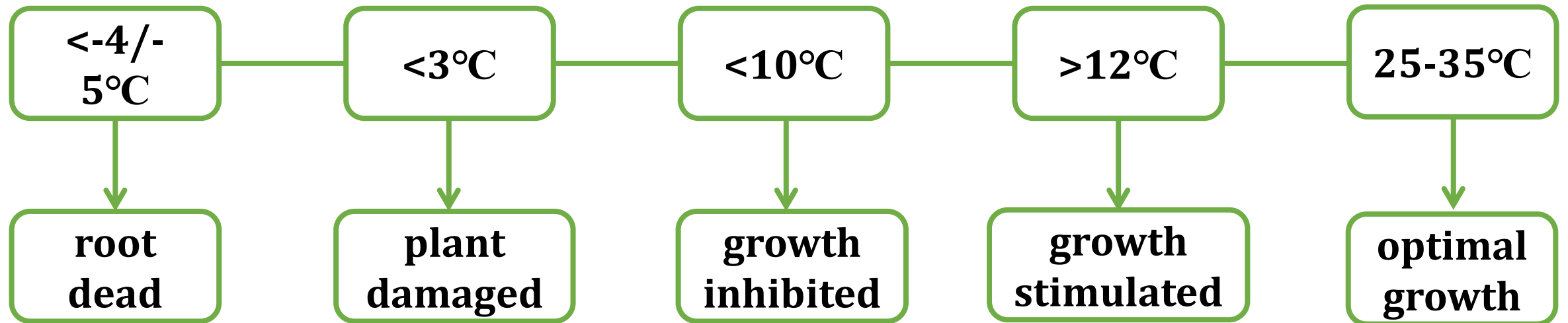


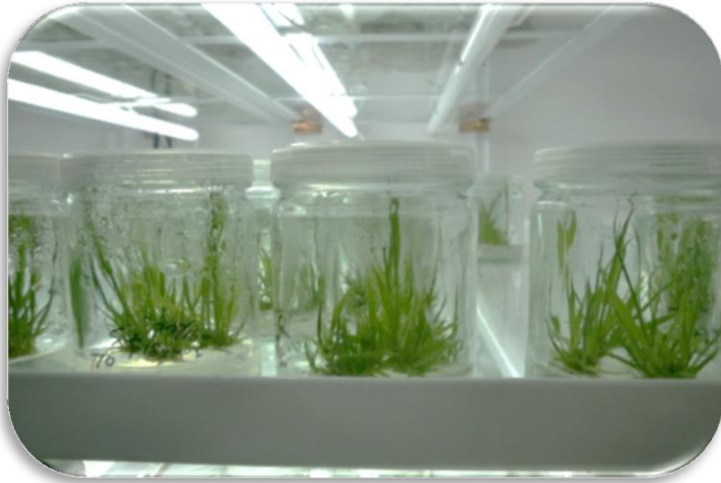
2. Introduction of Giant Juncao Grass

Biological characteristics of Giant Juncao Grass

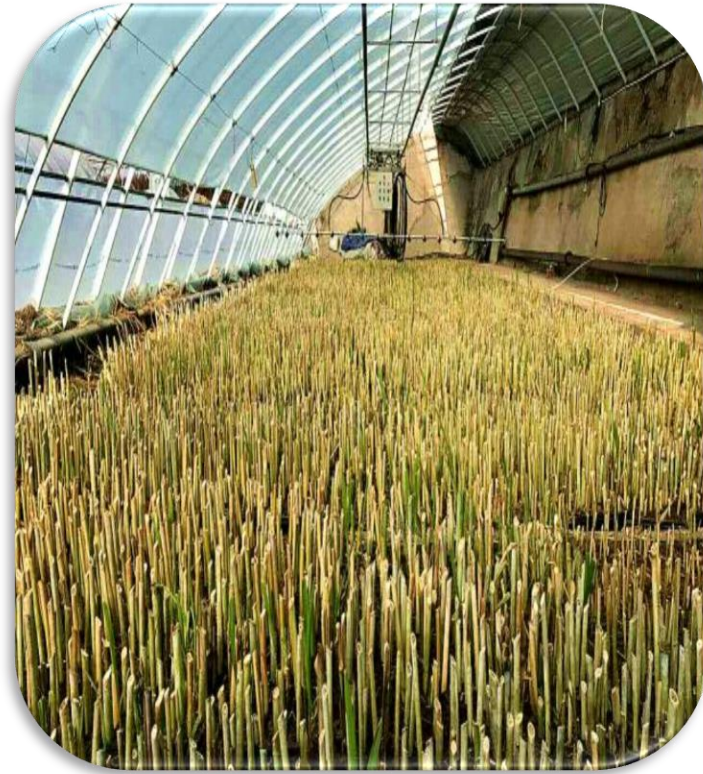
Scientific name	<i>Pennisetum spp.</i>
Plant height	4-5m, max 8m
Stem diameter	1.5-2.5 cm
Perennial	T>-4°C
Yield (fresh grass)	Temperate zone: 75-225 tonnes
	Sub-tropical zone: 225-300 tonnes
	Tropical zone: 300-600 tonnes
Carbon storage	C4 plant , fix Carbon 7-60t/ha

Biological characteristics of Giant Juncao Grass





Tissue culture & propagation



Cutting propagation

Biosafety

A risk assessment index system of *Giant Juncao* grass was established with the aim to evaluate the risk rank of Giant Juncao grass in Fujian Province.

Dispersal controllable

- no seeds, asexual reproduction
- no rhizome
- cannot regenerate when $T < -4\text{ }^{\circ}\text{C}$
- easy to control, easy to eradicate

No risk of invasion

The Biosafety Assessment of Introduced *Pennisetum* sp. in Fujian Province, China

PENG Lu^{1,2,3}, YANG Yi-Fan^{2,3,4}, HOU You-Ming^{1,2,3*}, LU Guo-Dong^{1,2}

(1. Department of Plant Protection, Fujian Agriculture and Forestry University, Fuzhou, Fujian 350002, China; 2. Key Laboratory of Integrated Pest Management on Crops in Fujian-Taiwan, Ministry of Agriculture, Fuzhou, Fujian 350002, China; 3. Fujian Provincial Key Laboratory of Insect Ecology, Fuzhou, Fujian 350002, China; 4. College of Life Science, Fujian Agriculture and Forestry University, Fuzhou, Fujian 350002, China)

Abstract: Based on analyzing the introduced ways, biological characteristics, and potential hazards of *Pennisetum* sp, as well as the ecological environment and management status, an index system for risk assessment of *Pennisetum* sp. was established, consisting of 3 different layers, ie. objective, criteria, and index layers, which include 20 index parameters, by following the principle of essentiality, systematicness, practicality and portability, and used to evaluate the risk rank of *Pennisetum* sp. in Fujian Province. The results showed that there was no risk to plant *Pennisetum* sp. in Fujian Province, which can be introduced or need not to take any preventive measures. Our work provides a theoretical basis for the safety of introduction, and large-scale cultivation and production of *Pennisetum* sp. in Fujian Province, beside that it will be of great importance in improving the economic benefit and protecting the biodiversity in our country.

Key words: introduction; *Pennisetum* sp. ; biosafety; risk assessment; biological invasion

Biodiversity

in Humid Area & Arid Area

Mingqing County, Fujian province, China



Insect species richness increased by more than **260%**, significantly affect the community of plant and insect diversity.

It increases **the soil microbial community functional diversity** and improve **soil fertility**.



1 month after planting

3 months after planting

Before: desert sandune

Insects: 16 species

Plants: 7 species



+ 143.75%



+ 185.71%

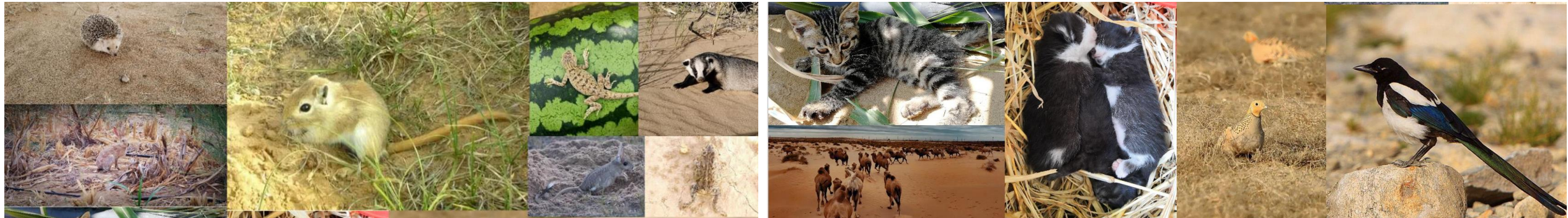
After: desert with Juncao grass planted

Insects: 39 species

Plants: 20 species



Animals attracted to Juncao technology desertification control experiment base, Inner Mongolia



3. Application Scenarios in Ecological Management

Juncao Eco-safety Barrier

refers to the application of Juncao technology at ecological fragile area for ecological management and economic development, through planting Juncao grass to restore vegetation, and carrying out the activities with comprehensive utilization of Juncao grass for the production of livestock, mushroom, fertilizer and materials, so as to provide sustainable ecological services for the survival and development of human beings in the region, and to promote the harmonious development of ecology, production and life.*

* Definition

菌草生态安全屏障

指的是在生态脆弱地区应用菌草技术进行生态治理的同时发展经济，通过种植菌草恢复植被以及进行菌、畜、肥、材料等综合开发利用的生产活动，为区域人类生存和发展提供可持续的生态服务，促进生态、生产和生活的协调发展。

Climate Change

Disaster prevention

Soil erosion control, flood regulation,

Disaster reduction

Tolerant to drought, flood, cold, wind...

Production recovery after disaster

Island & Beach

Pingtang Island

More than 300 days of strong winds above level 6 and 200 days of strong winds above level 7 and at least 5 typhoons every year.



Juncao grass are planted at Changjiangao where offshore wind power farm is located, and Xingfuyang where the reclamation land has high salinity. *Casuarina equisetifolia* is difficult to survive at both sites.



Island & Beach

Resource utilization and environment protection

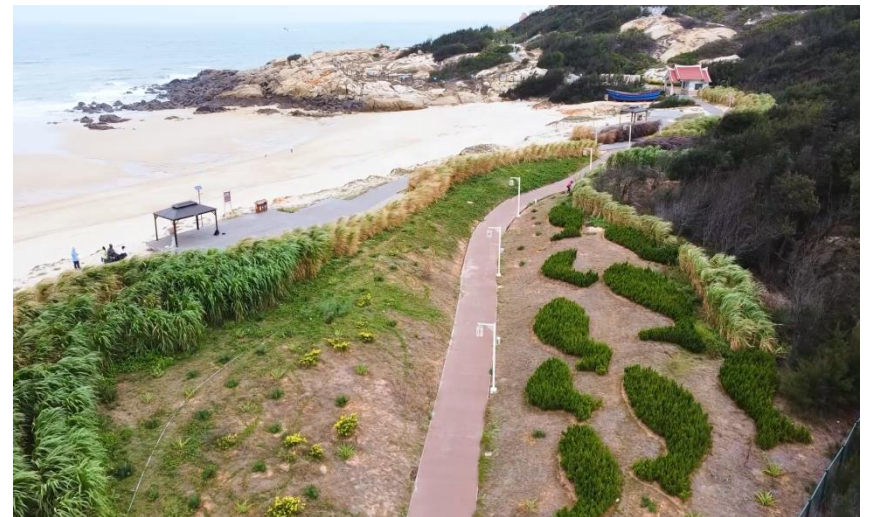
1. Juncao grass as shelter belt at wind gap

Fixes sand and blocks wind to protect the plants, farmland, roads and buildings.

2. Juncao grass planting improves land utilization

- Saline & alkaline land
- Solid waste (construction waste) landfill
- Rocky shore

3. Juncao grass planting sites become tourism attraction



Desertification Area

In the Yellow River basin, Juncao grass are planted to reconstruct or restore vegetation and act as shelter belt or pilot plant to build a biological barrier

Ecological functions: windbreaking, sand fixation, water conservation, improvement of soil quality, biodiversity, habitat and so on

Economic functions: production of feed, mushroom and organic fertilizer

Social functions: poverty reduction and job creation.



Demonstration of the **Ecological Safety Juncao Barrier** using Juncao grass as **pioneer plant** along **Yellow River**,
successful wind-preventing and sand-fixing within **80 to 100** days



Location	Ulan Buh Desert
Growth period	115 days
Plant height	246.5cm
No. of tillers	68
Fresh weight above the ground	12.71kg
Fresh weight under the ground (root system)	11.04kg
The number of roots	618
The depth of root	121.5cm
Sand fixing surface area	18.85m²
Sand fixing volume	11.45m³



Rocky Desertification Area

Bangadng Town, Ziyun County, Guizhou province

The 3 villages of Xintang, Xiaozaiguan and Luomai were area of deep poverty, with steep hills and shallow soil, very little income for local people from crop production.

Juncao Industry lifted more than **2000 households** out of poverty. Poverty reduction rate of Luomai village reduced from **15.7%** (2016) to **0.98%** (2020).

An ecological cyclic industry chain based on Juncao grass

Grass: about 140 ha of Giant Juncao grass planted

Livestock: fresh grass feed (selling at 400 yuan RMB/ton) to feed rabbit, pig, goat, cattle, and poultry, or be processed into silage feed (selling at 550 yuan RMB/ton).

Mushroom: produce 7 million mushroom substrates packs per year with Juncao grass, 160 mushroom green houses built

Organic fertilizer: spent mushroom substrates are turned into organic fertilizer and applied back into the grassland.



Soil Erosion Area

Rwanda: the soil loss rate and water loss rate were reduced by **97.05-98.9%** and **80.0-91.9%** respectively.

Cultivation models	Wet weight of soil (kg)	Dry weight of soil (kg)	Reduce soil loss rate compared to traditional crops (%)
Model of local traditional crop cultivation	656.7	484.18	—
Model of intercropping crops with Giant Juncao grass on contour line	27.18	20.25	95.80%
Model of planting JUNCAO grass	8.6	5.93	98.90%



Maize cultivation



Intercropping Juncao grass with maize



Juncao grass planting

* Rainfall 51ml from 17:00-19:30 on 30th Oct. 2012

River Bank & Flood Land

- Conserve river water source
- Intercept non-point source (NPS) pollutants and purify water
- Wave dissipation
- Shore line protection
- Provides rich resources for animals, insects, birds and other organisms, and is a paradise for organisms
- Form a landscape
- Regulating local microclimate



Abandoned Mine Land




Heavy metal contamination

Absorb heavy metals in soil, e.g. Cu 3781 g/ha, Hg 297g/ha, Cd 28.8 g/ha

Heavy Metal Absorption

Metabolic properties, gene functions, and biosafety analysis reveal the action of three rhizospheric plant growth-promoting bacteria of Jujuncao (*Pennisetum giganteum*)

Richard Yankey^{1,2,3}  · Ibrahim N. A. Omoor^{1,2} · Joseph K. Karanja⁴ · Lifang Wang^{1,2} · Regassa Terefe Urga⁵ · Chew Hui Fang^{1,2} · Lin Dongmei¹ · Hui Lin¹ · Jacob Eyalira Okal^{1,2} · Ibrahim Lawandi Datti^{1,2} · Aimable Nsanzinshuti^{1,2} · Christopher Rensing⁶ · Zhanxi Lin^{1,2}

Received: 7 July 2021 / Accepted: 26 November 2021

© The Author(s), under exclusive licence to Springer-Verlag GmbH Germany, part of Springer Nature 2021

Abstract

This study aimed to identify the specific genes associated with plant growth promotion and cadmium tolerance in three bacteria strains associated with *Pennisetum giganteum* as well as to determine their biosafety levels in their potential use as biofertilizers for promoting plant growth and phytoremediation activities. The plant growth-promoting (PGP) abilities of *Enterobacter cloacae* strain RCB980 (A3), *Klebsiella pneumoniae* strain kpa (A4), and *Klebsiella* sp. strain XT-2 (A7) were determined by a growth promotion trial and through testing for PGP traits such as 1-aminocyclopropane-1-carboxylic acid (ACC) deaminase enzyme production, phosphorus solubilization, siderophore synthesis, and indole-3 acetic acid (IAA) production. The genes that potentially contribute to the beneficial activities of these three strains were identified through an analysis of their genomes. To establish the biosafety of the candidate PGPB, a pathological study was undertaken whereby 20 Kunming mice were injected intraperitoneally to study and analyze the effects of the strains on growth and lung paraffin sections of the mice. The strains had no obvious toxicity effect on the tested mice and were therefore not considered as highly virulent strains. These strains are thus considered non-toxic, safe, and highly recommended for use in environmental remediation strategies and agricultural production.

Saline & Alkaline Land

Eg. Giant Juncao grass can survive and grow normally under low and moderate salinity (pH 4-8.7).



Soil Improvement

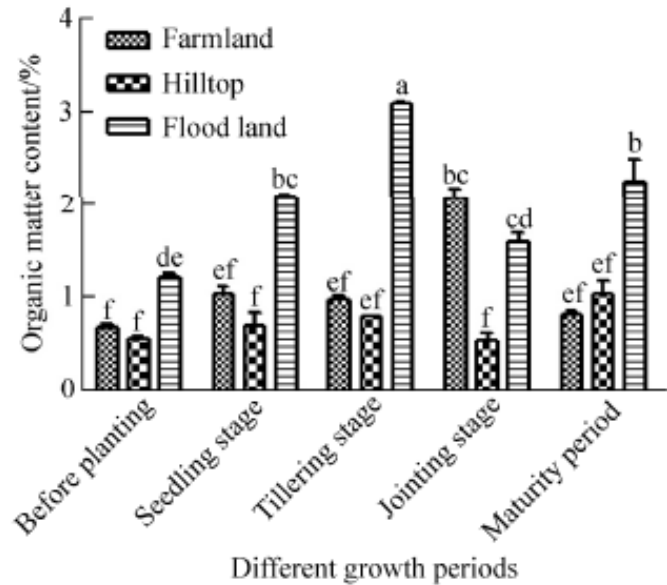


图 2. 不同生长时期巨菌草土壤有机质含量的变化
Figure 2. The change of organic matter in the soil at different growth stages of *Pennisetum* sp. The significant difference ($P < 0.05$) between the organic matter contents of different soils is indicated by the letters a, b, c, d, e, or f.

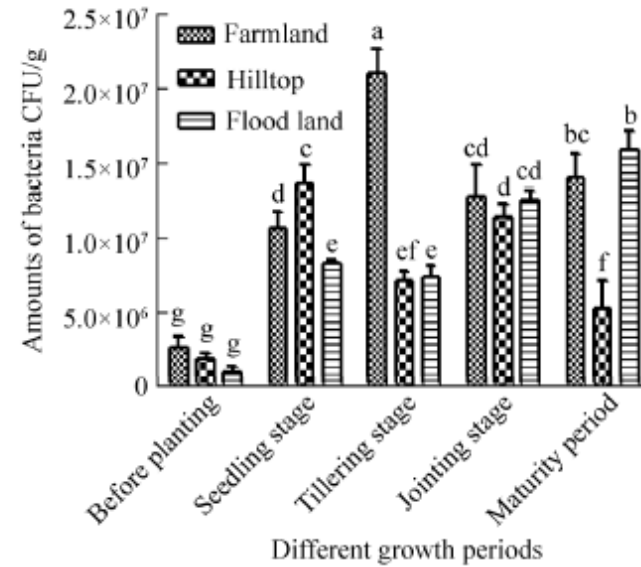
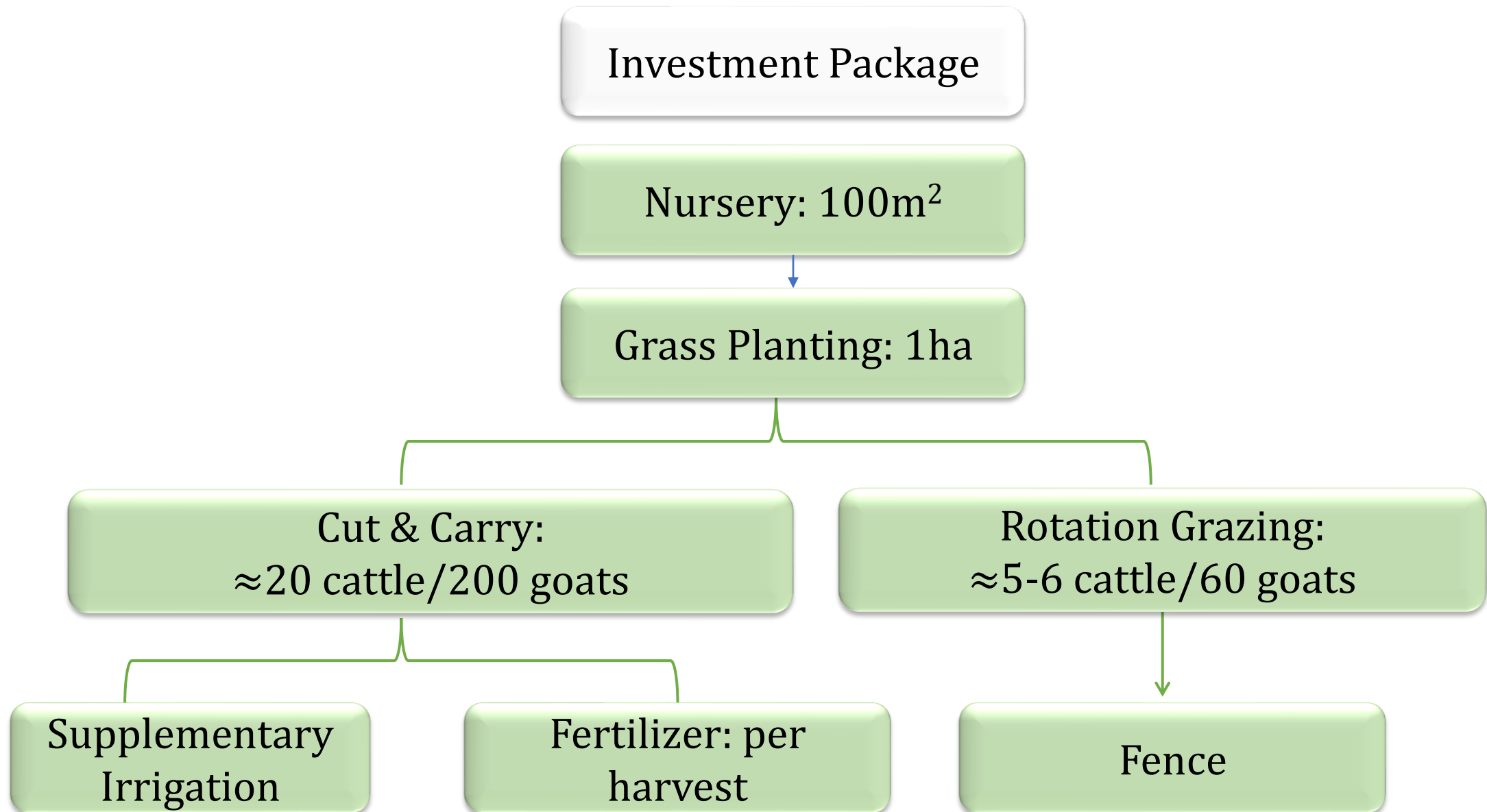


图 4. 不同生长时期巨菌草土壤细菌量的变化
Figure 4. The change of the amounts of bacteria in the soil at different growth stages of *Pennisetum* sp.. The significant difference ($P < 0.05$) between the number of culturable bacteria of different soils is indicated by the letters a, b, c, d, e, f or g.

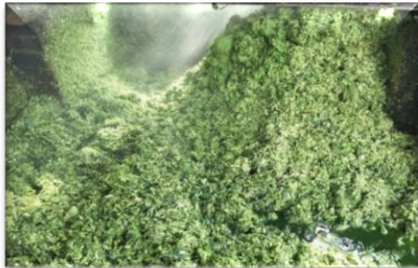
Juncao grass planting significantly promotes the diversity and richness of soil bacterial flora and effectively improve soil organic matter content.

4. Livestock Raising with Juncao Grass



Juncao Forage

Green Forage



Silage Forage



Spent Mushroom Substrate
Feed/Feed Additives

Small-sized bag:
30-50kg

Large-sized bag:
500kg-1000kg

Forage

The crude protein content of Giant Juncao is 11-17.74%.

Silaged Giant Juncao grass **pH 3.94**。

The sensory evaluation of silage Giant Juncao is **excellent**, and the ratio of **ammonia nitrogen to total nitrogen** is 2.97, which meets the standard of high-quality forage.

The weight gain of cattle fed with silage Giant Juncao grass is similar to that of silage corn.

**Test of Comparative Effect of 3 Different Silage Feeds on
Fattening Cattle provided by the Farmers Cooperative of Gansu Province**

Group	(kg/head) Initial weight	(kg/head) Final weight	(kg/head) Weight gain	(kg/head) Daily gain
A Silage Giant Juncao grass	617.20±40.55	672.20±42.46	55.00±8.92	1.10±0.18
B Silage whole plant corn	622.00±25.80	680.00±26.09	58.00±4.85	1.16±0.97
C Silage sweet sorghum	618.00±23.45	671.20±23.81	53.20±2.05	1.06±0.41

* 16 kg silage grass per head per day + 8 kg concentrated feed per head per day.

**Test of Comparative Effect of 3 Different Silage Feeds on
Fattening Sheep provided by the Farmers Cooperative of Gansu Province**

Group	(kg/head) Initial weight	(kg/head) Final weight	(kg/head) Weight gain	(g/head) Daily gain
A Silage Giant Juncao grass	42.25±2.44	52.60±2.70	10.35±0.78	207±15.67
B Silage whole plant corn	41.80±1.55	50.40±1.74	8.60±0.99	172±19.89
C Silage sweet sorghum	42.00±2.13	50.90±2.66	8.90±0.66	178±13.17

* 3 kg silage grass per head per day + 1 kg concentrated feed per head per day.



Aerial photography Juncao planting base



Mechanized harvesting





Case 1-- Fiji

The Juncao planting area has exceeded **500 hectares**, and provides more than **50,000 tons** of high-quality forage every year, which effectively alleviated the shortage of green fodder in the dry season and beefed up the animal husbandry development.



Ministry of Agriculture
FIVE INITIATIVES

1. Optimizing the use of Juncao Grass to Enhance Livestock Production

In partnership with the Chinese Government's Juncao Technology Program, medium-large livestock farms will be chosen to plant 0.5 acres of Juncao grass, which farmers will later expand for livestock feed. For a single hectare of Juncao grass planted, a total of 450 tons of green feed can be produced and prepared as silage feed for livestock during drier periods of the year. The Agriculture Ministry will provide a limited number of air tight bags for storage of shredded forage to be used during droughts. Juncao grass can be supplied as green forage for livestock and highly appropriate for Fiji's Northern and Western divisions, where it can withstand annual dry spells. The project implementation will be equally distributed amongst locations with commodity specific to dairy, beef and small ruminant farms.



Case 2–Lesotho

“It's about now almost 3 to 4 years since I've been growing this grass. It's very, very good for feeding my cows. I have about 5 cows here that are feeding on this thing. I always cut and feed them. And they produce a lot of milk as a result of that. And above all, this grass is very, very good for soil conservation, because it preserves our soil. It is about 7 days since I've cut, but you cannot actually see this, and they grow very fast.”



Case 3–Rwanda

The water and soil conservation mode that integrates local traditional agricultural production and livestock feeding is demonstrated, such as “**contour Juncao grass planting**”, “**Juncao grass interplanting crops on the terrace**” with low investment and quick returns.



Case 4–Madagascar



Agricultural technicians learn to grow Juncao in Morondava City.



Juncao Demonstration Base was established at the Rural Development and Agricultural Application Research Station in Anchibeira City.



Case 5--China

Divide the areas of hillside to plant Juncao grass, more than 300 goats were raised in the way of rotation grazing and free-range rearing.



Case 6--China

4000m² of Giant Juncao grass were planted and 20 cattle were raised. Two people spend about 2 hours feeding the cattle every day, and the labor intensity is not very high.

Annual income: 70,000USD

Net profit: 40,000USD



5. Demonstration Base for quick Covid-19 Recovery

Small Scale Demonstration Base

- ◆ Meet the demands of initial stage for technology transfer;
- ◆ Lower set-up cost;
- ◆ Ready for operation within 3-4 months, using existing buildings/facilities mainly;
- ◆ Further expanded into a large scale base for industry development in future.
- ◆ Techniques: Juncao grass planting, forage production, environmental protection (soil erosion control & desertification control).

4 modules

- ◆ Construction package
- ◆ Seeds package
- ◆ Equipment & materials package
- ◆ Intelligent device (Smart) package where 3G/4G signal available

6 functions

- ◆ Seedlings propagation
- ◆ Demonstrative planting and feeding
- ◆ Grass processing & packaging
- ◆ Training
- ◆ Extension
- ◆ Education, practical lessons for schools





发展菌草业 造福全人类

Develop Juncao Industry for the Benefit of All Mankind



Thank You!

Please indicate the source for the citation of the data and statistics.