蘭州大學 草地农业科技学院
COLLEGE OF PASTORAL AGRICULTURE SCIENCE AND TECHNOLOGY, LANZHOU UNIVERSITY

11th INTERNATIONAL HERBAGE SEED GROUP CONFERENCE
11-18 JUNE 2023 ANGERS CONGRESS CENTRE LOIRE VALLEY·FRANCE

Forage Seed Production in Northern Arid China

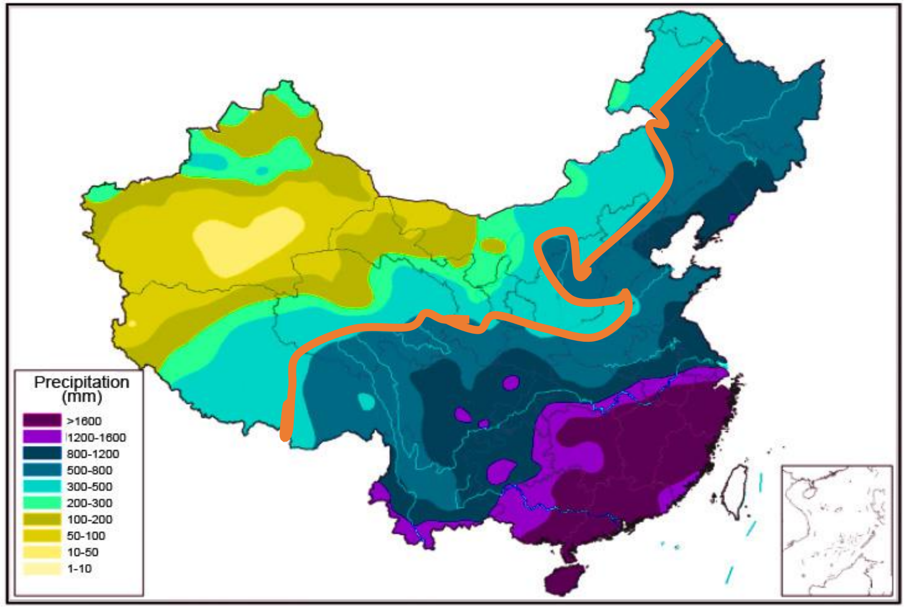
Jiyu Zhang
zhangjy@lzu.edu.cn
Lanzhou University, China
2023.6.11

Report Outline

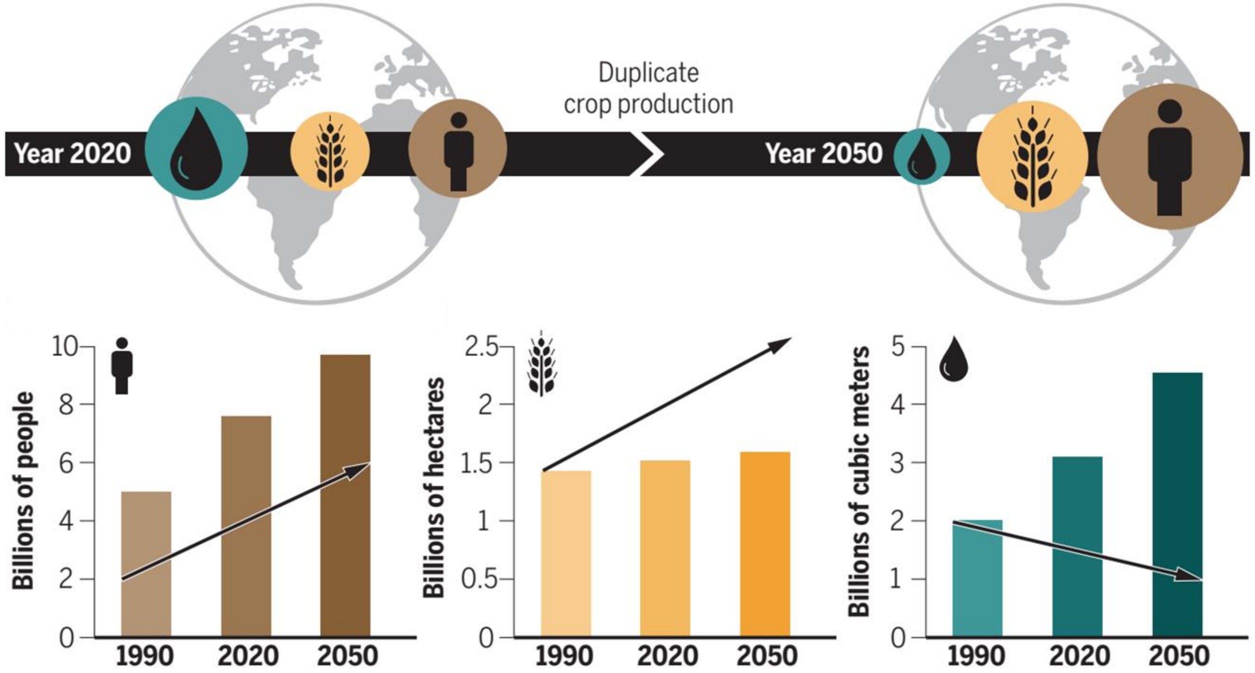
1. Background
2. Reproductive Characteristic
3. Variety Breeding
4. Seed Production
5. Application
6. Acknowledgements

1. Background

- **Climate change is leading us toward a hotter, more parched world. In the past decade, global losses in crop production due to drought totaled ~$30 billion (Gupta *et al.*, 2020).**
- **China is a major grassland country, with a total grassland area of 4×10^8 hm^2, accounting for 41.7% of the national territory (Fang et al., 2016).**

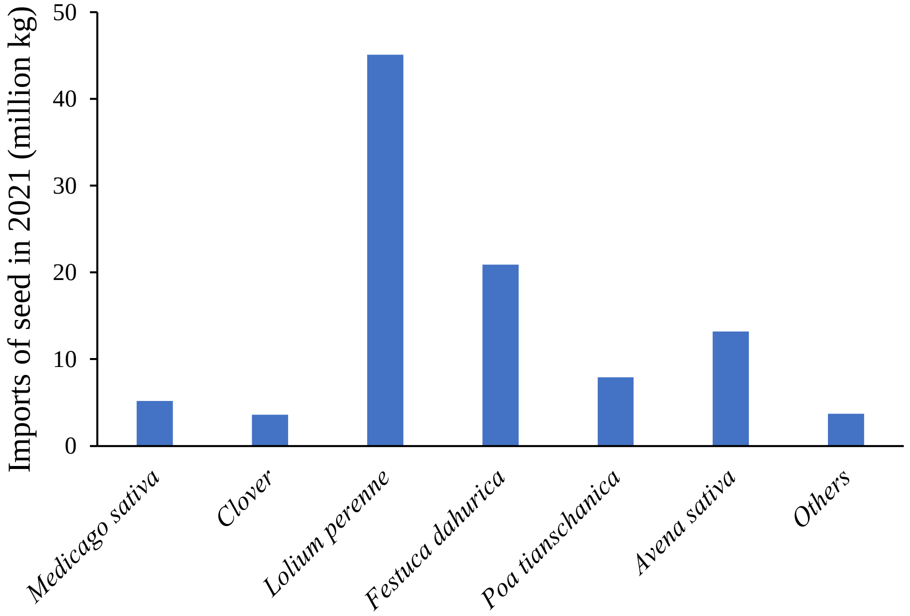


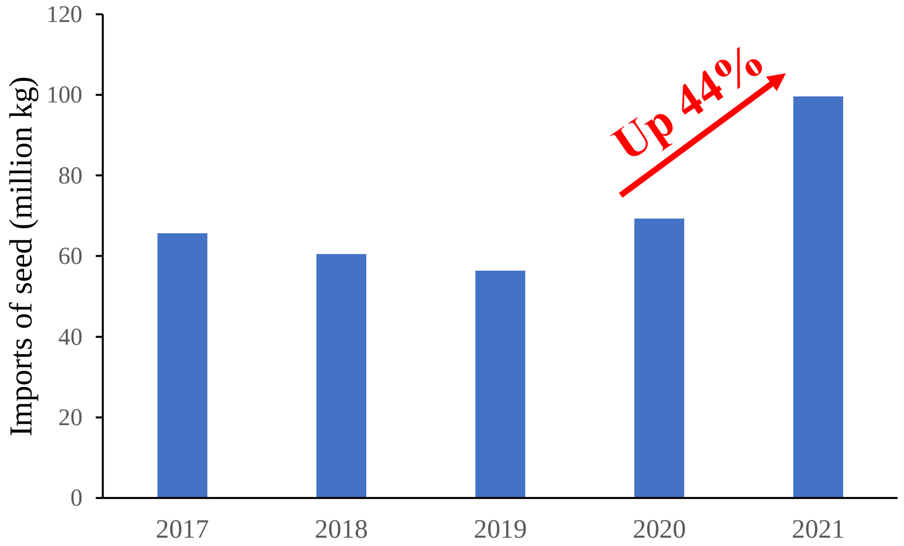
我国干旱半干旱地区分布图 **(Shan *et al.*, 2010)**

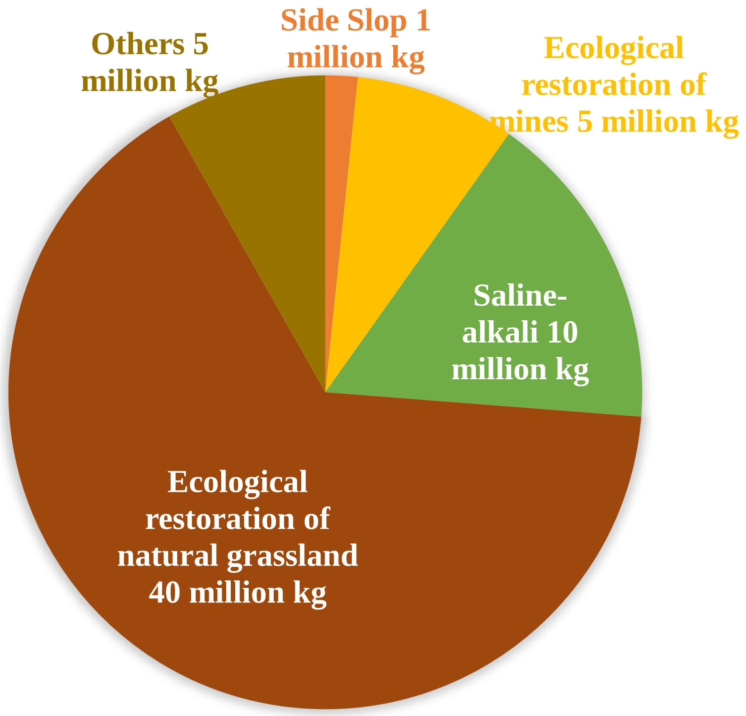


1. Background

- Grassland degradation has become a serious issue, resulting in a decline of vegetation cover, the ecological service functions of grasslands have declined (Shen, 2016).
- Grass seeds are essential production resources for the improvement of degraded grasslands and soil and water conservation (Wang, 2013).
- Native grass play important role in the improvement of degraded grasslands and the management of desertification.







Prediction of Ecological Seed Demand in China in 2023

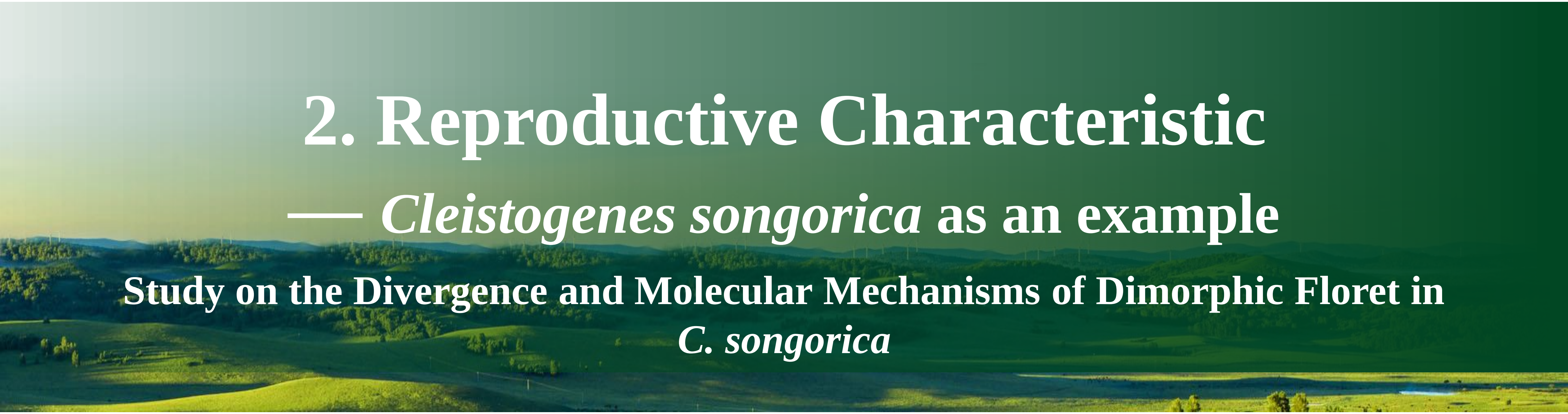
1. Background

- ➢ ***Cleistogenes songorica*** **is an important perennial forage, and ecologically significant C_4 grass in desert areas where average annual rainfall is below 110 mm.**
- ➢ ***Melilotus officinalis*** **is an annual or biennial herb, which has adapted to extreme environmental conditions such as cold, drought and saline-alkali.**
- ➢ ***Lespedeza potaninii*** **Vass is a perennial leguminous forage crop with drought, cold and barren tolerance.**

Cleistogenes songorica – Reproductive Characteristic

Melilotus officinalis – Breeding Methods

Lespedeza potaninii Vass.) – Seed Production



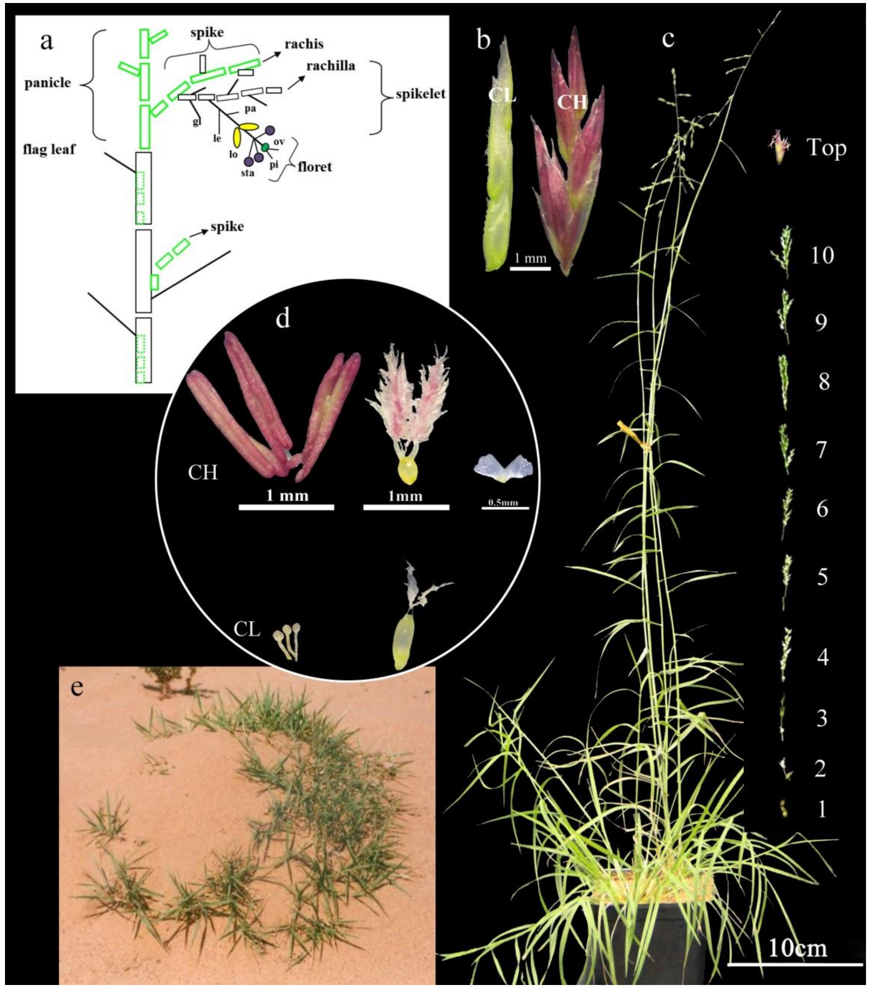
2. Reproductive Characteristic

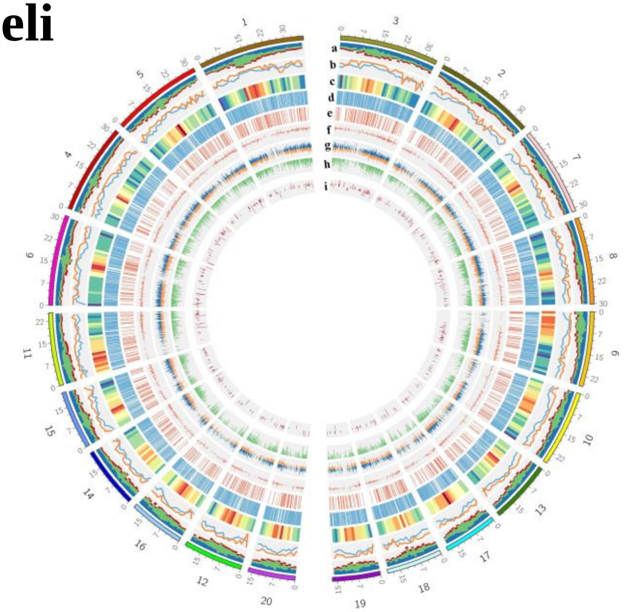
— *Cleistogenes songorica* as an example

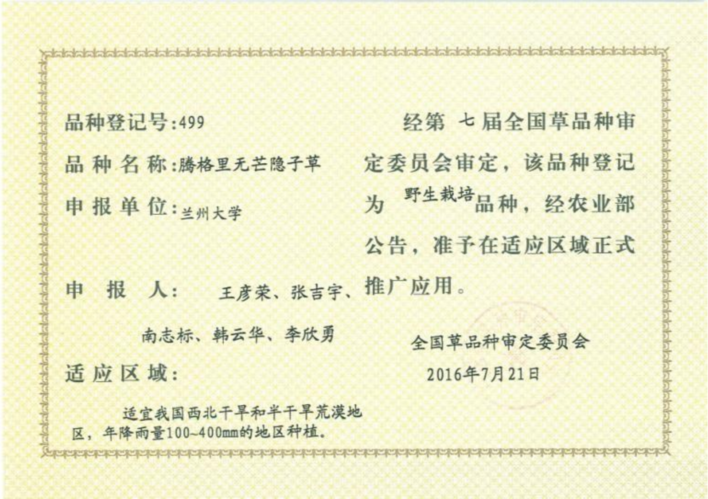
Study on the Divergence and Molecular Mechanisms of Dimorphic Floret in *C. songorica*

2. Reproductive Characteristic— *Cleistogenes songorica* as an example

- ***C. songorica*** **develops two types of inflorescences in a single plant, enabling open pollination (chasmogamy, CH) on the top panicle, and self-pollination (cleistogamy, CL) on spike flowers embedded in the leaf sheath at each node.**
- **We sequenced and assembled a high-quality chromosome-level *C. songorica* genome (Zhang et al., 2021).**
- **Domestication and variety breeding a new cultivar: *Cleistogenes songorica* cv Tenggeli**







品种登记号:499

品 种 名 称:腾格里无芒隐子草

申 报 单 位:兰州大学

申　报　人:　王彦荣、张吉宇、南志标、韩云华、李欣勇

适 应 区 域:

适宜我国西北干旱和半干旱荒漠地区，年降雨量100~400mm的地区种植。

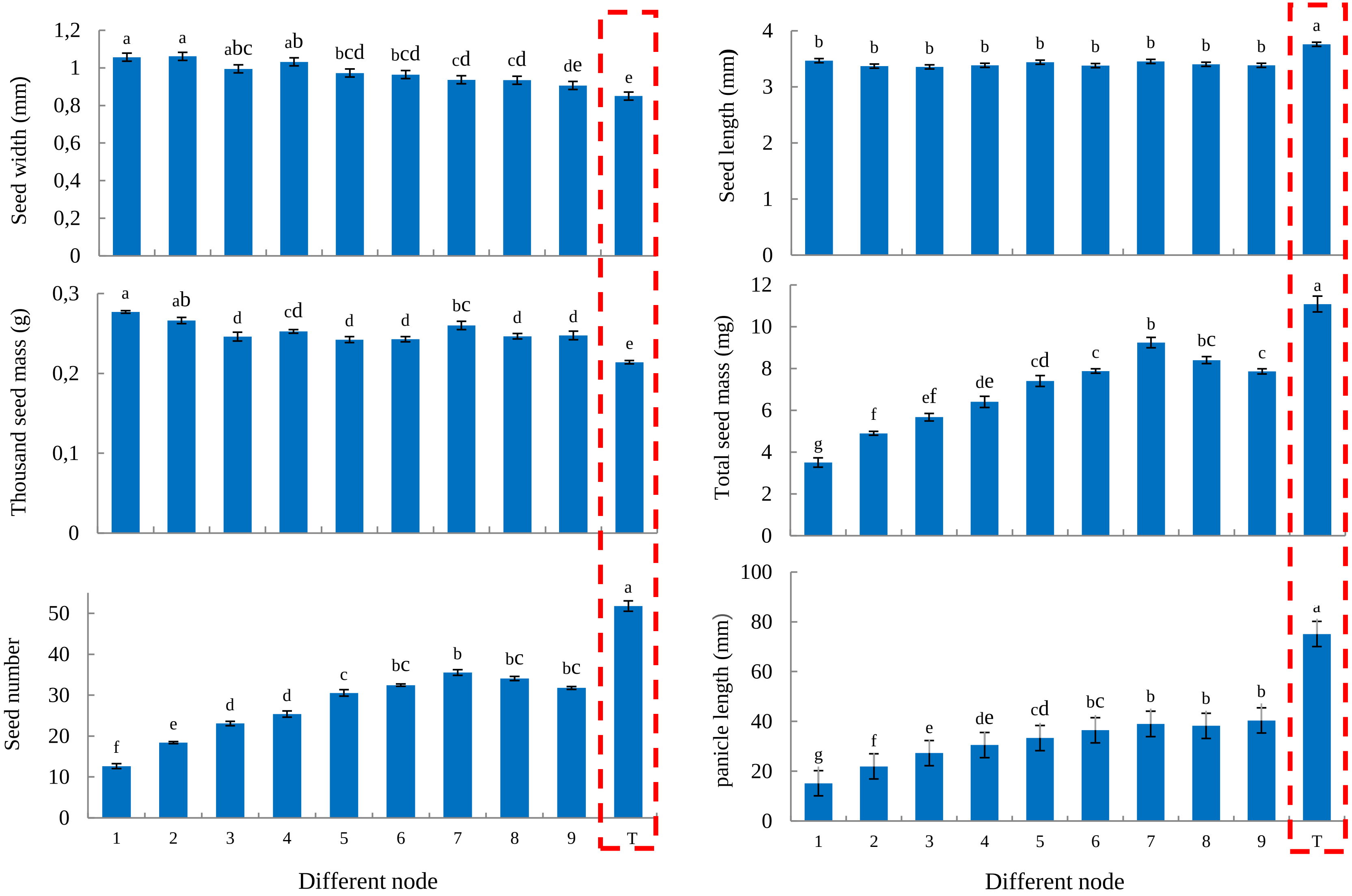
经第 七 届全国草品种审定委员会审定，该品种登记为 野生栽培 品种，经农业部公告，准予在适应区域正式推广应用。

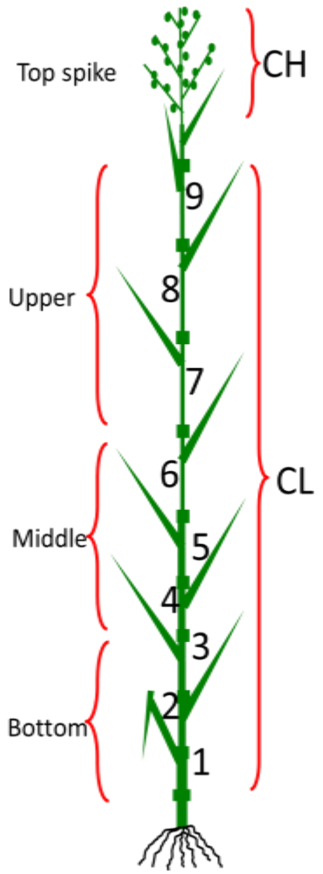
全国草品种审定委员会

2016年7月21日

2.1 Seed divergence from different positions

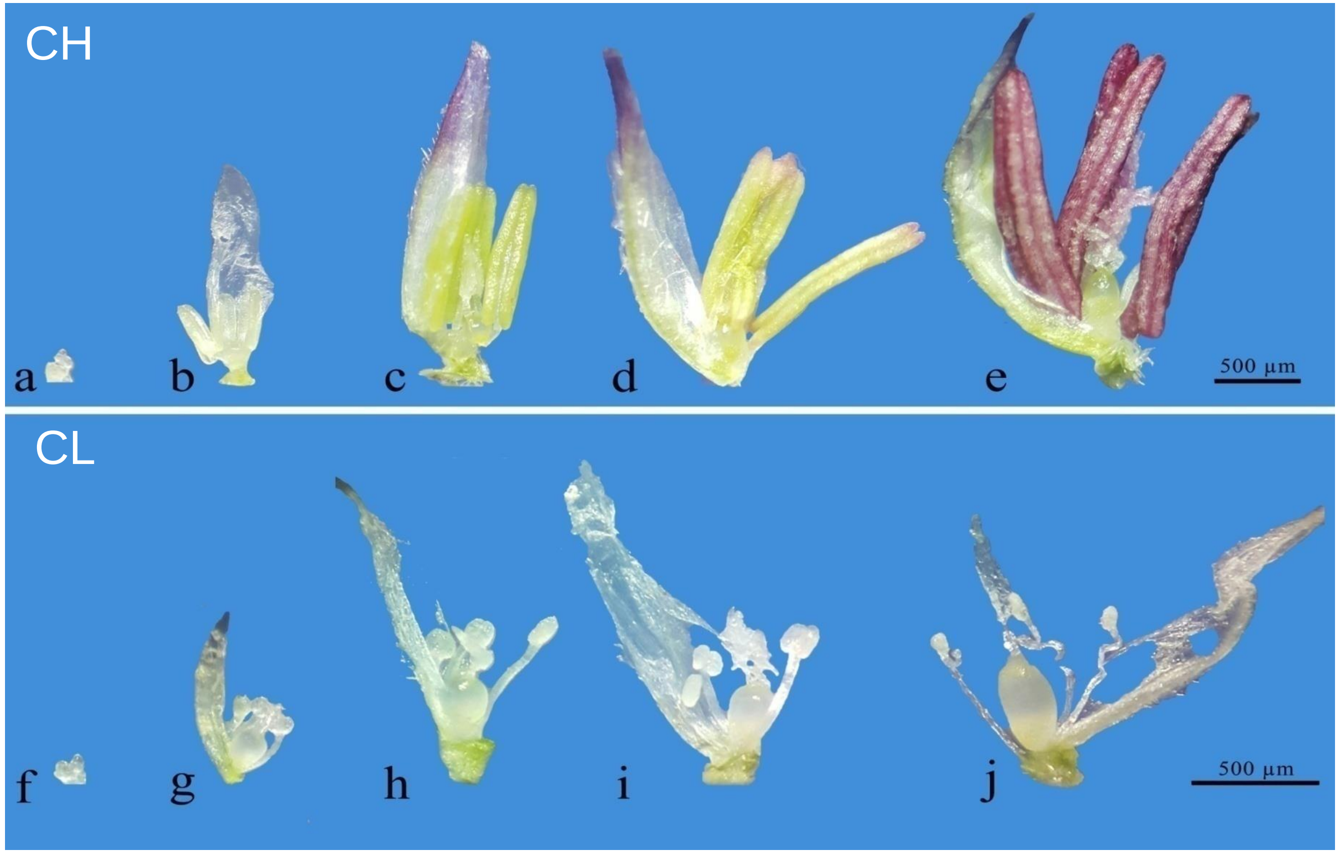
- **There was progressive increasing in seed number, seed mass and length of spikelet from the bottom to the top**



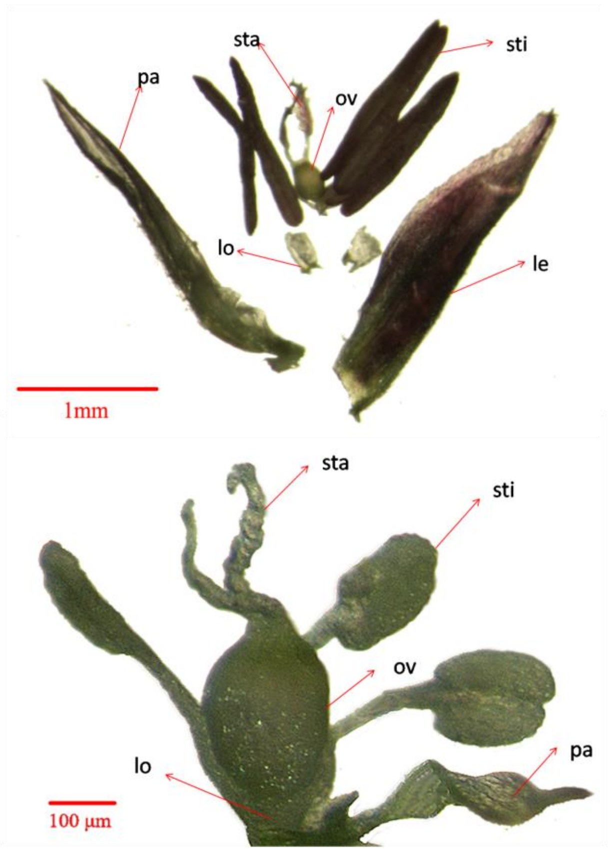


2.2 Different developmental stages of CH and CL flower

- ➢ *C. songorica* could develop both CH and CL flowers, but there were some morphology difference between CH and CL floral organs



Different developmental stages of chasmogamy (CH) and cleistogamy (CL) flower

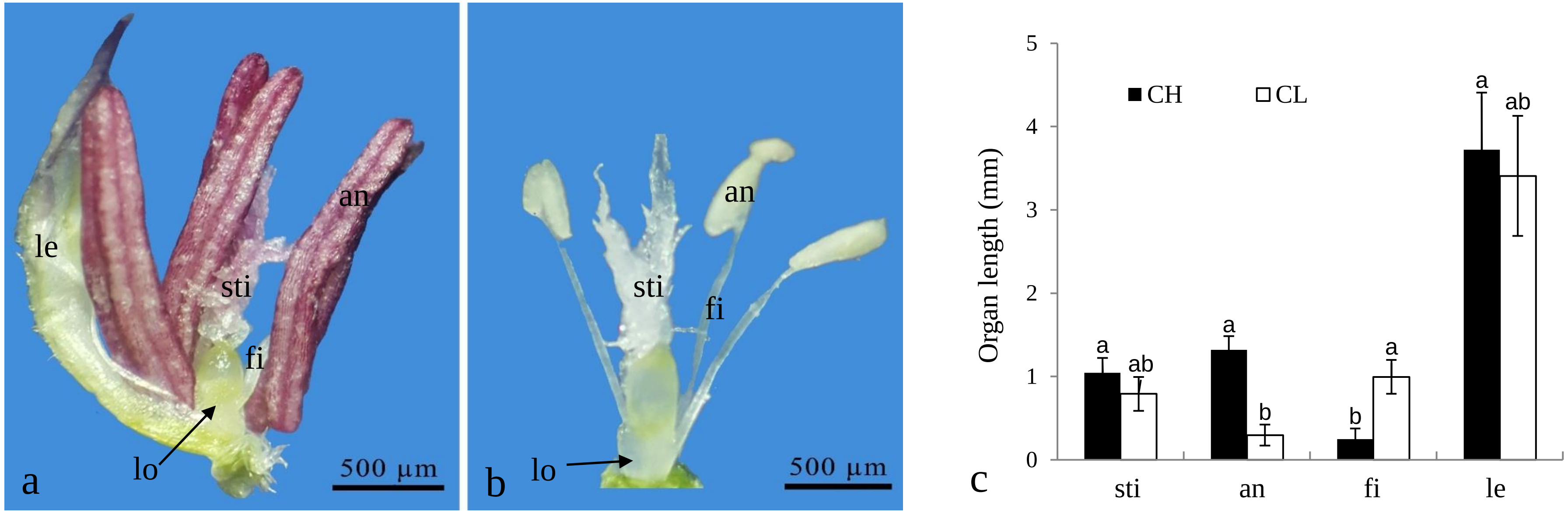


Floral organ structure of CH and CL

Note: lo, lodicule; ov, overy; le, lemma; pa, palea; sti, stigma; an, anthers; fi, filaments.

2.3 The morphology divergence of CH and CL flower

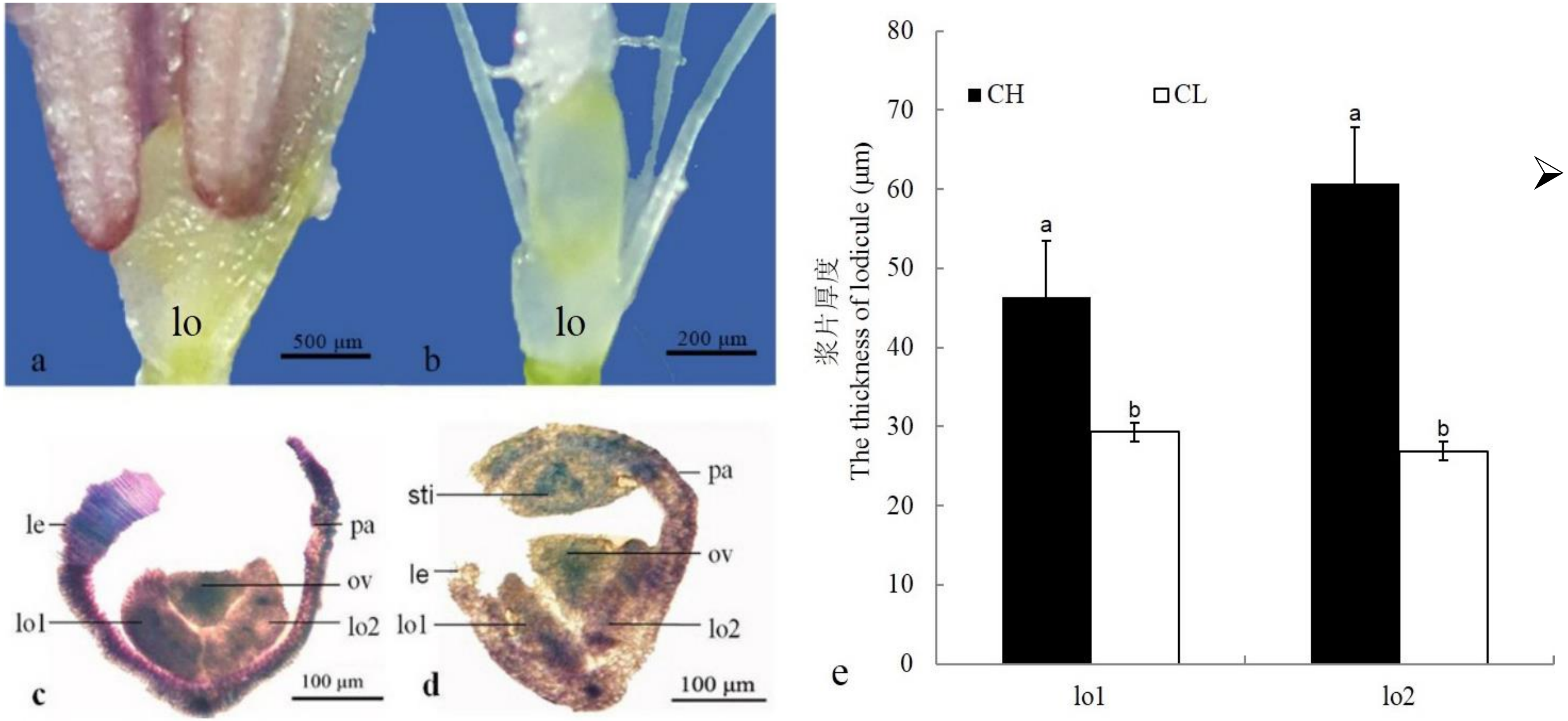
- **The anther of CL was obviously smaller than that of CH, whereas the filaments were opposite.**



Morphology of CH (a) and CL (b) flowers. c, Length of CH and CL floral organ

Note: lo, lodicule; ov, overy; le, lemma; pa, palea; sti, stigma; an, anthers; fi, filaments.

2.4 The lodicule divergence of CH and CL flower



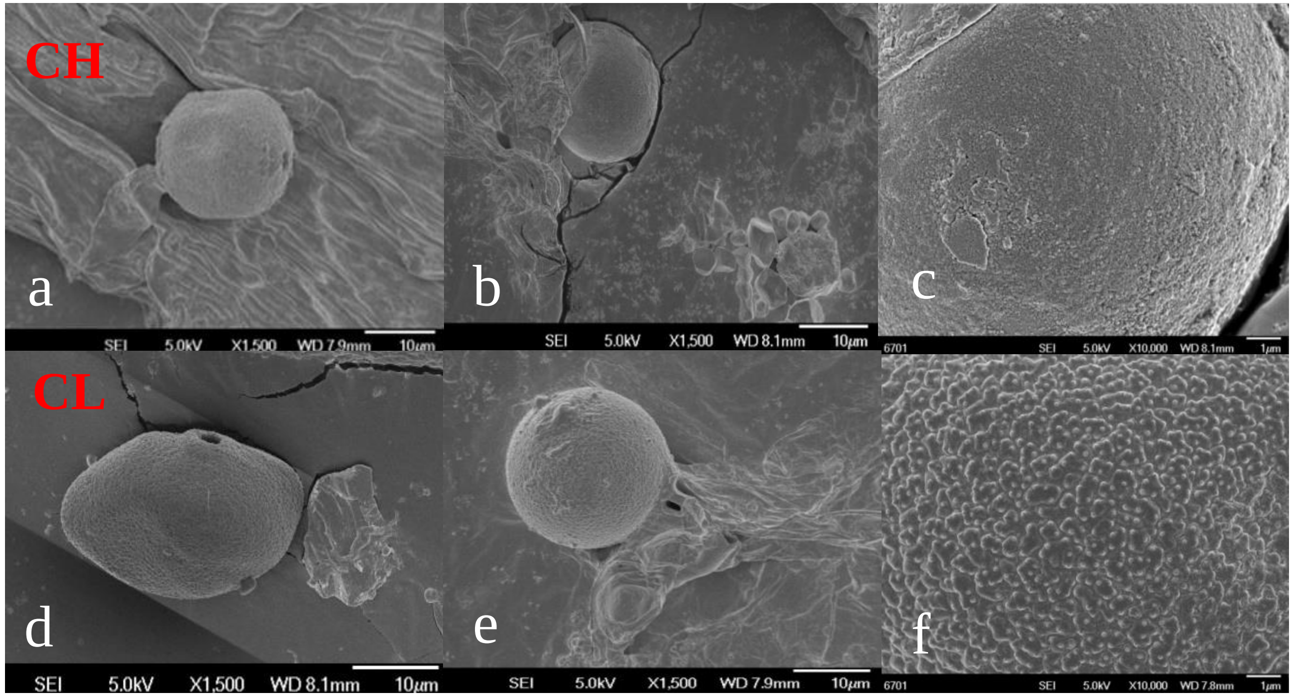
- **The lodicule of CL was obviously smaller than that of CH.**

Microscopic structure of CH and CL lodicule

lo1, the first lodicule; lo2, the second lodicule; ov, overy; le, lemma; pa, palea; sti, stigma; an, anthers; fi, filaments.

2.5 The pollen divergence of CH and CL flower

- **Both CH and CL pollen grains have one germination aperture, and polar view of pollen grains are circular**
- **Germination hole diameter of CL is larger than that of CH**

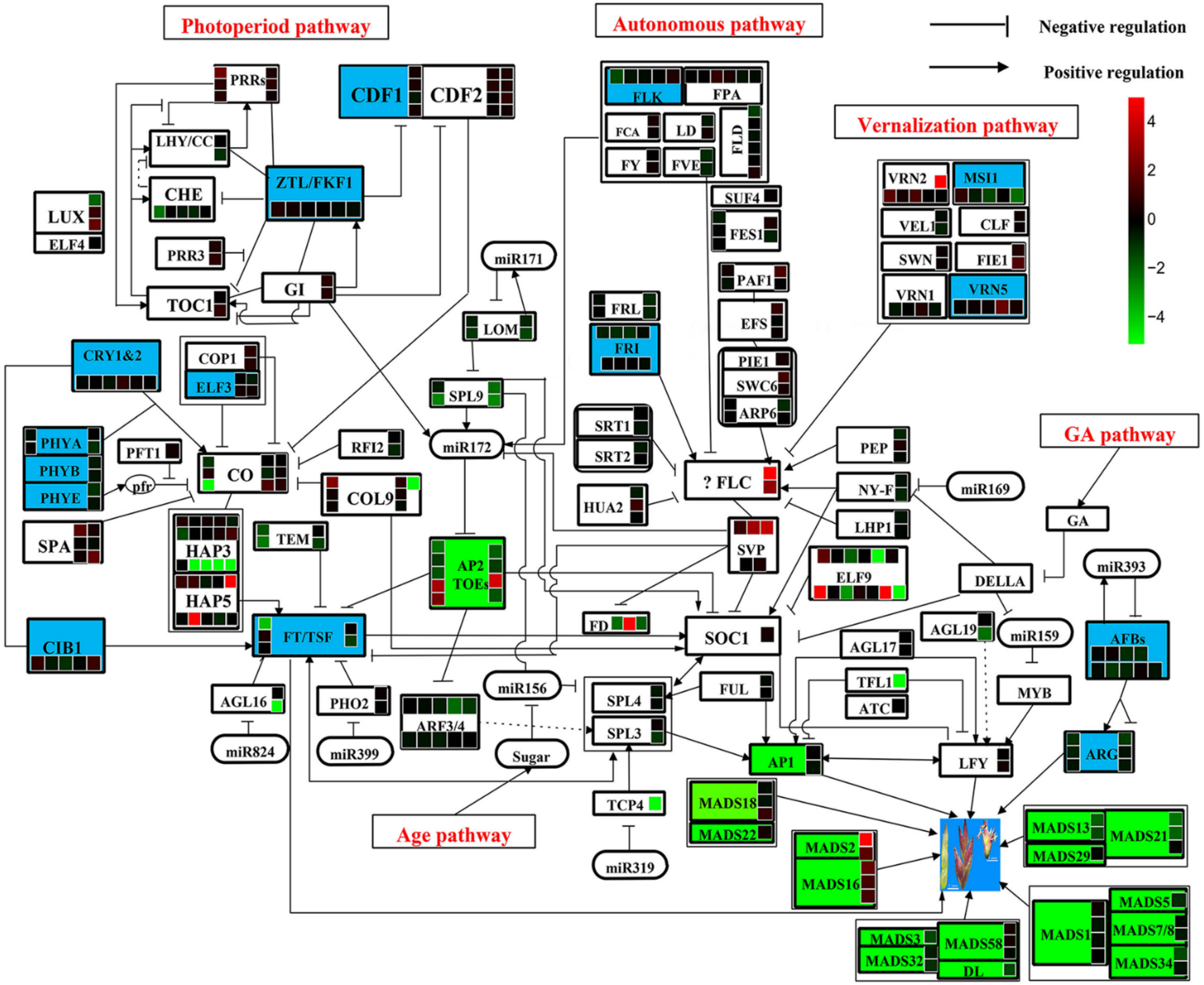


Micrographs of CH and CL pollen grain

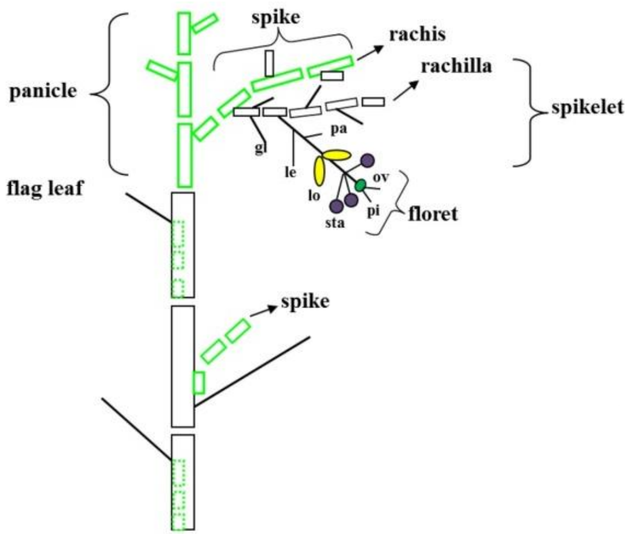
Main characteristics of pollen morphology in CH and CL

Polli-nation type	Germination hole diameter（μm）	Polar axis (μm)	Equatorial diameter (μm)	P/E ratio	Exine sculpture
CH	2.43 ±0.06b	13.00 ±1.82b	16.67 ±2.02	0.78	Smooth
CL	2.68 ±0.26a	28.26 ±1.31a	17.56 ±1.30	1.63	Granulate

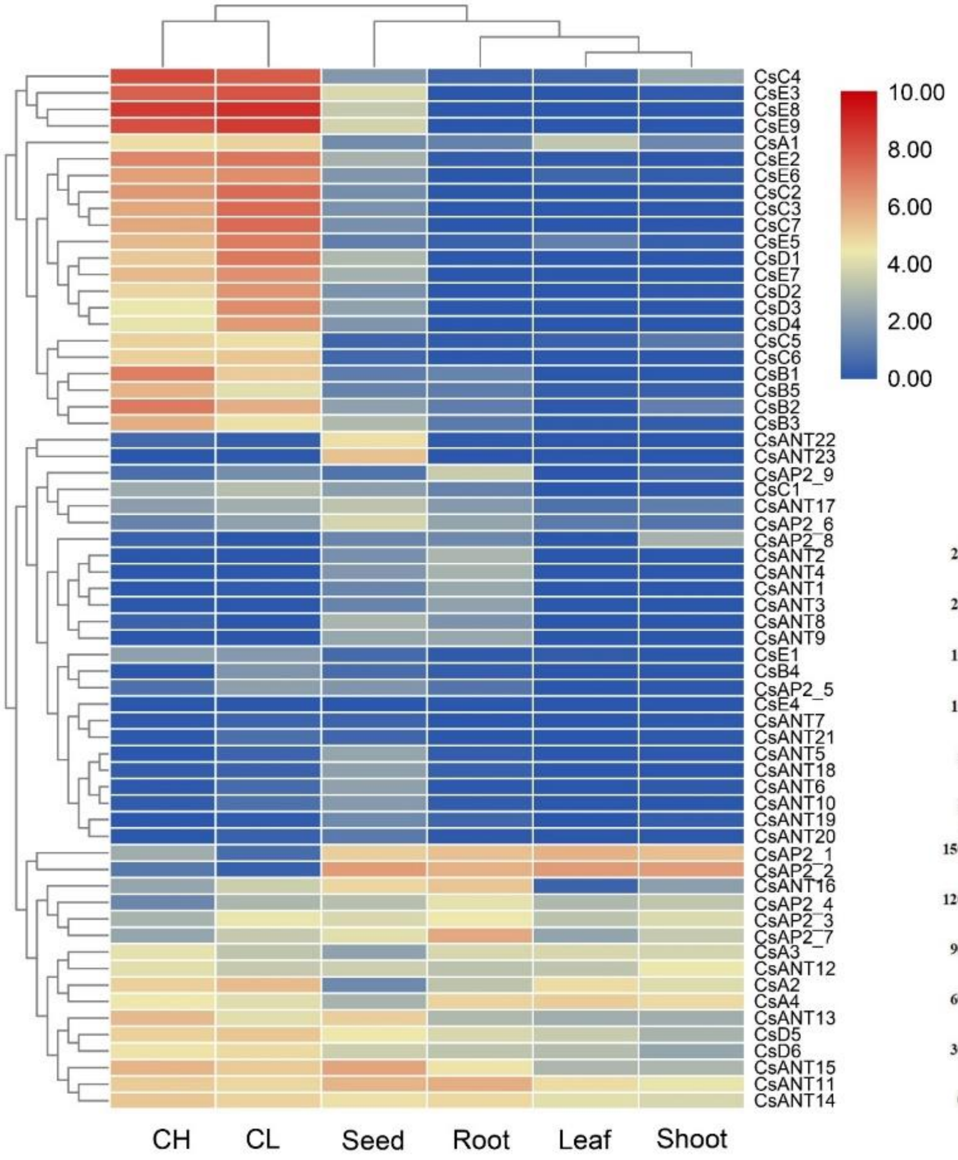
2.6 Constructed a flowering gene related network

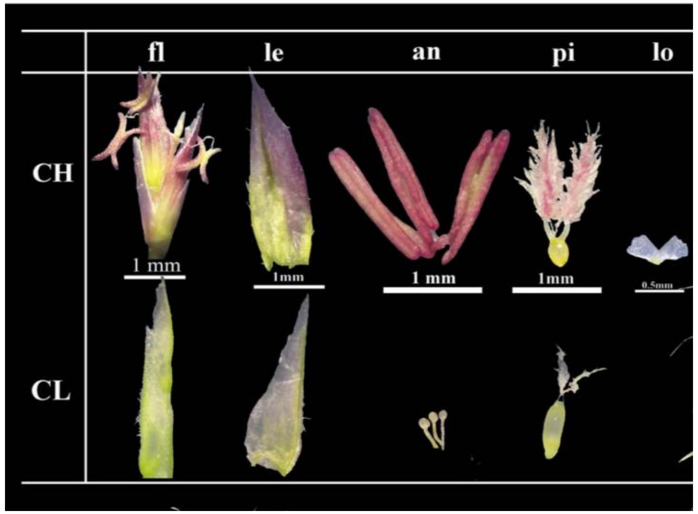


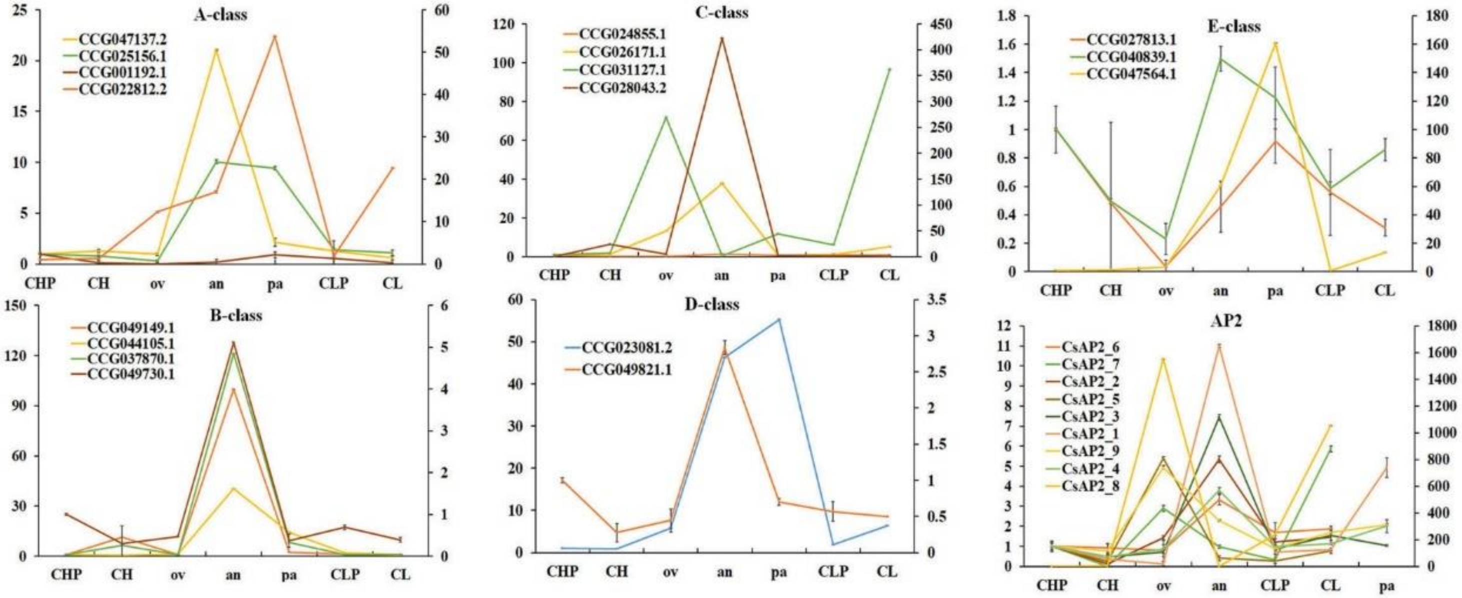
- **Flowering gene network: 83 gene families including 302 genes；**
- **Expanded gene family, photoperiod pathway, may relate to regulated dimorphic flower development.**



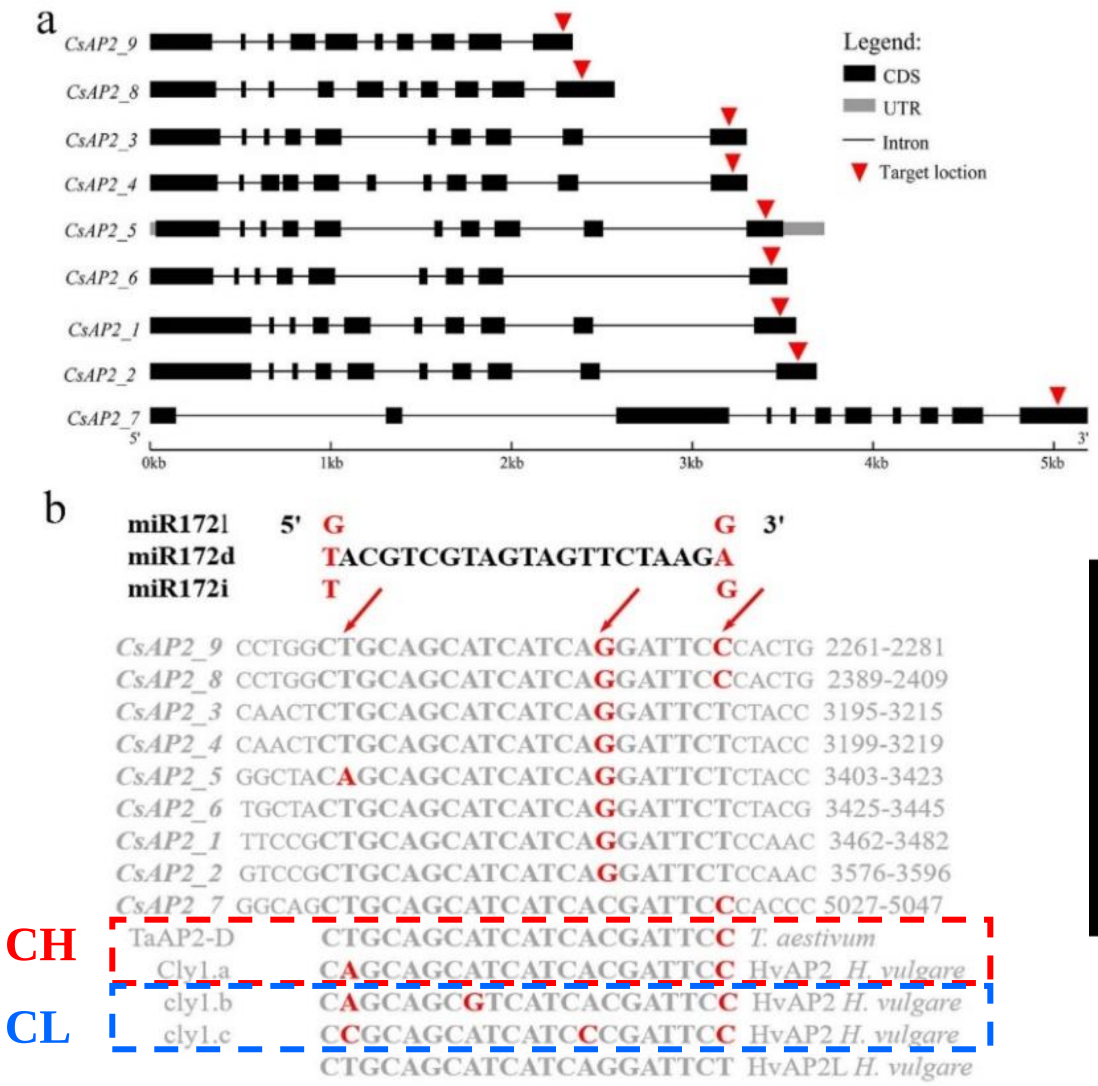
2.7 Identified the ABCDE model genes

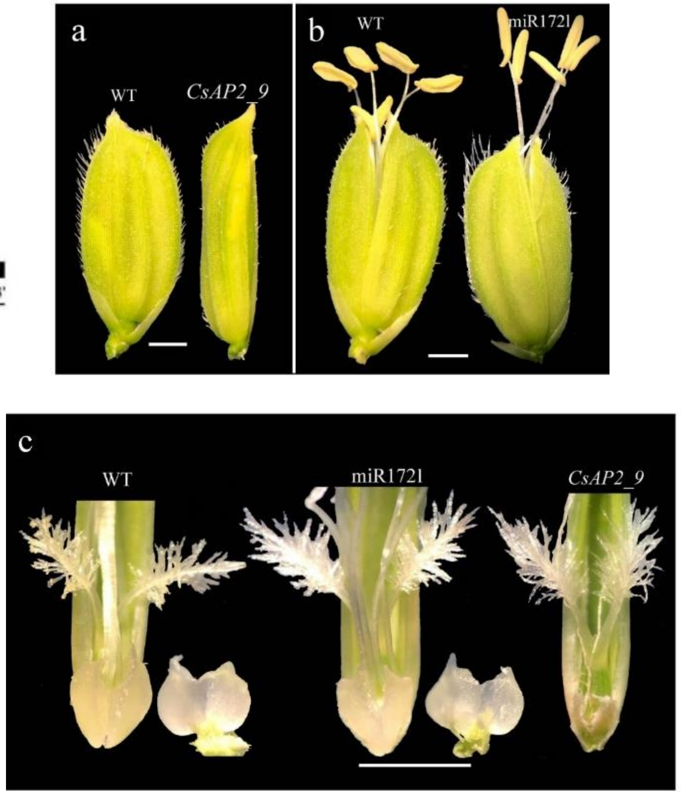






2.8 miR172l and *CsAP2_9* contribute to the regulation of cleistogamy





- ***CsAP2_9*** **transgenic lines showing abnormal palea, and smaller and thinner lodicules;**
- **miR172l lines showing longer filaments, and reduced anther numbers.**

3. Recurrent Selection Breeding

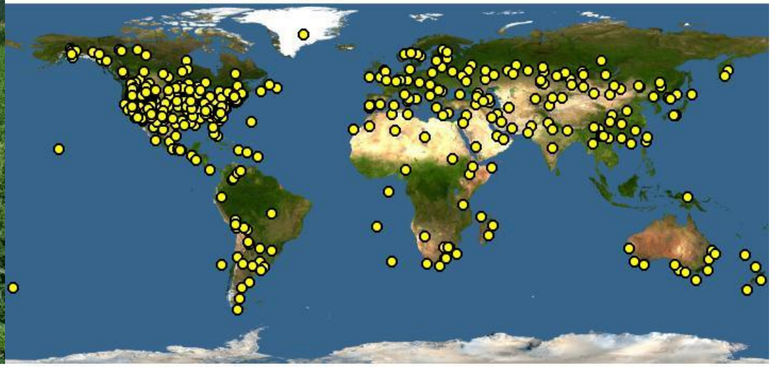
—— *Melilotus officinalis* as an example

Recurrent selection of new breeding lines of *M. officinalis*

3. Variety Breeding— *Melilotus officinalis* as an example

- **Sweet clover has been used as green manure and grazing leguminous forage in the southern US and later throughout the western region of the US and used to be addressed as the king of grazing pasture during first half of the 20th century (Clark, 2007).**
- **Yield and nitrogen-fixation of *M. officinalis* are considerably superior over two years old *Medicago sativa* (Mcewen and Johnston, 1985).**
- **Breeding a *M. officinalis* new line: *Melilotus officinalis* cv Lanxi NO.1**

Melilotus officinalis **cv LanxiNO.1**



Global adaptation area of *Melilotus*

	Hay yield of first year t ha^{-1}	Total nitrogen of hay of kg N ha^{-1}
M. officinalis	**9.4**	**143**
Medicago sativa	**4.6**	**84**

3.1 Genotypic variance components of *M. officinalis* HS families

- **The genotypic variances were significant ($P < 0.05$) among the 25 *M. officinalis* HS families for the agronomic and quality traits at two locations except SN, ADL and AIA.**

Location		PH/cm	DB/ g plant^{-1}	SD/mm	SN	LSR	Cou/%	CP/%	ADF/%	NDF/%	ADL/%	AIA/%
Yuzhong	Average	109.45	139.45	8.29	18.19	0.86	0.62	16.87	30.69	44.37	6.84	0.9
	Range	25.00-180.00	19.21-359.37	4.43-14.08	2-44	0.30-1.93	0.26-1.18	10.7-21.5	16.02-55.42	27.5-56.37	4.7-10.3	0.52-1.17
	σ^2_g	223.17±93.48	1327.33±420.75	0.58±0.29	n.s.	0.03±0.01	0.085±0.04	0.91±0.51	3.10±1.73	2.89±1.67	n.s.	n.s.
	σ^2_ε	735.42±90.46	14451.44±156.54	2.79±0.31	65.49±6.8	0.10±0.01	0.31±0.36	3.46±0.48	19.81±2.49	18.29±2.34	0.37±0.05	0.01±0.001
Linze	Average	128.51	122.89	7.5	14.3	0.49	0.39	11.89	33.01	47.48	7.89	0.81
	Range	43.01-192.00	17.7-384.98	3.40-11.50	2-38	0.23-1.14	0.32-0.82	7.97-15.46	18.8-48.2	37.81-57.11	5.64-10.51	0.10-1.60
	σ^2_g	223.51±84.84	1327.33±420.73	0.31±0.18	n.s.	0.004±0.002	0.088±0.035	0.34±0.14	2.36±1.28	3.58±1.48	n.s.	n.s.
	σ^2_ε	533.67±57.25	1451.44±156.54	2.36±0.25	52.66±5.6	0.018±0.002	0.01±0.001	1.14±0.13	14.39±1.58	9.92±1.18	0.84±1.04	0.07±0.01

	PH/cm	DB/g plant^{-1}	SD/mm	SN	LSR	Cou/%	CP/%	ADF/%	NDF/%	ADL/%	AIA/%
Average	118.84	131.21	7.89	16.24	0.67	0.51	14.48	31.83	45.87	7.44	0.86
Range	25.00-192.00	17.7-359	2.55-14.68	2-44	0.23-1.93	0.28-1.42	7.66-24.49	16.01-55.42	27.45-64.50	4.74-10.31	0.37-1.24
σ^2_{gl}	104.86±52.98	948.88±336.63	n.s.	n.s.	0.01±0.005	n.s.	0.39±0.26	n.s.	n.s.	0.07±0.04	0.002±0.001
σ^2_ε	647.79±48.54	1975.83±164.82	3.09±0.23	21.52±1.77	0.05±0.004	3.85±0.30	3.98±0.33	17.34±1.33	17.61±1.47	0.54±0.04	0.015±0.001
R	0.58	0.35	0.41	0.55	0.47	0.61	0.72	0.71	0.7	0.24	0.28

SD, stem diameter; SN, number of stems; PH, plant height; LSR, leaf/stem ratio; DB, dry biomass; Cou, coumarin, CP, crude protein; ADF, acid detergent fiber; NDF, neutral detergent fiber; ADL, acid detergent lignin; AIA, acid insoluble ash.

3.4 Comparative testing of different breeding lines of *M. officinalis*

- **Line3 had relatively low Cou, and high DB and PH which was an optimal line compared with the controls and other lines, and Line2 followed Line3.**

Comparative test of different lines of *M. officinalis*.

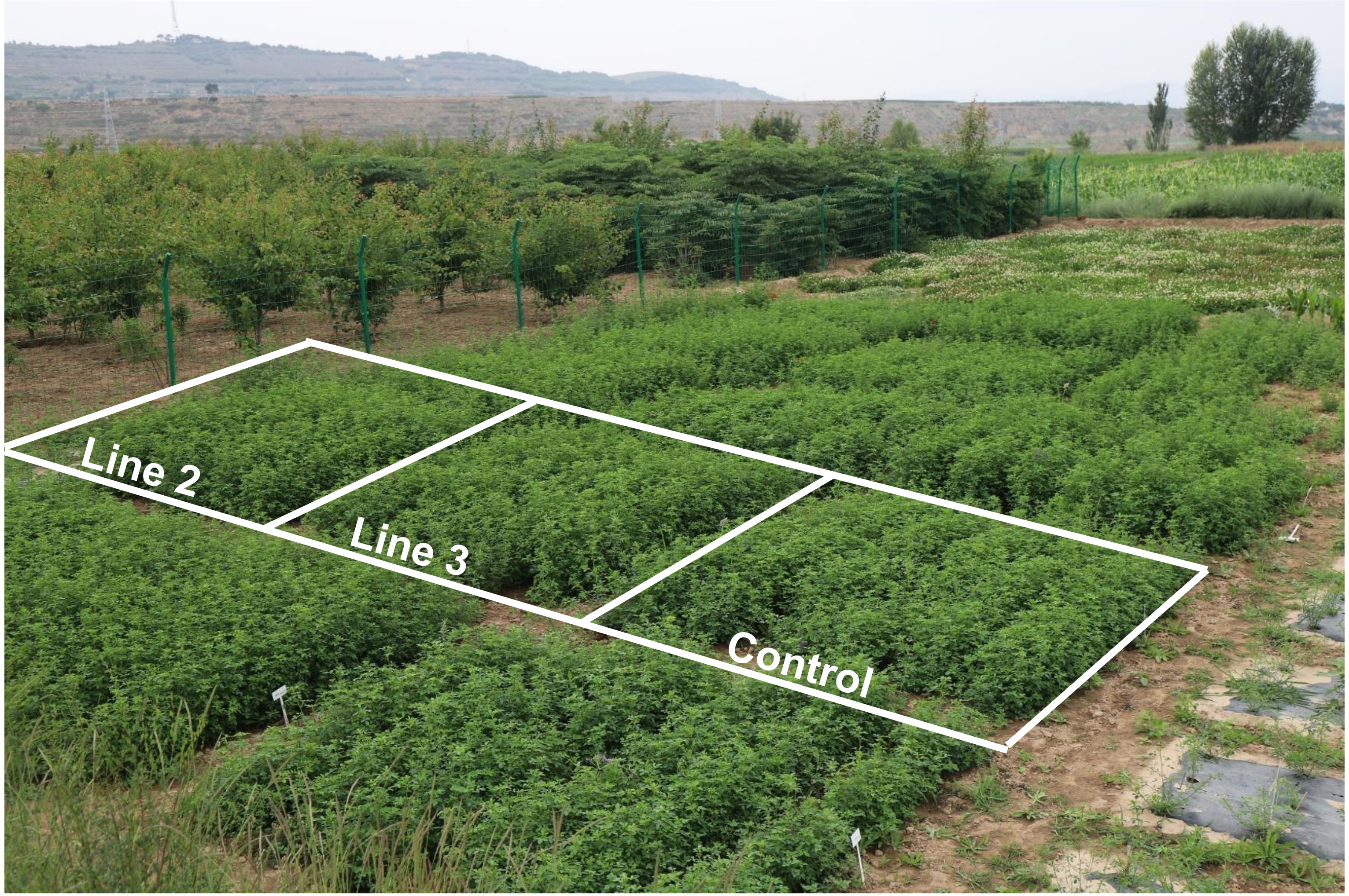
	DB/(kg/ha)	PH/cm	LSR	CP/%	ADF/%	NDF/%	ADL/%	AIA/%	Cou/%
Line1	31.97% **14453.33±705.98a**	**181.53±4.83a**	**0.66±0.01b**	**13.33±0.38a**	**39.55±0.83b**	**47.44±0.99b**	**7.17±0.09a**	**1.61±0.01b**	-44.44% **0.40±0.00c**
Line2	40.37% **15373.33±600.22a**	**182.07±4.11a**	**0.65±0.02b**	**13.45±0.62a**	**41.33±0.39ab**	**49.92±1.58a**	**7.27±0.14a**	**1.16±0.31c**	-44.44% **0.40±0.00c**
Line3	42.73% **15632.00±297.33a**	**183.30±4.00a**	**0.63±0.01b**	**13.02±0.15a**	**42.41±2.29a**	**49.76±2.05a**	**7.34±0.61a**	**1.53±0.13b**	-51.39% **0.35±0.03d**
CK-MoGongnong	**10538.67±140.58b**	**147.37±5.58b**	**0.72±0.04a**	**14.10±1.76a**	**35.48±2.14c**	**42.22±3.29c**	**6.18±0.18b**	**1.94±0.04a**	**0.96±0.05a**
CK-Norgold	**11365.33±230.82b**	**151.43±7.83b**	**0.75±0.01a**	**13.23±0.17a**	**39.45±0.81b**	**46.26±0.62b**	**6.32±0.51b**	**1.69±0.07b**	**0.48±0.03b**

3.3 Predicted ΔG per selection cycle

- **The genetic gains of all traits of the second recurrent selection cycle were lower than that of the first recurrent selection cycle in *M. officinalis*, except of PH and LSR.**
- **The ΔG of all traits are positive, except for Cou.**

Traits	Second recurrent selection		First recurrent selection (Luo et al., 2016)	
	ΔG	%ΔG	ΔG	%ΔG
DB/g	5.6	3.9	17.17	16.5
PH/cm	4.9	4	4.08	2.6
SD/mm	0.16	1.9	0.17	11.9
SN	0.15	3.5	0.33	5.7
LSR	0.03	4.5	0.02	2.4
Cou/%	-0.033	-6.66	-0.05	-11.8
CP/%	0.006	0.04		
ADF/%	0.91	2.86		
NDF/%	0.86	1.88		
ADL/%	0.03	0.45		
AIA/%	0.006	0.66		

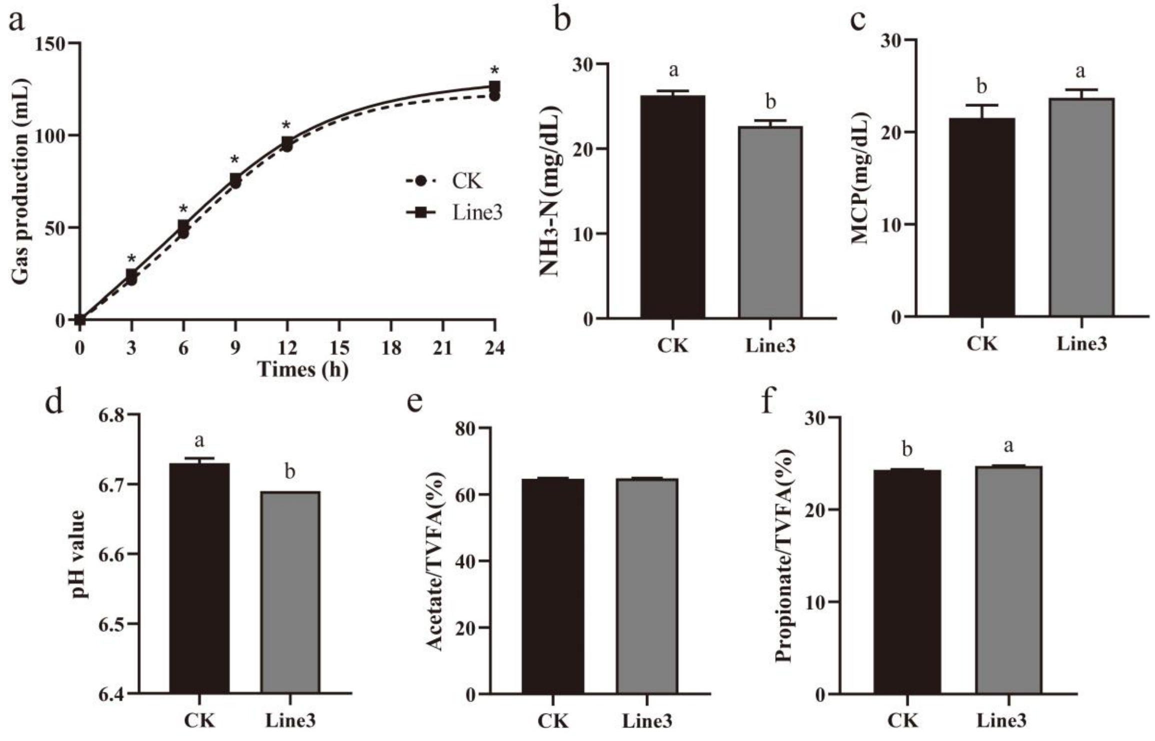
3.4 Comparative testing of different breeding lines of *M. officinalis*

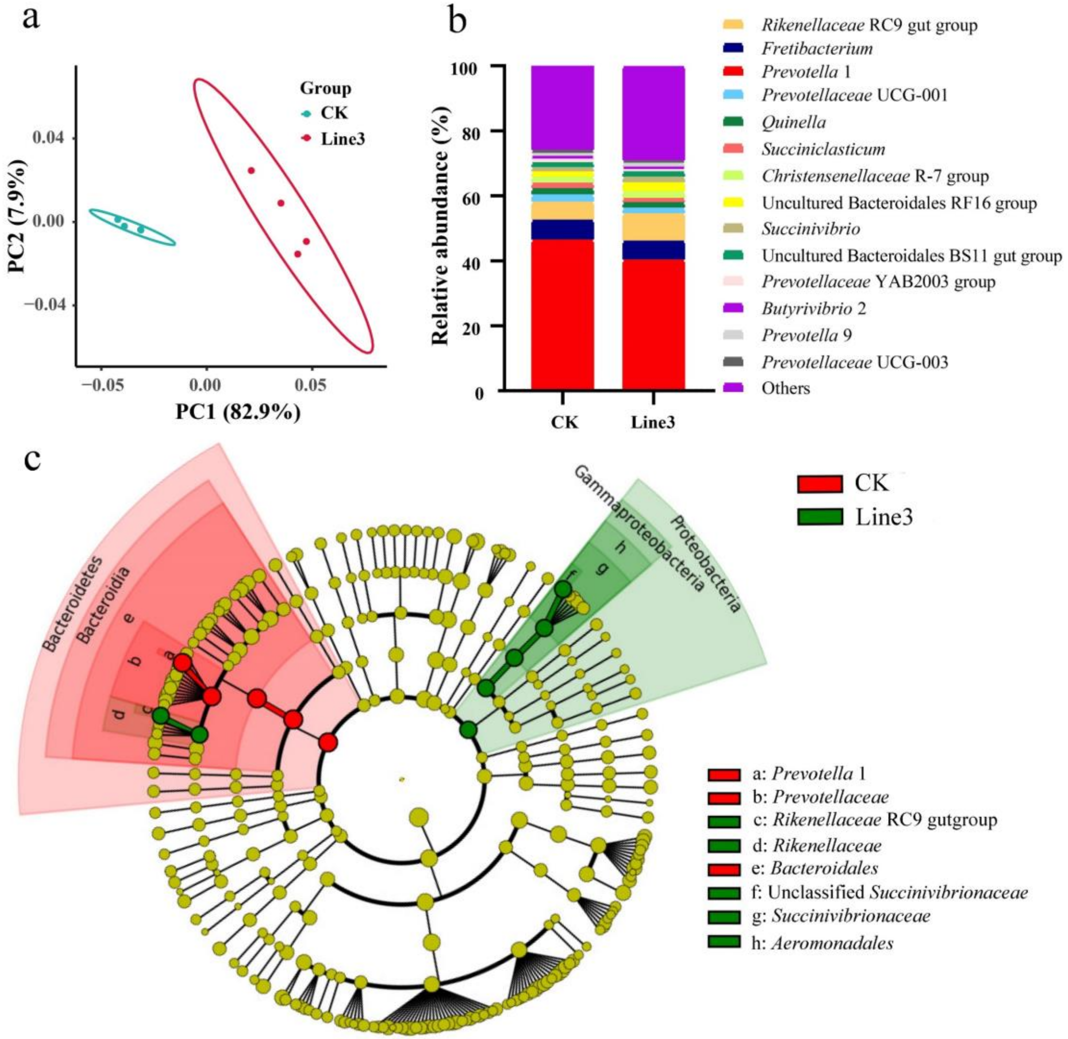


2020年黄花草木樨品系比较试验

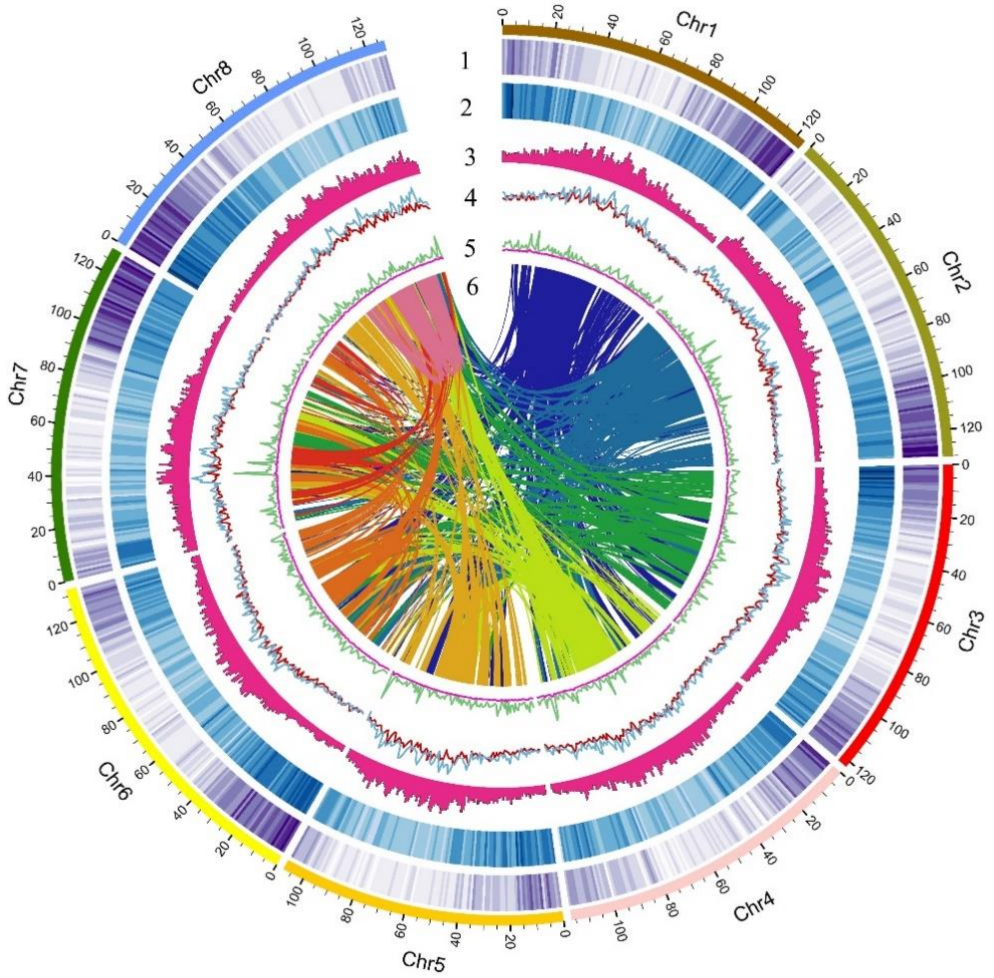
3.5 *In vitro* rumen fermentation profile

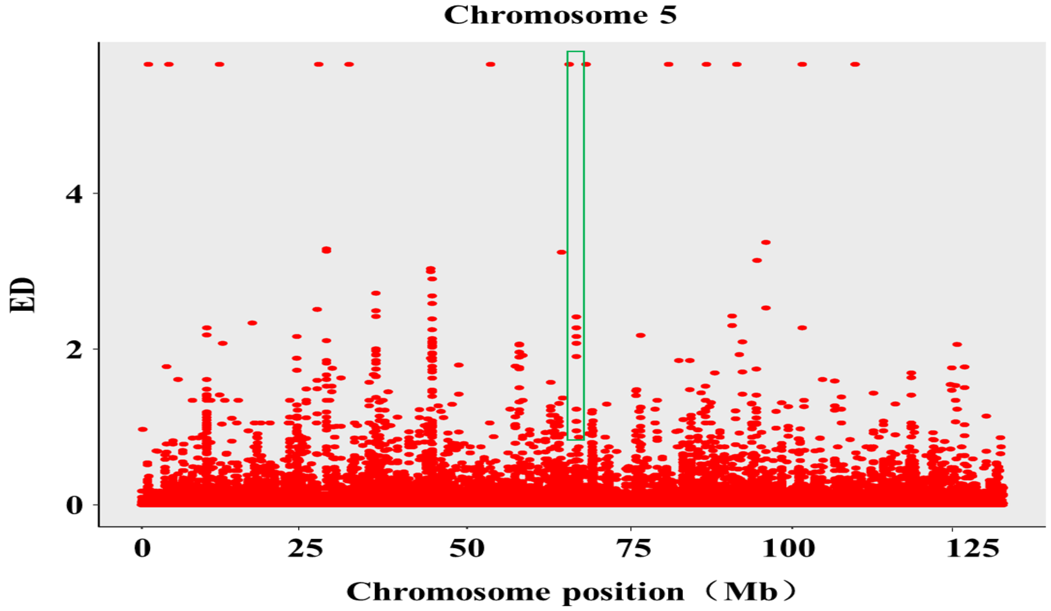
- **The gas production of Line3 was significantly higher than that of the CK-MoGongnong, indicating that it might be due to differences in the contents of Cou.**
- **The abundance of *Prevotella* was higher in CK-MoGongnong, suggesting that *Prevotella* in rumen is involve in the degradation of coumarin.**

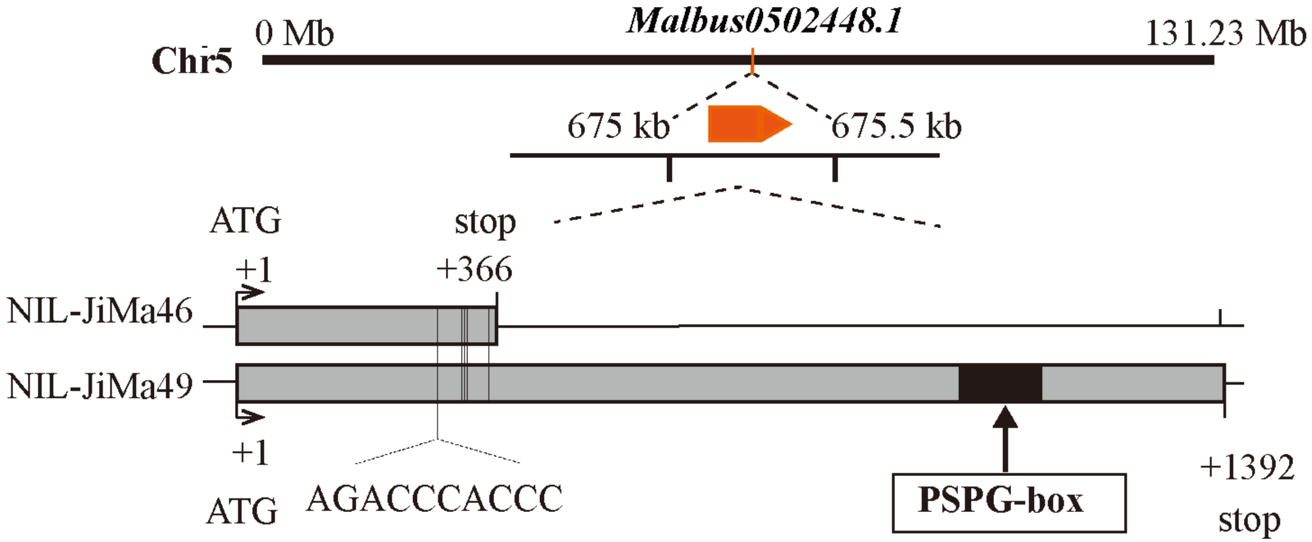




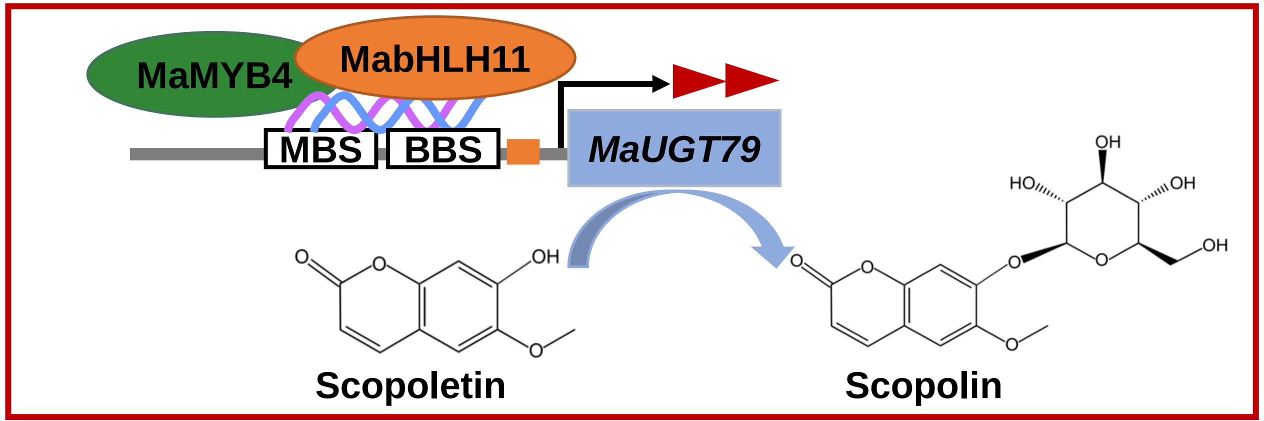
- The genome of *Melilotus albus* (2n = 2x = 16) size was 1.15 Gb.
- The *MaUGT79* was identified based on BSA-seq.

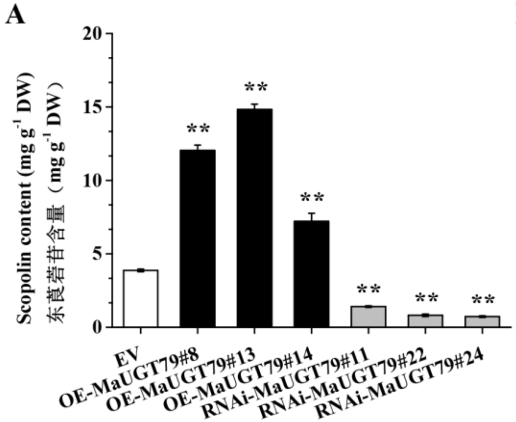


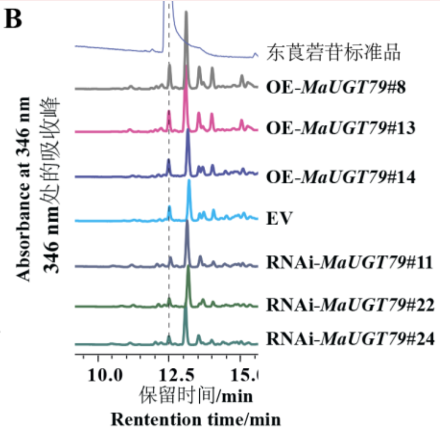


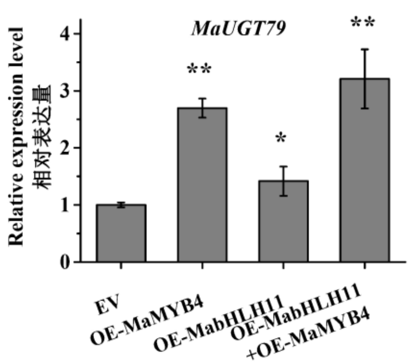


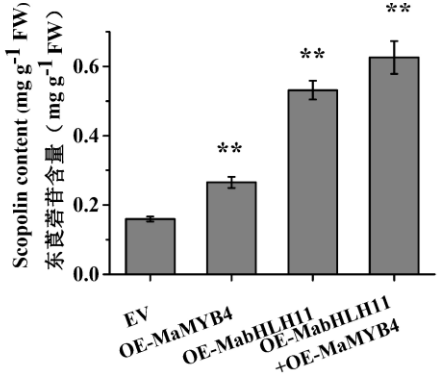
The regulation model MaMYB4-MabHLH11-*MaUGT79* mediated scopolin biosynthesis in *M. albus*

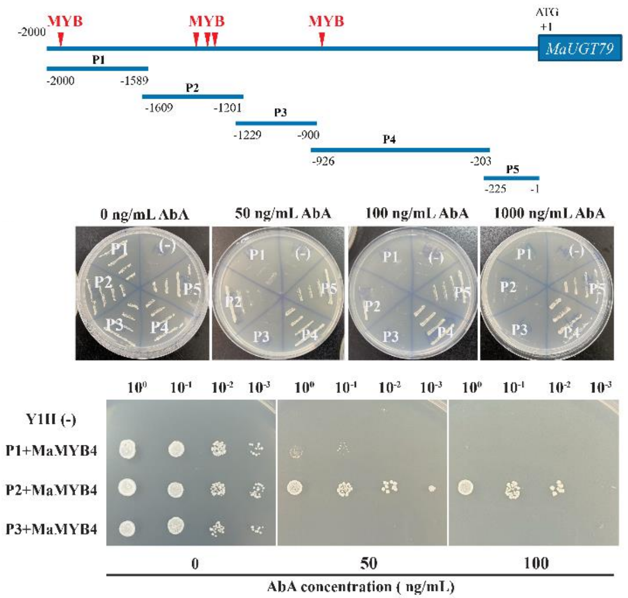


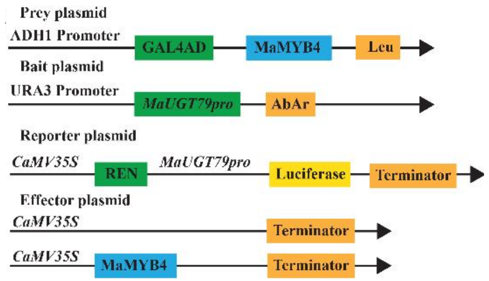


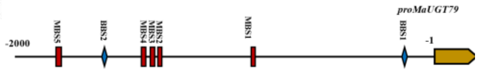


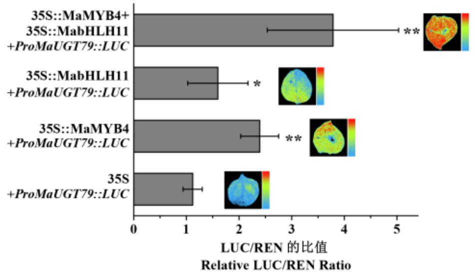


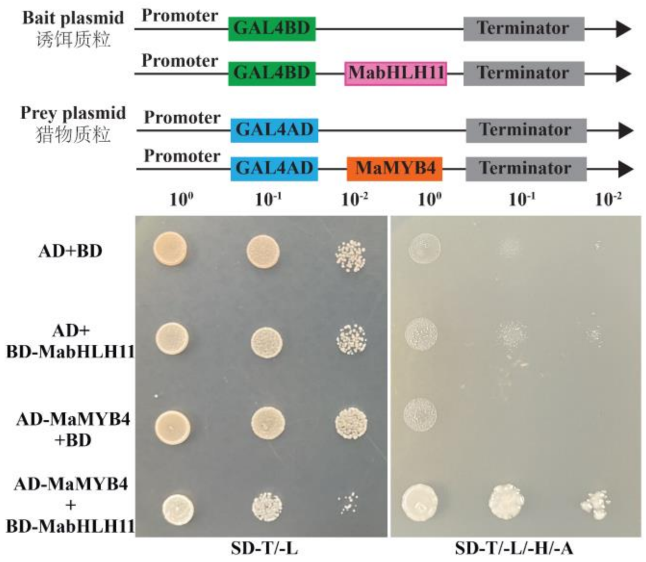


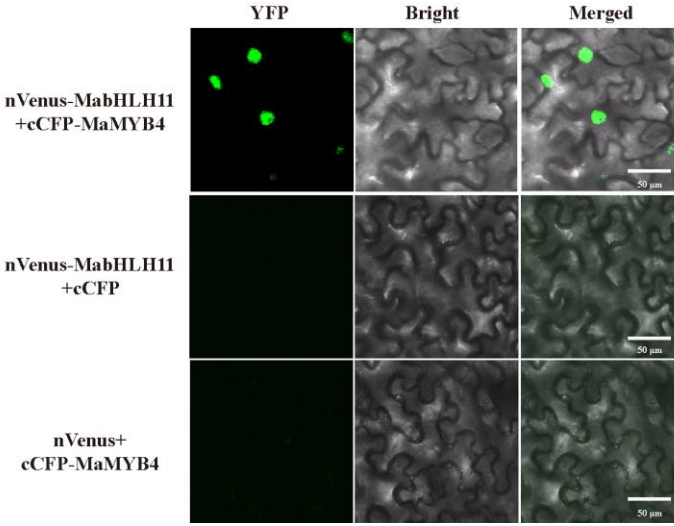


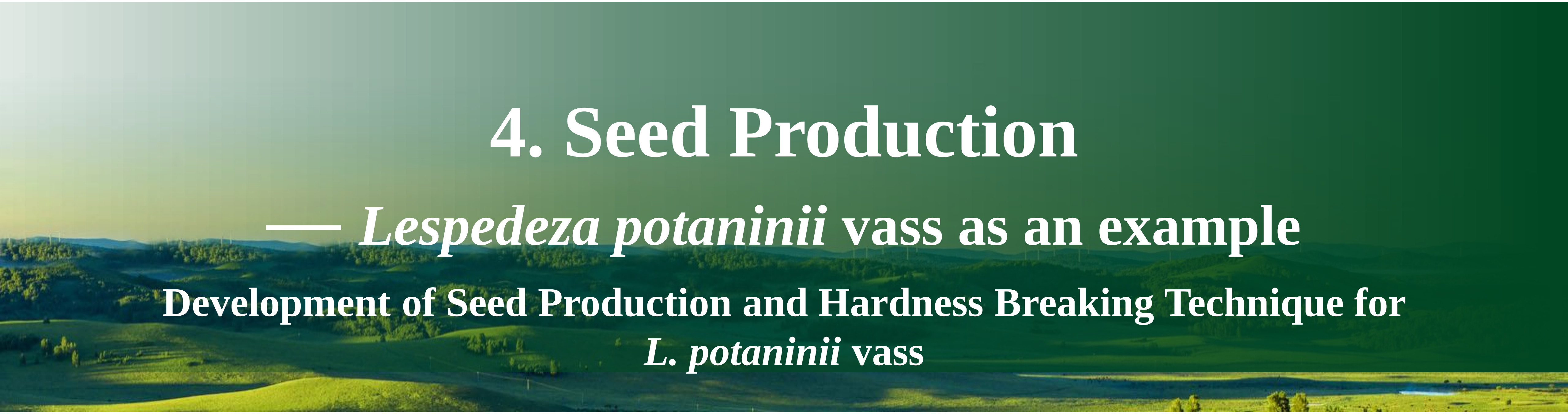












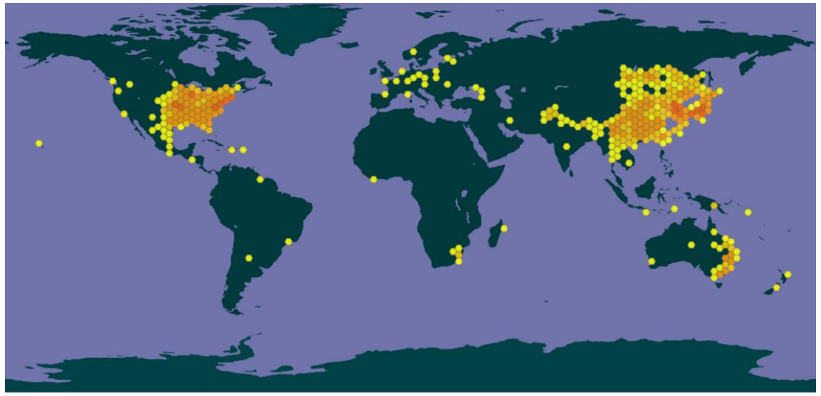
4. Seed Production

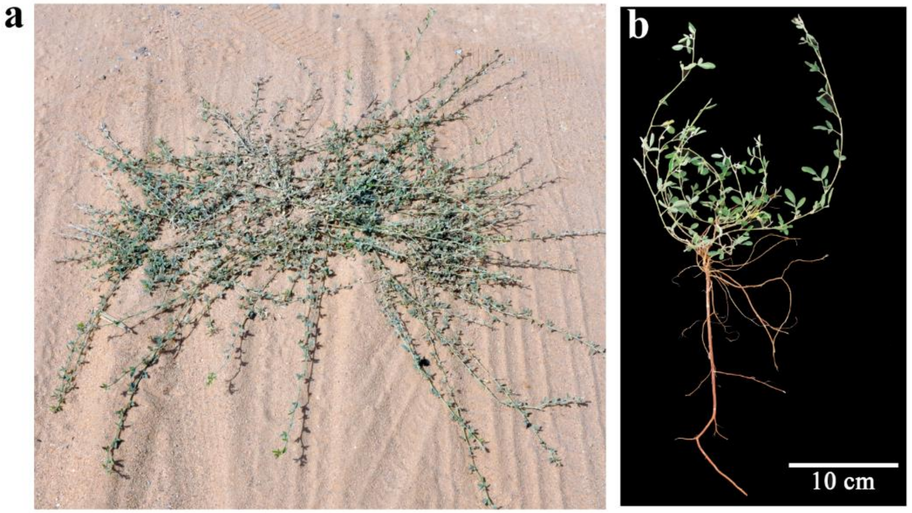
—— *Lespedeza potaninii* vass as an example

Development of Seed Production and Hardness Breaking Technique for *L. potaninii* vass

4. Seed Production *Lespedeza potaninii* vass as an example

- ➢ *L. potaninii* plays an important role in livestock nutrition, grassland restoration and soil and water conservation in arid and semi-arid areas of China (Zhang et al., 2007).
- ➢ Under natural growing conditions, seed yield of *L. potaninii* is low.
- ➢ Breeding a *L. potaninii* new cultivar: *L. potaninii* cv Tenggeli （GS-CWV-2020-007）





Lespedeza potaninii cv Tenggeli

品种名称 腾格里牛枝子

草种名称 牛枝子

学名 *Lespedeza potaninii* 'Tenggeli'

品种编号 GS-CWV-2020-007

申报单位 兰州大学

选育人 张吉宇、王彦荣、闫启、胡小文

适宜推广生态区域

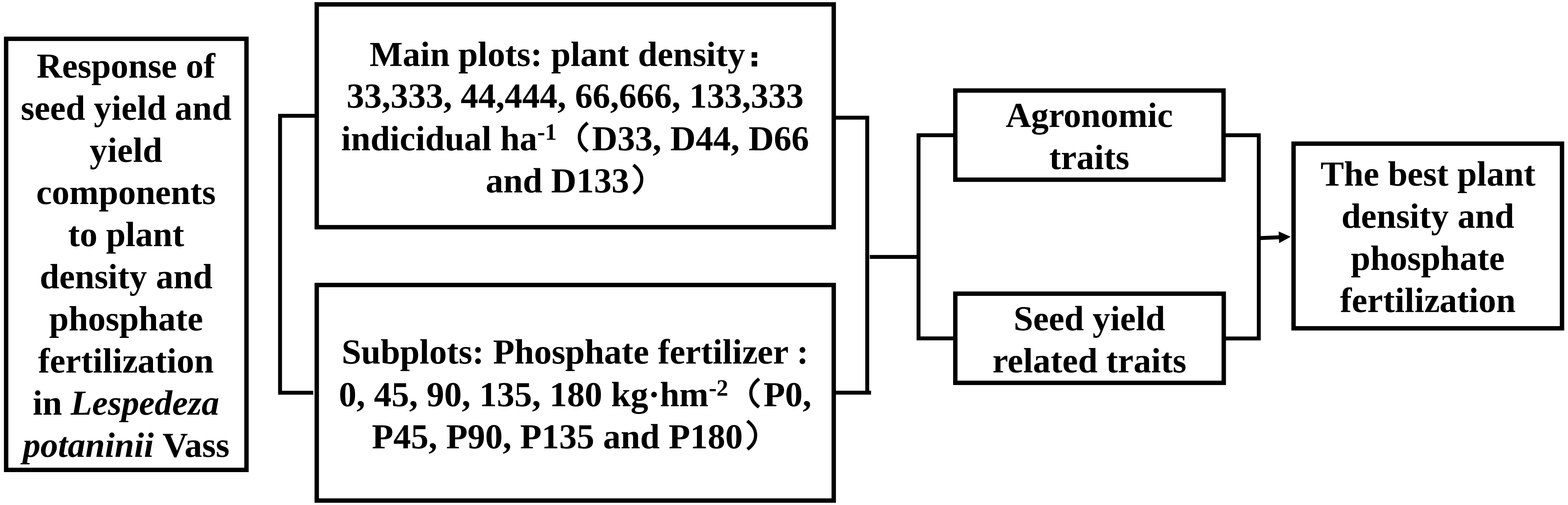
适宜我国北方干旱半干旱、年降雨量为100-400 mm的地区，黄土高原半农半牧区等。

发证机关

2021年8 月3日

4.1 Materials and methods

- **Materials：*Lespedeza potaninii* cv Tenggeli（ID：GS-CWV-2020-007）**
- **Location：Hexi Corridor in Zhangye City in Gansu Province, China (latitude: 39° 04′ N, longitude: 100° 20′ E, elevation: 1397 m), from 2019 to 2021 growing seasons.**
- **Experimental design：**



Response of seed yield and yield components to plant density and phosphate fertilization in *Lespedeza potaninii* Vass

Main plots: plant density：33,333, 44,444, 66,666, 133,333 indicidual ha^{-1}（D33, D44, D66 and D133）

Subplots: Phosphate fertilizer : 0, 45, 90, 135, 180 kg·hm^{-2}（P0, P45, P90, P135 and P180）

Agronomic traits

Seed yield related traits

The best plant density and phosphate fertilization

4.2 Variance analysis for Y, P and D on yield components

- **Plant density, phosphate fertilizer and their interactions significantly affected seed yield.**

Analysis of variance for year (Y), plant density (D), phosphate fertilizer rate(P), and their interaction on seed yield and yield components

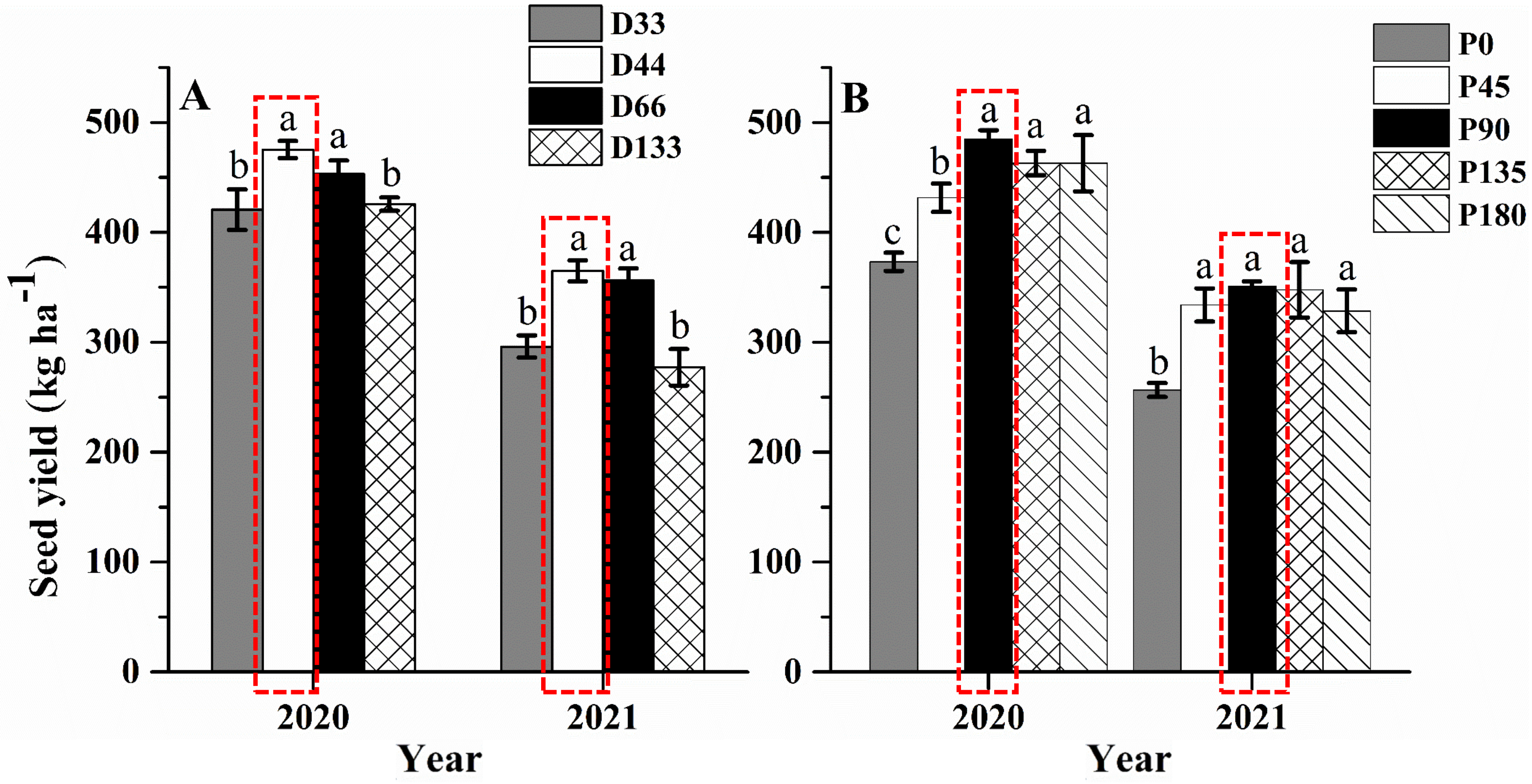
Source	Seed yield	Stems /m^{-2}	Racemes /Stem	Florets/ Raceme	Pods/ Raceme	1000 seeds weight	Seed yield per plant
Year (Y)	*	**	**	**	**	**	**
Plant density (D)	**	**	**	**	**	ns	**
Phosphate fertilizer (P)	**	**	**	ns	*	ns	**
D×P	**	**	**	ns	ns	*	**
D×Y	**	**	**	**	ns	ns	**
P×Y	ns	**	**	*	*	ns	ns
D×P×Y	**	ns	ns	ns	ns	ns	ns

4.3 Effect of D and P on seed yield

Effect of plant density and phosphate fertilization on seed yield in 2020 and 2021

Plant density	Seed yield in 2020 (kg·ha^{-1})					Seed yield in 2021 (kg·ha^{-1})					Mean seed yield (kg·ha^{-1})				
	P0	P45	P90	P135	P180	P0	P45	P90	P135	P180	P0	P45	P90	P135	P180
D33	381.04	395.91	428.88	445.33	452.62	258.66	296.48	307.32	304.40	313.55	319.85b	346.19ab	368.10ab	374.87a	383.09a
D44	338.37	419.31	559.28	538.07	521.71	300.66	315.48	395.66	412.43	400.19	319.52c	367.40b	477.47a	475.25a	460.95a
D66	407.11	462.22	459.91	484.08	451.91	312.95	397.87	384.52	372.03	313.40	360.03b	430.04a	422.21a	428.06a	382.65ab
D133	366.58	448.71	503.47	385.07	425.24	154.28	326.25	316.73	301.92	286.96	260.43d	387.48ab	410.10a	343.49c	356.10bc

4.4 Relationship between seed yield and D and P



Relationship between seed yield and plant density (A) and phosphate fertilizaer rate (B).

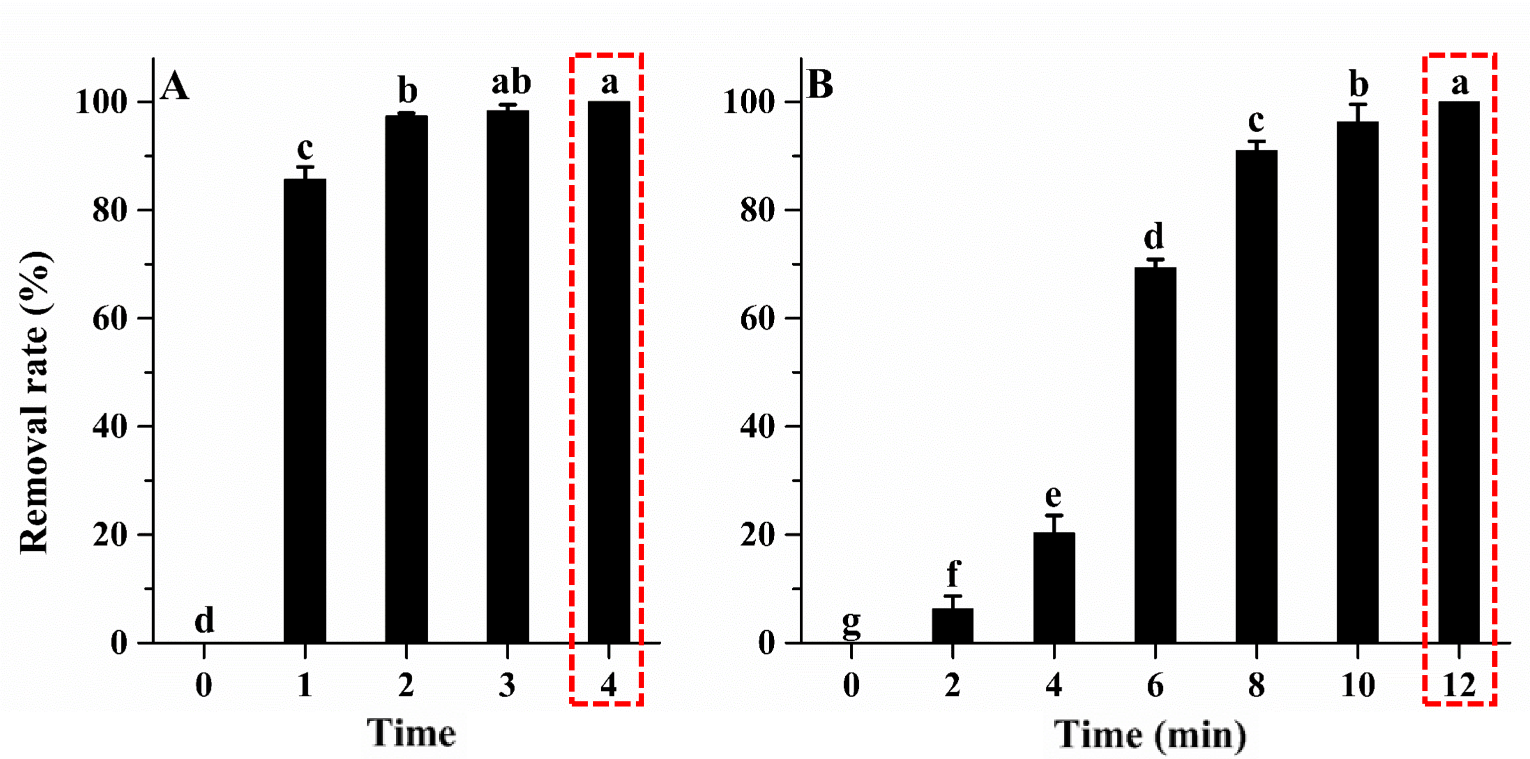
4.7 Correlation coefficients between yield components and seed yield

Correlation coefficients between contribution of yield components (stems per square meter, racemes per stem, florets per raceme, pods per raceme, 1000-seed weight and Seed yield per plant) and seed yield of *L. potaninii* Vass .

	Stems/m^{-2}	Racemes/Stem	Florets/Raceme	Pods/Raceme	1000-seed weight	Seed yield per plant	Correlation coefficients
Stems/m^{-2}	1	-0.836**	-0.833**	-0.832**	-0.335	-0.911**	-0.094
Racemes/Stem		1	0.791**	0.731**	0.241	0.897**	0.136
Florets/Raceme			1	0.858**	0.215	0.948**	0.454*
Pods/Raceme				1	0.209	0.862**	0.545*
1000-seed weight					1	0.305	0.013
Seed yield per plant						1	0.356

4.8 Persistent sepals of *L. potaninii* Vass cleaning

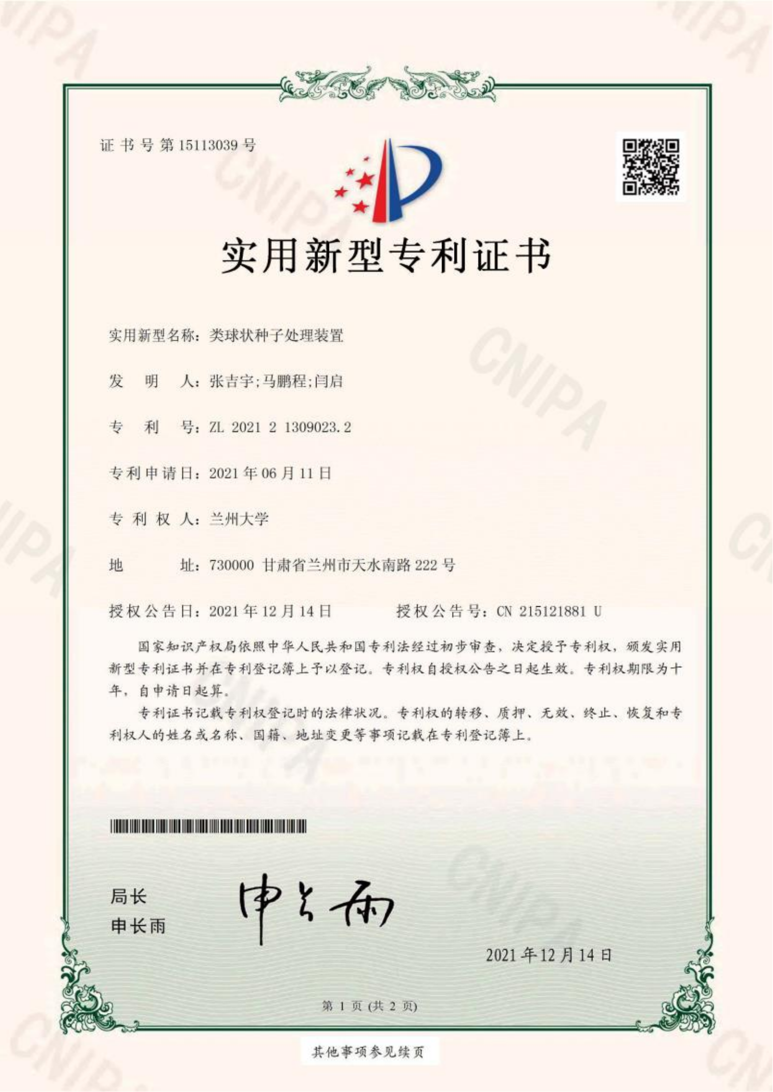
- **All the persistent sepals were removed when the seeds were treated four times with the seed coat breaking machine and 12 minutes with concentrated sulfuric acid.**



Effect of the seed coat breaking machine and concentrated sulfuric acid treatments on the persistent sepals of *L. potaninii* Vass

4.8 Persistent sepals breaking of *L. potaninii* Vass

Utility Model Patent



证书号第 15113039 号

实用新型专利证书

实用新型名称：类球状种子处理装置

发　明　人：张吉宇；马鹏程；闫启

专　利　号：ZL 2021 2 1309023.2

专利申请日：2021 年 06 月 11 日

专利权人：兰州大学

地　　址：730000 甘肃省兰州市天水南路 222 号

授权公告日：2021 年 12 月 14 日　　授权公告号：CN 215121881 U

国家知识产权局依照中华人民共和国专利法经过初步审查，决定授予专利权，颁发实用新型专利证书并在专利登记簿上予以登记。专利权自授权公告之日起生效。专利权期限为十年，自申请日起算。

专利证书记载专利权登记时的法律状况。专利权的转移、质押、无效、终止、恢复和专利权人的姓名或名称、国籍、地址变更等事项记载在专利登记簿上。

局长
申长雨

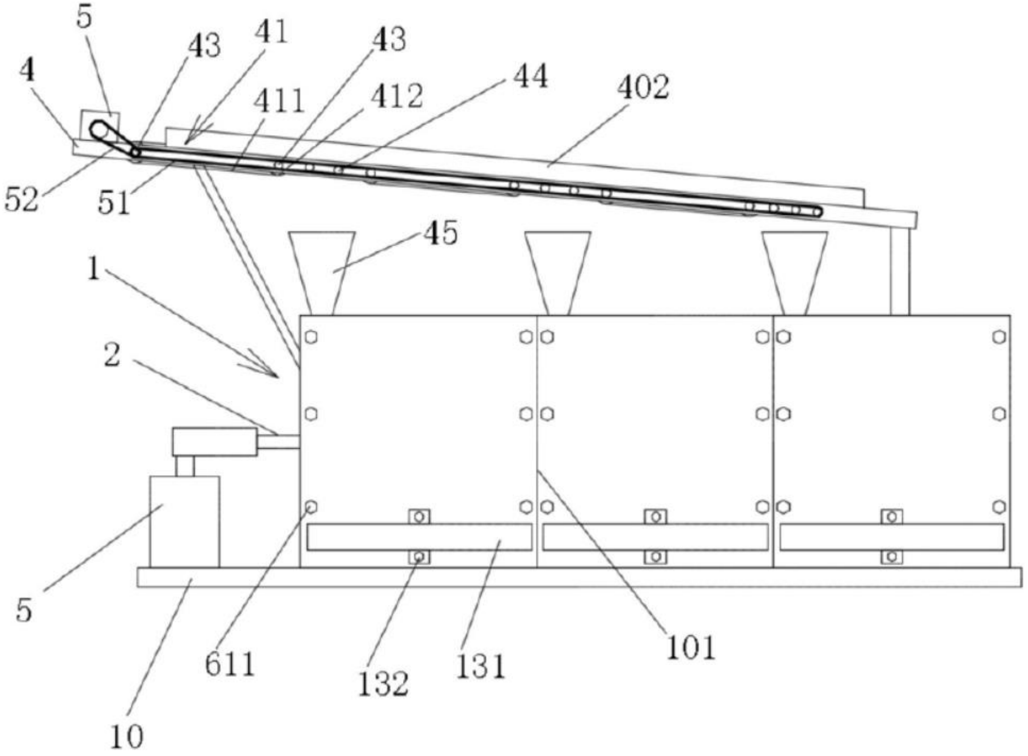
申长雨

2021 年 12 月 14 日

第 1 页 (共 2 页)

其他事项参见续页

Sepals breaking machine model



4.9 Effects of different treatments on seed germination

Effects of seed coat breaking machine treatment on seed germination of *L. potaninii* Vass

Treatments	Percentage of damage (%)	Percentage of hard seeds (%)	Germination energy (%)	Germination rate (%)	Germination index	Vigor index
CK	0.00e	96.67a	2.00f	2.67f	0.72g	0.02f
1	0.67de	91.00a	8.33f	8.67f	4.56f	0.09ef
2	0.67de	80.33b	17.00e	18.00e	8.39e	0.16ef
3	1.00ced	73.67b	20.33e	23.67e	10.19e	0.21de
4	2.67bc	59.67c	34.00d	38.00d	17.01d	0.34cd
5	2.67bc	50.00d	43.33c	48.33c	21.38c	0.40c
6	2.33cd	46.67de	48.33bc	53.33bc	22.68c	0.39c
7	4.33b	38.67ef	56.00ab	60.00ab	28.36b	0.56b
8	7.00a	36.33f	57.33a	61.33a	31.68ab	0.87a
9	7.67a	33.00fg	61.67a	66.33a	33.14a	0.75a
10	8.00a	24.33g	60.00a	65.33a	31.59ab	0.50bc

4.9 Effects of different treatments on seed germination

Effects of sulfuric acid treatment on seed germination of *L. potaninii* Vass

Treatments	Percentage of hard seeds (%)	Germination energy (%)	Germination rate (%)	Germination index	Vigor index
CK	96.00a	4.00d	4.00e	1.93e	0.07d
5 min	84.67b	10.67d	12.66d	4.69e	0.17cd
10 min	51.33c	33.33c	44.00c	14.10d	0.45c
15 min	16.67d	67.33b	74.67b	26.94c	0.81b
20 min	14.67d	74.67ab	82.67a	35.8ab	1.13a
25 min	17.33d	72.67ab	81.33ab	34.12b	1.14a
30 min	13.33d	80.00a	84.00a	38.73a	1.03ab

4.9 Effects of different treatments on seed germination

Effects of high temperature treatment on seed germination of *L. potaninii* Vass

Treatments	Percentage of hard seeds (%)	Germination energy (%)	Germination rate (%)	Germination index	Vigor index
CK	96.00a	4.00e	4.00g	1.93e	0.07e
80℃, 0.5 h	94.67a	5.33de	5.33fg	3.13e	0.14de
80℃, 1.0 h	92.67ab	7.33de	7.33efg	5.11de	0.19cde
80℃, 1.5 h	96.00a	6.67de	7.33efg	4.39de	0.15de
80℃, 2.0 h	92.00b	8.00de	8.00efg	4.67de	0.21bcde
90℃, 0.5 h	83.33ab	8.00de	9.33defg	4.87de	0.23bcd
90℃, 1.0 h	86.67ab	7.33de	10.67def	5.26de	0.21bcde
90℃, 1.5 h	87.33b	10.00d	12.00de	7.66d	0.40a
90℃, 2.0 h	84.00b	10.67d	14.67d	7.95d	0.36ab
100℃, 0.5 h	74.00b	20.00c	21.33c	12.87c	0.36ab
100℃, 1.0 h	61.00d	27.00b	30.00ab	16.92b	0.36ab
100℃, 1.5 h	53.33d	32.67a	35.33a	21.75a	0.47a
100 ℃, 2.0 h	36.00e	25.33b	28.00b	16.67b	0.35abc

4.9 Effects of different treatments on seed germination

Effects of hot water treatment on seed germination of *L. potaninii* Vass

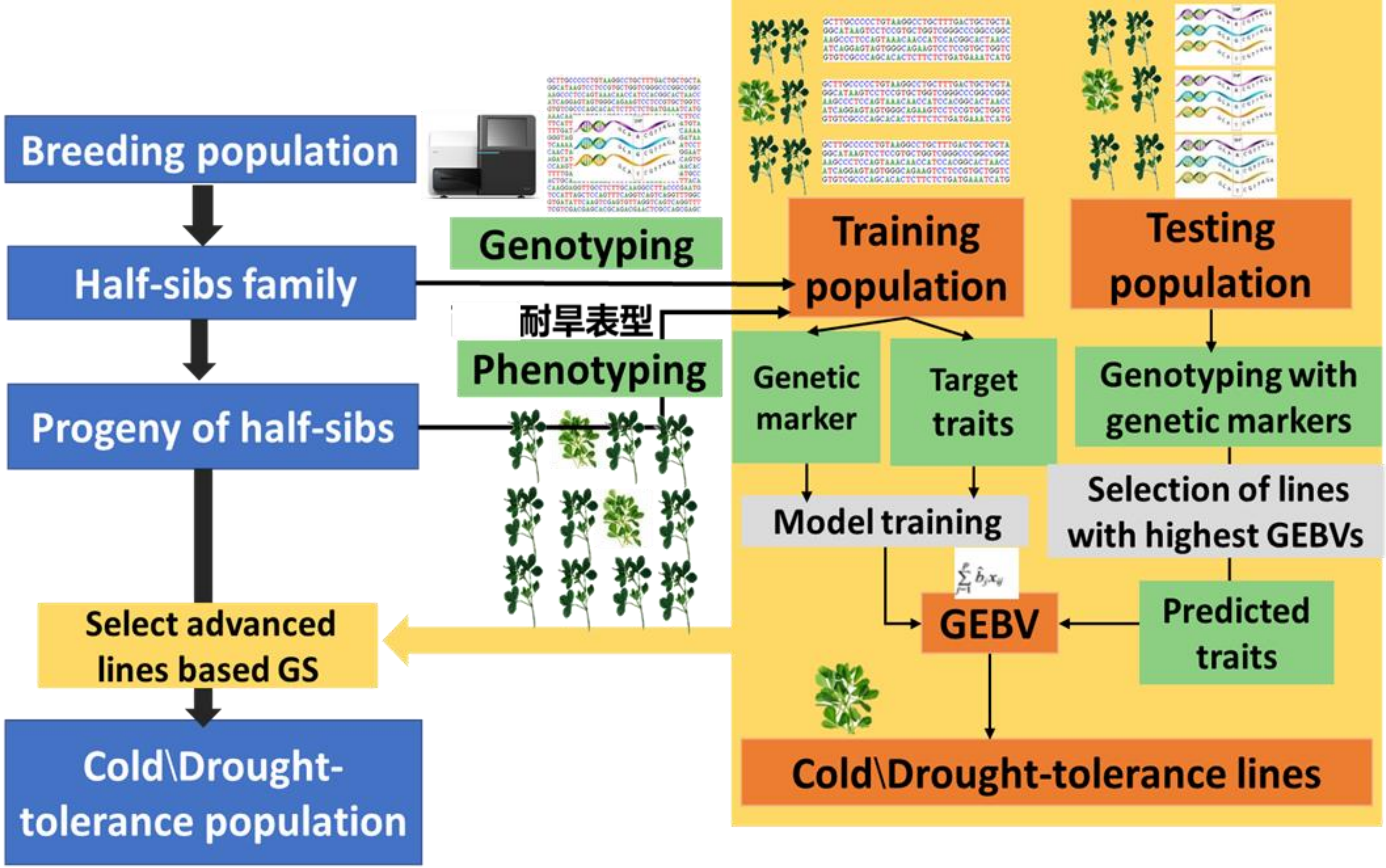
Treatments	Percentage of hard seeds (%)	Germination energy (%)	Germination rate (%)	Germination index	Vigor index
CK	96.00a	4.00c	4.00d	1.93d	0.07d
70℃	95.33a	4.00c	4.67d	1.70d	0.08cd
80℃	82.00b	10.00b	15.33c	4.66c	0.21b
90℃	60.00c	22.67a	38.00a	12.19a	0.42a
97℃	40.00d	12.00b	28.67b	7.52b	0.18bc

Effects of liquid nitrogen treatment on seed germination of *L. potaninii* Vass

Treatments	Percentage of hard seeds (%)	Germination energy (%)	Germination rate (%)	Germination index	Vigor index
CK	96.00a	4.00b	4.00b	1.93b	0.07b
3 min	85.00b	8.00ab	14.00a	5.02ab	0.19a
5 min	84.66b	8.00ab	13.33a	5.05ab	0.16ab
10 min	81.33b	14.00a	16.67a	6.78a	0.17ab

5. Application of molecular breeding

Construction of Genomic Selection (GS) Model



Breeding population

Half-sibs family

Progeny of half-sibs

Select advanced lines based GS

Cold\Drought-tolerance population

Genotyping

耐旱表型

Phenotyping

Training population

Testing population

Genetic marker

Target traits

Genotyping with genetic markers

Model training

Selection of lines with highest GEBVs

$\sum_{j=1}^{p} \hat{b}_j x_{ij}$

GEBV

Predicted traits

Cold\Drought-tolerance lines

Drought Tolerance and European Half-sib Families

Creation of Ms02Dr and Ms03Eu

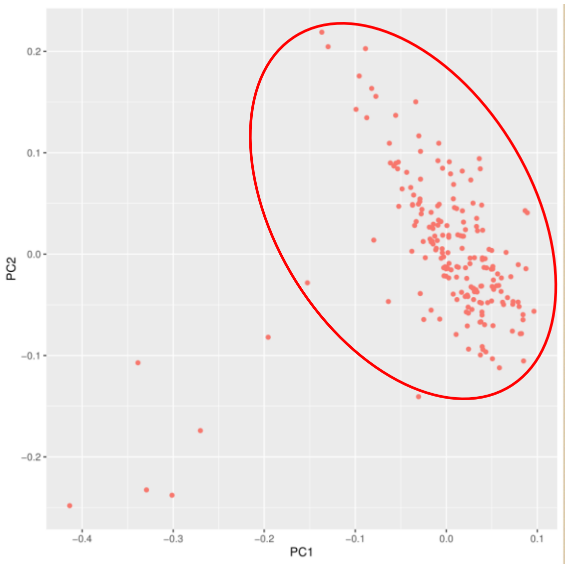
Name	Abbreviation	Parental Source	Half-sib Family Progenies	Genotyping
Drought-Tolerance Half-sib family	Ms02Dr	23 drougt tolerant cultivars from China and other countries	199	Resequencing up to 35 X
European Half-sib family	Ms03Eu	10 cultivars from 7 European countries	136	GBS by CREA

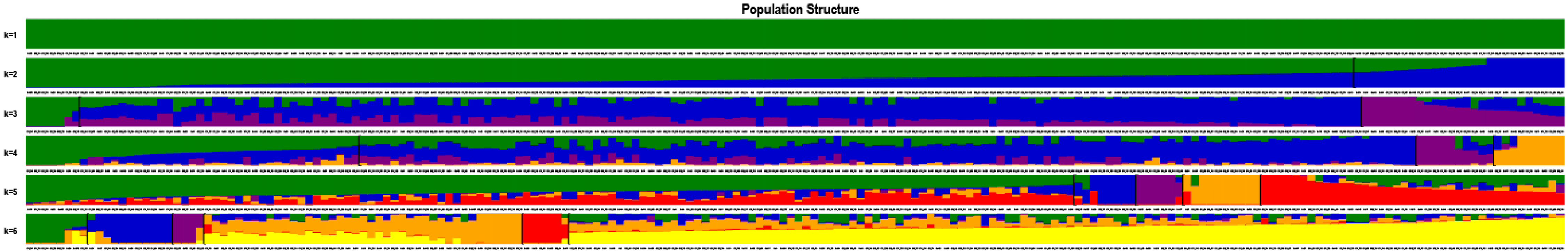
Oct. 2020 in Yuzhong

Apr. 2022 in Yuzhong

Resequencing of 199 Ms02Dr half-sib family

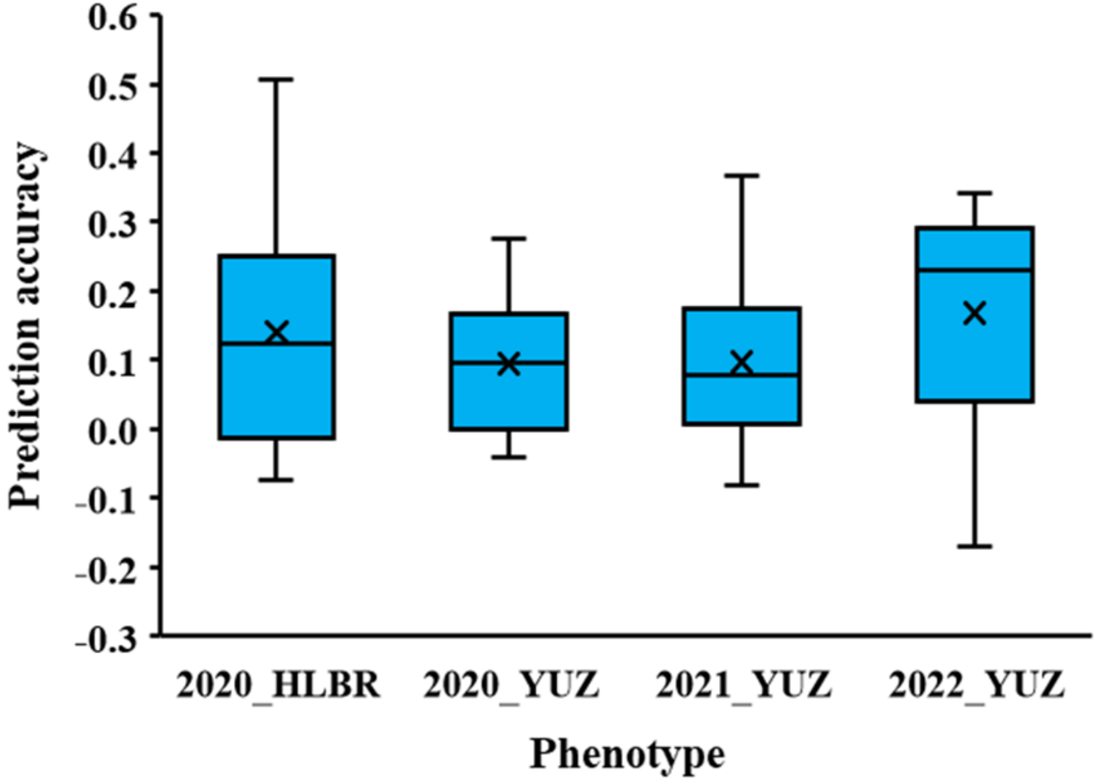
- **10.37 million SNPs were obtained through 35X resequencing of 199 half-sib family. After filtering with LD=0.8, 6.21 million SNPs were obtained, distributed on 8 chromosomes.**

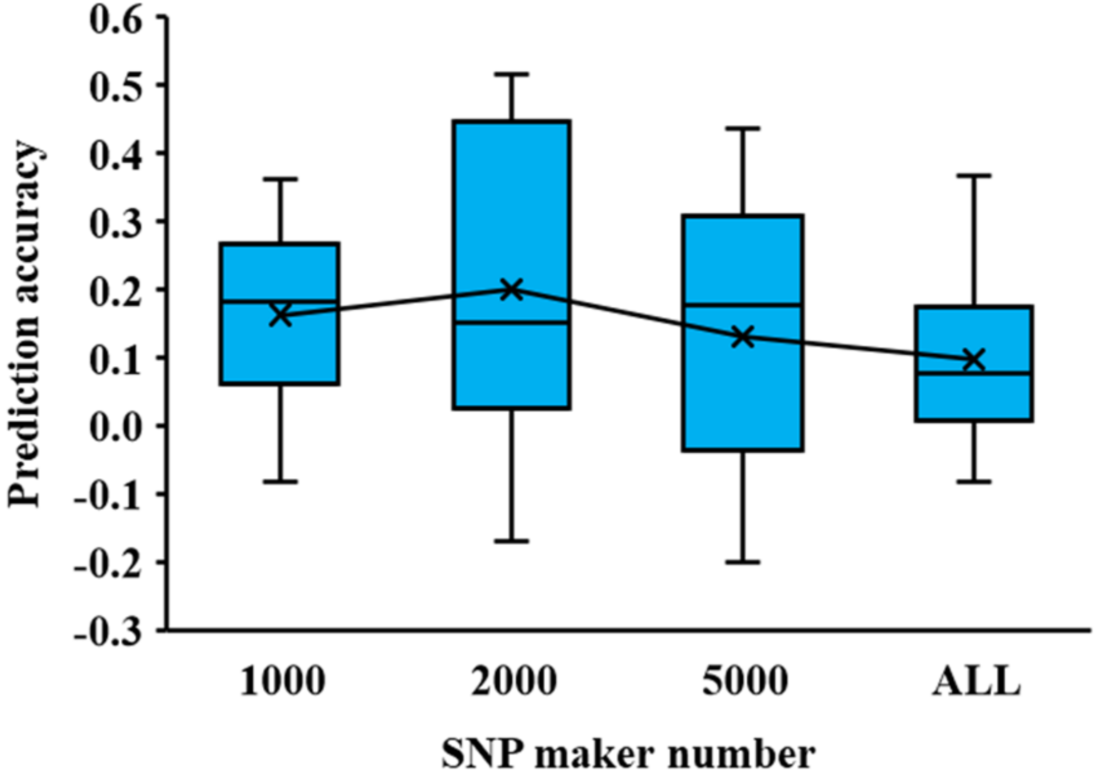




According to the PCA and population structure analysis of SNP, it conforms to the characteristics of its half-sib family (K=1).

Construction of Genomic Selection (GS) Model Using gBLUP Method

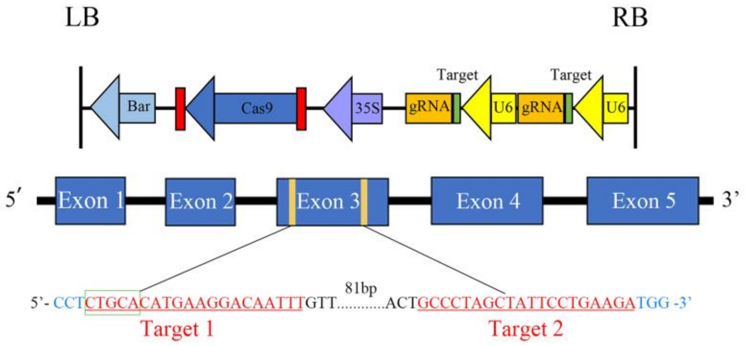




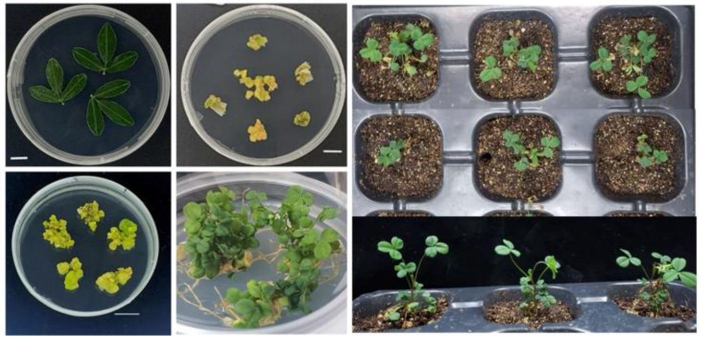
The accuracy of predicting dry weight traits ranges from 9% to 15% with all SNPs participating in the prediction. Combining GWAS to select different numbers of topSNPs, the prediction accuracy can reach from 9% to 20%.

Breeding low lignin alfalfa lines by CRISPR/Cas9

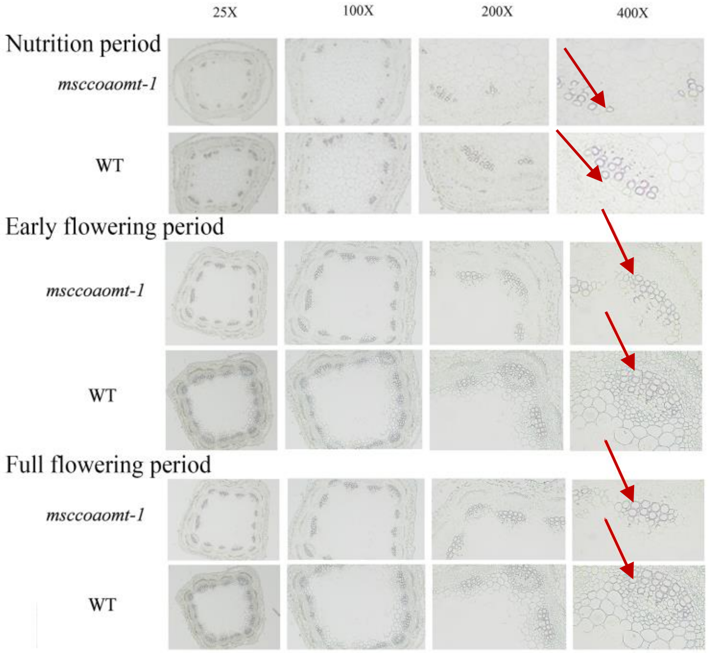
Construction of CRISPR / Cas9



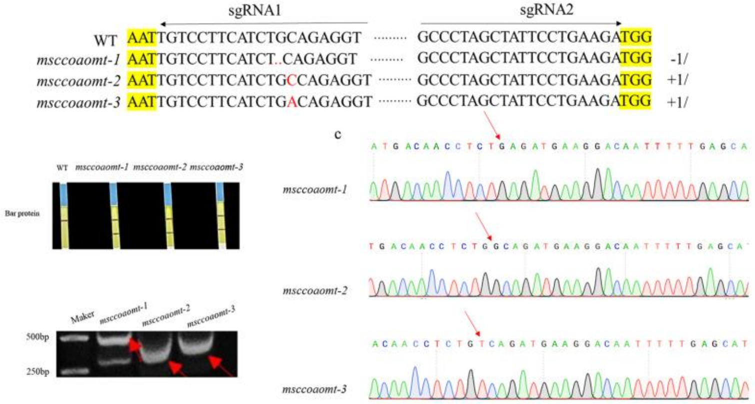
Tissue culture



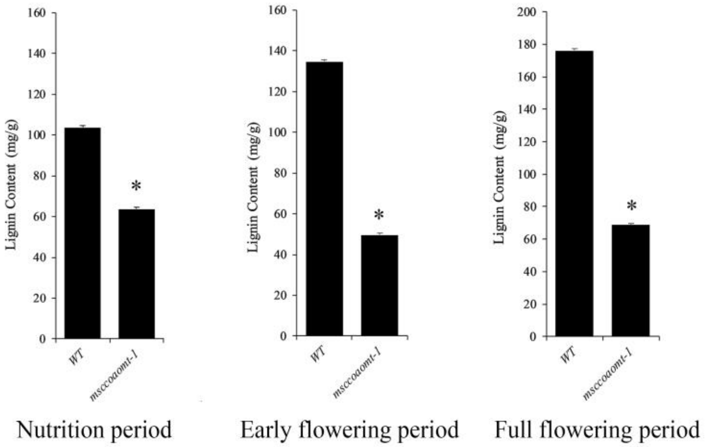
Histochemical staining of mutant plantzzz at different stages



Screening of positive plants



Lignin content of mutant plant in different periods



5. Acknowledgements

NSFC

- **National Natural Science Foundation of China (31101759, 31572453, 32061143035)**

CGIAR

- **Gansu Province Science and Technology Major Project the Gansu Provincial Science and Technology Major Projects (19ZD2NA002)；**

AgResearch Limited, Grasslands Research Centre, New Zealand

Phil Rolston, Zulfi Jahufer, Mingshu Cao

Agriculture Victoria Research, Department of Jobs, Precincts and Regions, AgriBio, Centre for AgriBioscience, La Trobe University, Australia

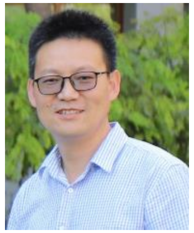
International Livestock Research Institute, Nairobi, Kenya;

Chris Jones

蘭州大學
LANZHOU UNIVERSITY

Zhibiao Nan

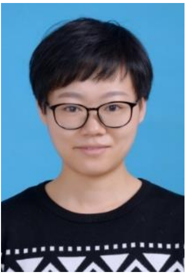
Yanrong Wang



Jiyu Zhang

Kai Luo

Daiyu Zhang



Fan Wu

Qi Yan

Lijun Chen

Zhuanzhuan Yan

Penglei Wang

Pengcheng Ma

8th IHSG, Lanzhou university - 2015

Thank you for your attention!

Welcome to join Lanzhou University as postdoctor

Annul salary:		
	Postdoctor,	¥ 200000+
	“Cuiying” Postdoctor,	¥ 350000+
	Youth Research Professor,	¥ 350000+
	Distinguished Professor,	+++