GLOBAL SYMPOSIUM ON SALT-AFFECTED SOILS

20 - 22 October, 2021
Virtual meeting

Biological improvement of saline-alkali land by planting two cultivated species of barnyard

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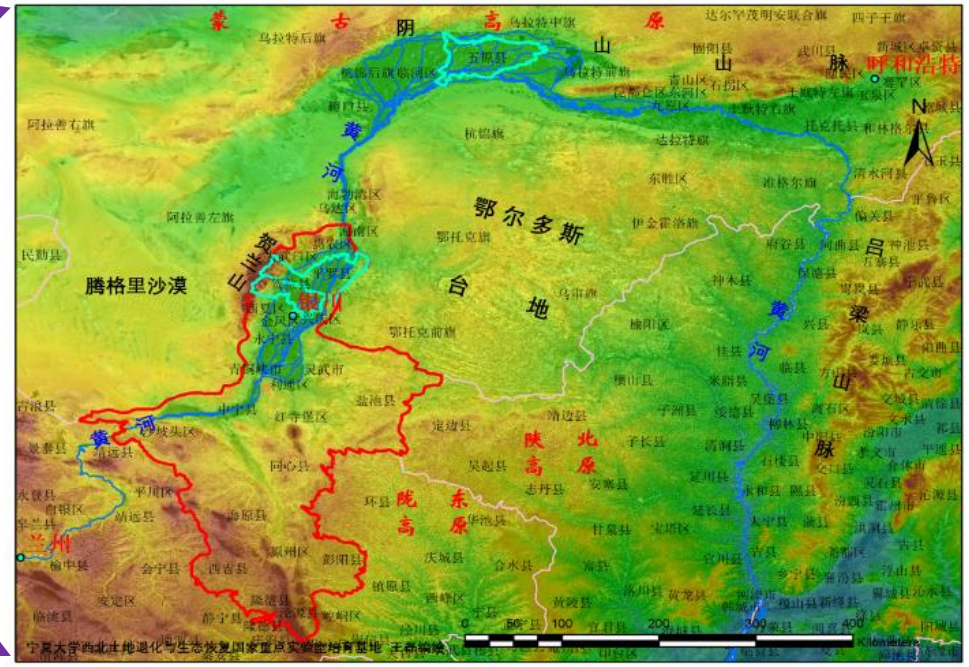


- **China has 26 to 33 million ha saline-alkali soil, accounting for 4.88% in the world.**
- **HetaoYellow River irrigation area is an important ecological barrier in western China. More than 1/3 of irrigated farmland affected by different degrees of soil salinization.**

History of the improvement and utilization of saline-alkali land in Hetao Ningxia Plain

Irrigation and Drainage Engineering

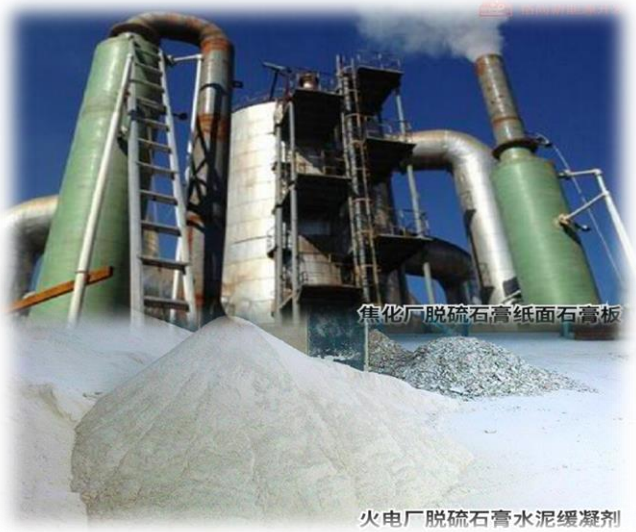
Engineering, agronomical, chemical integrative improvements

Ecological management based on biological improvement

Before the 1990s

Around the year 2000

After 2010



complicated irrigation and drainage system

modifier base on desulfurization gypsum

"rice fishing" integrated model

: Salt tolerance mechanism and biological improvement technology of native plants in Hetao Ningxia Plain

Mechanism of biological improvement

- Reducing soil pH by plant roots secrete organic acids ;
- Reducing soil salt content by plant absorbing soil salt ;
- Salt leaching by plant root penetration and decay process ;

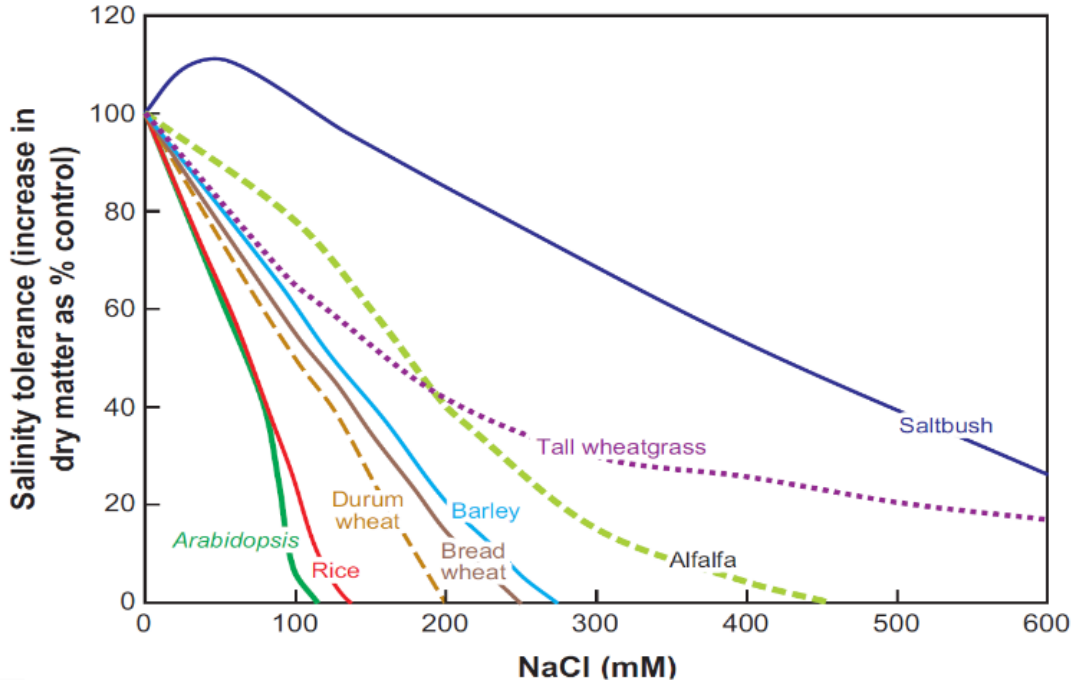
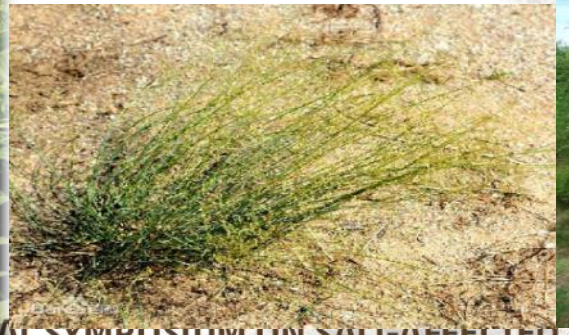
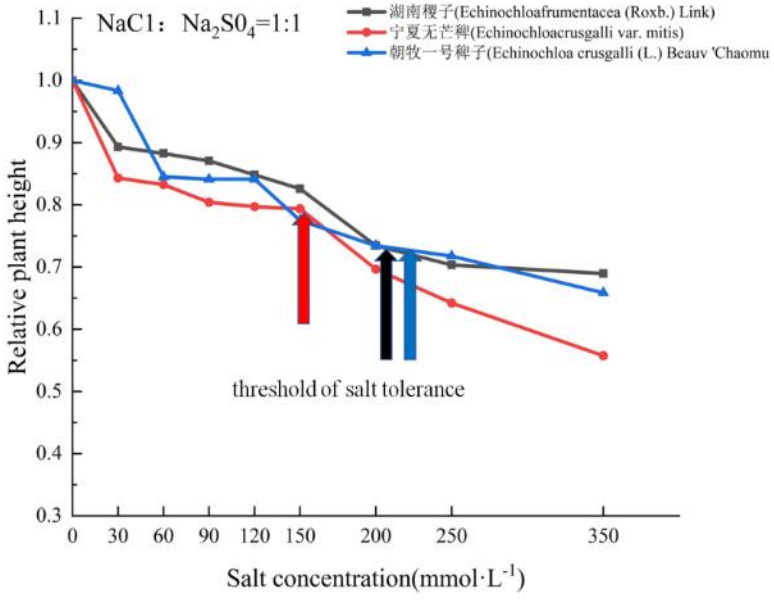
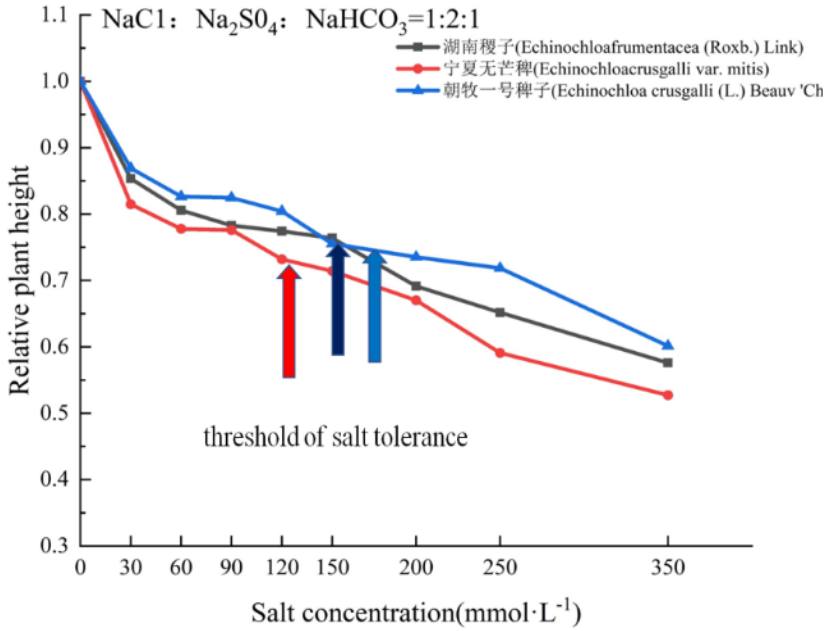


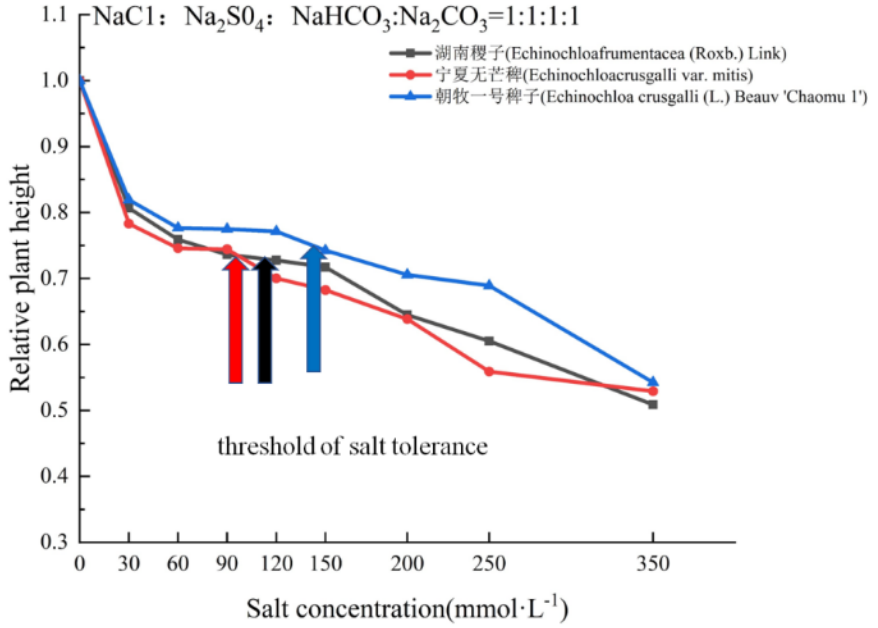
Fig.1 Difference in salinity tolerance of native plants



Salinity tolerance of three barnyard species to salinity or salinity+alkali stresses







The ranking of threshold value of salt tolerance is *Echinochloa crusgalli* (L.) Beauv ‘Zhaomu 1'>*Echinochloa frumentacea* (Roxb.) Link>*Echinochloa crusgalli* var. mitis).

Improve saline-alkali land by planting barnyard grasses

Cultivars of barnyard grasses (*Echinochloa*) in ameliorating saline-alkali lands

- Many species of barnyard grass (*Echinochloa*) have high feeding value and wide ecological adaptability.

- *Echinochloa frumentacea* (Roxb.) link (Japanese millet) and *Echinochloa crusgalli* (L.) Beauv. Var. mitis (Pursh) Petermann are high-quality gramineous forages.
- The two cultivars of *Echinochloa* are different in plant height, leaf length and width, heading stage, spike color and shape.

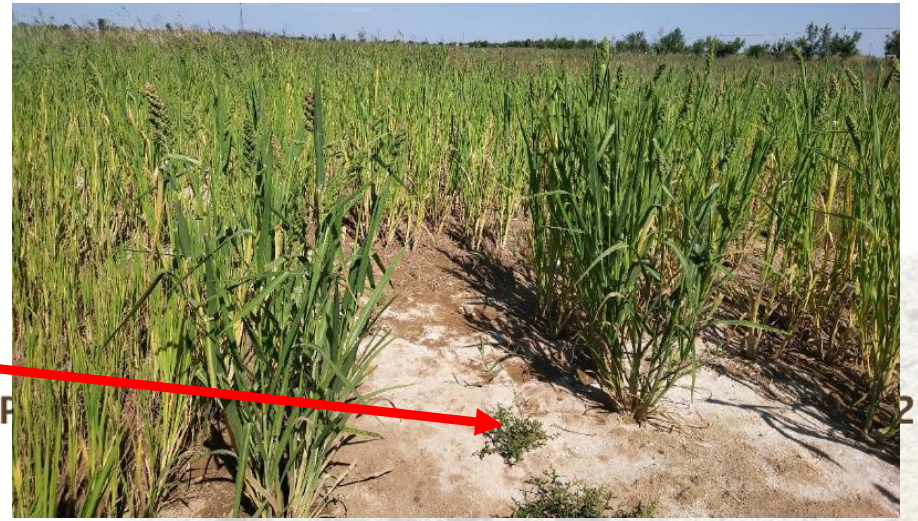
Echinochloa fruntacea (Roxb.) link

Echinochloa crusgalli (L.) Beauv. Var. mitis (Pursh) Petermann

Context of the practice

- The barnyard forages can be cultivated in tropic and teperate climates, with sufficient annual light (2800-3200 h).
- Frost free period should be above 155 days. Sufficient rainfall or well irrigation is necessary.
- It has wide adaptation to the soil types.
- The limiting growth condition in saline alkali soil is pH 9.0, total water-soluble salt 0.7g/kg and alkalinity 20.0%.

Barnyard grass can grow in flood land beside river and salt spot.



Planting of barnyard forages in saline-alkali land

- Sowing date is from the beginning of April to June.
- Sowing rate is 37.5-45.0kg/ha.
- Row spacing is 15-30cm.
- In the first two years, the stubbles are usually turned over into the soil in the autumn, and the hay can be harvested in the third year.

The cost and ecological and economic impacts of the practice

The positive impact of the practice in addressing soil salinity / sodicity

Table 1 pH, TS and ESP variance of soil by planting two years herbages under saline alkali stress (2019-2020)

Soil layer	Species	pH	Compared with CK(%)	Total salt（g·kg^{-1}）	Compared with CK(%)	Basicity（%）	Compared with CK(%)
0-20cm	bare land (CK)	9.18a	—	4.72d	—	20.42a	—
	Japanese millet	8.42e	-8.28	4.37d	-7.35	15.50e	-24.08
	barnyard grass	8.70c	-5.23	4.43d	-6.14	16.33c	-20.01
	oat	8.64cd	-5.88	4.45cd	-5.72	17.01b	-16.68
	alfalfa	8.55d	-6.86	4.39d	-6.99	15.84d	-22.43
	licorice	8.94b	-2.61	4.57b	-3.11	17.06b	-16.45
20-40cm	bare land (CK)	9.22a	—	4.13a	—	21.64a	—
	Japanese millet	9.18b	-0.43	3.96c	-4.2	19.99de	-7.62
	barnyard grass	9.18b	-0.43	3.96c	-4.12	20.27bc	-6.33
	oat	9.18b	-0.43	4b	-3.15	20.35b	-5.96
	alfalfa	9.03d	-2.06	3.93c	-4.84	18.66f	-13.77
	licorice	9.15c	-0.76	3.98b	-3.71	19.86e	-8.23

Sharp contrast before and after planting of barnyard forages !

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Costs of the practice

Table 1 The investment requirement for planting barnyard grasses

Seed (CNY/ha)	Fertilizer (CNY/ha)	Irrigation (CNY/ha)	Herbicide pesticide (CNY/ha)	Machine cultivation (CNY/ha)	Rent of land (CNY/ha)	Total investment (CNY/ha)
225	3,060	675	510	4,155	8,250	16,875

The cost of growing barnyard grasses includes seed, fertilizer, irrigation, herbicide, pesticide and so on with total investment around 1,6875 CNY (2,615.6 USD) per hectare.

The economic return by planting *E. frumentacea* and *E. crusgalli* (L.) Beauv. Var. mitis (Pursh) Petermann

Table 2 The income for planting *E. frumentacea*

Yield of hay（t/ha）	Unit-price of hay (CNY/t)	Income of hay (CNY/ha)	Yield of grain (kg/ha)	Unit price of grain (CNY/kg)	Income of grain (CNY/ha)	Total income (CNY/ha)
14.05	1, 000	14, 050	2, 395.8	5	11,979	26,029

The feeding value of *E. fruntacea* and *E. crusgalli* (L.) Beauv. Var. mitis (Pursh) Petermann

Table 3 Comparison of nutrients in the stalks of barnyard grasses with other forages at the beginning of heading stage

Species	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Neutral detergent fibe (%)	Acid detergent fibe (%)	Acid detergent lignin (%)	Crude ash (%)	Calcium (%)	Energy (J/g)
E. fruntacea	9.44	1.48	34.6	68.1	39.0	14.7	10.0	0.63	15,058
E. crusgalli (L.)	9.97	1.78	33.0	60.8	37.2	10.3	8.9	0.64	15,832
Paddy	7.8	1.6	8.2				4.6		

Plant species	Crude protein(%)	Lysine(%)	Methionine(%)	Histidine(%)	Arginine(%)
Barnyard grass	10.84	0.29	0.12	0.26	0.46
Maize	9.40	0.26	0.19	0.23	0.38
Sorghum	9.00	0.18	0.17	0.18	0.33

- The crude protein content is higher than or equal to those of paddy or wheat.
- The fiber content is higher than that of paddy or wheat. Heading stage is the suitable period to cut the stalk for feeding animals.

Challenges for scaling up the practice

- **There are no risks on environment for planting barnyard grasses.**
- **There is a little economic risk for planting barnyard grasses in the good quality land.**
- **The economic value of barnyard grasses is lower than that of such crops as maize, alfalfa, wheat or rice, etc.**
- **The barnyard is usually used in the medium and severe saline-alkali lands.**

We appreciate the financial support by special program of forage breeding in Ningxia Hui Autonomous Region “The innovation of salt-tolerant pasture germplasm resources and the breeding of new varieties”

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