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Preliminary evaluation of adaptability of 13 quinoa varieties in the Linxia arid area of Gansu Province, China

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Background/Introduction

Quinoa Introduction

- Quinoa is an annual dicotyledonous herb belonging to *Chenopodium*, Chenopodiaceae, Amarantaceae.
- Quinoa, originated in Andes mountain of South America and native to Peru, Bolivia and Ecuador, has a planting history of 5000-7000 years.
- Quinoa is rich in protein, human essential amino acids, B vitamins, vitamin E, dietary fiber and mineral elements, low contents of sugar and fatty acids.
- FAO officially recommends quinoa as a perfect "full nutrition food" that is most suitable for human, and praises it as the only monomer plant that can meet the basic food demand of human.



Background/Introduction

- Quinoa was introduced to China by both Tibet Academy of Agricultural and Animal Husbandry Sciences and Tibet Agricultural and Animal Husbandry College in 1988.
- Currently, quinoa had been planted in different scales in Zhejiang, Shanxi, Jilin and Qinghai provinces.
- In 2011, quinoa was successfully introduced to Gansu by Yang Farong et al. in Institute of Pasture and Green Agriculture, Gansu Academy of Agricultural Sciences.
- In order to effectively develop and utilize quinoa germplasm resources and breed quinoa varieties suitable for domestic growth to enrich quinoa strain resources, we conducted breeding work of new quinoa varieties through the methods of line breeding, cultivation and domestication.



Quinoa planted in Yongdeng county, Lanzhou City, Gansu Province, China

Quinoa planted in Anning district, Lanzhou City, Gansu Province, China





Quinoa planted in Jiayuguan City, Gansu Province, China

Quinoa planted in Minle county, Zhangye City, Gansu Province, China



Quinoa planted in Shandan county, Zhangye City, Gansu Province, China

Quinoa planted in Jingtai county, Baiyin City, Gansu Province, China



Quinoa sowed by hill-drop drill

Quinoa sowed by laminatingsowing machine





Seedling period

Flowering period





Grain-filling period

Maturing period





Quinoa matured in Minle county, Zhangye City, Gansu Province, China

Quinoa matured in Minle county, Zhangye City, Gansu Province, China





Quinoa matured in Yongchang county, Jinchang City, Gansu Province, China

Quinoa matured in Yongchang county, Jinchang City, Gansu Province, China





Quinoa matured in Yongdeng county, Lanzhou City, Gansu Province, China

Quinoa matured in Yongchang county, Jinchang City, Gansu Province, China





South African experts visited Yongchang county quinoa planting base

South African experts visited Shandan county quinoa planting base

Experimental site

- Yongjing county, Linxia City, Gansu Province, China
- The altitude is 1816 m, the average temperature is 10 centigrade, amount of precipitation is 260 mm, amount of evaporation is 1500 mm, frostless period is 145 d.
- The soil index
 - ✓ Organ matter content was 9.02 g/kg
 - ✓ Nitrogen content was 0.6 g/kg
 - ✓ Phosphorus content was 0.35 g/kg
 - ✓ Potassium content was 25.85 g/kg
 - ✓ Water content was 9.45%
 - ✓ pH 8.64

Applied treatments

Experiment design

The experiment started in 4/5, 2014. It used Shanxi quinoa as CK, randomized block design, the area of experiment plot was 18 m², 3 seeds were planted in one plot, the sowing depth was 3 cm, line-width was 50 cm, row-spacing was 30 cm, thinning out seedlings in 4-6 leaves period, one seedling in one plot, the cultivation density is 4446 plant/ m². We put fertilizer before sowing.

> Materials

Sources and characteristics of quinoa varieties can be seen in the following table.

Sources and characteristics of quinoa varieties

Variaty	Source	1000-kernel weight	Germination rate
variety	Source	(g)	(%)
СК	Jingle county, Shanxi Province	3.42	61
Q1	Gansu Academy of Agricultural Science, Lanzhou city, Gansu province	3.36	82
Q2	Gansu Academy of Agricultural Science, Lanzhou city, Gansu province	3.61	81
Q3	Shanxi Huaqing Quinoa Products Development Co.,Ltd.	3.25	79
Q4	Shanxi Jiaqi Quinoa Co.,Ltd.	3.23	84
Q5	Jingle county, Shanxi Province	3.18	86
Q6	Zhangjiakou Academy of Agricultural Sciences	3.02	88
Q7	Heshui county, Gansu Province	2.21	34
Q8	Zhengning county, Gansu Province	1.85	22
Q9	Gansu Academy of Agricultural Science, Lanzhou city, Gansu province	3.12	84
Q10	Gansu Academy of Agricultural Science, Lanzhou city, Gansu province	2.97	82
Q11	Gansu Academy of Agricultural Science, Lanzhou city, Gansu province	3.24	72
Q12	Gansu Academy of Agricultural Science, Lanzhou city, Gansu province	3.42	69

- Index determination
 - ✓ Seed germination rate
 - ✓ Agronomic character
 - Growth period
 - Plant height
 - Branches number
 - Length and diameter of branches
 - 1000-kenel weight
 - Yield
 - Lodging rate
 - ✓ Quality analyze
 - ✓ Disease analyze

The standard of disease classification

ΙονοΙ	The percentage of lesion covered the total area of the leaves			
	Downy mildew	Leaf spot		
0	No diseased spot	No diseased spot		
	<5% The percentage of lesion	<5% The percentage of lesion		
1	covered the total area of the leaves	covered the total area of the leaves		
	is below5%	is below 5%		
	$6\% \sim 25\%$ The percentage of lesion	6%~10% The percentage of lesion		
3	covered the total area of the leaves	covered the total area of the leaves		
	is 6%-25%	is 6%-10%		
	26%~50% The percentage of	11%~20% The percentage of		
5	lesion covered the total area of the	lesion covered the total area of the		
	leaves is 26%-50%	leaves is 11%-20%		
	51%~75% The percentage of	21%~50% The percentage of		
7	lesion covered the total area of the	lesion covered the total area of the		
	leaves is 51%-75%	leaves is 21%-50%		
	>76% The percentage of lesion	>50% The percentage of lesion		
9	covered the total area of the leaves	covered the total area of the leaves		
	is above 76%	is above 50%		

• Comparison of Growth Period

Variety	Sowing (Month-day)	Seeding (Month- day)	Branch (Month- day)	Initial flowering (Month- day)	Mature (Month- day)	Growth period (d)
СК	5-4	5-15	6-7	7-5	9-25	134
Q1	5-4	5-15	6-6	7-8	9-18	127
Q2	5-4	5-15	6-6	7-9	9-20	129
Q3	5-4	5-15	6-5	7-5	9-13	122
Q4	5-4	5-15	6-4	7-3	9-12	121
Q5	5-4	5-15	6-5	7-6	9-13	122
Q6	5-4	5-15	6-5	7-5	9-13	122
Q7	5-4	5-17	6-6	7-8	9-9	116
Q8	5-4	5-17	6-6	7-8	9-8	115
Q9	5-4	5-15	6-6	7-10	9-15	124
Q10	5-4	5-15	6-6	7-3	9-19	128
Q11	5-4	5-15	6-6	7-6	9-20	129
Q12	5-4	5-15	6-6	7-6	9-20	129

• Biological Character

Variety	Plant height (cm)	Number of branches
СК	190.5 ± 8.1a	22.2 ± 2.2a
Q1	190.9±15.8a	24.3±1.5a
Q2	200.4±22.5a	22.2 ± 2.1a
Q3	178.6 ± 23.2ab	22.2 ± 2.1a
Q4	179.1 ± 8.3ab	22.2 ± 2.1a
Q5	173.0±6.9abc	22.2 ± 2.1a
Q6	168.5±8.6abc	22.2 ± 2.1a
Q7	145.5±12.0c	22.2 ± 2.2a
Q8	149.8±4.9bc	22.2 ± 2.2a
Q9	178.7±10.2ab	22.2 ± 2.2a
Q10	177.7 ± 27.1ab	22.2 ± 2.7a
Q11	189.7 ± 19.0a	22.2 ± 2.8a
Q12	186.1 ± 29.0a	22.2 ± 2.9a

• Biological Character

Variety	Effective number of branches (%)	Length of bough ear (cm)	Length of lateral ear (cm)	Diameter of main branch ear (cm)	Diameter of lateral ear (cm)
СК	67.0±4.1abc	58.6±3.8a	22.4 ± 2.9 ab	14.5±2.0ab	3.7 ± 0.2ab
Q1	62.0±10.1abc	54.2 ± 2.1abc	20.1±5.1 abc	14.1±1.3abc	3.7 ± 0.3ab
Q2	49.8±8.7c	56.5 ± 7.9ab	13.8 ± 4.2 d	10.2 ± 1.9d	2.3 ± 0.3c
Q3	66.1 ± 8.8abc	52.7±3.4abc	18.5±0.5 abcd	11.8±2.0bcd	3.6 ± 0.7ab
Q4	55.8±5.7bc	56.5 ± 3.8ab	20.1±1.9 abc	13.3 ± 1.4abcd	3.6 ± 0.8ab
Q5	60.8±10.4abc	48.1±2.9abc	18.3 ± 2.1 abcd	10.8±0.9cd	3.2 ± 0.3ab
Q6	69.3 ± 7.9ab	46.1±4.1bc	15.3 ± 0.1 cd	10.7±1.7cd	3.3 ± 0.2ab
Q7	74.5±6.1a	45.8±3.5bc	19.9±3.0 abc	11.8±1.4bcd	4.0±0.4 a
Q8	68.0±15.3ab	44.6±0.3c	18.7±1.4 abcd	12.7±0.7abcd	3.6 ± 0.1ab
Q9	60.2 ± 6.2abc	56.6±3.9ab	24.3±3.3 a	15.6 ± 2.8a	3.5 ± 0.6ab
Q10	70.4 ± 14.6ab	57.0±12.5ab	21.7 ± 2.4 ab	12.4±1.9abcd	2.9±0.5bc
Q11	63.5 ± 3.3abc	58.7±5.5a	19.5 ± 4.9 abcd	12.8±2.5abcd	3.0±0.2bc
Q12	60.0±6.7abc	55.1 ± 9.4abc	17.4±3.3 bcd	10.8 ± 2.1cd	2.9±0.1bc

• Biological Character

Variety	Color of mature leaf	Color of mature stem	Color of mature ear	Plant type
СК	Yellow	Yellow	Yellow	Compact
Q1	Yellow	Red	Yellow	Compact
Q2	Yellow	Yellow	Red	Compact
Q3	Yellow	Yellow	Yellow	Compact
Q4	Yellow	Red	Yellow	Compact
Q5	Yellow	Red	Red	Compact
Q6	Yellow	Yellow	Yellow	Compact
Q7	Yellow	Yellow	Yellow	Compact
Q8	Yellow	Yellow	Yellow	Compact
Q9	Yellow	Red	Red	Compact
Q10	Yellow	Yellow	Red	Compact
Q11	Yellow	Yellow	Yellow	Compact
Q12	Yellow	Yellow	Yellow	Compact



The experiment of different quinoa varieties

The experiment of different quinoa varieties



• Yield Trait



• Quality Characteristics

Variety	1000-kernel weight (g)	Crude protein (%)	Crude fat (%)
СК	3.0	16.50 ± 0.46a	6.08±0.01bcd
Q1	3.5	16.37 ± 0.59a	5.14±0.15g
Q2	3.6	16.69±0.64 a	4.03 ± 0.27j
Q3	2.9	15.88 ± 0.13a	5.27 ± 0.25fg
Q4	3.0	16.34 ± 1.29a	5.44±0.36efg
Q5	3.1	15.80 ± 0.34a	5.68±0.33def
Q6	2.8	16.33 ± 0.62a	5.69±0.42def
Q7	2.2	16.51 ± 0.22a	5.96±0.17cde
Q8	2.0	16.08 ± 0.64a	5.84±0.11cde
Q 9	2.4	16.05 ± 0.73a	6.99±0.59a
Q10	2.3	15.90 ± 0.38a	6.58±0.25ab
Q11	2.6	16.82 ± 0.71a	6.11±0.40bcd
Q12	2.9	16.63 ± 0.91a	6.25±0.49bc

• Resistance of Root Lodging Rate



• Resistance of Stem Lodging Rate



• Resistance of Downy Mildew and Leaf Spot Disease



Conclusions

- The plant height of quinoa varieties Q2 was the highest, the branches number of quinoa varieties Q1 was the most.
- The effective number of branches of quinoa varieties Q7 was higher than others.
- The plant type of all quinoa varieties was compact.
- The highest yield of all quinoa varieties was Q9, the lowest was Q8.

Conclusions

- The 1000-kenel weight, crude protein and fatty contents of all quinoa varieties had the significantly differences.
- The resistance of root lodging rate and stem lodging rate of quinoa varieties Q9 was the strongest.
- Quinoa varieties Q9 had the lowest disease index.
- All quinoa varieties were separated into 3 groups, the first group is mid-later maturing varieties, the second group is late maturing varieties, and the third group is early maturing varieties.

Conclusions

- Quinoa varieties Q7 and Q8 were early maturing varieties, they can be planted in some regions which had short frostless season. Q8 and Q9 had the strongest resistance of lodging rate, they can be planted in mountains.
- Quinoa varieties Q1 and Q2 had the best qualities, so they can be used to develop foods.
- Q9 had the highest yield, strongest resistance of lodging rate and disease index, so it can be planted and developed in everywhere in China.

Thank you!