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Short Communication

Genetic diversity in barley and its utilization in Yunnan plateau, China

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The genetic diversity of barley in Yunnan plateau of China is very rich and varied. The rich resources, sunlight, heat and water constitute the factors contributing to high yield and quality in barley. Barley is used as food, forage and also as industrial crop in Yunnan. Barley is also a good crop for rotation and for inter-planting to increase the multiple crop produce. It's genetic characters such as early maturity, high yield, resistant to abiotic stresses and wide use offer a great advantage and wide perspective for its utilization in the cropping system improvement, beer brewing and animal husbandry development in Yunnan plateau.

Diversity of barley in Yunnan plateau

1.1 *The taxonomical and morphological diversity of Yunnan barley* : From 1959 to 1997, 734 cultivars of barley were reported from China, including 599 new named cultivars, 86 of them were peculiar to Yunnan [1-4]. 181 cultivars of Yunnan barley belonging to (175 two-rowed and six poly-rowed) cultivated barley species were reported in 1990, including 68 cultivars which were reported in China and the rest abroad, [4, 5]. 18 new cultivars of Yunnan barley were reported in 1991 [4].

Over 500 accessions of barley collected from 16 districts (prefectures) of Yunnan were studied for the taxonomy system of species-subspecies-variety [6, 7] from 1989 to 1995. Results showed that 305 accessions belonged to two subspecies of two-rowed and poly-rowed common barley, including 154 new cultivars (86 of them were reported before).

The subspecies of two-rowed barley in Yunnan plateau is very rich containing 129 land races (74 hulled and 55 hull-less), much greater than in Tibet which was called as the center of origin of barley in the world. They are distributed mainly in Luquan, Zhaotong, Jinghong, Lunan, Luoping and Baoshan with an elevation of 1600 to 1990 m asl. The subspecies of poly-rowed barley in Yunnan containing 176 genotypes Including 69 new cultivars, (100 hulled and 76 hull-less) which constitute the majority of cultivated barley of Yunnan are distributed widely in the high-cool, temperate and hot regions of the province with an elevation of 550 to 3600 m asl. The wide distribution of rich and varied populations of the cultivated barley in Yunnan suggest that the domestication over a long time formed the basis of diversity in barley of Yunnan plateau.

Moreover, out of the 305 cultivars of Yunnan barley, (i) 174 were hulled, being 57% of total, (ii) 147 were with denticulates and diverse awns, being 48.2% of total; (iii) 96.7% were with narrow glumes; (iv) 41.4% of total were with dark ears, and (v) 70.8% were having dark seeds.

The diversity in planting time of Yunnan barley

The importance of sowing of barley in four different seasons : In central Yunnan, barley could be sown in all the 4 seasons, so, the seeding types of barley in Yunnan could be divided into (i) spring barley, (ii) summer barley, (iii) autumn barley, early dry land barley and (iv) winter barley. The spring barley is distributed in the high lands of northwest Yunnan where it is very cold in winter, and the hull-less barley is planted there. Barley is seeded in March-April and matures in August-September with a growth duration of 120-150 days.

(ii) The summer barley forms the ideal seed propagation base for winter crop breeding in Kunming, China. Barley is sown in June, grows in the rainy and hot season for about 100 days and ripens in August- September.

Some cultivars of barley with strong spring nature were selected for taking an autumn catch crop to be cultivated after harvest of potato (July) and before plantation of winter crop in order to make full use of

Table. 1. Comparison of five sowing types of barley in Yunnan

Type*	Sowing date	Maturing (Month/day)	Growth duration (d)	Yield (t/ha)	Elevation (m)	Representative cultivars	Distribution (prefectures)
A	3/10-4/10	8/1-9/20	120-150	1.5-2.5	>3000	Heqingke, Huangqinke	Diqing, Nujiang etc.
B	6/1-6/20	8/20-9/10	70-80	1.1-2.0	1900-3000	Humai No.6, 80d qingke	Kunming, Diqing
C	7/15-7/30	10/1-10/20	80-90	1.4-3.0	1900-2900	84-23, Zhaoshu No.3	Kunming, Diqing
D	8/25-9/10	1/1-1/20	100-120	3.8-7.5	1300-2500	Tequila, V24, 84113, 86-40	Yuxi, Kunming
E	10/20-12/1	4/10-5/1	150-170	4.0-10.0	550-3600	Tequila, Mylt44, Supi No. 1	All prefectures

*A=Spring barley; B=Summer propagating barley; C=Autumn barley; D=Early dry land barley; E=Winter barley.

the resources of light, heat and water. Its growth duration is about 80-90 days.

in order to make full use of autumn rain and the damp soil, and enough sunlight, early dry land barley is sown in the last ten-days of September, between autumn barley and the ordinary winter barley, grows for 100-120 days and ripens in February next year. It escapes the hot, wet spells as well as pest and weed injuries caused by the high temperature, too much rain and strong sunshine from July to October, reduces the risk of the cold injury of winter barley, as well as the serious drought injury and high temperature of March-April;

(iv) Winter barley is sown from the end of October to the beginning of November, grows for 150-170 days and ripens by the end of April upto the beginning of May of the next year.

The four-season sown barley in Yunnan plateau with its diversity and the complexities of the climatic conditions there, provides a good materials for the study of the genetic characteristics of barley. Moreover, Yunnan belongs to monsoon climate for low latitudes plateau, the drought-season and rainy-season are distinctly separated, the ecological conditions for humid land and dry land are very different. The winter barley in Yunnan is also divided into humid-land barley and dry-land barley. Generally, two-rowed barley is adapted in humid land, and the poly-rowed barley is adapted to both humid and dry land conditions.

The yield of four-season sown barley in Yunnan: The climatic conditions in Yunnan plateau have caused the diversity in sowing types of barley and variation in their yield levels e.g. 4500 kg/ha. for spring barley, 3000 kg/ha. for summer propagated barley, 3150 kg/ha. for autumn barley, 7500 kg/ha. for early-dry land barley and 10500 kg/ha. for winter barley.

There is a local cultivar in northwest highlands of the province named "80d qingke", it could be sown in spring, summer, autumn and winter. This is good example which overrides the limitations of winter and summer crops. As winter barley, it is grown in the regions of 2400-2900 m asl, it is sown from the last ten-days of October to the first ten-days of December, grows for 180-200 days, ripens in the mid-last ten-days of June of the next year, and can yield upto 3000 kg/ha. It can be sown in summer too, with its growth duration of 80-90 days, and a yield potential of 1500 kg/ha. It could also be sown in spring season in March-April for regions above 3000 m asl and ripens in August with its growth duration of 100-130 days.

Comprehensive utilization of barley in Yunnan

Normally, the annual planting area of barley in Yunnan plateau is about 70,000 to 100,000 ha. with an average yield of 2,250 to 3,000 kg/ha., the highest record is about 10,500 kg/ha. The consumption of barley in Yunnan is as food, feed and forage. 70% of total is used as animal feed, 20% is used to brew beer and the rest 10% is used as food and for seed.

Hull-less barley is still the major food and is used to make wine "Qingke" for the people in the mountainous regions of Diqing and Nujiang prefectures in northwest Yunnan. People in Luquan county eat barley after shelling its hull with rice mill.

Barley is considered as a better forage to feed the domestic animals in Yuxi, Xuanwei, etc. Barley planted in Yunnan plateau is considered as the best raw material for quality beer and meets one third of the need for an annual production of 15 t beer in the province. The malt of barley is good for the stomach and used in Chinese traditional medicine in Yunnan.

The utilization of barley in the cropping system improvement in Yunnan plateau

Wide adaptation overcomes the seasonal limitations of summer and winter crops : With its short growth duration and early maturity, barley is used to overcome the seasonal contradictions in the highland with an elevation of ≥ 1800 m in central, west, northwest and northeast Yunnan to ensure the intensive cultivation, high yield and assures economic benefit to tobacco and rice planters there. The better cropping combination of barley-tobacco or barley-rice is one of the reasons for the extensive barley cultivation in these regions.

Utilization in multiple cropping : (1) In Yuxi, the transformation of planting pattern from the traditional

food and economic crop to the food - economic - forage crop was made possible by the use of Tequila, a cultivar of barley. The cropping combinations of tobacco - *Codonopsis pilosula* (Chinese medicine dangshen) - Tequila, tobacco - sweet potato - Tequila, tobacco - vegetables - Tequila, rice - vegetables - Tequila, has increased the cropping index from 2 crops to 3 crops a year. The economic benefit to the people therefore increased in the period 1984-1994, the demonstration area of Tequila in Yuxi amounted to 41200 ha. with an average yield of 5250 to 6000 kg/ha.

The improvement in dry land cropping system

1) The cropping combination of wheat-corn could be changed to wheat-barley-corn to increase the yield per unit area: taking it to 1.8 m in intercropping belt (I m for wheat and 0.8 m for barley), after the harvest of barley, 2 rows of corn could be sown. Consequently, a yield increase of 12.6%-92.9% could be gained ;

2) The change in cropping pattern from wheat - corn to barley - corn could make a yield increase of 19.2%;

3) The change from a single crop of potato to potato + barley could make a yield increase of 134.9%.

(3) Barley could be used also as a winter catch crop to increase the idle winter paddy fields or dry land from 1 crop to 2 or 3 crops a year.

Utilization in the intercropping in paddy fields and dry lands :

(1) Intercropping of broad bean and barley in paddy fields: In 1991-92, scientists of Yuxi Institute of Agricultural Sciences did an intercropping test of broad bean and barley. 2 rows of broad bean cultivars 8462 and 4 rows of barley cultivar 85V24 were inter-planted in order to make full use of sunlight, air, soil fertility and marginal rows superiority. Results showed that the intercropping not only overcame the limitations of sowing and harvesting seasons, but also got a higher comprehensive yield of 9133.5 kg/ha.

(2) In the dry land of Qujing district, the comprehensive yield of intercropped wheat and barley was 8.7 % and 5.2 % higher than that in single cultivation of wheat and barley, respectively.

(3) The reasons for yield increase for intercrops of different families (bean & grass) or genera (barley& wheat) are as follows:

1) Intercropping leads to good air ventilation, decreases the lodging of crops, decreases humidity, controls the populations of pest and weeds;

2) Intercropping could make full use of the resources of light, heat and water at different stages in different gradations, increases utilization ratio of light, enhances the marginal effect and the mutual superiority;

3) Intercropping can make full use of water and fertilizer, and soil nutrients and increases the soil fertility. Barley belongs to a shallow rooting crop, beans take deeper root, water and fertilizer in soil could be fully used, the root tubercle bacteria of bean could increase soil fertility. For this reason, the intercropping of bean and grass crops could increase the yield and economic value, and make the production of barley in Yunnan economical with ecological benefits.

Setting up of commodity production base for quality beer brewing barley

The favorable natural climatic conditions caused by the monsoon climate of low-altitudes plateau of Yunnan and the rich and varied genetic resources of barley there provide good opportunities for the set up of a commodity production base of quality beer brewing barley. Moreover, as a window and as a thoroughfare of the Southwest China to Southeast Asia, along with the opening of the border cities, the need of barley as raw material for beer brewing and forage industry augmented, the geological superiority of Yunnan provided a bright prospect of barley production. All the beer brewer in Yunnan acknowledge that the quality of the beer brewing barley planted in Yunnan is much better than those of introduced lines. But the production bases of beer brewing barley in Yunnan are short and very small, the utilization in forage production has aggravated the short supply of raw material for beer brewing barley. The cultivar mixture and deterioration of seed quality of cultivated barley threatens the quality of beer brewing barley in Yunnan. So, it's imperative to set up a commodity production base of beer brewing barley.

3. Discussion

(1) Yunnan barley is rich in germplasm resources with greater genetic diversity and peculiar traits. Most cultivars of Yunnan barley are controlled by the dominant genetic traits such as denticulates and diverse awns, narrow glumes, and dark-colored seeds. Wild relatives of barley were discovered in the cultivated barley of Yunnan. Results suggest that Yunnan plateau maybe the secondary center of origin [Zeng *et al.*, 1995] and a part of the genetic diversity center of cultivated barley in China.

(2) The scientific research institutions should take up the conservation and utilization study of the rich and varied genetic resources of barley in Yunnan plateau, introduce quality germplasm of barley from other provinces and abroad in order to promote the evaluation and utilization of the cultivars suitable in

different cropping systems (dry land and humid land), the net plantation, inter- and alternative cropping of spring barley, summer sown barley, autumn barley, early dry land barley and ordinary winter barley, etc.)

(3) Using the experiences of other countries for reference, setting up the scientific units along with agricultural and industrial units which may coordinate on the basis of a contract to set up the commodity production base for supply of quality raw material for the beer brewers.

(4) On the basis of the development and utilization of quality beer brewing barley cultivars and the economic benefits, the comprehensive development and utilization of barley should be reinforced. A new situation of high yield by multiple ways for the production of barley in Yunnan plateau has appeared now. Combining system of good cultivars with good cultivation methods of barley for different ecological and productive conditions had caused the leap of barley production in the province in the period 1980s-1990s. A comprehensive scientific system formed with scientific research and production, processing, selling (feeding) will be the key for the development of barley development of Yunnan in the new century.

References

1. **Lu Liangsu**. 1996. Barley in China. China Agriculture Press, Beijing, 88-113.
2. **Ma Dequan *et al.*** 1996. Taxonomy study on the cultivated Barley in Linzhi of Tibet, China. Crop Genetic Resources, **3**: 32-34.
3. **Ma Dequan *et al.*** 1997. Taxonomy study on the cultivated Barley in Tibet, China. Tibetan Science and Technology, **1**: 2-8.
4. **Lu Wei *et al.*** 1991. Regionallization of Barley ecology in China. Zhejiang Sci-Tech. Press, Hangzhou, 26-41, 254-258.
5. **Zeng Yawen *et al.*** 1993. Preliminary report on the study and utilization of Yunnan Barley resources. Barley Science in China (Third collection), Barley Committee of Chinese Crop Society, 1993. JiangXi Sci-Tech. Press, Nanchang, 65-69.
6. **Zeng Yawen and Wang Jianjun**. 1998. Study on the Taxonomy of the cultivated Barley in Yunnan, China. Crop Genetic Resources, **2**: 7-9.
7. **Xu Tingwen**. 1982. Taxonomy and variety differentiation of the cultivated Barley in China. Agronomica Sinica, **6**: 39-46.
8. **Zeng Yawen *et al.*** 1996. Crop genetic resources in Yunnan province, China. Plant Genetic Resources Newsletter, **105**: 42.
9. **Zeng Yawen, Liao Xinhua and Zheng Ruchang**. 1995. Preliminary report on the study of the comprehensive utilization of barley cultivars in Yunnan Plateau, China. Barley Science, **1**: I-2.
10. **Zeng Yawen and Wang Jianjun**. 1997. Ecology and genetic diversity of Barley genetic resources in Yunnan Province, China. Plant Genet. Resour. Newsl., **112**: 95-96.