

BRASSICA AND BRASSICA-RELATED OILSEED CROPS IN GANSU, CHINA

W.C. Sun(1), Q.Y. Pan(2), X.H. An(1), Y.P. Yang(1)

- (1) Gansu Academy of Agric. Sci., Lanzhou, China 730070
(2) Gansu Academy of Agric. Sci., Lanzhou, China 730070;
currently studying at Dept. of Agronomy,
University of Maryland, College Park, Md 20742, USA

INTRODUCTION

Gansu Province is located in northwest China, with an area of 454,000 km² and a population of 22.4 million (Fig. 1(a)). Brassica crops in Gansu are of special interest because the province has the following three characteristics:

1. An extremely diverse climate and topography: The province is at the juncture of the Qinghai-Xizang Plateau, the Loess Plateau and the Mongolia-Xinjiang Plateau (Fig. 1 (a)). High mountains, river valleys, plains, deserts, grasslands, forests, etc., combine to form an extremely varied landscape. With the latitudes ranging from 32° 3'N to 42° 57'N and the elevations varying from 500 to 6,200 m, the province's climate varies from subtropical areas in the south, where the Giant Panda lives, to the permanently snow-covered Qilian Mountains in the north, where one of the world's largest glaciers lies. All these features result in a great variety of agricultural environments, which creates and preserves the diversity of the Brassicas.

2. A long history of agriculture (Wu 1985): There were human activities in this region 100,000 years ago. Many pre-history legends in Chinese culture are related to Gansu. Agriculture in this region can be traced back to 6,000 years ago. Brassicas are among those crops that were first cultivated by the ancient people in this region, therefore they have had ample time to evolve under the care of mankind.

3. A strategic location (Wu 1985): Gansu was the northwest border of Chinese civilization for thousands of years. Extending 1653 km from southeast to northwest, the province served as the world famous "silk road", which was a pathway between China and the western world in history and which Marco Polo took to travel to central China. In ancient times this region had the priority over any other region in China to receive introduced Brassicas from the western world.

No other place in the world possesses all the three characteristics. The combination of these three gives some unique features to Brassica and Brassica-related oilseed crops in Gansu. This paper introduces some of these features while the process of understanding them is still going on.

LONG HISTORY OF BRASSICA CULTIVATION IN GANSU

It is believed that B. campestris, and probably B. juncea as well, originated in Gansu and the surrounding areas. Records on Brassicas can be found in "The Book of Songs (诗经)", a collection of poems written about 3000 years ago and edited by Confucius (551-479 BC). In his classic works "Compendium of Materia Medica (本草纲目)", Li Shizheng (李时珍) (1578), China's foremost expert on medical herbs and one of the World's notable pioneer botanists, pointed out that Brassicas in China were first cultivated in Gansu. Ancient records and discoveries on

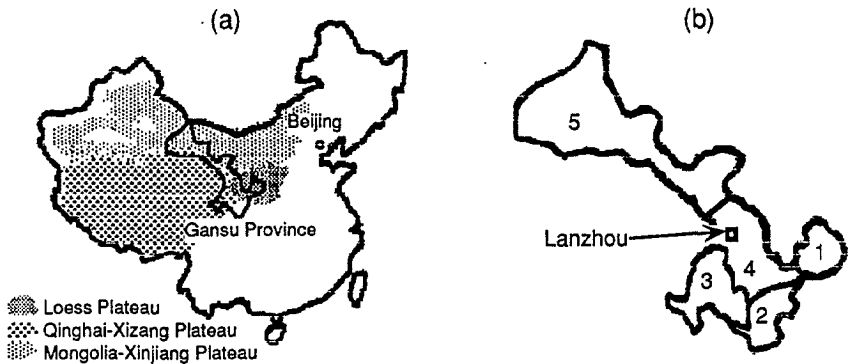


Fig. 1. (a) Gansu Province is in northwest China, at the juncture of the Loess Plateau, the Qinghai-Xizang Plateau and the Mongolia-Xinjiang Plateau. (b) The five ecological regions of *Brassica* oil crops in Gansu: 1. Eastern Gansu winter rapeseed region; 2. Southern Gansu winter rapeseed region; 3. Southwestern Gansu spring rapeseed region; 4. Middle Gansu *Eruca sativa* region; 5. Hexi Corridor spring rapeseed region.

the early cultivation of *Brassic*as in China can all be related to Gansu. China and India have the longest history of *Brassic*a cultivation in the world, and Gansu has the longest history of *Brassic*a cultivation in China (Liu 1984; Liu 1985).

A NATURAL MUSEUM OF BRASSICA AND BRASSICA-RELATED OILSEED CROPS

Almost all the world's *Brassic*a and *Brassic*a-related crop species can be found in Gansu. There are three major *Brassic*a oilseed species in the world: *B. napus*, *B. campestris* and *B. juncea*. It is often noted that only one of these three species is dominant in a specific region. However all three species are equally important in Gansu. In other regions of the world there is often one ecotype of *Brassic*a oil crops that is dominant. In Gansu many *Brassic*a ecotypes exist. In some mountain areas, for example, only spring types can be grown on the slopes while 5 kilometers away in the valley winter types are grown. *B. rapa*, *B. napus* and *Brassic*a-related species *Eruca sativa* and *Sinapis alba* are minor oilseed crops in the world whose production is often confined to certain regions. Yet they all exist in Gansu (Wang et al 1982; Li 1981). There are numerous landraces of these *Brassic*a and *Brassic*a-related oil crops. Gansu is indeed a natural museum of *Brassic*a and *Brassic*a-related oil crops, which is not surprising based upon Gansu's environment, history and location.

THE DIVERSE ECOTYPES

*Brassic*a and *Brassic*a-related oil crops are grown throughout the whole province. Five ecological regions (or ecotypes) of *Brassic*a oil crops can be identified (Table 1;

Fig. 1 (b); Li 1981).

1. Eastern-Gansu winter rapeseed region: This region occupies the central zone of the Loess Plateau and has a typical temperate continental climate. Winter type *B. campestris* is the major rapeseed. Varieties have strong winter hardiness.

2. Southern Gansu winter rapeseed region: The region is hilly and mountainous and has very complicated topography. The southern part of the region has a subtropical climate. Both *B. campestris* and *B. napus* are grown. Varieties have medium or weak winter hardiness.

3. Southwestern Gansu spring rapeseed region: This mountainous region is on the eastern edge of the Qinghai-Xizang Plateau and has a very varied topography. Most areas in this region are high, cool and humid. In some counties there are vast grasslands with animal husbandry as the major industry. *B. juncea* is the major oil crop species. *B. campestris* and *B. rapa* are also grown. *B. napus* has been very successful in the last 10 years in the areas with an elevation of 1800-2400 m.

Table 1. Elevation and major climatic parameters of five ecotopes for *Brassica* oilseed crops in Gansu Province, China.

Regions	Elevation* (m)	Annual Average Temperature (°C)	Annual Precipitation (mm)	Frost-Free Days
Eastern Gansu	1000-1500	7-10	400-650	140-190
Southern Gansu	500-3000	7-15	430-950	160-285
Southwest Gansu	1800-1300	≤7	500-600	80-150
Central Gansu	1400-2400	3.4-10	300-500	120-210
Hexi Corridor	1000-3000	5-9.3	40-250	80-150

*Cropped land only

Varieties here are usually early maturing and cold tolerant. This region can probably be defined as a small center of diversity for *B. juncea* and *B. campestris* because numerous landraces of the two species have been found. It is the most important rapeseed production region in Gansu.

4. Central Gansu *E. sativa* region: This region is on the western side of the Loess Plateau. The dry climate and lack of irrigation make this region unsuitable to most *Brassica* species which are generally water-demanding. "Yunjie" (*E. sativa*) is a traditional oilseed crop in this region (details below). Early-mature *B. campestris* is grown in more moist areas of this region. *B. napus* can be found in irrigated fields.

5. Hexi Corridor spring rapeseed region: This region is connected to the northeast corner of the Qinghai-Xizang Plateau. Most of this region lies within the Mongolia-Xinjiang Plateau.

There are high mountains in the west and deserts in the east. Precipitation is very low and all the farmland is irrigated with the snow-melted water from the mountains. Rapeseed is grown at the foot and on the slope of the mountains. Early mature and winter hardy *B. campestris* varieties are dominant in areas of 2500 m or higher. *B. napus* is dominant in areas of 1800-2500 m. *B. juncea* is also grown in some areas.

SPECIAL GENOTYPES

"Dongmanjing (冬蔓菁)" (*B. rapa*)

This crop is mainly found in Minxian and Zhangxian in southwest Gansu. There may be different landraces. The plant branches profusely and has 150-450 pods with 22-24 seeds per pod. Oil content of the seed is about 43%. The oil has 44% erucic acid and is much preferred for cooking by the local people. It is grown on the mountain slopes at elevations of 2500-3100 m, where few other crops can be grown due to the long, cold winter, very short frost-free period and low annual average temperature (Table 1). This crop is unusual in the following three aspects: (1) The long growth period. It is planted in July and harvested from June to August the following year. The time from planting to harvesting is 340-380 days in its native region - probably the longest among all the winter type *Brassica* oil crops in the world. It is interesting to note that in the same area there are summer *B. juncea* and *B. campestris* landraces that can mature in 70-90 days. These two types of Brassicas adapt to this region by different strategies, one by maturing early and the other by surviving the cold winter. (2) Strong winter hardiness. The coldest winter rapeseed area in China has an annual average temperature of 10-15°C and a monthly average temperature in January of about -5°C, whereas a traditional "Dongmanjing" production area in Minxian County has an annual average temperature of 3.9°C and a monthly average temperature in January as low as -9.2°C. It is probably the most winterhardy *Brassica* in China and perhaps in the world. (3) A unique cultivation system. The typical and the most high-yielding "Dongmanjing" is grown on newly-opened perennial grassland. The grassland is plowed 2-3 times in the summer so that the grasses are dead and undergoing decomposition. The crop is then planted the following summer. No other management is required before harvesting. Perhaps the good soil structure derived from the organic matter of the grasses and from the time plowing helps the crop to survive the cold winter.

"Yunjie (芸芥)" (*E. sativa*)

"Yunjie" is a traditional oil crop in central Gansu where precipitation changes greatly from year to year and drought is a constant threat. The plant has well-developed tap root and hairy leaves, stem and pods. It matures in about 100 days. The seed contains 30-38% protein and 23-32% oil with 34-37% erucic acid. "Yunjie" is very tolerant to drought and poor soil fertility. It has few pests. The seedling can tolerate -5°C. The seed oil content is not high, and as a food the oil is considered low quality because of its pungent taste. For centuries it has maintained itself well in the local agricultural system because it can be grown on marginal land with little input and it will have some harvest when other crops fail due to drought and/or poor soil fertility. A common cropping practice is to plant "Yunjie" in a mixture with flax which is the other major oilseed crop in the province. The "Yunjie"-flax mixture is better

adapted to environmental changes than pure stands. Nineteen landraces of the crop have been collected by Gansu Academy of Agricultural Sciences (GAAS). (An 1990; Lu et al 1979).

"Lintao Caizi (涝洮菜籽)" (B. chinensis)

B. chinensis is known to the world as a vegetable, but in the province's Lintao County it is used as both an oilseed crop and a vegetable. The vegetable is "Baicai (白菜)" and the seed "Caizi". Most regions in northwestern China can grow "Baicai", but only some places can produce the seed. The Tao River valley in Lintao County has fertile land and a well developed irrigation system, making it an ideal place to produce "Caizi". The seed is used for both planting the vegetable and producing cooking oil. Though grown in the spring rapeseed region, "Caizi" is a winter crop. To produce the seed the crop is seeded in late August. In late October the whole plant is dug out. The leaves are removed at 2-4 cm from the crown and used as a vegetable. The root, which is 2-4 cm in diameter at the collar, is then either saved in a cellar or piled up and buried under earth about 30 cm deep. It is transplanted to the fields in early to mid-March next year. The seed is harvested a week earlier than wheat, which is very desirable for double cropping. "Caizi" is high-yielding. It can yield 3500 kg per ha in fields where wheat can produce 4500 kg per ha. Perhaps "Lintao Caizi" represents a stage in evolution of oilseed Brassicas. All oilseed Brassicas of the present time were probably used as both vegetables and oilseeds sometime in the history.

Early-maturing Genotypes

"Jinyuan 60-Days (靖远六十天)" (*B. campestris*): Originated in Jinyuan County in Middle Gansu and spread into eastern Gansu. It can mature in 70 days and is still in use.

"Wuwei Xiaoyoucai (武威小油菜)" (*B. campestris*): A landrace in Wuwei County in the Hexi Corridor. It has wide adaptation and has been introduced to other provinces including Heilongjiang and Liaoning in Northeast China. It can mature in 80 days and is still grown (mainly for double cropping).

"Longxi Reman (陇西热蔓)" (*B. juncea*): A landrace grown in southwestern Gansu that can mature in 80-90 days.

"Gangu Xiaoyoucai (甘谷小油菜)" (*B. juncea*): Found in Gangu County which is at the transition zone of Middle Gansu and Southern Gansu (Fig. 1 (b)). It can mature in 80-90 days.

PRODUCTION AND RESEARCH

Rapeseed and mustard production has tripled in Gansu in the last ten years. At the present time Gansu grows more than 80,000 ha of rapeseed and mustard. The seed production is more than 80,000 tons --- nearly 40% of the province's oilseed production. The major development of rapeseed production in Gansu in the last 12 years is that of *B. napus*, which was grown in only small quantities before 1978, but has suddenly increased its hectareage and became one of the major rapeseed species. This change is mainly attributed to the success of the Canadian cultivar "Oro". "Oro" was introduced in 1975, and after a few years of testing it was tried on a commercial scale in 1978. By 1984 its acreage had reached 10,000 ha. "Oro" was the first low erucic acid rapeseed variety commercially grown in China. "Longyou 1", registered in 1987 by GAAS, and "WW1256", introduced from Sweden in 1981, have now replaced "Oro" as the most prominent low erucic acid, high-yield *B. napus* cultivars.

Presently there are 20,000 ha of low erucic acid rapeseed in Gansu.

Rapeseed research in Gansu can be traced back to 1916 when experiments were conducted to evaluate local and introduced varieties. However, it was not until 1975 that Gansu started well-planned systematic research on rapeseed. Now there are five research institutions in the province engaged in rapeseed research. Among them are the Cash Crops Institute of GAAS and Gansu Agricultural University. Research projects have concerned mainly the following aspects: (1) Collection and evaluation of germplasm. The project started in 1975 and emphasizes on conservation and evaluation of landraces. Nearly 300 accessions have been collected and evaluated, 200 of which are landraces in Gansu. (2) Cultivar improvement. A group of varieties have been successfully introduced from other provinces and foreign countries. Varieties bred in Gansu include "Longyou 1" (*B. napus*), "Ganjie 1" (*B. juncea*), "Ganjie 2" (*B. juncea*) and a few others. "Longyou 1" has low erucic acid (0.34%), high oil content (46.6%) and high yield. A number of low erucic acid or canola quality lines of *B. campestris* and *B. napus* are currently in regional tests. (3) Improvement of cultivation techniques. *B. napus* is new to most farmers in Gansu. From 1978 to 1986 detailed cultivation techniques for *B. napus* were established and regions suitable for *B. napus* were defined. (4) Studies on genetics and hybrid utilization. Heritability of some characters was studied. Researchers in Gansu Agricultural University invented a technique to break self-incompatibility of Crucifers, which was considered a breakthrough in hybrid utilization.

REFERENCES (all in Chinese)

- AN, X.H. 1990. "Yunjie" in Gansu. Gansu Agric. Sci. and Techn., 1988-7: 14-15. 安贤惠, 甘肃芸芥。"甘肃农业科技" 88-7.
- LI, B.H. 1981. Ecological regions of oilseed crops in Gansu. Gansu Academy of Agric. Sci. 李秉衡, 甘肃省油料作物种植区划
- LIU, H.L. 1984 The origin and evolution of *Brassica* oilseed crops. Gansu Agric. Sci. and Techn., 1984-3: 2-5. 刘后利, 油菜的起源与进化。"甘肃农业科技" 84-3.
- LIU, H.L. 1985. Genetics and breeding of *Brassica* oil crops. Shanghai Publishing House of Sci. and Techn., Shanghai. 刘后利, pp. 1-63. 油菜的遗传和育种
- LU, X.M. 1979. "Yunjie", a drought-resistant oil crop. Oil Crops of China, 1979-2: 81-82. 陆孝睦, 介绍一种旱生油料作物——芸芥
- PAN, Q.Y. 1987 "Dongmanjing" in Gansu and its values. Oil Crops of China, 1987-1: 79-81. 潘启元, 甘肃的冬蔓菁及其利用价值
- WANG, L.Z., LI, A.M., HUANG, J.X. LI, R.X. 1982. The new record of *Brassica nigra* (L.) Koch. Acta Botanica Yunnanica 4: 367-373. 汪良中, 李安明, 黄祥焯, 李睿光, 黑芥在我国的新分布。"云南植物志" 4
- WU, Y. 1985. Cultural history of Gansu. People's Publishing House of Gansu, Lanzhou, China. 吴月, 甘肃风物志