Production Trend and Cropping System of Asparagus in China

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Asparagus (Asparagus officinalis L.) is a high value vegetable, rich in bioactive factors such as rutin, saponin, polysaccharide, and organic selenium. At present, China is the largest asparagus production country in the world. Due to the quick expansion in acreage over the last two decades, asparagus has become a huge industry in China. In the early 1990’s, China was an asparagus exporter, especially can processing, and white asparagus was mainly grown in plantation areas. From the mid-90’s, green asparagus production increased step by step because of the demand for fresh green eating and many kinds of processing products such as tea, juice, medicine, and powder. These changes led to increasing domestic usage of harvest spears and reduction of exports. To increase the asparagus yield and productivity, white asparagus cultivation was changed to green production mainly in the northern, cool region of China. On the other hand, the long-term production system called mother-fern cropping in plastics has been started mainly in the middle and southern part of China. Around three-month old seedlings were used for transplantation in plastic house. The method of transplantation and harvest basically depends on manual labor. Spray irrigation and drip irrigation system were performed for management of soil water. The hot temperature was controlled by covering the sunshade net in summer. The white asparagus production decreased because of the world economic crisis in 2008 and recovered after 2009. The most serious disease was called stem blight, which has been considered as one important limiting factor for sustainable development, especially in southern China. A national project was launched to breed a domestic cultivar with resistance to stem blight disease.

Key Words: asparagus, China, domestic demand, industry, production

1. Introduction

Asparagus (Asparagus officinalis L.) is an important vegetable crop with the edible parts known as spears (Benson 2012; Wei et al. 2011). It is grown under a wide range of climatic conditions from subtropical to cool temperature with a history of cultivation for over 2000 years.

This vegetable is one of the typical world-wide vegetables. The seeds and harvested spears have been traded among countries. In 2009, the cultivated area of asparagus was 195819 ha worldwide, mainly in Asia, Europe, North America, South America, and Australia (Benson, 2012). Green asparagus is
produced all over the world, however the white variety is mainly grown in Europe.

At present, China has become the biggest producer and exporter in the world (Benson 2012) and asparagus is considered one of the vegetable crops with high economic benefit for growers in China. One of the world asparagus industry development trends is that it has been constantly shifting from developed countries to developing countries recently. In this process, China’s asparagus industry has undergone swift and noteworthy development because of domestic market expansion based on people better realizing the nutritional value and healthy function of asparagus, combined with the advantages in such aspects as land and labor.

The production and export amount of Chinese asparagus dramatically changed from the 1990’s owing to world-wide economic conditions. Domestic use of asparagus dramatically increased because of increased demand for fresh vegetables. In addition, this situation has led to a change in the asparagus cropping system in China.

The change that has occurred in China is good material to understand the effect of world economies and domestic demand on the production trend of world-wide vegetables such as asparagus. Unfortunately, detailed data on asparagus production in China has not been published.

In the present report, we describe the history and recent trend of asparagus production, cropping system, marketing and cultivar breeding in China, regarding the development of the asparagus industry. The outline of production and main cultivars was published in Japanese commercial magazine (Motoki et al. 2014) and book (Motoki 2016). So the authors try to provide detail and recent trend of Chinese asparagus and the possibility to improve the cultivars for adaptation to Chinese environment because Dr. Zhang, one of authors, is a member of the Jiangxi Academy of Agricultural Sciences, center of asparagus research in China.

2. Materials and Methods

The Jiangxi Academy of Agricultural Sciences, Nanchang, China, is the center of asparagus research in China and has been keeping data on asparagus production in China (Chen 2010, 2013). The present paper uses this data, but national official statistical data on asparagus production is still lacking. Data on asparagus production in China was collected following the methods mentioned below, based on references, communications at conferences, interviews and field surveys in production areas.

1) References

The following 3 kinds of references were used in the following papers: 1) Works of Dr. Benson (Benson 1999, 2008, 2012), the leader of the International Asparagus Research Group (1997 – 2005). 2) The book by Dr. Chen (2010), the Chairman of the Chinese Asparagus Association, Jiangxi Academy of Agricultural Sciences. 3) Local researcher’s papers (He and Chen 2009; Tang 2008; Xu et al. 1996) in different provinces of China.

2) Presentation and communication in national asparagus meeting

Dr. Chen (Chief asparagus scientist) organized a national asparagus meeting in China. At that meeting, attendees from different areas provided the newest information on planting areas in China, e.g., the top areas of Shandong, Shanxi, Fujian, Jiangsu, etc. Such information was used in the present paper.

3) Interview, field survey, and personal communications in production area

Dr. Zhang, one of the authors, conducted field surveys in some leading production areas such as Shanxi Province in the north, and Zhejiang Province in the south. He also obtained detail data on farm areas by personal communications with the local researchers and growers, mainly based on oral interview or communications. For other production areas such as Shandong, which Dr. Zhang did not visit, he conducted interviews and made inquires of local researchers by email, message or phone call communications.

3. Results and Discussion

1) Originality and development
In traditional Chinese medicine, as early as 2000 years ago, *A. cochinchinensis*, one wild relative of garden asparagus, was used in treatment of tumor, neuritis and arthritis, toothache, and diuresis (Wen et al. 1993). However, the large-scale commercial plantation history of garden asparagus is only around thirty years old in China (Chen 2013).

Around the beginning of the 20th century, asparagus cultivation was introduced to China, limited to a few areas such as Beijing, Tianjin, and Shanghai, where foreigners were concentrated; asparagus was produced mainly for foreigners living in China at that time.

Plantation area, production amount and the ratio of white and green spear was described in Table 1. In the early stage, 1990’s, the frequency of white spear production was high and more than 90% of the white asparagus was canned for export to Europe, the United States and other foreign countries (Chen 2010, Fig. 1, Fig. 2). The asparagus production depended on export-orientation at that time in China.

### Table 1 Change of plantation area, production amount and the ratio of white and green spear in Chinese asparagus from 1982 to 2013.

| Year | Plantation area (×1000 ha) | Spear yield (×1000 t) | Spear color | White (%) | Green (%) |
|------|---------------------------|----------------------|-------------|-----------|-----------|
| 1982 | 6.6                       | 20                   | –           | –         | –         |
| 1985 | 12                        | 150                  | –           | –         | –         |
| 1988 | 26                        | 290                  | –           | –         | –         |
| 1992 | 60                        | 480                  | –           | –         | –         |
| 1997 | 55                        | 350                  | 89.5        | 10.5      |
| 2001 | 90                        | 620                  | 67.9        | 32.1      |
| 2005 | 80                        | 640                  | 50.0        | 50.0      |
| 2009 | 57                        | 430                  | 39.8        | 60.2      |
| 2013 | 80                        | 720                  | 37.5        | 62.5      |

In Fig. 1, the ratio of usage of asparagus spears harvested in China from 1997 to 2012 is shown. The industrial structure of product forms and markets greatly changed from white and export-oriented to green and domestic sale type of asparagus. The ratio of fresh asparagus, frozen asparagus, and canned asparagus developed more and more on local people in China who realized its high-value healthy function for human beings (Fig. 2). The asparagus product structure was greatly changed during the last ten years; the international white asparagus market decreased and the domestic green asparagus market has been booming (Chen 2013). The industrial structure of product forms and markets greatly changed from white and export-oriented to green and domestic sale type of asparagus. The ratio of fresh asparagus, frozen asparagus, and canned asparagus developed from around 1%: 9%: 90% in 1997 to around 62%: 20%: 18% in 2012 (Fig. 1).

Green asparagus production now accounts for the total output of more than 60% in China (Table 1). The domestic sales ratio has increased from 1% in 1997 to 65% in 2012 (Fig. 2). This shows the transition from export-oriented to domestic

2) Change of domestic market

(1) Increase of domestic consumption

Interestingly, asparagus domestic consumption, especially that of fresh green asparagus, has increased step by step since the past decade based
consumption of asparagus in China.

(2) Effect of international financial crisis, 2007

However, since 2007, the foreign asparagus markets have looked relatively saturated because of the international financial crisis (Xie et al. 2014). Affected by the global economic crisis of 2008-2009, European and American countries have reduced the import of asparagus, and the export of canned asparagus in China has been greatly affected.

Since the second half of 2007, the amount of foreign trade was sharply reduced, causing sales prices to tumble, especially making for a massive negative impact on canned asparagus in China. More and more people have realized the importance of better exploration of the Chinese domestic market in future. Meanwhile, the falling demand for exports encouraged growers and factories to focus more on the further development of the domestic market than in the early stages.

The other key point causing greater domestic consumption increasing has been the enhanced public understanding of asparagus for its value in contributing to nutritional health care. Asparagus consumption has become part of daily diet among citizens in some large and medium-sized cities such as Beijing, Shanghai, Guangzhou, and Nanchang. In some cities, asparagus production bases have been established even in the suburbs in order to offer fresh and delicious asparagus conveniently for citizens and international hotels located in urban areas.

(3) Development of industry related to asparagus quality

A large number of researches on functional effect were carried out in asparagus. Based on such knowledges, new industry has been established. The so-called “asparagus sunrise industry” has broad development prospects in food, medicine, feed, nutrition, and other fields because of its many unique biological characteristics in China. For example, since the spears are rich in bioactive compounds such as rutin (Lee et al. 2010), saponin (Sun et al. 2010), polysaccharide (Yang et al. 2012), and organic selenium (Whanger 2004), asparagus extract has been used as medicinal material for treatment of mammal diseases including tumor (Shao et al. 1996), cytotoxic (Almehdar et al. 2012), hypertension (Matsuda and Aoyagi 2013; Nishimura et al. 2013), hyperlipidemia (Zhu et al. 2011), and hyperglycemia (Hafizur et al. 2012) in addition to a popular health vegetable (Kim et al. 2009, Sun et al. 2010; Wang et al. 2011). Several prescription medicines such as ‘Lusun tablet’ and ‘Aikangbao’ made with bioactive component extraction from asparagus for anti-tumor have been approved by the Ministry of Health in China.

Asparagus has a long processing industrial chain containing multiple products such as canned asparagus, asparagus tea, asparagus wine, asparagus juice, asparagus powder, asparagus feed, asparagus cosmetics, and asparagus medicine. Its huge potential processing value is now more and more realized in China.

Asparagus tea, for example, is made of fresh green asparagus spears or phylloclade through a complex process of rolling, drying, baking, and frying. Asparagus tea is considered a high-quality tea with high rutin content, pure taste, and health-giving characteristics in line with Chinese tea culture (Zou 1990). Asparagus juice is rich in protein, amino acid, vitamins and other nutrients. Currently, there were some different kinds of commercial asparagus juice such as ‘Kangaicao’, ‘Lusunyin’ and ‘Manxialai’ in Chinese market.

Terpenoids rich in the bottom of asparagus spears had a very similar function like active ingredients of the hops used for making beer (Chen 2013). Asparagus beer not only has the foam and bitter taste like traditional beer, but also the special fresh scent of asparagus. Based on the rich content in antioxidants, asparagus extraction could be used for cosmetics such as oral liquid, skin care products to get rid of wrinkles, remove spots, and provide anti-aging (Chen 2013).

The production of garden asparagus spears, which could be available for commercial sale, has only accounted for around half of the total biomass. Much waste including residual wastes by cutting and mother stalks which are also rich in active ingredients, are not being property utilized currently.
(Hu et al. 2015). It is a serious waste of valuable resources. The compound feed added extraction from asparagus waste straw could improve the egg laying rate and immune function of hens (Li et al. 2014).

2) Present status

(1) Plantation area and yield

The asparagus plantation area in China reached to about 90000 ha in 2001, which accounted for about 40% of the world level (Benson 2012) (Table 1). In the past decade, a relatively stable asparagus plantation area has been developed by improving the average yield production in China (Benson 2012; He and Chen 2009; Tang 2008). In 2013, the total plantation area grew to about 80000 ha. And fresh green asparagus production for domestic consumption keeps increasing compared with the white type which is still mainly destined for export (Table 1).

At present, asparagus production is distributed almost all over China from south to north with the main production provinces of Shanxi, Shandong, Hebei, Zhejiang, Jiangsu, and Fujian (Table 2, Fig. 3).

The average production yield has most depended on the climate zones due to the available annual harvest period. Generally, a higher yield is possible in the warm regions with suitable temperature and sunshine duration (Table 2). From north to south, the average yield has risen from nearly 5 to over 20 tons per ha. Shanxi, Shandong, and Hebei are the top three production regions, located in the Huanghuai River valley of northern China, now boasting 20000, 19780, and 13700 ha respectively currently. Meanwhile, some southern areas like Jiangxi, Hubei, Yunnan, and Hainan are increasing dramatically due to the favorable climate conditions and domestic consumption market.

(2) Cultivation system

Asparagus cultivation systems were often mainly divided into white and green to adapt to the different consumption habits. Western Europe, especially Germany, has a traditional culture of consuming white asparagus (Peng et al. 2015). It could be cultivated by soil mound cover or other technologies of blocking light to make spears white during the period of spear emergence.

In China, white asparagus used to be the dominant asparagus cultivation system, and most of it has been canned for export mainly to Europe or the United States (Chen 2013). The main production of white asparagus is located in northern China in Shanxi and Shandong provinces. However, white asparagus cultivation is also considered for time and labor-saving, especially for harvesting currently in China (Fig. 4). Compared with green asparagus, its plantation area and production yields were decreased year by year, driven by the rapidly increasing domestic green market demand.

Chinese people prefers green asparagus like Americans, Japanese, and British people. Green asparagus production, which is rapidly becoming an important cultivation mode with high development recently in China, is a totally different cultivation system from the white one. Nowadays, the green
asparagus cultivation is distributed almost nationwide, even in cold regions such as Heilongjiang, and warm regions such as Hainan.

Basically, there have been two important methods of open field and plastic greenhouse for green asparagus production in China. Normally, open field cultivation is located in northern China where the climate is relatively cool or cold with much snow cover. Cold regions have a shorter harvest period and lower production yield than warm regions (Table 2).

Plastic greenhouse cultivation, which developed quickly in the past few years, is located in southern China, where the climate is warm with high temperature, large precipitation, and high humidity. One of the most important functions of plastic greenhouses is to reduce the severe destructive disease named stem blight in warm regions (Zhang et al. 2012). The mother stalk system in which spears are harvested for a long term is the most popular cultivation method for green asparagus production. Usually, around three-month old seedlings were used for transplantation in plastic house. The method of transplantation and harvest basically depends on manual labor. Spray irrigation and drip irrigation system were used for management of soil water. The hot temperature was controlled by covering the sunshade net in summer. Fertilization and pesticide were applied after removal of mother stalk. Three harvest periods are possible, including spring, summer, and autumn with a total of around 240 days harvest period per year in warm regions such as Jiangxi Province in plastic greenhouse (Fig. 5).

3) Prospect for future variety

It is very important to select suitable cultivars to grow asparagus spears with high yield and good quality, especially in green asparagus. Asparagus traditional breeding and seed production mainly developed in Europe and the United States, which show a great difference in climate and soil ecological environment from China.

The dominant asparagus varieties imported...
from the United States and Europe include ‘UC157’, ‘Grande’, ‘Apollo’, ‘Gijnlim’, and ‘Jersey Knight’ in China. One of the serious problems after introduction to China was that many foreign varieties showed poor ecological adaptation in various climate and soil environments. Not only easy infection by various kinds of serious diseases causing severe yield loss has appeared, but also there has been a negative impact on quality in terms of stem diameters, tip head tightness, and taste (Lu et al. 2008; Zhang et al. 2012).

Some research institutions in mainland China carried out asparagus breeding since the early 1980’s (Zhang et al. 1995). In the past ten years, an important improvement in the asparagus breeding program was obtained by both the introduction of a large amount of excellent exotic germplasm and the application of biotechnology for breeding (Chen 2013; Zhang et al. 2013).

It was confirmed that the germplasm resources of current commercial asparagus varieties worldwide had a narrow genetic background by using DNA marker technology such as EST-SSR (Caruso et al. 2008). However, as a genus, Asparagus comprising 100-300 species has been distributed in the arid and subarid regions of the Old World (Fukuda et al. 2005; Kubituki and Rudall 1998).

With production and industry further development, promotion development of own domestic ecological adaptation varieties is the direction of asparagus breeding in China. Disease resistance, interspecific hybridization, polyploidy, all male and rich in active ingredients varieties could be the key research field for breeding in future.

Recently, a few Chinese domestic varieties such as ‘JK701’, ‘Guanjun’, and ‘Shuofeng’ have been planted. The genus Asparagus with abundant genetic diversity may well be an important gene pool for future commercial asparagus breeding to break out of the bottleneck of a narrow genetic background, especially to breed cultivars with resistance to stem blight.

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要旨
アスパラガスはカルチオン、サポニン、多糖類や有機セレン（セレニウム）が豊富に含有される高付加価値野菜の1つである。現在、中国は世界有数のアスパラガス生産国である。それほどこの約20年間での急速な生産面積拡大により、アスパラガスは中国における巨大な産業になった。1990年代初頭、中国はアスパラガスの培養方法の輸出国であり、生産地において主にホワイトアスパラガスが栽培されていた。90年代中盤から、中国国内でのグリーンアスパラガスの消費やお茶、ジュース、果物や粉末等の多様な加工品の重要拡大により、グリーンアスパラガスの生産が徐々に増加した。このような国内での変化は収穫品基の国内重要増加と輸出量の減少につながった。アスパラガス栽培の収量や生産性の向上のために、冷蔵装置の中国北部において、ホワイトアスパラガス栽培はグリーン生産に推奨された。一方、中国の中央部や南部では、プラスチックハウス内において、立架栽培と呼ばれる長期生産体系が実施された。この栽培体系では約3か月育成した種苗を定植して翌年からの収穫となる。定植と収穫は手作業で、株上からの霧状散水と土壌への点滴滴液で水が供給されている。夏の遮熱対策として、遮光ネットを配置されている。2008年の世界経済危機においてアスパラガス生産も減少したが、2009年以降回復した。蒸枯病と呼ばれる病害の被害は深刻で、特に中国南部においてはこの病害が、アスパラガス生産の持続的発展を制限する重大要因となっている。蒸枯病に抵抗性を有する国内品種を育成の国家プロジェクト研究が遂行されている。

キーワード
アスパラガス、国内需要、産業、生産、中国