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Review of Research Situation of *Brassica oleracea* var. italica

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Abstract Broccoli (*Brassica oleracea* var. italica), also called green broccoli, green cauliflower, and calabrese, belongs to genus *Brassica* in family Cruciferae, and is annual or biennial herbaceous plant. Both broccoli and cauliflower are varieties of *Brassica oleracea* L. Broccoli is rich in nutrients. Its protein, amino acids and vitamins are higher than cauliflower, and broccoli is easy to grow, the supply period is long, and it has a good market and economic value. This paper introduced broccoli-related information from broccoli's nutritional value, cultivation techniques, existing problems and prospects. In addition, on the basis of existing studies, it discussed the future development prospects of broccoli, in order to promote the production research of broccoli in China.

Key words Broccoli (*Brassica oleracea* var. italica), Nutritional value, Cultivation techniques, Field management, Prospects

1 Introduction

Broccoli (*Brassica oleracea* var. italica), also called green broccoli, green cauliflower, and calabrese, belongs to genus Brassica in family Cruciferae[1], and is annual or biennial herbaceous plant. The broccoli part most commonly eaten is called the curd, or head. The earliest records of broccoli can be traced back to the Greek and Roman literature in BC, and they were brought into the Mediterranean area by the Romans. The earliest description of sprouting form of cabbage by Romans may be the original type of broccoli. It was domesticated by wild mustard, and the original edible parts are stems and flower buds[2]. In the 1980s - 1990s, the varieties of broccoli planted in China were mainly introduced from foreign countries, such as Lilu, Wanlu 320, Luling, Dongjinglu, Luxiu, Mantuolu, and Youxiu, *etc.*[3]. In this period, the requirements for broccoli edible quality, ball shape, ball color and disease resistance are not high. At that time, the economic value of broccoli was low. In early 2000, Japan introduced the F1 hybrid male sterile represented by Youxiu, because of its strong adaptability, it was quickly promoted throughout Japan[4]. Around 2010, Japan launched the cold-resistant Youxiu, which had strong regional adaptability, a wide range of temperature adaptation, and can be cultivated in both the northern and southern areas. Due to its simple cultivation technology, low input cost, and low planting risk, now it is widely planted throughout the country. Although China has a long history of broccoli cultivation, there are still some urgent problems to be solved. In this paper, we summarized the nutritional value, development status, cultivation techniques, existing problems and development prospects of broccoli in China, hoping to provide broccoli-related information support for the government, enterprises, cooperatives and vegetable farmers, so as to promote the healthy development of the broccoli industry in China.

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2 Nutritional value of broccoli

Both broccoli and cauliflower are varieties of *Brassica oleracea* L., and their edible parts are stems, florets and flower buds[5]. From the perspective of the appearance, broccoli has a rougher surface than cauliflower buds, looser curds and smaller flower patterns. In terms of nutritional elements, broccoli has a higher nutritional value than cauliflower, and its carotene, protein, amino acids, and minerals are higher than cauliflower. It has become a preferred vegetable for modern people in nutrition and health care. In addition, broccoli is rich in calcium, phosphorus, iron, potassium, zinc, manganese and other elements, and its mineral components are more comprehensive than other vegetables. Some studies have shown that broccoli contains a variety of vitamins, which play a vital role in human health and development. For example, vitamin K can maintain the toughness of blood vessels, vitamin C is beneficial to human growth and development, can improve the body's immune function and promote liver detoxification, and also has a strong free radical scavenging effect, and can significantly block the formation of carcinogen nitrite[6]. Broccoli contains selenium which is a trace element essential for the human body. Selenium has the functions of anticancer, anti-aging, strengthening immunity and promoting brain development of infants. In addition, selenium can also help prevent elderly diseases such as hypertension and heart disease. The dithiophene thione in broccoli can reduce the formation of melanin and prevent the formation of skin pigment spots. Regular eating can bring a good whitening and moisturizing effect on the skin[7]. The flavonoids and ascorbic acid in broccoli can reduce the occurrence of cardiovascular diseases, enhance cardiovascular toughness, improve the detoxification ability of the liver and improve the body's immunity[8]. Broccoli plays an important role in promoting weight loss and health care. Broccoli has a high water con-

tent, low energy and fat content, and 100 grams of broccoli only contains 24 kcal energy[9]. The high fiber contained in broccoli can enhance the sense of satiety, not only fill the stomach but also not get fat, so it is a good diet food for those who want to become slim. Besides, studies have found that frequently eating broccoli can reduce gastrointestinal absorption of sugars and fats, lower blood sugar, and have an adjuvant treatment effect on diabetes. In addition, broccoli can prevent cancer and resist cancer, regular eating can reduce the occurrence of rectal cancer and gastric cancer. Whats' more, various indole derivatives contained in broccoli can also reduce the level of estrogen in the body and reduce breast cancer. The sulforaphane in broccoli can stimulate the body to produce anti-cancer protein enzymes, which can inhibit the growth of cancer cells. In summary, broccoli is a preferred vegetable for health care and weight loss[10].

3 Cultivation and planting of broccoli

3.1 Seed selection and sowing Before the planting, the seeds of broccoli should be selected, and the selected seeds should be bright without defects, round and plump without external damage. When choosing land, it is required to select the field with the fertile soil, well ventilation and light transmission, and convenient drainage as the planting land[11-12].

3.2 Seedling breeding and strengthening First, it is necessary to select the plots where the previous crops are not Cruciferae plants. Before planting, mix organic fertilizer with half of the plant ash and the soil to thoroughly mix and apply the base fertilizer. Shade nets should be installed in high-temperature and high-sunlight seasons. After sowing, water and fertilizer management should be strengthened to maintain soil moisture at around 70%. The suitable temperature in the seedling stage is 20 – 25 ℃, remove the shade net according to the weather conditions after seedling emergence, strengthen the seedlings, transplant when 4 – 5 true leaves appear, keep the plant spacing 40 cm, row spacing 50 cm; when transplanting, try to bring as much original soil as possible, to minimize the damage to the root system[13]. The optimum growth temperature for broccoli in the rosette stage is 20 – 22 ℃, and the optimum temperature for curd development is 15 – 18 ℃. When the temperature exceeds 25 ℃, the curd will become loose and the taste will be tough. During the growth of broccoli, providing suitable light conditions is favorable for the progress of photosynthesis and the accumulation of nutrients, but too long exposure time under direct sunlight will cause the color of the curd to turn yellow and reduce the broccoli value, thus, it is necessary to take proper shading treatment[14].

3.3 Fertilizer and water management During the growth of broccoli, watering and fertilization techniques are the key to its quality. It is required to ensure that the soil humidity is above 70%, the air humidity is around 80%[15]. In particular, the water demand is large during the formation of curd. In the event of drought, it will easily lead to hollow stems, black hearts, stem cracks and other problems, which affect both the yield and quality. In the rainy season, the water should be drained in time. In summer, the temperature is high and the sun is strong. The leaves are liable to wither and fall off, and the roots and stems are easy to rot. Therefore, it is necessary to conduct intertillage, weed, and earth up in a timely manner to facilitate the growth of broccoli roots[16]. During the growth of broccoli, it is required to pay attention to fertilization; during the period of vigorous growth of stems and leaves, nitrogen and potassium are the most needed. When the curds are formed, the demand for phosphorus increases, and at the same time, it is necessary to add appropriate amount of boron, magnesium, calcium and other micro-element fertilizers[17]. Broccoli's demand for boron fertilizer is particularly sensitive. If there is a lack of boron fertilizer, the center of the flower stem will crack, the flower will be damaged, and the taste will be somewhat bitter; when the magnesium fertilizer is lacking, the leaves will curl, and the growth will be particularly slow[18]. In this situation, it is required to apply fertilizers containing magnesium and boron. When using fertilizers, use more good farm fertilizers, compound fertilizers, and less chemical fertilizers. During the development period of curds, applying phosphate fertilizer can promote the development of curds.

3.4 Prevention and control of plant diseases and pests Too much water at the seedling stage of broccoli can easily cause diseases such as black rot and black spot diseases. The main pests include *Plutella xylostella*, *Pieris rapae*, and Aphidoidea. It is necessary to adopt integrated pest and disease prevention and control technology and adhere to the principle of "prevention first, green prevention and control, and integrated prevention and control". According to the occurrence rules of diseases and the habit characteristics of pests, priority is given to physical control and biological control methods for agricultural control. When necessary, it is necessary to make proper use of chemical prevention interventions. The main measures to prevent these diseases and insect pests are as follows. (i) Choose healthy broccoli for seed retention, choose healthy and strong seedlings during planting, try to avoid seedlings with pathogens, and prevent the onset of growth period[19]. (ii) Deeply turn over the soil before planting, and manually pick out the pests to reduce the pests during the growing period. (iii) Pay attention to the rotation of crops to prevent continuous cropping with cruciferous vegetables. It is preferred to rotate crops with beans, eggplants and onions and garlic vegetables. (iv) Take physical prevention and control, install yellow aphid board to stick and kill aphids[20]. (v) Take biochemical prevention and control, spray 800% of 25% metalaxyl-organocupric salt wettable powder in the early stage of downy mildew. At the beginning of the onset of black spot disease, it is recommended to spray 600 times 65% of linsin wettable powder, or 500 times 75% chlorothalonil wettable powder, once a week. For black rot, 100 – 200 mg/L of agricultural streptomycin can be used, spray once every

7 d, and spray 2 – 3 times continuously. It is recommended to change the pesticides to avoid insect resistance. When taking the chemical control of aphids, it is recommended to use 2 000 – 3 000 times 50% anti-aphid wettable powder, continuously spray 2 – 3 times, or spray 1 000 times 5% high-efficiency cypermethrin emulsifiable concentrate or 1 000 times 25% fenvalerate emulsifiable concentrate[21]. (vi) It is recommended to carefully observe the growth of broccoli, spray with light lime water or 1∶1∶200 Bordeaux mixture, once every 7 – 10 d, and continuously spray 2 to 3 times; remove vegetable plants with severe disease and disinfect with lime around those plants[22].

4 Existing problems and prospects

China's broccoli breeding started late, and the lack of high-quality resources and excellent technical personnel has seriously hindered the development of excellent broccoli varieties in China[23]. Besides, the promotion of green and efficient cultivation techniques for broccoli is insufficient, and there is a lack of processed products of broccoli. In addition, the planting area of broccoli is scattered, and no industrialization model has been formed. In the future, the planting area of broccoli will show an upward trend. However, comprehensive consideration of water resources, climate, land, market and other conditions, the Yangtze River Basin will become a superior production area of broccoli. Therefore, it is recommended to strengthen the promotion of green and efficient cultivation techniques, improve the overall quality of broccoli, form an industrial model, and increase the added economic benefits of broccoli.

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