

The Edible and Medicinal Value of *Coix lacryma-jobi* and Key Cultivation Techniques for High and Stable Yield

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Abstract

In this paper, it was introduced that *Coix lacryma-jobi* is a traditional dual-use edible and medicine crops in China, and the nutritional components and medicinal value of *Coix lacryma-jobi* were described. Based on the published literature at home and abroad, a variety of chemical components found in *Coix lacryma jobi* and their medicinal effects were reviewed. At the same time, the problems existing in the production of *Coix lacryma jobi* were put forward. With the improvement of people's living standards, the nutritional and health care value of *Coix lacryma-jobi* has been paid more and more attention. The problems of *Coix lacryma-jobi* in production were analyzed. Some biological characteristics of *Coix lacryma-jobi*, especially its hygrophyte characteristics, were re-recognized, which is very important to increase the yield of *Coix lacryma jobi*. In the paper, the key cultivation techniques for high and stable yield of *Coix lacryma-jobi* were also summarized. In order to obtain high quality, high and stable yield, we should adopt the new technical methods of "two wet, two dry and two water" in water management. At the same time, if artificial pollination is applied in the peak of flowering period, the seed setting rate and the yield will be increased.

Keywords

Artificial Pollination, Edible and Medicinal Value, High and Stable Yield, Key Cultivation Techniques, Yellow River Delta

1. Introduction

Coix (*Coix lacryma-jobi* L.), belonging to *Coix* in *Gramineae*, is an annual or

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perennial herb with thick and tall stalks, commonly known as bodhi bead, six-millet, pearl rice, medicinal corn, *Coix* bead etc., and the seed after hulled, is also called *Coix* rice, *Coix* seed, job's tears rice, etc. *Coix lacryma-jobi* is an important crop having medicine and food function with important medicinal and economic value, and it is widely distributed in tropical and subtropical regions of the world [1] [2]. In China, it is mainly planted (or wild) in Guizhou, Yunnan, Sichuan, Fujian, Taiwan, Guangdong, Guangxi, Hainan, Shandong, Shanxi, Henan, Hebei, Liaoning and other places [3] [4]. Ishiguro *et al.* isolated 3,5-dimethoxy-1h-inden-1-one with antibacterial activity from *Coix* seeds and the results showed that the compound had certain effects on bacteria, yeasts and fungi. In addition, benzoxazinone compounds extracted from *Coix lacryma-jobi* root also had antibacterial activity [5]. *Coix* is widely used not only in medical treatment, health care and food, but also in beauty.

Coix lacryma-jobi seeds are one of the traditional food and medicine resources in China, which can be used to make porridge, rice and various pastas for people to eat. They are sweet in taste and cold in nature, and have the effects of strengthening spleen and dampness, clearing heat and detoxification, beautifying and beautifying [3] [6]. They can also be used as drug to treat various diseases. It is recorded in the illustrated handbook of Chinese herbal plants, *Coix lacryma-jobi* seeds could treat pulmonary edema, wet pleurisy, chronic gastrointestinal disease, chronic ulcer, dysuria and other diseases. According to traditional Chinese medicine, *Coix* seeds had the function of promoting dampness and diuresis, clearing heat and removing pus, tonifying spleen, stopping diarrhea and eliminating dampness [7]. *Coix lacryma-jobi* is not only a traditional and ancient crop, but also a crop that is re-recognized by people today. In recent years, because *Coix* seeds have a special function of food therapy and health care, and the planting of *Coix* has very high economic benefits, therefore, the planting area of *Coix lacryma-jobi* is expanding rapidly [1]. However, due to the lack of comprehensive understanding of the biological characteristics, the lack of in-depth study on the cultivation techniques of *Coix lacryma-jobi* and traditional extensive field management in production, the yield and benefit of *Coix lacryma-jobi* have been affected very much [8]. In this paper, some nutritional health value and biological characteristics of *Coix lacryma-jobi*, especially its hygrophyte characteristics, were re-recognized, and the cultivation techniques of high quality, high and stable yield were summarized in order to provide the scientific reference for the development of *Coix lacryma-jobi* cultivation.

2. Nutritional Value of *Coix*

The hulled seeds of *Coix lacryma-jobi* are called *Coix* rice. The nutritional value of *Coix* rice is very high, and the nutrition is relatively comprehensive. It ranks the first among the gramineous crops and is known as “the king of gramineous crops in the world”. According to the determination by Chinese Academy of Sciences, *Coix* rice contains 14% protein, 5% fat, 56% carbohydrate, 3% crude

fiber, 0.07% calcium, 0.224% phosphorus and 0.001% iron, the content of these components is higher than that of rice. In addition, *Coix* rice also contains vitamin B1, vitamin B2, vitamin E, niacin, dietary fiber and other nutrients [9]. *Coix* rice is also a kind of green food with high protein, medium fat, medium sugar and rich zinc. Many studies have shown that *Coix* rice not only contains a large amount of protein, but also contains many kinds of amino acids necessary for human body. Hu Jun *et al.* (2007) reported that *Coix lacryma-jobi* seeds contained 8 kinds of amino acids necessary for human body, and the proportion of them is very close to the needs of human body, and they are easier to be absorbed and used by the body than that of rice [5]. Besides, Xie Jing *et al.* (2016) reported that the content of calcium in *Coix* seeds was higher than that in other grains [10]. Because *Coix* rice contains rich nutrients and high calorie, and it can promote metabolism and reduce gastrointestinal burden, so it is a very good tonic food for patients or weak people.

3. Medicinal Value of *Coix lacryma-jobi*

Coix lacryma-jobi is a Chinese traditional medicinal crop, which has many medical effects (e.g. diuretic, spleen, lung, dispel dampness and heat, eliminate edema, discharge pus, stop diarrhea, etc.). Early medicine studies showed that *Coix* seed had antipyretic, analgesic and sedative effects, and has an exciting effect on isolated heart, intestine and uterus, etc. [11]. As early as in *Shennong materia medica classic*, there was a clear record: “the main tendons were urgent convulsion and constricted, do not bend rheumatic arthralgia, lower vitality, take long, light body and replenish vitality” [7]. In addition, it was also said in Compendium of Materia Medica: “*Coix* rice porridge can remove dampness and heat, and benefit intestines and stomach. At present, the researches on the medicinal value of *Coix* are mainly focused on *Coix* seeds. Yumei Zhang *et al.* reported that the roots, stems, leaves and seeds of *Coix lacryma-jobi* could be used as medicine, specially the seed of it had higher medicinal value [2] [5]. The comprehensive research showed that *Coix* rice contained many active chemical components (e.g. lipids, polysaccharides, lignans, phenols and adenosine, etc). Some scholars’ researches showed that *Coix* seed oil contained odd carbon chain fatty acids with strong anticancer activity, which had significant inhibitory effect on tumor growth. There are two kinds of sitosterol (e.g. β -sitosterol and γ -sitosterol) in *Coix* rice, which have high medicinal value. These special active components may be the important material basis for the anti-cancer effect of *Coix* rice [9]. In addition, *Coix* rice has the effect of preventing hyperlipidemia, hypertension, stroke and cardiovascular diseases, etc. *Coix* rice is also a kind of food of improving one’s looks, which can keep the skin lustrous and delicate. It can eliminate acne, freckles, senile plaque, pregnancy spots and butterfly spots, which has good curative effect on hemorrhoids and rough skin [11]. In short, *Coix lacryma-jobi*, as a traditional Chinese medicine plant in China, has both medicinal and edible functions. Therefore, it is necessary to conduct in-depth research and develop-

ment in medicine and health food of *Coix lacryma jobi*.

4. Key Techniques of *Coix lacryma-jobi* for High and Stable Yield

4.1. Cultivation Season

The growth period of *Coix lacryma-jobi* is longer, generally, it is 125 - 180 days. It is suitable to select varieties with a duration of more than 160 days in South China, about 150 days in North China and about 125 days in Northeast China. The sowing time is generally as follows: early maturing varieties are sown in early March, middle maturing varieties are sown from late March to early April, and late maturing varieties are sown from late April to early May. Sowing should be early rather than late. If sowing is too late, it will affect the yield and even the seeds can not mature after autumn [8] [12]. In North China, especially in the Yellow River Delta region, early maturing variety is the best choice for *Coix* cultivation, which should be arranged to be planted in summer autumn season. That is: sowing in late spring and early summer, harvesting in early October. In this season, there is abundant rainfall and even water logging in this region, but it just meets the characteristics of hygroscopicity of *Coix lacryma-jobi*, which can promote the growth and development of *Coix lacryma-jobi* and improve the yield. In this area, if spring sowing is adopted, it is easy to be harmed by drought, at the same time, it is easy to be harmed by dry and hot wind weather at heading stage. In this way, the pollen loses its vitality and can not be pollinated, which leads to the hollow seeds, and the yield will be reduced in light and the yield will be zero in heavy.

4.2. Crops for Rotation

Crop rotation arrangement should consider not only the time of succession, but also the effects of previous crop on soil nutrients, diseases and insect pests (especially soil borne diseases). Most of the medicinal plants are not resistant to continuous cropping, But *Coix lacryma-jobi* is a gramineous crop, and its autotoxicity is less. In general, rice, soybean and rape are the best previous crops of *Coix lacryma-jobi* [13] [14]. In the Yellow River Delta, *Coix lacryma-jobi* should be arranged to be planted in summer autumn season, which can be rotated with overwintering crops (e. g. garlic, onion, overwintering spinach and overwintering wheat, etc.). In the Yellow River Delta region, overwintering crops such as wheat, garlic and onion are usually harvested in the first ten days of June. When the wheat, garlic and onion are harvested, the land preparation will be done simply or even not, and then *Coix lacryma-jobi* will be sown in time. If the sowing is delayed, the seeds of *Coix lacryma-jobi* will not mature well.

4.3. Land Selection

Coix lacryma-jobi is a kind of hygrophilic plant, which likes soil moisture and has strong resistance to soil moisture [12]. Therefore, we can choose low-lying and

waterlogged plots of land, but at the same time, we should prepare good irrigation conditions to ensure that the soil moisture is sufficient in the early growth stage and flowering stage of *Coix lacryma-jobi*. In the early growth stage and flowering stage of *Coix lacryma-jobi*, if the soil is short of water or drought, the yield will be reduced [15].

4.4. Variety and Density

Density is an important factor affecting the yield of *Coix lacryma-jobi*. In order to obtain high yield, we must adopt reasonable planting density. Reasonable planting density depends on cultivation season, variety type and soil fertility [16]. As far as the cultivation of *Coix lacryma-jobi* is concerned in the Yellow River Delta, the cultivation in summer autumn season is applied, it is better to select the variety of early maturing red shell *Coix lacryma-jobi* in Liao Ning. The planting density is generally that row spacing is 25 - 30 cm, the plant spacing is 10 - 13 cm, and the number of seedlings is 20,000 - 26,000 plants per 667 m² [13] [17].

4.5. Water Management

Water management is the key to obtain stable and high yield of *Coix lacryma-jobi*. In the past, people used to think that *Coix lacryma-jobi* was an xerophyte, and the cultivation method of dryland was often used in production, as a result, no high yield has been obtained [18]. In recent years, with the development of *Coix lacryma-jobi* cultivation technology and the practice of many growers, it has been proved that *Coix lacryma-jobi* is not a dry crop, but a hygrophilic crop with strong moisture tolerance. In order to obtain high quality, high and stable yield, it is necessary to correct the misunderstanding of dryland cultivation on *Coix lacryma-jobi*, and adopt the wet cultivation method similar to rice [4] [19]. If the *Coix lacryma-jobi* is planted on dry land, it is necessary that sufficient irrigation conditions must be ensured. We should adopt the technical methods of “two wet, two dry and two water” in water management. That is: the soil should be kept to be moist in the early stage of growth to promote seedling growth, dry farming should be applied at jointing stage, there is water in the field at booting and heading stage, the soil should be kept to be moist at filling stage, and the soil should be kept to be dry during harvest period.

4.6. Artificial Pollination

Coix lacryma-jobi is a monoecious and different flower spikes plant. In the same inflorescence, the male flower matures first, maturation period of which is not consistent with that of the female flower. Female flowers often need to be pollinated by the pollen from different plants. *Coix lacryma-jobi* can be pollinated by wind pollination, but if artificial pollination is applied in the peak of flowering period, the effect of pollination would be more better [10] [15]. The specific method is that the ropes, long bamboo poles and other tools are pulled forward

horizontally at 10 - 12 a.m. on sunny days over the plants of *Coix lacryma jobi*, and make the plants vibrate continuously, so as to make the pollen fly, which can increase the seed setting rate and the yield.

5. Concluding Remarks

In China, *Coix lacryma jobi* is not only a traditional medicinal and edible crop, but also an important modern medicinal plant. With the development of society and the improvement of people's living standard, the health value of *Coix lacryma jobi* has been paid more and more attention. Therefore, the development of plant resources of *Coix lacryma jobi* is imperative in the future. At present, the production of *Coix lacryma jobi* is mainly distributed in the southwest and southeast of China, but less in the north. The main reason is that most of the existing *Coix lacryma jobi* varieties are late maturing varieties with long growth period, and lack early maturing varieties with short growth period. However, the climate and environmental characteristics in north of China are very conducive to the synthesis and accumulation of the nutritional contents in *Coix* seeds, so it's good for the production of high-quality *Coix* rice. Therefore, in the future, we should strengthen the breeding of early maturing varieties with short growth period, popularize new, simple and low-cost production technology, especially vigorously popularize the mechanized sowing and mechanized harvesting technology of *Coix lacryma jobi*, which is the key to develop the production of *Coix lacryma jobi* in north and even northeast of China. At the same time, it is an urgent problem to explore the cultivation model and key technology to increase the content of medicinal components in *Coix* seeds.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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