



Production Technology for Selenium Enrichment, Quality Improvement and Efficiency Enhancement in Rapeseed (*Brassica Napus* L.)

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Abstract

The application of selenium-enriched rapeseed production technology can increase rapeseed yield and improve agricultural production efficiency. This paper summarizes the soil selenium status, the development status of the selenium-enriched industry, and the current status of rapeseed production in Jingzhou, Hubei. It also introduces the production technology for selenium enrichment, quality improvement, and efficiency enhancement in rapeseed from the aspects of production environment, variety selection, field preparation, timely sowing, cultivation management, timely harvesting, quality control, and extension and application, with the aim of providing technical reference for farmers and enterprises.

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1. Introduction

Jingzhou City lies in the heart of the Jiangnan Plain, it is one of the core rapeseed production areas in China, it boasts unique natural conditions for developing selenium-enriched rapeseed for both oil and vegetable use. As the city with the largest rapeseed planting area nationwide, Jingzhou has 3.2 million mu of rapeseed fields, it occupies a pivotal position in China's rapeseed industry. Since 2023, we have conducted research on selenium-enriched rapeseed production technology in Jingzhou in collaboration with local enterprises, and developed the technologies for selenium enrichment, quality improvement and efficiency enhancement of rapeseed. Through its popularization and application across the city, rapeseed yield has been improved, and achieves prominent income-increasing effects. According to field production trials, rapeseed yield increases by 8%-10%, the production benefit increases by 5,000-8,000 yuan/hm². Selenium can promote rapeseed growth and enhance photosynthesis, so rapeseed yields rise markedly after selenium enrichment^[1]. Meanwhile, oil pressed from selenium-enriched rapeseed is selenium-enriched rapeseed oil, selenium-enriched rapeseed oil sells at 10-15 yuan/kg higher than conventional rapeseed oil, planting benefits increase significantly. In addition, long-term consumption of selenium-enriched rapeseed oil helps strengthen physical health and prolong life, so this oil is favored by consumers^[2]. Numerous reports about rapeseed production technologies have been published, while few studies focus on integrated selenium-enriched rapeseed production technologies for quality and efficiency improvement. To improve the scientific cultivation of rapeseed by farmers, enhance rapeseed quality, increase rapeseed yield and farmers' incomes, promote the development of a high-quality, high-yield, and high-efficiency rapeseed industry, and advance the standardization and normalization of rapeseed production technology, this study conducted integrated research on efficient selenium-enriched rapeseed production technology. The research integrated key technical components, including production environment, variety selection, vigorous seedling cultivation, timely transplanting, precise fertilization, water management, disease, pest, and weed control, scientific selenium enrichment, and timely harvesting, thereby establishing an integrated green production technology system for selenium enrichment, quality improvement, and efficiency enhancement in rapeseed. This work aims to provide a technical reference for farmers and enterprises.

2. Utilization of Selenium Resources and Status of Rapeseed Production

2.1. Soil Selenium Status

Jingzhou is located in the selenium-rich belt of the Jiangnan Plain, selenium-rich cultivated lands are continuously distributed in river and lakeside regions including Honghu and Jianli within the city, selenium-rich cultivated lands are continuously distributed in river and lakeside regions including Honghu and Jianli within the city 0.322 mg/kg, it exceeds the national soil background value, soils mainly develop from fluvio-lacustrine parent materials, most soils are loam and clay loam in texture, soil pH is mostly neutral to slightly alkaline, soil organic matter content is relatively high, and the soil has strong fertilizer and water retention capacity. However, selenium shows uneven spatial distribution across this region, most farmlands meet the total selenium standard, the proportion of available selenium is relatively low, selenium in soils mostly exists in inert bound forms, rapeseed roots can hardly absorb and utilize this selenium, this is the key limitation causing unstable selenium accumulation in rapeseed seeds and stalks from local naturally selenium-rich fields, rhizosphere regulation technologies are required to activate soil selenium and improve its bioavailability^[3].

2.2. Development Status of Selenium-Enriched Industry

Jingzhou leverages selenium resources of the Jiangnan Plain, it steadily promotes the development of selenium-enriched characteristic agricultural products, it carries out demonstration planting and industrial exploration led by selenium-enriched rice, eggs, fruits and vegetables, it has initially formed a development pattern of brand cultivation and base demonstration for selenium-enriched agricultural products. However, the current selenium-enriched industry still has several shortcomings: the standardized production technology system for selenium-enriched rapeseed (selenium-enriched rapeseed sprouts + selenium-enriched rapeseed oil) remains incomplete, most practices rely on foliar application of selenium fertilizer, selenium use efficiency is low, and organic selenium contents in seeds and rapeseed sprouts fluctuate greatly; models for selenium-enriched production integrating rhizosphere microbial regulation and phosphorus-selenium synergy are lacking, the certification scale of selenium-enriched rapeseed products is limited, the industrial chain of selenium-enriched rapeseed for both oil and vegetable use has not been fully exploited, development of high-value products from selenium-enriched rapeseed sprouts and selenium-enriched rapeseed oil is insufficient, it is urgent to integrate standardized production technologies for selenium-enriched rapeseed to support quality improvement and upgrading of Jingzhou's selenium-enriched grain and oil industry^[4].

2.3. Current Status of Rapeseed Production

Jingzhou ranks first nationwide in rapeseed planting, with an annual planting area of over 3.2 million mu, counties such as Jianli, Jiangling, Songzi and Gong'an are core production areas, the rice-rapeseed rotation system is dominant, low-erucic acid, low-glucosinolate, high-oil and oil-vegetable dual-purpose rapeseed varieties are widely promoted, rapeseed sprout harvesting and seed production are developed simultaneously, it achieves 'one crop for dual purposes', improve comprehensive benefits. The city has built multiple 7D functional rapeseed oil primary processing

bases, it has built regional public rapeseed oil brands such as "Qianli Jiangling", light and simplified mechanization technologies including mechanical sowing and harvesting are widely applied, it has an industrial foundation for large-scale demonstration of selenium-enriched rapeseed technologies. Under the traditional production mode, rapeseed suffers from poor rhizosphere environment, nutrient imbalance and low selenium uptake efficiency, selenium-enriched production techniques are fragmented, complete standardized technologies ranging from rhizosphere microecological regulation to selenium content control in products are lacking, it restricts the large-scale promotion of the selenium-enriched rapeseed industry^[5].

3. Production Technologies for Selenium-Enriched Rapeseed with Improved Quality and Efficiency

3.1. Production Environment

Select fields with flat terrain, smooth drainage and irrigation, proper groundwater level, low heavy metal content, and no pollution from industrial "three wastes"; priority is given to potential or selenium-enriched cultivated land with total soil selenium ≥ 0.3 mg/kg; rice stubble fields need well-matched three-ditch systems, ensure that ridge ditches, middle ditches and surrounding ditches are connected, no standing water remains in the field after rainfall, reduce the inhibition of waterlogging on selenium uptake by roots, the quality of the production site environment meets the requirements of NY/T846.

3.2. Variety Selection

Select double-low Brassica napus varieties, high-yield, high-oil, lodging-resistant and disease-resistant varieties are selected for oil production mode, such as Huayouza 50, Huayouza 62, and Zhongyouza 501; varieties with strong selenium accumulation capacity and good regrowth performance are selected for the oil-vegetable dual-use mode, such as Xiziyuan 1, Xiziyuan 2, and Ganyouza 8; seed quality meets the requirements of GB4407.2, adopt centralized and contiguous planting in target regions, prevent cross-pollination from different varieties to avoid quality decline.

3.3. Field Preparation

After harvesting the previous rice crop, clear field straw residues in a timely manner, straw can be crushed and returned to the field or removed from the field; use rotary tillers for soil crushing and land preparation. Apply organic fertilizer, formula fertilizer and rhizosphere functional microbial agents as base fertilizers during land preparation. Dig ridge ditches, middle ditches and surrounding ditches to connect them, with no water left in ditches after rain. Set the ridge width to 1.8-2.0 m, the ditch width is 30 cm and ditch depth ranges from 25 to 30 cm. Large-scale producers can adopt precision combined seeders for rapeseed, complete rotary tillage, fertilization, base application of microbial agents, ditching and sowing in one pass.

3.4. Timely Sowing

Simplified direct sowing is recommended, seedling transplanting is also acceptable. For seedling transplanting, sowing is conducted from September 10 to 20, cultivate robust seedlings in seedbeds, transplant seedlings at 30-35 days old with 5 to 6 true leaves, complete transplanting before the end of October; transplant 90 000 plants/hm² in fertile fields, adopt appropriately dense planting in barren upland

fields, transplant 105 000 plants/hm². The suitable sowing period for direct seeding is late September to mid-early October; large-scale bases can conduct sowing in batches to realize staggered harvest of rapeseed bolts. The direct seeding rate is 3500–4500 g/hm², apply moderate soil covering after sowing, ensure seeds are not exposed. Irrigate shallow flood water promptly after sowing when soil moisture is insufficient, do not let water cover the ridge surface. Perform seedling thinning, gap filling at the 2-3 true leaf stage of seedlings; finalize seedling establishment at the 4-5 leaf stage; retain 220 000-280 000 plants/hm² after final thinning in direct-sown fields; increase the basic seedling density appropriately for the oil-vegetable dual-use model.

3.5. Cultivation Management

3.5.1 Scientific Fertilization

Apply sufficient base fertilizer, mainly organic fertilizer and special compound fertilizer for rapeseed, apply boron fertilizer as supplement; apply heavy winter fertilizer, stable bolting fertilizer and proper flowering fertilizer^[6]. Apply 22500-30000 kg/hm² of bio-organic fertilizer or 600 kg/hm² of rapeseed cake fertilizer, or apply 7500 kg/hm² of bio-organic fertilizer and 525-600 kg/hm² of 'Yishizhuang' rapeseed formula compound fertilizer (N-P-K: 25-7-8). Incorporate organic fertilizer into soil during plowing, apply formula compound fertilizer to ridge surfaces or sowing rows at sowing. For oil-vegetable dual-use fields, apply additional quick-acting nitrogen fertilizer 7-10 d before bolting harvest. This offsets nutrient loss from rapeseed bolt picking and guarantees later rapeseed yield. apply 1-2 foliar sprays of 1% urea or 0.2% borax solution as flowering fertilizer. Fertilizer application complies with NY/T 496 standard.

3.5.2 Water Management

Maintain moist soil in rapeseed fields to promote seedling growth and prevent plant senescence. No irrigation is needed when soil stays moist, water promptly under prolonged drought. After entering the next spring, rainfall gradually increases, dredge ditches timely to avoid standing water in fields. High field humidity will trigger disease outbreaks. Suitable water conditions benefit the metabolic activity of functional microbes and selenium migration in soil, promote selenium uptake by rapeseed roots. Irrigate timely to preserve soil moisture under drought conditions, clear ditches and drain waterlogging after spring^[7].

3.5.3 Pest, Disease and Weed Control

Pest control is the priority throughout the whole growth period of rapeseed, use biological pesticides or low-toxicity and low-residue pesticides for chemical control; pull out diseased individual plants and remove them from fields^[8]. For controlling cabbage caterpillars and aphids, spray with 1.5% emamectin benzoate EC at 2000-fold dilution, or 32000 IU/m² *Bacillus thuringiensis* WP at 200-fold dilution plus 3% acetamiprid EC at 600 mL/hm²; Within 3 d after sowing, spray the soil surface with 96% isopropyl-metolachlor EC at 300–500-fold dilution for pre-emergence weed sealing. After rapeseed seedlings reach the 3-4 leaf stage, adopt manual weeding or weed suppression by crop canopy.

3.5.4 Scientific Selenium Application

Selenium application in rapeseed improves quality, raises yield and increases benefits^[9]. Apply 150 g/hm² sodium nitrite containing 44.7% selenium or selenium-supplement

products with equivalent selenium content, add 37.5 mL/hm² Jiabunate or 75 mL/hm² Haoshi, mix with 300-450 kg/hm² water., stir thoroughly for later use. Apply selenium once respectively at the bolting, flowering and pod stages of rapeseed, spray 450-600 kg/hm² selenium solution each time. Selenium application should be carried out on cloudy days or after 16:00 on sunny days. Re-spray promptly if rainfall occurs within 4 h after selenium application. Spray evenly with fine droplets, cover both sides of leaves, stems and pod surfaces with selenium solution. Selenium solution cannot be mixed with alkaline pesticides and fertilizers^[10]. Stop selenium application 20 d before harvest.

3.6. Timely Harvest

Mechanical harvest of oil-use rapeseed starts when over 75% of pods turn loquat yellow; manual harvest begins when 80% of pods turn loquat yellow and seeds in main raceme pods become brown, stack harvested plants for 4-5 d to complete after-ripening, then thresh, clean, dry and store. Oil-vegetable dual-purpose mode, when the main bolting height reaches 45-55 cm, harvest 15-20 cm young bolts and young rapeseed bolts in batches at different stages; continue field management after rapeseed bolt harvest to ensure normal seed maturation.

3.7. Quality Control

Establish production record files throughout the whole process, truthfully record information including planting plots, varieties, sowing date, microbial agent application, fertilizers, time and dosage of selenium preparation application, pest, disease and weed control, harvest time, and product test results to realize traceability of product quality. Test total selenium and organic selenium contents batch by batch after harvesting rapeseed bolts and seeds. Determine selenium content of samples according to national standard methods, the organic selenium content of rapeseed grains reaches 0.15-0.3 mg/kg, and that of rapeseed bolts reaches 0.1-0.2 mg/kg, selenium-enriched labels can be affixed for market sale only after meeting the standards for selenium-enriched agricultural products. Simultaneously test heavy metal indicators including lead, cadmium, arsenic and mercury to guarantee product quality and safety.

4. Promotion and Application

Rely on the standardized production bases of double-low rapeseed in Jingzhou, establish demonstration zones for standardized production of selenium-enriched rapeseed, focus on demonstrating and popularizing new selenium-enriched rapeseed varieties, rhizosphere functional microorganism inoculation technology, rhizosphere microecology regulation technology, combined phosphorus and selenium application technology, and selenium application technology at key growth stages. Agricultural extension departments cooperate with oil processing enterprises, by establishing standardized production bases for rapeseed seeds, supply high-quality double-low rapeseed seeds to farmers uniformly, provide standardized technical guidance, purchase rapeseed uniformly, leading enterprises can obtain double-low rapeseed raw materials with consistent quality standards, thus laying a foundation to accelerate the industrialization of rapeseed. Through training and demonstration, guide farmers to apply fertilizers and pesticides rationally and conduct production and management following standards, improve

the standardization level of scientific production of selenium-enriched rapeseed.

5. Conclusion

The standardized production technology of selenium-enriched rapeseed in Jingzhou is developed for rice-rapeseed rotation systems in the Jiangnan Plain. It breaks the traditional model of simple foliar selenium fertilizer application, start with rhizosphere microecology, use functional microorganisms to regulate selenium speciation transformation in soil, alleviate phosphorus-selenium antagonism, achieve efficient selenium biofortification, simultaneously increase yield, improve selenium use efficiency, and stabilize selenium content in seeds and rapeseed bolts to meet required standards, it suits mechanical operations for large-scale growers and also adapts to smallholder production. The popularization of this technology, it helps promote the industrial development of selenium-enriched rapeseed oil and rapeseed bolts in Jingzhou, extend the whole industrial chain of rapeseed, achieve multiple goals including grain and oil production, functional agricultural products and increased farmers' income. Further demonstration and verification should be conducted for different soil types and cropping sequences, and optimize microbial agent dosage and phosphorus-selenium ratio parameters, and improve localized operating procedures.

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