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Pollution-free Production Technology of Linshu Sweet Potato

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Abstract This paper elaborated the quality characteristics, nutritional value and specific production area of Linshu sweet potato. Besides, it summarized the pollution-free production technology of Linshu sweet potato from the aspects of origin selection, variety selection, production management, harvest and storage, so as to guide the normalization and standardization of production technology, improve production and quality, and further enhance the brand awareness of Linshu sweet potato in both the national and international markets.

Key words Linshu sweet potato, Pollution-production production, Production technology

1 Introduction

Linshu sweet potato is a specialty product of Linshu County, Linyi City, Shandong Province, and also a national geographical indication agricultural product. On December 22, 2017, the former Ministry of Agriculture of the People's Republic of China officially approved the registration and protection of geographical indications of agricultural products for "Linshu Sweet Potato".

2 Quality characteristics

Linshu sweet potato is characterized by good qualities of moderate size of potato, smooth skin, delicate meat and sweet taste. The baked Linshu sweet potatoes have a fragrant, sweet, soft and waxy taste after roasting and processing. Linshu sweet potatoes are purple-red to yellow, spindle-shaped and irregularly round, with yellow, orange-red to red flesh, and delicate flesh. The tuber roots of sweet potatoes are thick and concentrated, and the potato skins are smooth. A single plant has 1 to dozens of potato tubers, and there is no abnormal external moisture, which has the basic characteristics of Linshu sweet potato variety. It has no mildew and other odors. Linshu sweet potatoes are delicate in texture, sweet and good in taste. Linshu sweet potatoes are rich in various nutrients, containing 1.5% - 2.0% protein, 10.0% - 12.5% starch, 5.0% - 7.0% total sugar, and 2.5 - 4.5 μg/kg selenium.

3 Protection scope of geographical indication products

The protection scope of Linshu Sweet Potato Geographical Indication is limited to the area announced by the former Ministry of Agriculture of the People's Republic of China (No. 2520). The protection area (118°26′00″ - 118°84′00″ E, 34°40′00″ - 35°06′00″ N) is located in Linshu County of Linyi City in Shandong Province. The registered protection scope of Linshu Sweet Potato includes Linshu Residential District, Zhengshan Residential District, Qingyun Town, Yushan Town, Jiaolong Town, Shimen Town, Daxing Town, Diantou Town and Caozhuang Town under the jurisdiction of Linshu County, a total of 9 towns (residential districts).

4 Environment of production area

4.1 Selection of production area The environmental conditions of the production area (environmental air quality, irrigation water quality, and soil environment quality) should comply with the provisions of *Environmental Conditions of Production Area of Pollution-free Agricultural Product Planting* (NY/T 5010-2016). It is necessary to choose a sweet potato production area far away from pollution sources, free from industrial and agricultural pollution and its influence, with good ecological conditions and sustainable production capacity.

4.2 Soil conditions Neutral or slightly acidic sandy loam or loamy soil with deep soil layer, loose soil structure, and convenient drainage and irrigation, requiring plots without any diseases.

4.3 Previous stubble requirements Convolvulaceae crops have not been planted within 2 - 3 years.

5 Production management measures

5.1 Cultivating strong seedlings

5.1.1 Variety selection. It is necessary to select high-quality, high-yield, pest-resistant, adaptable, and good commodity performance varieties according to local market demand and different uses. Old varieties that have been grown locally for many years should not be used, and genetically modified varieties should not be used. Selecting good seed potatoes and cultivating strong seedlings is the basis of high-yield cultivation. Attention should be paid to the introduction of varieties: it is not allowed to introduce varieties s from epidemic areas, and it is not allowed to blindly introduce varieties from places where the source of the varieties and the origin of the disease are unknown. Sweet potatoes are susceptible to viruses, causing degradation. It is necessary to select varieties with high quality, high yield, resistance to diseases and insect pests, strong adaptability, and good commodity performance in accordance with different purposes.

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5.1.2 Cultivate disease-free strong seedlings. (i) Seedling time and seed quantity. In Linshu County, the seedlings are generally raised in the middle and late March, and the amount of seeds used is 50 kg/667 m^2. (ii) Seed potato treatment. Soak the seed potatoes in warm water at 52 – 54 ℃ for 10 min, or soak the seed potatoes in 50% thiophanate-methyl WP (or 50% carbendazim WP) 600 times solution for 5 min to prevent black spot. (iii) Potato arranging method. At 3 – 4 d before the potatoes are arranged, the bed should be warmed and the film is covered to achieve a suitable temperature (above 28 ℃) for the potatoes to be arranged. Big and small potatoes should be separated and horizontally arranged. The distance between the seed potatoes is 1.5 cm, the head and the tail are facing each other, the sunny side is facing upwards, the shady side is facing downwards, and the top is flat and the bottom is uneven. Water at proper time and cover with soil. (iv) Seedbed management. It is necessary to follow the principles of high temperature germination (30 – 35 ℃), medium temperature seedling growth (25 – 30 ℃), and low temperature seedling hardening (20 ℃). Potato tuber germination period (from seeding to potato seedlings unearthed): mainly promote germination, and the bed temperature should be kept at 30 – 35 ℃ to promote more germination. The key to management is to increase temperature and heat preservation, while paying attention to the humidity of the seedbed. The stage of cultivating strong seedlings (potato seedlings unearthed to before picking seedlings): mainly promote seedlings, combine seedling promotion with hardening, and keep the bed temperature at 25 – 30 ℃. As the seedlings increase and the temperature rises, the amount of watering should be increased to keep the bed soil moist. When the potato seedlings grow close to 20 – 25 cm, the seedbed management is mainly to harden the seedlings, stop heating and watering, and lower the bed temperature to about 20 ℃. (v) Picking seedlings in time. When picking seedlings, use the method of cutting seedlings. The big seedlings should be cut to keep the small seedlings, and high-cut seedlings should be implemented, that is, 1 – 3 leaf nodes should be reserved at a place 3 cm away from the bed surface. (vi) Criteria for strong seedlings. The stem is thick, the internodes are short, the leaves are large and thick, the top three leaves are flush, the seedling length is 20 – 25 cm, and the fresh weight of 100 seedlings is more than 0.75 kg. The seedlings should be properly tender, have a lot of juice, no white roots, and no pests and diseases.

5.2 Cultivation management

5.2.1 Soil preparation and ridge making. Deep plowing of the site can make the soil loose, deep and rich in oxygen, which is conducive to the growth of sweet potato roots and the expansion of potato tubers. In Linshu area, 25 – 30 cm deep plowing is generally carried out before winter, and planted in narrow ridges and single rows. If the ridges are artificially made, the ridge spacing is 70 – 80 cm, the plant spacing is 30 – 35 cm, and the ridge height is 20 cm; if mechanized deep plowing is used to make ridges, the distance between ridges is 85 – 95 cm, the plant spacing is 25 cm, and the ridge height is 20 cm.

5.2.2 Application of base fertilizer. In accordance with the requirements of the *Guidelines for the Rational Application of Fertilizers* (NY/T 1105-2006), it is required to follow the principles of using base fertilizers as the main fertilizer, organic fertilizers as the main fertilizer, less nitrogen fertilizers, and more potassium and phosphorus fertilizers. Combining with land preparation, it should apply 3 000 – 4 000 kg of decomposed farmyard manure, 12 – 15 kg of urea, 45 – 50 kg of superphosphate, 25 – 30 kg of potassium sulfate or 50 – 100 kg of plant ash, and the ratio of nitrogen, phosphorus and potassium is 2∶1∶4.

5.2.3 Prevention and control of underground pests. It is necessary to use 2.5 kg of 5% phoxim granule for a land of 667 m^2, spread evenly on the surface, and plow into the ground as the site is prepared for soil treatment. Alternatively, it is possible to make poisonous soil and spread it in the holes dug on the ridges: use 75% phoxim 500 g for a land of 667 m^2, mix well with 20 kg of humidified soil, and scatter in the holes along with the planted seedlings. Trichlorfon and 50 – 100 parts of fried wheat bran can also be used as poisonous bait to control cutworms.

5.2.4 Cultivation time. Spring potatoes can be planted in the field when the ground temperature 10 cm below the surface is stable above 15 ℃. If film-mulched cultivation is used, it can be cultivated 10 – 15 d in advance.

5.2.5 Cultivation density. The cultivation density should follow the principle that fertile land should be thin, dry and thin land should be dense, spring potato should be thin, and short vine varieties should be dense. Generally, 3 000 – 3 800 seedlings are planted for a land of 667 m^2.

5.2.6 Cultivation methods. First dig holes on the ridges, then pour water, then cultivate seedlings and cover with soil. The method of planting seedlings: that is, "first insert, then lie, then raise, bury more and expose less (expose two leaves and one bud). It is necessary to insert deep to protect seedlings but bury not deep. In other words, shallow cultivation should be implemented under the premise of survival of seedlings.

5.2.7 Field management. The field management should adhere to the management principle of "focusing on promotion in the early stage, proper control in the middle stage, and prevention of premature aging in the later stage". (i) Checking and replenishing seedlings. It is necessary to check the seedlings 4 – 5 d after planting, and replant immediately if there is a lack of seedlings to ensure full seedlings. Strong seedlings should be selected for replenishing, plant them in the afternoon or evening, and plant some preparatory seedlings in the field to fill in the gaps. For weak seedlings, water them in time to promote growth. (ii) Intertillage and weeding. Timely cultivation and weeding are required. Herbicide spraying should be carried before planting seedlings and mulching, so as to avoid the impact of phytotoxicity on sweet potato seedlings. For every 667 m^2 land, spray 100 g of acetochlor mixed with 100 kg of water on the ridge surface, and plant seedlings after 5 – 10 d. (iii) Watering. Watering should adopt small

water infiltration irrigation, not flood irrigation, and water does not reach the top of the ridge, so as to facilitate the expansion of potato tubers. (iv) Chemical control. Before and after closing rows, chemical control should be carried out in a timely manner for some fields with high fertility or overgrown fields. It is necessary to use paclobutrazol 75 g for a land of 667 m^2, add 50 kg of water and spray evenly to avoid overgrowth. (v) Top dressing. In order to prevent premature aging and increase yield, generally before and after the closure, when the sweet potato enters the tuber expansion period, the leaves are sprayed with fertilizer 2 – 3 times every 10 d. Mix 15 kg of water and 20 g of potassium dihydrogen phosphate for every 667 m^2, and spray evenly on the leaves. In the middle and late stages, strictly control the amount of nitrogen fertilizer and irrigation water, and increase the application of plant ash.

5.3 Prevention and control of plant diseases and insect pests In accordance with the policy of "prevention first, comprehensive prevention and control", it is required to follow the pollution-free management principle of "agricultural control, physical control, biological control as the main, and chemical control as the supplement".

5.3.1 Agricultural control. (i) Enhancing potato seedlings and implementing crop rotation and stubble. For the main pest control targets, it is necessary to select resistant (tolerant) varieties according to local conditions, and establish disease-free seedling land (including field cultivation). From seedling cultivation to storage, it is necessary to use healthy potato seedlings to raise seedlings, and use seed potatoes without viruses, germs, and insect eggs. In addition, it is necessary to cultivate with healthy seedlings, choose healthy soil, and implement crop rotation. (ii) Balanced fertilization and increased application of organic fertilizers. Through balanced fertilization, it is necessary to increase the application of phosphorus and potassium fertilizers, increase the application of fully decomposed organic fertilizers, and apply appropriate amount of chemical fertilizers in a timely manner. (iii) Reasonably dense planting and cleaning fields. It is necessary to strengthen field management measures such as intertillage weeding, field cleaning, and field weeds to reduce the number of sources of diseases and insect pests. (iv) Removing diseased potatoes and plants in time. During storage and seedling raising, if diseased potatoes and diseased plant residues are found, remove them in time and keep away from deep burial.

5.3.2 Biological control. It is recommended to use 16 000 IU/mg *Bacillus thuringiensis* wettable powder, that is, Bt biological agent, use 500 – 1 000 times liquid 60 – 75 kg for a land of 667 m^2 to prevent and control Lepidoptera larvae such as sweet potato *Agrius convolvuli* and sweet potato *Sitotroga cerealella*. Use 0.38% matrine EC 300 – 500 times to control aphids, *Chiagosnius obscuripes*, cutworms, grubs and other underground pests, and use 2% *Beauveria bassiana* powder to control grubs, the dosage is 2 kg for a land of 667 m^2. Spread before ridging or implement hole fertilization when planting, and cover the soil after application to prevent sun exposure.

5.3.3 Chemical control. (i) Sweet potato black rot. When raising seedlings and storing potato seeds, use 500 times of 50% carbendazim or 500 – 700 times of 70% thiophanate-methyl to soak the seeds or soak the base of the seedlings for 10 min when planting. (ii) Sweet potato stem nematode (*Ditylenchus destructor*) disease. Treat the nursery land with chemicals, use 50% phoxim 1 000 mL for a land of 667 m^2 to water 300 times, combine with cultivated land and apply it to 15 cm deep soil to prevent sun exposure. When planting in the field, under the premise of selecting disease-free and healthy seedlings, use 50% phoxim 1 000 – 1 500 times liquid for hole fertilization. Apply 0.2 – 0.3 kg for each hole and then close tightly. After preparing 30% phoxim microcapsules at a ratio of 1∶5, completely immerse the base of potato seedlings 10 – 15 cm in the liquid medicine, make the liquid medicine fully adhere to the surface of the potato seedlings, then soak the roots for 5 min. Then the potato seedlings after dipping the roots are planted according to the normal planting procedure. If there is excess liquid medicine after soaking the roots, the liquid medicine can be directly put into the hole water for planting and poured into the hole together. (iii) Brachmia macroscopa, Agrius convolvuli, Spodoptera litura, and Bedellia somnulentella. Every 667 m^2 use 90% trichlorfon 1 000 times liquid, or 50% phoxim 1 000 times liquid or use 2.5% deltamethrin (dichlor) 2 000 times liquid, or 10% cypermethrin (Mebaca) 2 000 times liquid spray, 50 kg for a land of 667 m^2, the above agents are used alternately.

6 Harvesting

6.1 Time Sweet potatoes for storage should be harvested in time after frost to prevent frost damage. Sweet potatoes for starch can extend the harvest period.

6.2 Methods Sweet potatoes should be harvested on sunny days. When harvesting, they should be gently dug and handled without damaging the skin. They should be dried in the sun for 2 – 3 h and then transported lightly into the cellar for storage.

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