Dry Breeding and Dry Planting Techniques for Indica Hybrid Rice in Karst Mountain Areas of Gejiu City

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Abstract Based on the arable land situation in Gejiu City, upland dry planting of indica hybrid rice is being expanded in Karst mountain areas with a rainfall of over 1 400 mm and an altitude of 1 100 - 1 600 m to develop grain production. This paper gives a specific description of hybrid rice upland dry seedling technology, upland transplanting technology, fertilization technology, field management, weed prevention and control technology, and disease and pest control.

Key words Karst mountain area; Hybrid rice; Dry breeding; Dry planting

1 Introduction

Gejiu City is located in the Honghe Hani and Yi Autonomous Prefecture of Yunnan Province. It covers an area of 1 587 km^2 and is situated at 102°54′ - 103°25′ E, 23°01′ - 23°36′ N. The area features a subtropical plateau monsoon climate, with each season feeling like spring and abundant rainfall. The average annual temperature is 16 ℃, with a maximum temperature of 29 ℃ in the summer. The region is mountainous, with an altitude ranging from 150 - 2 740 m. Drought and water scarcity have become critical constraints in securing food production today. The distribution of water resources in Gejiu City is highly uneven both spatially and temporally, with significant variations in rainfall between different townships and villages. Atmospheric precipitation is the primary source of soil moisture, which is a necessary condition for the growth and development of dry-planted rice[1]. Dry planting can fully utilize natural precipitation, freeing rice cultivation from the constraints of artificial irrigation. This can significantly expand the area of rice cultivation and improve rice production. The extension area for dry hybrid rice in Gejiu City is approximately 200 hm^2, resulting in a yield of 6.00 - 6.75 t/hm^2. Large-scale production and planting are conducted in Doumuge Village, located at Kafang Town. Upland hybrid rice can grow in areas with altitudes ranging from 1 100 - 1 600 m due to its growth habit and water requirements. To enhance grain production, it can be cultivated in suitable areas of Gejiu City, such as Goujie Village of Kafang Township, Laochang Township, Jasha Township, *etc.* These areas receive rainfall exceeding 1 400 mm, which can significantly increase grain output and economic benefits. Upland rice cultivation in mountainous areas can conserve agricultural water, decrease production costs, and enhance economic benefits. Meanwhile, drying planting of hybrid rice in mountainous areas overcomes the limitations of rice planted in paddy fields. This promotes the planting of rice in traditional maize and other dryland crop areas, changing the pattern of mountainous or dry land utilization. It improves the efficiency of land use and promotes economic development and income for farmers in mountainous areas, achieving good economic and social benefits.

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2 Selecting good seeds

Varieties featured by early maturity, disease resistance, high yield and drought tolerance suitable for local planting were selected, such as Yixiang 3003, Yixiang 4245, Yexiangyou 9901, Chuanyou 3727, *etc.*

3 Cultivating robust seedlings

3.1 Seedbed selection The selected seedbed should have good soil texture, be windward and sunny, and be located near a water source. It is not recommended to plant seedlings in uneven or easily waterlogged low-lying land.

3.2 Seedbed area The recommended seedbed areas for a 1 hm^2 field are as follows: 255 - 300 m^2 for small seedling (below 4.0 leaf age) transplants, 330 - 375 m^2 for medium seedling (4.0 - 5.5 leaves) transplants, and 450 m^2 for large seedling (above 5.5 leaves) transplants.

3.3 Pre-winter fertilization Well-decomposed farmyard manure is applied at a dose of 30 t/hm^2. Then, it is turned over deeply to ensure full mixing with the soil.

3.4 Pre-sowing fertilization 30 t/hm^2 of rotted farmyard manure, 1.5 t/hm^2 of calcium superphosphate, and 750 kg/hm^2 of potassium sulphate are evenly mixed and spread on the moist surface. Then, they are turned over to a depth of 20 cm to ensure full mixing of the fertilizer and soil.

3.5 Moisture adjustment The moisture width is typically 1.3 - 1.4 m, while the ditch (ridge) ranges from 30 to 40 cm in width, with a length of 10 - 15 m and a depth (height) of 5 - 10 cm. Depending on the situation, either a high-moisture (low-ridge) or low-moisture (high-ridge) seedbed type is used.

3.6 Seedbed disinfection After thoroughly watering the soil,

70% dexon 200 times dilution is sprayed or splashed on the seedbed for soil disinfection. When fertilizing before sowing, 1.5 – 2.0 g/m^2 of dexon is mixed with a small amount of soil prior to broadcasting it onto the moist surface. Then, they are turned over deeply to a depth of 15 cm to sterilize the soil.

3.7 Sowing and covering Before sowing, the seeds undergo several processing measures, including sun-drying, selection, soaking, sterilization, and accelerated germination. The seeds should be sown once more than 70% of them have sprouted. The seeds can be sown after flooding the seedling bed and waiting for the water to recede from the surface. Seeds should be sown between middle March and early April, with a sowing amount of 50 – 60 g/m^2. For dry planting of hybrid rice, the optimum age is 35 – 50 d.

3.8 Sowing method After sowing the seeds, the plot is covered with 1 cm of sifted, fertile, fine soil to avoid exposing the seeds.

3.9 Chemical weeding To control weeds, 500 times dilution of 50% butachlor EC should be sprayed.

3.10 Covering It requires the use of either arch film or flat perforated film for seedbed covering. When using flat film, it is recommended to lay straw under the membrane to prevent seedling burn. The soil should be compacted firmly around the cover before placing the rodenticide to prevent harm from rats.

3.11 Seedbed management

3.11.1 Temperature. The temperature is maintained at 25 – 28 ℃ and then adjusted to 20 – 25 ℃ when the seedlings have 1.5 – 2.5 leaves. The seedlings should be gradually exposed to the outside temperature after 2-leaf stage. The film should be removed at the 3-leaf and 1-heart stage. The film is generally exposed during sunny afternoons, cloudy mornings, or after rainfall. If a low-temperature cold wave occurs, the film will not be exposed until the cold wave has passed.

3.11.2 Moisture. Moisture management is typically carried out from sowing until the film is uncovered. Watering is unnecessary unless the bottom water has not been fully irrigated prior to sowing. The plot should be thoroughly watered in the following cases: when the bed soil is dry in the morning and evening, when there are no water droplets at leaf tips, or when the leaves are rolled due to drought in the midday. It is recommended to irrigate in the afternoon before sunset.

3.11.3 Diseases. The diseases such as bacterial wilt and damping off should be prevented in seedling stage. About 12 d after sowing, most of the seedling beds have been uncovered. To prevent bacterial wilt and damping off, 1.5 – 2.0 g/m^2 of dexon should be mixed with sand evenly before being broadcasted on the seedbed, and the seedbed is thoroughly irrigated.

4 Transplanting

4.1 Selecting and preparing land When dry planting hybrid rice in mountainous areas, it is important to select flat terrain with moist, low-lying land and moderate soil quality. To facilitate seedling transplants, the soil should be finely cultivated with additional plowing and harrowing to achieve a flat grain.

4.2 Heavy application of base fertilizer In upland dry planting, rice requires additional fertilizer, particularly nitrogen, phosphorus, and potassium, which are crucial for growth and yield formation. Therefore, it is necessary to apply sufficient base fertilizer. To address the issue of soil fixation of phosphorus in acidic red soil and the dissolution of nitrate nitrogen in dry land due to rain, it is recommended to increase the application of nitrogen and phosphate fertilizer. Therefore, the main fertilizers should be nitrogen and phosphorus, followed by potassium. Generally, 15.0 – 22.5 t/hm^2 of farmyard manure, 750 kg/hm^2 of ordinary superphosphate, 75 – 150 kg/hm^2 of potassium sulfate, and 15 – 30 kg/hm^2 of zinc sulfate are mixed and applied 3 – 5 d prior to transplantation when raking.

4.3 Timely transplanting It is recommended that upland rice seedlings can be transplanted after reaching the 3-leaf and 1-heart stage. However, seedlings with 4 – 5 leaves or more than 5 leaves are typically planted in early and middle May for production. Transplanting should be done promptly in areas with irrigation, while in areas without irrigation, transplanting should be done based on local rainfall conditions[2]. Entering the rainy season during the rice tillering stage is preferable as it promotes the nutritional and reproductive growth of rice, leading to increased production.

4.4 Rational close planting The high yield of hybrid rice depends on both main stem and tiller-earing. Typically, dry-planted plants are spaced at 10 cm × 25 cm with a density of 390 000 plants/hm^2, and basic seedlings are planted at a density of 795 000 plants/hm^2 to achieve optimal yield.

4.5 Cultivation methods The ditch should be opened to a depth of 3 – 5 cm with a row spacing of 25 cm. The seedlings should then be transplanted with a spacing of 10 cm. It is important to press the roots firmly with the thumb to ensure full contact between the roots and soil. Opening ditches or planting seedlings too deeply can negatively impact tillering. It is recommended to keep roots intact and maintain neat rows of seedlings.

4.6 Intertillage and weeding Annual and perennial weeds, such as *Digitaria sanguinalis*, *Eleusine indica*, *Echinochloa crus-galli*, *Ageratum conyzoides*, *Bidens alba*, *Crassocephalum crepidioides*, *Galinsoga parviflora*, *Sigesbeckia glabrescens*, *Portulaca oleracea*, *Commelina paludosa*, *Triumfetta cana*, *etc.*, are common in dry planting of hybrid rice in mountainous areas. After dry rice transplanting, a mixture of metamifop · fluroxypyr-meptyl · cyhalofop-butyl and water at a dosage of 600 – 750 mL/hm^2 and 900 kg/hm^2, respectively, can be applied to the stems and leaves of weeds when they reach the 3 – 5 leaf stage.

4.7 Rational topdressing To prevent loss of fertilizer due to water leaching, dry planting in hybrid rice in mountainous areas requires a greater amount of fertilizer application compared to pad-

dy fields. It is recommended to apply the fertilizer in small amounts multiple times. The effective tillering period is generally 15 days after transplanting. To ensure sufficient effective tillering number and improve the heading rate, 300 kg/hm^2 of urea can be applied. In plots with deficient fertilizer, 45 kg/hm^2 of urea and 2 250 – 3 000 g/hm^2 of potassium dihydrogen phosphate can be applied 18 – 20 d prior to heading. The application is designed to enhance plant stress resistance and meet the potassium supply needs, resulting in increased grain fullness and weight, and decreased grain emptiness.

4.8 Disease control The diseases, such as rice blast, false smut and rice brown spot, often occur in hybrid rice dry planting in mountainous area, which is similar to those in paddy field.

Rice blast is a major disease that can cause yield reduction or even total crop failure. It has three major forms: leaf blast, neck blast, and grain blast. Among these, neck blast is particularly damaging. Fungus-bearing seed is the main source of disease. During the booting and heading stages in July and August, the pathogen infects more rapidly in the presence of continuous rain, heavy fog and dew, and moderate temperatures. Neck blast can often cause severe damage in the late stage. Elimination of fungal sources is a major prevention and control measure in production. Usually, 1 kg of seeds are soaked in the mixed solution of 1 g of 50% carbendazim and 1 kg of water for 24 h. During the growth period of rice plants, 1 200 – 1 500 mL/hm^2 of 40% isoprothiolane or 450 – 750 mL/hm^2 of 75% tricyclazole can be diluted with 600 L/hm^2 water and sprayed in the early stage of rice blast. These measures should be combined with the application of phosphorus and potassium fertilizer to improve crop disease resistance.

False smut is a serious disease of dry planting rice, which affects the yield and quality of rice by affecting spikelets. False smut often seriously occurs in heading and flowering stage due to high temperature and high humidity. In addition, excessive application of nitrogen fertilizer is also a factor inducing false smut. Therefore, seed disinfection is an important prevention measure in production. Usually, seeds are soaked in 1 000 times dilution of 50% carbendazim WP for 24 h or 3% – 5% lime water for 12 – 20 h for seed disinfection. Reasonable fertilization is a cultivation measure to prevent false smut, while the application of phosphorus and potassium fertilizer should be increased. 20% Jinggangmycin can be used to spray rice at initial heading stage[2-3].

Rice brown spot[4] can cause damage throughout the growth stage of dry planting hybrid rice in mountainous areas, with leaf as the priority target. The damaged leaves initially show small brown spots, which then expand into circular brown lesions. The lesions are yellowish-brown or grayish-white in the middle and brown in the margin. Sometimes, the lesions on the vein develop into stripe spots. The lesions are small in nitrogen deficiency, and large in potassium deficiency. When the disease is severe, the growth of rice plants is hindered, with dry leaves, less tillers and delayed heading. The symptoms of the affected spikes are similar to that of neck blast, and the disease only affects plumpness of kernel without presence of white spot. The disease's occurrence and prevalence are greatly affected by soil fertility, quality, and variety. It is more serious when the soil is thin and lacks fertilizer, particularly potassium. The disease typically occurs alongside rice blast when the temperature is between 29 – 30 ℃ and the relative humidity is above 90%. This happens in conditions of high nitrogen and potassium deficiency, and the plants are vulnerable during the seedling and heading stages. As brown spot in rice is a physiological disease that shares a similar occurrence pattern with rice blast, the same measures for seed disinfection and chemical control can be applied. In addition, since additional application of potassium fertilizer inhibits the occurrence of rice brown spot, 2 250 – 3 000 g/hm^2 potassium dihydrogen phosphate can be diluted with 450 kg/hm^2 of water, and sprayed at booting and heading stages to increase the resistance of rice plants.

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