Breeding and Seed Production Techniques of New Aromatic Danxiangyouzhenliang Rice Variety with Good Quality and High Yield

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Abstract Danxiangyouzhenliang rice is a high-quality rice variety derived from the hybrid breeding of Danxiang 12A and Xianghuixiangmiao R133. Its unique temperature-sensitive three-line characteristics endow it with significant advantages of high and stable yield, and its rice fragrance is exquisite and its taste is delicate. Danxiangyouzhenliang rice showed good resistance to rice blast and bacterial blight. On June 10, 2021, Danxiangyouzhenliang rice passed the Guangxi Crop Variety Approval (Guishendao 2021074). Danxiangyouzhenliang rice is suitable to be planted as early and late rice in southern, central and northern Guangxi. This study summarized the breeding process and high-yielding seed production techniques of Danxiangyouzhenliang rice, in order to provide useful reference for rice breeders and growers.

Key words Danxiangyouzhenliang rice, Seed production technology, High-quality rice, Hybrid breeding, Temperature-sensitive three-line

1 Introduction

Danxiangyouzhenliang rice is a three-line temperature sensitive rice variety with high quality developed by Guangxi Pusi Agriculture Development Co., Ltd. in cooperation with Xiangzhou County Huangshi Rice Research Institute through breeding by crossing sterile line Danxiang 12A with restorer line Xianghuixiangmiao R133. This variety shows excellent performance in many aspects, such as high and stable yield characteristics. Danxiangyouzhenliang rice is of high quality and rich in flavor. This variety also shows moderate resistance to rice blast and bacterial blight. On June 10, 2021, Danxiangyouzhenliang rice passed the Guangxi Crop Variety Approval of Guangxi Zhuang Autonomous Region Crop Variety Examination and Approval Committee (Guishendao 2021074). Danxiangyouzhenliang rice is suitable to be planted as early and late rice in southern, central and northern Guangxi.

2 Breeding process

2.1 Sterile line Danxiang 12A Danxiang 12A is a rice variety bred by Xiangzhou County Huangshi Rice Research Institute of Guangxi Zhuang Autonomous Region. In 2011, early crop used Yinfeng A as the male parent to cross with Xianghui 1973 as the female parent, F_1 was crossed with Xiangnuo, the additional generation was selected to bF4 generation, the individual plant of bF4 generation was selected as the male parent and then test-crossed with Manxiang 16A as the female parent, and the individual plant with good plant leaf type, good flowering habit, strong tillering ability and high stigma exsertion rate (SER) was selected from the hybrid offspring. The excellent individual plants were selected from F_5 generation for test crossing, and the lines with complete sterility were continuously backcrossed. By 2015, the late rice maintainer lines were selfed to F_6 generation and backcrossed to BC9, and the maintainer lines with consistent agronomic traits, complete abortion and stable sterility and the corresponding sterile lines were obtained. Then, the rice quality and resistance of these lines were identified, and the maintainer lines and corresponding sterile lines with uniform and stable agronomic traits, strong resistance and good rice quality were selected, numbered 12A/12B. At the same time, it was screened and propagated, and mated with R141, R2015, R513, R133 and other restoration lines, and was tested for early rice trial and identification in Nanning, Liuzhou, Hechi, Guilin and other places in 2017, and screened from 2017 to 2018. In 2019, they participated in the Haokai association regional trials and production trials.

2.2 Restoring line Xianghuixiangmiao R133 Xianghuixiangmiao R133 was bred by Xiangzhou County Huangshi Rice Research Institute. In 2012, a late-maturing restoring line of medium indica rice was selected from multi-generation self-pollinated plants by artificial pollination. Its relatives are composed of upland japonica rice/Xianghui 9601, in which upland japonica rice is the female parent, and Xianghui 9601 is the excellent intermediate material selected by the self-fertile wild hybrid offspring, the F_1 generation was planted in 2012, the impurities were removed, and the F_1 seeds were harvested, and the offspring were screened, identified and eliminated for 5 years and 10 generations, and 4 excellent single plants (F_5 generation) were selected. In 2014, the selected excellent individual plants were planted into two plant rows, and two excellent plant lines with good plant type, good

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flowering habit, strong tillering ability and uniform performance were selected. From 2014 to 2017, the two selected lines were matched with the sterile lines of Yuanxiang 39A, 12A, 9A, Yexiang A, *etc.*, and the combination of strong restoring advantages was screened for testing restoring performance, and at the same time, the best of the male parents were selected, and the strains numbered R133 were finally selected with consistent population traits and stable restoring performance, and named Xianghuixiangmiao R133.

2.3 Combination Danxiangyouzhenliang rice From 2015 to 2017, the restorer lines were selected to mate with Danxiang 12A test, and at the same time, the plot ratio test and small-area seed production were carried out. The experiment was carried out in Nanning, Laibin, Guilin and other places to observe its high yield, stress resistance and adaptability, and finally the combination 12A/R133 with moderate growth period, luxuriant growth, good ripening color in the late stage, high yield, good rice quality and strong resistance was selected and named Danxiangyouzhenliang rice. In 2019 – 2020, it participated in Haokai association regional trials and production trials for late maturity group of late rice in central and northern Guangxi. Danxiangyouzhenliang rice passed the Guangxi Crop Variety Approval of Guangxi Zhuang Autonomous Region Crop Variety Examination and Approval Committee (Guishendao 2021074).

3 Yield performance

In the regional test of late rice of Danxiangyouzhenliang rice 2019, the average yield of six test sites was 8.24 t/ha, which was 2.38% (not significant) higher than that of Tianyouhuazhan (CK), the yield increase rate was 83.3%, and the seed setting rate was less than 65%; in 2020, the average yield of six experimental sites was 7.08 t/ha, which was 1.65% (not significant) higher than that of Tianyouhuazhan (CK), the yield increase rate was 83.3%, and the seed setting rate was less than 65%, the average yield was 7.66 t/ha, which was 2.02% higher than that of Tianyouhuazhan (CK). In 2020, the average yield of late rice production in central and northern Guizhou was 7.15 t/ha, which was 0.66% higher than that of Tianyouhuazhan (CK), and the proportion of yield increase points was 50%. In 2020, the average yield of early rice in Guinan was 7.34 t/ha, which was 0.36% higher than that of the control Teyou 7118, and the proportion of yield increase was 60%, and the average yield of late rice was 7.60 t/ha, which was 3.14% higher than that of the control Fengtianyou 553, and the proportion of yield increase was 60%.

4 Main features and characteristics

4.1 Morphological and growth period characteristics This variety has good luxuriance, strong tillering ability, green leaf sheath, green leaf color, colorless auricle and stigma, yellow rice tip, compact plant type, raised leaf posture in the middle and late stages, slightly rolled in tile shape. The plant height is 105.1 cm, the panicle type is long, the grain density is general, the panicle length is 23.2 cm, the total number of grains per panicle is 232.5, the seed setting rate is 78.2%, the grain is yellow, some awns are short, the grain length is 8.3 mm, the length-width ratio is 3.9, and the 1 000-grain weight is 20.1 g. Danxiangyouzhenliang rice is a three-line indica hybrid rice variety. It is planted as early rice in the south of Guangxi. Its average growth period is 121.6 d, which is 3.4 d shorter than that of Teyou 7118. When planted as late rice in the south of Guangxi, the whole growth period was 112.6 d, which is 6.2 d shorter than that of Fengtianyou 553. When planted as late rice in the middle and north of Guangxi, the whole growth period is 111.5 d, which is 0.5 d longer than that of Tianyouhuazhan.

4.2 Resistance performance According to the rice blast resistance identification by the Plant Protection Institute of Guangxi Academy of Agricultural Sciences from 2019 to 2020, the comprehensive indexes were 6.0 and 4.5, respectively. The highest loss rate of panicle blast was grade 5, and the resistance evaluation was resistant; the annual bacterial blight was grade 9 and grade 5, respectively, and the resistance evaluation was moderately sensitive.

4.3 Rice quality Through testing by the Rice and Products Quality Supervision and Inspection Center of the Ministry of Agriculture, the brown rice rate was 82.9%, the whole milled rice rate was 65.7%, the gel consistency was 72 mm, the amylose content was 15.5%, the chalkiness was 0.2%, the transparency was 1 grade, and the alkali spreading value (ASV) was 7.0 grade. The grain length was 6.8 mm, and the length-width ratio was 3.9, which reached the first-class standard of *Cooking Rice Variety Quality* (NY/T593-2013); the aroma score was 76, which met the aroma standard of *Aromatic Rice* (NY/T596-2002).

5 Key points of cultivation techniques

5.1 Timely sowing and cultivating strong seedlings The sowing time is about March 15 for early rice and before July 3 for late rice in northern Guangxi. The weight of seeds used was 22.5 – 30.0 kg/ha for early rice in central Guangxi on March 10 and for late rice before July 12. The seedling age of early rice was 25 – 30 d and that of late rice was 18 – 20 d, the row spacing was (16.7 – 20.0) cm × 26.7 cm, and 2 – 3 seedlings are planted per hour. 180 000 to 225 000 hole/ha of seedlings are planted, and more than 750 000 hole/ha of basic seedlings are guaranteed. In the field with poor fertility, the transplanting density should be increased appropriately.

5.2 Scientific fertilizer and water management According to the fertilizer tolerance of this variety, the amount of fertilizer used depends on the basic fertility of the planting plot. For medium fertility fields, 120 – 150 kg/ha of pure nitrogen is generally applied; the ratio of nitrogen, phosphorus and potassium is 1∶0.5∶1, and sufficient base fertilizer is applied. When harrowing, 300 kg of 45% compound fertilizer (15-15-15), 75 kg/ha of urea, 35 kg/ha of phosphate fertilizer and 75 kg/ha of potassium chloride are applied. Topdressing with 60 kg/ha of urea, 28 kg/ha of phosphate fertilizer and 60 kg/ha of potassium chloride was carried out 6 – 7 d after transplanting, so that the seed-

lings could grow early and quickly. In addition, 15 kg/ha of urea, 7 kg/ha of phosphate fertilizer and 15 kg/ha of potassium chloride should be topdressed at the end of the fifth stage and the beginning of the sixth stage of young panicle differentiation. Fertilization includes base fertilizer, tillering fertilizer and panicle fertilizer, and the fertilization ratio is 5∶4∶1. It is necessary to apply enough base fertilizer, apply tillering fertilizer early, and apply strong seed fertilizer as appropriate in the later period. Water management: shallow water transplanting, thin water to promote tillering, enough seedlings to dry the field, keep dry, dry, wet and wet to mature.

5.3 Prevention and control of plant diseases and insect pests In combination with fertilizer and water management, the main diseases and insect pests such as rice planthopper, rice borer, rice blast and bacterial blight should be controlled with pesticides in time according to the growth condition of seedlings and the forecast of diseases and insects.

6 Seed production technology

6.1 Trial production In 2020, the trial area of winter seed production in Yazhou seed production base in Sanya City, Hainan Province was 1.56 ha, the yield was 4.56 t, and the average yield was 2.92 t/ha. In 2020, the trial area was 0.75 ha in Huangguan Town, Guanyang County, Guilin City, Guangxi and the total seed yield was 2.25 t, and the average yield of 3.0 t/ha. In 2020, the trial area was 4.07 ha in Xialintun, Luoxi Village, Yongle Town, Rongshui County, Guangxi and the stored seeds were 10.37 t, and the average yield of 2.55 t/ha. After trial production in various plots in 2020, the seed production technology is mature, and a set of targeted high-yield seed production technology of Danxiangyouzhenliang rice is summarized. In the whole process of seed production, management should be carried out according to each production link: good seedling is the premise, good seedling is the foundation, flowering period meeting is the key, every effort should be made to improve the seed setting rate, disease prevention and pest control is the guarantee. Further, it should implement strict isolation, impurity removal and timely harvesting.

6.2 Meteorological analysis In the selection of seed production season, three safe periods must be analyzed at the same time: the daily average temperature is about 25 – 28 ℃; the air relative humidity for the best performance of outcrossing and fruiting ability of rice seed production is about 80%; there should be no more than 3 d of rainy weather and "dry hot wind" during flowering and pollination. According to the meteorological data provided by the Rongshui County Meteorological Bureau, from the end of August to the beginning of September, the average daily temperature was about 26.9 ℃, and the temperature was not lower than 23 ℃. When the relative humidity is about 81.3% and there is no rain for more than 3 d, it is the best time for heading and flowering of hybrid rice. The produced seeds have good appearance quality and high germination rate.

6.3 Base selection and precautions Paddy fields should be concentrated and connected, easy to isolate, with good soil structure, high fertility level, no cold water paddy fields, rusty paddy fields, deep mud fields, abundant sunshine, convenient irrigation and drainage, and strong ability to retain fertilizer and water. It should avoid sugarcane fields, perennial wastelands, and dry crop fields. Varieties were isolated, and the flowering period of parents was staggered with the flowering period of other rice varieties for more than 25 d. There is no rice planting within 500 m of the downwind side of the space isolation.

6.4 Arranging the sowing time difference according to the fertility characteristics of the parents It is necessary to sum up the means of seed production of the combination in various places, the growth period of the parents does not change much, the growth period is stable, the duration from sowing to beginning of the female parent was about 68 d, and the duration from sowing to beginning of the male parent was about 73 d. The female parent blooms in a concentrated manner, and the best flowering period is 1 to 2 d earlier than the male parent, so that "the first flower of the female parent is not empty, the last flower of the male parent is not lost, and the flowers of the male parent meet in full bloom"[1]. The full bloom stage completely meet in that whole heading and bloom stage of the parents. For seed production in the autumn of 2020, the male parent is sown on June 20, the female parent is sown on June 25, the time difference is 5 d, the leaf difference is 1.65 leaves, the male parent is sown for one time, the transplanting is divided into two times, half of the male parent is transplanted with mud, half of the seedlings are washed and put in the shade at home for one night, the transplanting is carried out again in the afternoon of the second day, which is pseudo second stage, the heading is delayed for 1 – 2 d, but it can reach the concentration of full flowering. On the premise of determining the sowing time difference, we should strengthen the field management measures, formulate standardized field management measures from sowing to heading and flowering, investigate the growth and development changes of parents, and urge the timely implementation of various technical measures. It is necessary to ensure that the growth and development of the parents are normal, controllable and adjustable, and to avoid the deviation of the growth period caused by improper cultivation and management, which affects the flowering period.

6.5 Cultivating strong seedlings with more tillers and transplanting them in time Rice seedling beds should be selected with good fertility and convenient irrigation and drainage, and sufficient base fertilizer should be applied. The amount of seed used in the field was 18.8 – 22.5 kg/ha for the female parent, 135 – 150 kg/ha for the sowing amount in the seedling bed, 250 cm for the width of the box, double rows for the male parent, and the ratio of the male row to the female row was 2∶(12 – 14). The male parent is planted in large double rows, the planting size is 33.3 cm × 26.7 cm, one row is planted in the first stage and one row is planted in the second stage, two seedlings are planted in each hole, the interval between the male and female parents is 25 cm, the planting size of the female parent is 13.3 cm × 20.0 cm, 2 – 3

seedlings are planted in each hole, and 1.2 – 1.35 million basic seedlings are planted. It is necessary to sow sparsely and evenly. Weaning fertilizer, 112.5 kg/ha of urea and 90 kg/ha of potassium chloride fertilizer are applied to 1.5 to 2.1 leaves of the seedling bed, and 1 inch of water layer was kept within 3 d to prevent the seedlings from being burned by high temperature fertilizer. At 4 to 5 d before transplanting, that fertilize and the pesticide are applied once, so that the fertilizer and the pesticide are applied to the field, and the insect source and the pathogenic bacteria are eliminate in the seedling bed. During seed production in autumn, the leaf age of the male parent is 6.5 d, and the seedling age is 20 – 22 d. The leaf age of the female parent is 5.0 – 5.5 d, and the seedling age is 17 – 19 d. The male parent was transplanted first and then the female parent is transplanted, the row ratio of male and female parents is 2 ∶ 12, the row spacing is 25 cm, and the male parent is transplanted in large double rows. In the pseudo second stage, the male parents are planted at intervals, the row spacing is 20.0 cm × 23.3 cm, the row spacing of male parents is 33.3 cm × 26.7 cm, 2 – 3 seedlings are planted in each hole, 29 000 to 30 000 holes are planted in each ha, and 320 000 to 330 000 holes of basic seedlings are planted. The row spacing of female parent is 13.3 cm × 20 cm, 2 – 3 seedlings are planted per hole, 240 000 holes are planted per ha, and the basic seedling is 1.92 million – 2.16 million/ha.

6.6 Scientific fertilizer and water management Before transplanting and when leveling the field, spray 300 kg/ha of 45% compound fertilizer NPK (N-P-K = 15-15-15), 122.5 kg/ha of urea, 122.5 kg/ha of potassium chloride, mix them evenly and then apply them deeply (dry the field), 5 – 7 d after transplanting, apply evenly 90 kg/ha of urea and 175 kg/ha of potassium chloride. When the young panicle differentiation enters the end of the fifth stage and the beginning of the sixth stage (the leaf pillow is flat), the field is observed and the seedling is observed, the strong panicle fertilizer is applied in the sandy soil field and the field where the seedling is yellow, and 45 kg/ha of urea and 60 kg/ha of potassium chloride are applied. Base fertilizer should be applied much, topdressing should be applied early, and panicle fertilizer should be applied properly. After transplanting, the rice seedlings should be planted in deep water, tillering in shallow water, flowering in running water, and dry and wet irrigation alternately. When the total number of seedlings reaches 80%, the field should be dried in time to control ineffective tillering, consolidate effective tillering, improve soil environment, enhance root activity, inhibit pests and diseases, and improve disease resistance and lodging resistance. Sunning the field until the seedling leaves can be heard when wind blowing, the seedling tips prick the palm, the deep soil field is heavily sunned, the sandy soil field is lightly sunned, and irrigation should be carried out according to the conditions of the field, the weather and the seedlings. In the heading and flowering stage, in case of high temperature weather, irrigate deep water to cool down and increase field humidity. After the artificial pollination, in the later stage of growth, water should be not deficient, use root nutrients and water to maintain leaves, and use air to nourish the roots, and use leaves to increase the weight.

6.7 Prevention and control of plant diseases and insect pests According to the occurrence of diseases and insect pests in Rongshui County over the years, the seed production season is the season with the most abundant temperature and light conditions in a year, and also the season with the most active occurrence of diseases and insect pests in a year[2]. Prevention and control of diseases and insect pests should be based on prevention and combined with control. Seed production in autumn is mainly to prevent and control four pests and three diseases, namely *Scirpophaga incertulas*, *Cnaphalocrocis medinalis*, *Nilaparvata lugens*, southern rice black-streaked dwarf disease, rice blast and leaf smut. The prevention and control of rice diseases and insect pests should focus on three key periods: the early booting stage of rice, the breaking stage of rice (the stage at which a part of the ear (grain) of rice begins to protrude from the bract) and the filling stage after flowering. *Tarsonemus*, a new pest of rice occurring in Rongshui County in recent years, needs to be prevented and controlled. Because of its small body, hidden damage, no obvious symptoms in the early stage, it is difficult to see with the naked eye. It mainly damages the leaf sheath and young ear at the booting stage, causing the inner wall of the leaf sheath to break and turn brown, the young ear and spikelet to change color and die, forming withered ears or half-dead fruit reduction, resulting in the failure to survive after pollination, seriously affecting the yield of seed production. Because of its small body, hidden damage, no obvious symptoms in the early stage, it is difficult to see with the naked eye. It mainly damages the leaf sheath and young ear at the booting stage, causing the inner wall of the leaf sheath to break and turn brown, the young ear and spikelet to change color and die, forming withered ears or half-dead fruit reduction, resulting in the failure to survive after pollination, seriously affecting the yield of seed production. According to the occurrence of each pest and disease and the prediction and forecast of the local plant protection department, the corresponding pesticides should be selected in time for prevention and control.

6.8 Spraying appropriate amount of gibberellin (GA) at the right time to improve the seed setting rate The female parent Danxiang 12A and the male parent Xianghuixiangmiao R133 are sensitive to gibberellin (GA). When the initial panicle of the female parent is 15% – 20%, gibberellin should be sprayed according to the meeting of the flowering period, and the method of mild in the beginning, much in the middle, and supplementation in the end should be adopted. 60 g/ha of gibberellin with 450 kg/ha of water is used for the first time, 120 g/ha of gibberellin is used for the second time, and 30 g/ha of gibberellin is used for the third time. The female parent should be sprayed at the same time each time, the male parent is sprayed once again, 60 g/ha gibberellin is sprayed on the male parent at the same time each

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build patriotic values. Through the research on the integration of educational drama, we can open up a road of patriotic education that primary school students like. It can make primary school students feel that patriotic education is no longer a tasteless theoretical indoctrination and a formal process step by step, but a vivid, interesting, real and live education, so that primary school students can cultivate patriotic feelings in a subtle way and internalize them in their hearts and externalize them in their actions. Thirdly, it is also conducive to promoting educators in patriotism education of primary school students to improve their own quality. The research on the way of integration can make educators have a more specific understanding of the application of educational drama, and it is conducive to prompting educators to strengthen the use of educational drama in their work, so that educators can constantly reflect on teaching and change their educational ideas in the specific educational environment, truly put people first, and cultivate people with all-round moral, intellectual, physical, and aesthetical grounding with a hard-working spirit, so that educators' teaching philosophy and teaching level can be improved.

Therefore, the academic circles should pay enough attention to educational drama and the integration of educational drama into primary school students' patriotism education, and further strengthen the research on the integration of educational drama in primary school students' patriotism education.

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time, the male parent is sprayed once on the same day after the third gibberellin is sprayed, and 30 g/ha gibberellin is used when the flowering period meets. For a few fields with early male parent, in the afternoon of the day when the first gibberellin is sprayed, the male parent is sprayed only once, and the dosage of gibberellin can be increased appropriately, so that the tillering seedlings (three intact leaf seedlings) of the early male parent are pulled out higher than those of the female parent, which is beneficial to pollination. The dosage of Huaxile (Tiaohuabao) added for the second time was 90 g/ha. When spraying the gibberellin for the second time, the parents are sprayed at the same time. The male parent should be about 10 cm higher than the female parent, which is beneficial to pollination. After the male parent blooms, artificial pollination begins. At an interval of 25 min, artificial pollination should be repeated 4 to 5 times for 9 – 10 d until no pollens are found.

6.9 Removing impurities to ensure the seed quality It is necessary to strictly control the purity of parents, and parents must pass the purity identification above 99.5% before they can be used in production. Besides, it is necessary to prevent falling of the rice of the last year, and promptly remove different plants found in each link of production. In addition, it should seize three periods: 2 d before spraying gibberellin, after spraying the first gibberellin, and before harvesting, to thoroughly remove the miscellaneous plants in the parents. Through the investigation and identification of the purity in the field, the rice should not be harvested until the miscellaneous plants are kept within 1%.

6.10 Keeping strict control of the harvest of seeds to ensure the appearance quality In Rongshui County, the autumn seed production should be arranged to be harvested in late September, when the weather is very good and there is less rain. After 16 d of artificial pollination, 80% of the seeds should be harvested in time. It is required to clean up the threshing ground, take strict precautions against mechanical mixing, dry the seeds in time, and strictly prohibit the reduction of germination rate caused by stacking and heating.

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