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Study on the Biological Performance and Agronomic Trait Evaluation of Newly Introduced Fresh-Eating Maize Varieties in Linhai City

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Abstract As a special corn with the characteristics of both fruits and vegetables, the planting area of fresh corn in my country has expanded rapidly, and the market demand is strong. This study systematically evaluated several new varieties of fresh corn introduced in Linhai City, Zhejiang Province, and studied them from the aspects of biological traits, growth performance, agronomic traits, quality characteristics and regional adaptability. Regional trials and case studies showed that these new varieties showed good adaptability in Linhai City. Among them, varieties such as 'Caitiannuo 168' obtained a fresh ear yield of 900-1 200 kg per mu in Baishuiyang Town, which was significantly higher than the control variety; the new colorful sweet and glutinous varieties introduced in the coastal slightly saline-alkali land also achieved a fresh ear yield of more than 1 300 kg/mu, showing the advantage of salt tolerance. Based on the comprehensive trait evaluation and regional performance, excellent varieties such as 'Jinyin 208', 'Zhetian 19', 'Meiyu 25' and 'Caitiannuo 168' were selected for promotion in Linhai. This study also summarized the comprehensive performance of each variety, pointed out the current problems such as insufficient disease resistance, and put forward optimization suggestions for future introduction screening and efficient cultivation management, in order to provide a scientific basis for the renewal of fresh corn varieties and industrial development in Zhejiang coastal areas.

Keywords Fresh corn; Variety introduction; Biological characteristics; Agronomic traits; Regional adaptability

1 Introduction

Fresh corn refers to the type of corn that is harvested directly from fresh ears at the milky stage for consumption, including sweet corn and glutinous corn. Due to recessive mutations in the endosperm starch synthesis pathway, sugar accumulates in sweet corn kernels and the starch content decreases, making them sweet, crisp and tender; glutinous corn has a high content of amylopectin, is soft and sticky after cooking, has a thin skin and no residue, and is suitable for steaming and cooking (Li et al., 2022b). In recent years, fresh corn has been favored by consumers for its rich nutrition (rich in multiple vitamins, anthocyanins and dietary fiber) and its compliance with the concept of healthy eating, and its demand has been growing steadily worldwide. At present, the world's sweet corn planting area is about 1.34 million hectares, and the United States is the largest producer and consumer. China is the world's largest producer and consumer of fresh corn. In 2020, the national fresh corn planting area has exceeded 20 million mu, with an annual consumption of about 57 billion ears. The planting areas cover 24 provinces in Northeast China, North China, Southwest China, and East China, and the industry is developing rapidly. With the improvement of the living standards of urban residents, fresh corn has moved from first-tier cities to urban and rural markets across the country, and the demand has surged, becoming an emerging industry after feed corn and processed corn (Dang et al., 2023). Compared with ordinary corn, fresh corn has the advantages of high price and good benefits. The yield of fresh ears per mu can reach 4 500-5 000 ears, the wholesale price is 1.2-1.5 yuan/ear, and the output value per mu is about 3 000-4 000 yuan, which is far higher than ordinary corn. Therefore, vigorously developing fresh corn is of great significance to promoting farmers' income and meeting the diversified needs of the market.

Zhejiang Province is one of the important planting areas of fresh corn. Linhai City is located on the eastern coast of Zhejiang Province. It has a subtropical monsoon climate, sufficient light and heat, and abundant rainfall, and has good natural conditions for the development of fresh corn production. However, the local fresh corn industry

started late, and the high-quality varieties available for planting are limited. Introducing new varieties of fresh corn suitable for local cultivation is expected to improve the situation of single varieties and general quality, and meet the growing market demand for high-quality fresh corn (Li et al., 2022a). On the one hand, through variety introduction trials, the biological performance and yield potential of foreign bred varieties under coastal ecological conditions can be evaluated. On the other hand, the selected excellent varieties will provide new variety support for local agricultural structural adjustment and characteristic industrial development, help to create regional fresh corn brands and increase the added value of agricultural products. At the same time, the introduction trial can also provide a basis for the optimization of fresh corn cultivation technology and green pest control (Zhang et al., 2022; 2023). Therefore, the introduction of new varieties of fresh corn in Linhai City and the comprehensive trait evaluation research have important production practical significance and promotion value.

This study takes several new varieties of fresh corn introduced in Linhai City as the object, systematically evaluates their biological characteristics and agronomic traits, observes the emergence, growth dynamics and survival of each variety, analyzes their stress resistance and disease and pest resistance; determines the growth period and flowering characteristics; investigates the main agronomic traits such as plant height, ear position, plant type and ear morphological indicators (ear length, ear thickness, number of rows, etc.) and yield performance; determines quality traits such as the glutinous nature (branch starch content) and soluble sugar content of the grain, and conducts sensory tasting and market acceptance surveys; compares the adaptability differences of each variety under different environmental conditions in Linhai, calculates the regional recommendation index or comprehensive score; finally, combined with typical cases, analyzes the demonstration planting performance of excellent varieties, their adaptability on special soils (saline-alkali land), and the feedback from farmers participating in the trial planting. This study hopes to provide scientific basis and practical guidance for the variety renewal and efficient cultivation of fresh corn in Linhai City and even the coastal areas of Zhejiang Province.

2 Biological Performance

2.1 Germination, growth, and survival performance

The new varieties of fresh corn introduced in Linhai City showed good sowing emergence rate and seedling growth potential. The results of the field test showed that the seedlings of all varieties were basically uniform 4 to 5 days after sowing, and the seedlings emerged neatly and robustly, without obvious missing seedlings and broken ridges. The survival rate of the seedlings was generally above 95%. This is closely related to the seed vitality of the variety itself and the appropriate sowing period. The seeds of some super sweet corn (carrying the sh2 mutant gene) often have low seed vitality and difficulty in germination under low temperature conditions due to high sugar content and low starch in the endosperm (Revilla et al., 2021). However, the sweet corn varieties introduced this time were sown in time after the soil temperature rose in spring, and the seeds were coated to improve the germination rate and seedling resistance. It is reported that there are differences in the low-temperature germination ability of different types of sweet corn. The sh2 type sweet corn germinates the fastest under warmer conditions, but germination and seedling growth are most easily hindered in cold soil. Therefore, the local introduction experiment avoided the overcooling environment and ensured the normal emergence of super sweet corn. Field observations also found that the seedlings of each new variety had thick stems, well-developed root systems, and vigorous growth. A study on the introduction of fruit-type super sweet corn in Guangdong also pointed out that the 20 varieties tested were all early-maturing dwarf types, with high uniformity of seedlings and strong growth in the early stage (Wang et al., 2021). In this study, each variety entered a rapid growth period after the three-leaf stage, with rapid growth in plant height and dark green leaves, reflecting strong biological vitality and adaptability. The new varieties of fresh corn showed good emergence and seedling growth characteristics in coastal areas, and the high survival rate laid the foundation for subsequent normal growth and high yield.

2.2 Resistance to stress and pests

Fresh corn often faces challenges of high temperature and drought, soil salinity, and pests and diseases during its growth. The new varieties introduced in this study performed well in field stress resistance overall. Most varieties showed strong resistance to lodging and heat resistance. Plants can still bloom and bear fruit normally under high

temperature and high humidity conditions in summer, without serious lodging and stem rot problems. Among them, varieties such as 'Caitiannuo 168' also showed high tolerance to low temperature and cold damage. The seedlings were not frozen during early spring sowing, showing strong resistance to low temperatures (Figure 1). According to the performance of trial planting in coastal saline-alkali land, some sweet and glutinous corn varieties have certain salt tolerance and grow normally on plots with soil salt content of 0.2% to 0.3%, with almost no reduction in yield.

Figure 1 Seedlings of 'Caitiannuo 168'

In terms of disease and insect pest resistance, there are certain differences between different varieties. From the results of the adaptability identification of this introduction, it can be seen that the resistance evaluation of some varieties to major diseases is not ideal. For example, the results of the adaptability test in Zhejiang Province showed that varieties such as 'Xiantiannuo 88' and 'Ditiannuo 336' were susceptible to small spot disease, sheath blight, and southern rust after artificial inoculation of diseases. This suggests that some introduced varieties may lack the corresponding disease resistance genes locally, and field prevention and control need to be strengthened. Similarly, the study found that the overall disease resistance of fresh corn varieties in my country needs to be improved. In the evaluation of the resistance to head smut and gall smut of 58 fresh corn hybrids, no material showed high resistance, only one material ('Yuanyunuo 999') showed disease resistance (accounting for 1.7%), and another 4 materials were moderately resistant, and most of the remaining varieties were susceptible. Another similar identification of 47 fresh corns also showed that only 8.5% of the materials showed resistance to head smut, and most of the others were susceptible (Zhou et al., 2020). It can be seen that the current new varieties of fresh corn still need to be strengthened in disease resistance breeding. However, there are also differences between different varieties, and some varieties show relatively good resistance to diseases and insects. For example, the sweet corn 'Jingketian 608' bred in Beijing has strong disease resistance and stress resistance, and no epidemics of diseases such as large spot disease and rough dwarf disease have been seen in the field. For example, some glutinous corn varieties resistant to head smut ('Wannuo 2018', 'Jingkenuo 2000', etc.) are recommended as one of the key measures for disease prevention (Zou et al., 2024). In this study, no serious epidemic of pests and diseases occurred through agricultural control (such as crop rotation, clean fields) and necessary chemical control. The resistance of the introduced varieties to adversity can meet the needs of field planting in the coastal area, but it is still necessary to breed more resistant varieties or strengthen comprehensive control measures for susceptible diseases.

2.3 Phenological period and flowering characteristics

The growth process of various new fresh corn varieties in Linhai is generally early-middle maturity. The full growth period from sowing to fresh ear harvesting is mostly about 80 days, ranging from about 75 to 90 days, which is comparable to the control or local conventional varieties (Zhang et al., 2023). For example, the growth period of 'Xiantiannuo 88' in the spring sowing test was 84.8 days, which was similar to the control 'Suyunuo 5';

'Henuo 615' was 85.8 days from seedling emergence to harvest, which was about 5.6 days earlier than the control 'Meiyu 8'; the growth period of 'Ditiannuo 336' was 85.4 days, 5.2 days earlier than the control 'Zhenuoyu 5'; and the growth period of 'Zhencaitiannuo 608' was slightly longer at 89.4 days, but only 0.8 days earlier than the control. It can be seen that most of these new varieties are medium-early maturing and can fully mature in the spring and summer planting seasons in Zhejiang. A moderate growth period is very important for fresh corn: on the one hand, it ensures that the ears are harvested in time at the milky stage, and on the other hand, it also provides the possibility of two-season cultivation a year (spring sowing in early April and autumn sowing in late July can complete a growth cycle).

In terms of flowering characteristics, plants of all varieties tasseled and flowered about 50 to 60 days after sowing, with a relatively concentrated flowering period, sufficient pollen and good pollination synchronization. The test records show that the interval from tasseling to silking (filament exposure period) of different varieties is generally short, and pollination and fertilization can generally be completed in 2 to 3 days. The ear grain setting rate is high, and there is no serious bald tip and grain missing phenomenon. Among them, the "double ear rate" varies slightly among varieties: for example, about 4.7% of the plants of 'Henuo 615' can grow into double ears, and the double ear rate of 'Ditiannuo 336' is only 1.2% and the empty stalk rate is 0%, basically achieving one ear per plant and full ears per ear. The ear height is moderate (about 1/3 of the plant height), and the length of the filaments and the dispersion of pollen are conducive to fertilization. These characteristics ensure that fresh corn can fully set and increase yield at a suitable density. Most new varieties have medium-sized male spike branches, strong pollen vitality, and neat female spike filaments. It is rare to see missed flowering periods or poor pollination in the field. The new varieties of fresh corn introduced by Linhai City have a short or moderate growth cycle and can better adapt to the local climate and planting system; flowering synchronization and fruiting are good, laying a biological foundation for obtaining high-commodity fruits.

3 Evaluation of Agronomic Traits

3.1 Plant height, ear height, and plant structure stability

Through the actual measurement of agronomic traits of various varieties, the new fresh corn varieties introduced this time have a short and strong overall plant type, a low ear position and good stability, which is conducive to dense planting and lodging resistance (Table 1).

Table 1 Plant traits of the tested products (unit: cm, %)

-	Xuetian 7401	Jinyin 208	Zhetian 19	Putian 1	Qianjiangnuo 3	Zhenuoyu 18	Caitiannuo 168	Heitiannuo 168	Meiyu 25	Caitiannuo 617
Plant height	99	97	190	190	146	143	144	177	153	130
Empty stalk rate	0	0	0	0	0	0	0	0	0	0
Lodging rate	0	0	0	4	0	0	0	0	0	0

In terms of plant height, most varieties have a plant height between 1.7 m and 2.2 m, which is equivalent to or slightly shorter than conventional fresh corn. For example, the average plant height of 'Xiantiannuo 88' is 185.6 cm, the average plant height of 'Ditiannuo 336' is 176.2 cm, the plant height of 'Zhencaitiannuo 608' is 217.0 cm, and the plant height of 'Henuo 615' is 211.5 cm. Compared with the height of ordinary feed corn, which is often more than 2.5 m, the shorter plant height of fresh corn varieties is conducive to the transfer of nutrients to the ears and also enhances the ability to resist lodging. The ear height is generally around 70 cm to 75 cm, for example, the ear height of 'Ditiannuo 336' is 69.0 cm, the ear height of 'Xiantiannuo 88' is 70.5 cm, and the ear height of 'Zhencaitiannuo 608' is 74.2 cm. A moderate ear position means that the center of gravity of the plant is low and it is not easy to lodging in windy and rainy weather. Most varieties have semi-compact or compact plant types, with upright leaves and good ventilation and light transmission. This is also reflected in the 20 super sweet corns introduced in Guangdong: these varieties have high plant uniformity, short and strong plant types, and low field

density (Wang et al., 2021). Through the field lodging resistance test, it can be seen that the introduced varieties basically have no lodging from heading to maturity, and most varieties have strong stalks and well-developed root systems. For example, the lodging rate and bending rate recorded at the test sites of 'Xiantiannuo 88', 'Ditiannuo 336', and 'Zhencaitiannuo 608' are all 0%. This suggests that these varieties are genetically resistant to lodging, or that the plant shape and mechanical strength support the plants' high yields without falling over.

3.2 Ear length, thickness, and kernel row number

Ear traits are important indicators for measuring the commodity value of fresh corn varieties. The ear appearance and structure indicators of each variety measured in this study are as follows: the average ear length is between 18 cm and 22 cm, the ear diameter (ear transverse diameter) is about 4.5 cm to 5.5 cm, and the number of ear rows is mostly 12 to 16. There are slight differences between different varieties, but overall they can form medium-to-large ears, meeting the requirements of fresh corn commodities. For example, the ears of 'Xiantiannuo 88' are conical, with an ear length of 19.7 cm, an ear diameter of 4.8 cm, and 14 rows of ears; the ears of 'Henuo 615' are cylindrical, with an ear length of 20.7 cm, an ear diameter of 5.0 cm, and 14 rows of ears; the ears of 'Ditiannuo 336' are cylindrical, with an ear length of 19.4 cm, an ear diameter of 5.3 cm, and 13.1 rows of ears; the ears of 'Zhencaitiannuo 608' are 21.6 cm long, an ear diameter of 5.4 cm, and 14.9 rows of ears. It can be seen that the ear length of these new varieties is generally around 20 cm, the thickness is about 5 cm, and the size is uniform. In comparison, the ideal ear length of general fresh corn is between 18 cm and 22 cm. cm, and the number of ear rows is between 12 and 18 rows, so the ear type of this batch of varieties has reached or is close to the ideal target. In terms of the arrangement of the ear axis and grains, the performance of each variety is also relatively good. The results of field testing show that the tops of the ears of many varieties are well-formed, the bald tips are very short or even absent, and the grains are evenly full from the base to the top. For example, the bald tip length of 'Ditiannuo 336' is only 0.6 cm, and the bald tip length of 'Zhencaitiannuo 608' is 0.8 cm, which is basically negligible. This shows that they can be fully fertilized during the flowering and pollination period, and there is no poor pollination caused by stresses such as drought and high temperature. Neat and compact arrangement of ear rows is also one of the important traits of fresh-eating corn (Wang et al., 2023). The grains of the cited varieties are evenly arranged, and the number of grains in a row is generally between 30 and 40. For example, 'Henuo 615' has an average of 40.4 grains per row, and 'Ditiannuo 336' has 36.2 grains per row. These data show that a single ear can accommodate a large number of grains and has the potential to become a large-ear variety. The grain size of different varieties varies. Sweet corn grains are relatively small and round, while glutinous corn grains are relatively large and flat. When screening high-quality fruit corn in Guangdong, it was also found that the grain size of the test varieties ranged from small to medium, and the head and tail of the ear were uniform, with no obvious size differences. Similar situations were observed in this study: such as the sweet corn variety 'Jinyin 208' has relatively small grains but is closely arranged, while the glutinous corn variety 'Meiyu 25' has relatively large grains but has regular rows. The introduced varieties have excellent ear length, thickness, and number of rows, and outstanding commercial traits. The large, uniform, and full ear shape lays the foundation for its popularity in the market.

3.3 Yield performance and estimated economic benefits

Through two years of regional trials and field yield measurements, this batch of new fresh corn varieties have shown a high level of fresh ear yield, and some varieties have a significant yield advantage over local controls. The results of regional trials show that under ordinary field conditions (non-saline-alkali land), the yield of fresh ears per mu of most varieties is between 800 and 1 000 kilograms, and the yield of some excellent varieties exceeds 1 200 kilograms per mu. Taking the data of the adaptation test of introduced varieties in Zhejiang Province as an example: in the spring of 2019, 'Xiantiannuo 88' was tested in five pilot areas including Longyou, Jinhua and Ningbo, with an average yield of 1 230.2 kg per mu, 4.4% higher than the control 'Suyunuo 5'; 'Henuo 615' had an average yield of 895.1 kg per mu, 18.4% higher than the control 'Meiyu 8'; 'Ditiannuo 336' had an average yield of 807.5 kg per mu, 3.2% higher than the control 'Zhenuoyu 5' (especially good in the pilot area of Linhai); 'Zhencaitiannuo 608' had an average yield of 957.3 kg per mu, 22.3% higher than the control, with significant yield increase effect. These data show that in Linhai and similar ecological areas, these new varieties

generally have high yield potential, and some varieties can increase yield by more than 15% to 20%. Of course, there are also differences in yield between different varieties. For example, the sweet and sticky 'Caitiannuo 168' created the highest fresh ear yield in the experiment, and its yield per mu reached about 1 370 kg at the experimental site (about 25% higher than the control variety, the data has not been officially published, and it comes from the experimental records). In contrast, some varieties with excellent quality but slightly smaller ears (such as 'Jinyin 208') have slightly lower yields per mu, but can also reach more than 800 kg. In trials in other regions, the high-yield potential of new varieties of fresh corn has also been verified. For example, in a variety comparison study in Indonesia, the recommended sweet corn hybrid 'Bonanza' had the highest yield at 65 days of harvest, and the fresh ear yield per hectare was significantly better than other varieties (Subaedah et al., 2021). For example, the 'Lutiannuo 191' cultivated in Shandong Province is the first new variety of salt-alkali tolerant colored sweet and sticky corn. In recent years, the yield per mu in multi-point tests has increased by more than 10% compared with the control. In 2022, the yield per mu was measured in Wudi County, Binzhou, and the yield per mu was measured in Zhaoyuan City, Yantai, with outstanding results of 1 333.4 kg and 1 546 kg, respectively. These records have refreshed the yield level of fresh corn and demonstrated a very high potential for yield increase.

From the perspective of economic benefits, the promotion and planting of new varieties of fresh corn will bring considerable benefits to local farmers in Linhai. First of all, the market purchase price of fresh corn is significantly higher than that of feed corn, either by ear or by fresh weight. According to statistics, the output value of fresh corn (with ears) per mu can reach about 3 000 to 4 000 yuan, which is about 2 to 3 times that of ordinary corn. The high-quality varieties selected in this experiment (such as 'Caitiannuo 168', 'Zhetian 19', etc.) have both excellent yield and quality, and their per mu output value is conservatively estimated to be more than 3 500 yuan. If simple processing (such as vacuum packaging and quick freezing of fresh ears) is carried out, the selling price of the product can be doubled. Feedback from farmers participating in the trial planting shows that planting fresh corn can increase income by about 500 to 800 yuan per mu compared with planting ordinary corn, and about 6 000 yuan more per hectare. At the same time, corporate order acquisition and processing and export also provide farmers with stable sales channels and dividend income. Taking the "Nongsao" company in Gongzhuling City, Jilin Province as an example, farmers in its base can increase income by about 6 000 yuan per hectare after planting sweet corn, and realize multi-channel income increase through employment and dividends. If Linhai City promotes fresh corn, it can also adopt the "company+farmer" model to improve benefits. It is worth noting that some new varieties of fresh corn are not only effective in fresh ear sales, but also reflect economic value through the transfer of variety rights. For example, the auction price of the production and operation rights of the 'Lutiannuo 191' variety is as high as 1.5 million yuan, which shows the "gold content" of excellent varieties. It can be seen that the introduction and promotion of new varieties of high-yield and high-quality fresh corn can significantly increase unit area output and farmers' income. At the same time, through large-scale planting and brand building, it is hoped that a regional characteristic industrial chain will be formed to further enhance economic benefits.

4 Quality Trait Comparison

4.1 Stickiness and sweetness assessment

The quality of fresh corn is mainly reflected in the glutinousness (branch starch content and texture) and sweetness (soluble sugar content) of the kernels. The introduced varieties include sweet corn, glutinous corn and sweet and glutinous types, each with its own characteristics in kernel composition and taste. Sweet corn (normal sweet, super sweet, enhanced sweet) kernels contain a variety of soluble sugars, such as sucrose, glucose, fructose, etc., and the accumulation of sugars makes it sweet and delicious (Li et al., 2020). The total sugar content of fresh ears of super sweet types (such as those carrying the *sh2* gene) can reach 20%~30% of the dry matter of the kernels, which is higher than that of ordinary fruits (such as watermelon), and can be called "high-sugar vegetables". In this study, it was found that the soluble solids (sugar content) of sweet corn varieties at the milky stage averaged more than 15°Brix, and the highest variety was close to 20°Brix, which is much higher than the sweetness of ordinary corn. Since glutinous corn has the *wx* gene, it is almost 100% amylopectin. Its starch

structure makes the kernels have a special sticky taste after being cooked. Although the soluble sugar in the fresh kernels of glutinous corn varieties is not as high as that of sweet corn (generally only 2% to 5% of small molecule sugars), its starch is soft and sticky after gelatinization, without residue, and is suitable for steaming or baking (Zhang et al., 2017). Sweet and glutinous corn contains mutant genes of both sweet corn and glutinous corn. The kernels contain a certain amount of sugar and are mainly glutinous starch. It is a new category of breeding innovation in recent years. Sweet and glutinous corn has the advantages of both sweetness and stickiness. It is usually sweet and juicy when eaten raw, and soft, sticky and sweet when cooked (Wu et al., 2023). For example, varieties such as 'Lutiannuo 191' that are both sweet and glutinous have a ratio of 1: 3 between sweet and glutinous grains on the cob. The sweet grains are sweet and the glutinous grains are moderately sticky, achieving a balance between flavor and texture. 'Zhencaitiannuo 608' is a double-color sweet and glutinous corn, with purple and white grains, which are both sweet and glutinous, and rich in nutrients. Through indoor quality analysis, the sucrose and total soluble sugar content of some sweet corn varieties (such as 'Jinyin 208') is significantly higher than that of glutinous corn varieties, while the amylopectin content and amylose/amylopectin ratio of glutinous corn varieties (such as 'Meiyu 25') are significantly lower than those of sweet corn varieties. This is consistent with the conclusions of existing studies: sweet corn has good flavor sweetness due to the obstruction of starch synthesis caused by mutant genes, and the accumulation of sugars is increased; glutinous corn has no amylose at all, so it is thick and not hard after cooking, and has good glutinous properties. It should be noted that sweetness and stickiness are in a trade-off relationship among different varieties, that is, sweet corn is sweeter but not sticky, sticky corn is sticky but not sweet enough, and sweet and sticky varieties are in between. Therefore, for fresh consumption, diversified provision of sweet, sticky, and sweet and sticky varieties can meet the preferences of different consumers. The introduced new varieties have reached the standard of high-quality varieties of fresh corn in terms of quality chemical indicators: the proportion of amylopectin in sticky corn is more than 70%, and the soluble sugar content of sweet corn is significantly higher than that of ordinary corn. This provides strong support for its success in the market with flavor.

4.2 Sensory evaluation of appearance and taste

In order to more intuitively compare the edible quality of new varieties, the appearance and taste of the cobs of each variety were sensory evaluated. The evaluation indicators include cob appearance (size and shape, grain arrangement and color), taste (tenderness, amount of skin residue), flavor (fragrance and sweetness intensity), etc., each item is scored, and the total score of sensory quality is obtained comprehensively. The results show that the sensory quality of different fresh corn varieties is significantly different, among which some new varieties show excellent sensory quality, with scores much higher than those of the control varieties. In the sensory evaluation of the Linhai City trial, 'Jinyin 208' had the highest comprehensive score of 85 points; 'Caitiannuo 168' had a total score of 81 points, 'Zhetian 19' had a score of 78 points, and 'Meiyu 25' had a score of 78 points, all of which were significantly better than the control 'Caitiannuo 617' (70 points). 'Jinyin 208' is a sweet corn variety with symmetrical and full ears, bright green bracts tightly wrapped, golden and shiny grains, and its appearance score ranks among the best; after steaming and tasting, 'Jinyin 208' has thin and tender grains, full juice, rich sweetness and little residue, and excellent taste evaluation (tenderness score is close to full marks), which is the main reason for its highest total sensory score. 'Caitiannuo 168' is a sweet and glutinous colored corn with an ornamental appearance of purple and white, large ears, and beautiful color. It received high scores in both appearance and flavor. The judges reported that it tastes sweet and fragrant when steamed. 'Zhetian 19' (sweet corn) and 'Meiyu 25' (glutinous corn) each have their own strengths: the former has good sweetness, thin and crispy skin, and the latter has good glutinousness and a fragrant and palatable taste. They are both top-notch in their respective types. In contrast, the control 'Caitiannuo 617', although both sweet and glutinous, may have a thick skin and average flavor, so it ranked last.

In addition to subjective scores, some objective quality indicators also verify the excellent quality of the new varieties. For example, the test shows that the skin residue rate (the proportion of residue after chewing) of high-quality sweet corn varieties is significantly lower than that of ordinary varieties; the gelatin consistency (intuitive glutinous index) of sticky corn varieties is significantly higher than that of ordinary corn. Similar results

were also found in the tasting of fresh corn in Guangdong and Fujian: For example, the new super sweet corn variety 'Minshuangse 6" scored 86.8~89.2 points in the comprehensive appearance and taste tasting in the national regional trial, which is significantly better than the control 'Yuetian 16' (85.0 points); experts commented that its kernels are crisp, sweet, fragrant and delicious. Another example is the sweet and sticky corn 'Nongke 336' bred in Tianjin, which is famous for its outstanding taste. It has the characteristics of soft skin, juicy and sweet, and the fresh ears can be eaten raw directly. This variety has won the special prize for high-quality fresh corn at many tasting meetings. The judges said it was "sweet as honey, crisp and tender without residue", and ranked among the top in the sweet and sticky group. The new varieties of fresh corn introduced in this batch generally performed well in terms of cob commerciality and tasting quality. Many varieties have neat and beautiful cobs, uniform grain size and close arrangement, and some colored varieties are more attractive, which is conducive to increasing the market price. In terms of taste and flavor, high-quality varieties generally have the characteristics of "thin skin, crisp, sweet, and no residue", which meets the preference of modern consumers for fresh corn "soft, sweet and sweet in the mouth, no residue after eating" (Wang et al., 2021). These sensory advantages mean that the new varieties have strong competitiveness and promotion prospects in the high-end market of fresh corn.

4.3 Survey results on market acceptability

The market acceptance of new varieties is a factor that must be considered in variety selection and promotion. In order to evaluate the response of consumers and growers to the introduction of new fresh corn varieties, the test team collected market evaluation information through tasting surveys, production and marketing docking meetings, and demonstration planting feedback. Overall, the new high-quality fresh corn varieties have been generally welcomed by consumers and actively recognized by the planting entities. In the consumer tasting session, 20 randomly invited tasters blindly evaluated and scored different varieties of fresh boiled corn. The results were basically consistent with the expert scores: varieties such as 'Jinyin 208' and 'Caitiannuo 168' scored the highest, and more than 90% of consumers expressed their willingness to buy and taste again; while only 40% of the control variety 'Caitiannuo 617' said that "the taste is acceptable", showing a significant gap. During the daily management of the field and the mature harvest, many growers also took the initiative to taste different varieties of fresh corn in the field. They generally reported that the new varieties "are indeed much sweeter and more glutinous than the old varieties they planted before, and the taste is good." This word-of-mouth effect helps the spontaneous promotion of new varieties.

From the perspective of market sales, new varieties of fresh corn have high commodity value and market competitiveness. On the one hand, varieties with good appearance are more likely to be favored by consumers. For example, the two-color ears of 'Caitiannuo 168' attracted many merchants to consult at the agricultural product exhibition, and they all said that this "color corn" has an excellent appearance and is expected to be sold at a high price as a gift corn. On the other hand, varieties with outstanding flavor can establish a brand and increase loyalty. In the marketing of the "Northeast Nongsao" fresh corn brand in Jilin, it is precisely because of the selection of sweet and soft high-quality varieties that the products have been exported to Japan, Singapore and other countries and won the gold medal at the International Grain and Oil Trade Fair. It can be seen that fresh corn with excellent quality is easy to form a brand effect, and market acceptance and recognition will be significantly improved. After our trial demonstration, some local cooperatives have expressed their willingness to purchase seeds of new varieties and plan to carry out large-scale planting in the "one village, one product" model to meet the needs of the local vegetable market and sightseeing picking. It is worth noting that the sales of fresh ears of fresh corn are seasonal and immediate, while new varieties are generally high-yielding and early-maturing, and the listing period is concentrated. This requires regulating supply by staggered planting or developing primary processing at the production site. In this regard, we also consulted wholesalers and processing companies in the market survey: they generally believe that if these high-quality fresh corns can be processed by prefabricated vacuum packaging, quick freezing and other methods, the market period can be greatly extended and the sales radius can be expanded. This means that the new variety is not only popular in the fresh ear market, but also has potential demand in the processing field. At present, the domestic consumption of fresh corn has shown a diversified trend - fresh ears, catering ingredients, and quick-frozen cans coexist (Tang et al., 2024). This batch of new varieties performed well

in the vacuum packaging preservation test, and the quality remained at a high level after steaming, indicating that it is suitable for processing and value-added. Based on the feedback from all parties, it can be considered that the new varieties of fresh corn introduced by Linhai City have a high market acceptance: consumers love to eat, growers are willing to plant, and companies are optimistic. This has laid a market foundation for the next step of large-scale promotion. Of course, continuous market publicity and brand cultivation are also necessary, such as holding a "Fruit Corn Picking Festival" in combination with Linhai's local tourism resources to increase the popularity and reputation of new varieties. The new high-quality fresh corn varieties are gaining wide popularity and recognition in the market for their outstanding appearance and flavor advantages, indicating that they have good prospects for promotion and application in coastal areas.

5 Case Study

5.1 Overview of the demonstration area

Linhai Baishuiyang Town is located in the hilly coastal area of eastern Zhejiang. It is rich in mountain resources and has suitable light and temperature conditions, which is very suitable for the development of fresh corn production. In order to give full play to the resource and location advantages of Baishuiyang Town, Linhai City has launched a new fresh corn variety introduction test and demonstration and promotion project in recent years to screen out high-quality and efficient fresh corn varieties suitable for local planting and promote the healthy and sustainable development of the corn industry. Through many field visits, the project team selected Shuanglou Village, Baishuiyang Town as a demonstration base for new fresh corn varieties (Figure 2).

Figure 2 Demonstration planting area for new varieties of fresh corn

A demonstration planting area of 100 mu was established in Shuanglou Village, including a core demonstration area of 11.4 mu, and the demonstration varieties planted were 'Caitiannuo 168' and 'Zhetian 19'. In the autumn of 2022, four selected fresh corn varieties, 'Caitiannuo 168', 'Zhetian 19', 'Meiyu 25', and 'Jinyin 208', were promoted in the surrounding areas such as Le'an Village, Shuanglou Village, and Shanghu New Village in Baishuiyang Town. The cumulative demonstration area reached more than 300 mu, and the demonstration effect was good. The construction of the demonstration area has a clear phased expansion plan: after achieving phased planting results, the area will be further expanded to carry out high-yield and high-efficiency planting demonstrations, and it is planned to radiate and promote the selected varieties and supporting technologies to other towns in Linhai City to expand the influence of the green and efficient production model of fresh corn.

5.2 Breeding and field performance of demonstration varieties

After introduction test comparison, four new fresh corn varieties with outstanding performance, 'Jinyin 208', 'Zhetian 19', 'Caitiannuo 168' and 'Meiyu 25', were selected from 9 candidate varieties as demonstration and promotion varieties. These four varieties have different sources and types, including sweet corn varieties ('Jinyin 208', 'Zhetian 19'), glutinous corn varieties ('Caitiannuo 168') and sweet and glutinous varieties ('Meiyu 25'). Their growth period covers early, medium and late maturity types (the full growth period of spring sowing is about 98 to 113 days), which can meet the planting needs of different seasons and market listing periods.

'Jinyin 208' was introduced by Hangzhou Seed Industry Group Co., Ltd. (Zhejiang Introduction 2017 No. 001) and is a sweet corn variety. This variety has the shortest growth period, with about 98 days from sowing to harvesting in spring, and can be put on the market early to seize the high price period of fresh corn. Its fresh ear yield is average among the experimental varieties, with an output of about 500 kg per mu. Although the yield is not dominant, the ear quality of 'Jinyin 208' is outstanding, the grain tastes sweet, the skin is thin and the residue is less, the appearance is good, and the comprehensive score in the sensory evaluation is the highest (85 points). During the field growth process, the plant is relatively short and strong (plant height is about 1 m), with strong lodging resistance and relatively strong resistance to pests and diseases such as corn borers (Figure 3). 'Jinyin 208' is an early-maturing high-quality fresh corn variety, suitable for early spring sowing and planting that requires attention to taste quality.

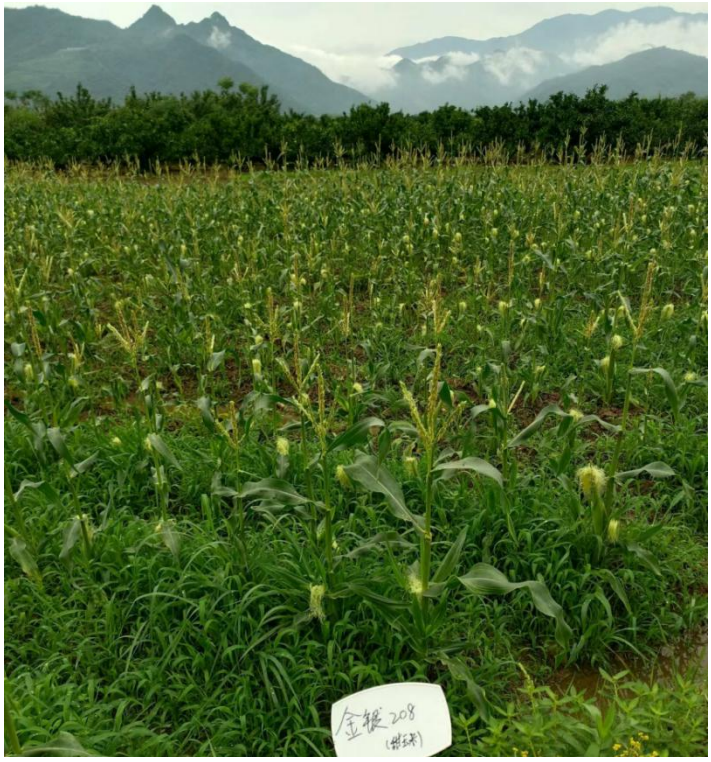

Figure 3 The plant of 'Jinyin 208'

'Zhetian 19' was bred by Dongyang Corn Research Institute of Zhejiang Province (Zheshenyu 2020002) and is a sweet corn variety. This variety has a relatively long growth period, with a full growth period of about 113 days in spring sowing, and matures the latest among the experimental varieties. The fresh ear yield of 'Zhetian 19' is relatively high, with an acreage yield of 1 068 kg, ranking among the top among all the tested varieties. Its ear quality is also good, with high sweetness, tender grains, thin seed coat, and good flavor and palatability evaluation (sensory score 78 points) (Figure 4). Field planting observations show that 'Zhetian 19' plants are tall and strong (plant height is close to 2 m), the ear position is relatively reasonable, there is no empty stalk or lodging phenomenon, and it shows good high yield and stable yield characteristics. 'Zhetian 19' is a new medium-late maturing and high-yield sweet corn variety with both yield and quality advantages, suitable for large-scale promotion and planting in coastal areas.

Figure 4 'Zhetian 19'

'Caitiannuo 168' is a colored glutinous corn variety bred by Dongyang Corn Research Institute of Zhejiang Province (National Approval Jade 20200536). This variety is a medium-early maturing type, with a growth period of about 108 days in spring sowing. 'Caitiannuo 168' has the most outstanding field yield performance, with a fresh ear yield of up to 1 560 kg per mu, significantly higher than other varieties. Its ear skin is purple-red, and the grains are golden and white, with a bright appearance and excellent commercial quality; it tastes fragrant, glutinous and sweet, and has the highest total score (81 points) in the sensory quality evaluation. This variety has strong adaptability, tolerance to dense planting, and especially good resistance to low temperatures. It sprouts neatly in early spring sowing and has obvious growth advantages under low temperature and rainy conditions (Figure 5). The test results show that 'Caitiannuo 168' is very suitable for promotion and planting in coastal areas, especially in Baishuiyang Town. It can be used as the leading variety of local fresh corn to achieve the dual goals of high yield and high efficiency and rich market supply.

Figure 5 'Caitiannuo 168'

'Meiyu 25' is a sweet and glutinous corn variety bred by Hainan Lvchuan Seedling Co., Ltd. (National Approved Yu 20233432). The growth period of this variety is medium to late, and the full growth period of spring sowing is about 111 days. The fresh ear yield of 'Meiyu 25' is medium, with an annual yield of about 800 kg, and the yield level is relatively stable. As a glutinous variety, 'Meiyu 25' has outstanding flavor and taste advantages: its sweetness ranks among the best in glutinous corn, with good glutinousness (viscosity), sweetness in glutinousness, soft and fragrant taste, full and beautiful appearance of commercial ears, and a high score of 78 points in the sensory evaluation. In terms of field performance, 'Meiyu 25' plants grew well, with strong comprehensive resistance, and no serious pests and diseases were found. 'Meiyu 25' is a new variety of fresh corn that is both sweet and sticky. While meeting consumers' demand for the sweet and fragrant taste of glutinous corn, it has a certain yield guarantee and is suitable for promotion in the cultivation of glutinous corn in Linhai area.

5.3 Integration and effectiveness of green pest control technologies

The demonstration area attaches great importance to the green control of pests and diseases throughout the production process of fresh corn, and strives to effectively control pests and diseases without or with less application of chemical pesticides. The main diseases of fresh corn in Linhai City include corn leaf spot, corn leaf spot, corn sheath blight and corn rough dwarf disease, and targeted green control plans have been formulated for each disease. Corn leaf spot usually occurs after corn tassels emerge. Plant resistance can be enhanced by selecting disease-resistant varieties and balanced fertilization, and low-toxic pesticides such as pyraclostrobin, difenoconazole or methyl thiophanate can be sprayed on the leaves at the early stage of the disease to curb the spread of the disease. Corn leaf spot is prone to epidemics in high temperature and high humidity environments. The key points of prevention and control are to plant disease-resistant and high-yield varieties, strengthen field management during the heading and flowering period, promptly remove diseased and damaged plants, and spray protective fungicides such as chlorothalonil or mancozeb once every 7 days. Spraying 2 to 3 times can effectively reduce its damage (Sudhakar et al., 2024). Corn sheath blight is a common soil-borne disease in corn production. It often begins to infect and harm corn from the jointing to the large trumpet stage. It is advisable to apply appropriate pesticides (such as oxamycin and tebuconazole, etc.) from the jointing to the tasseling stage for prevention and control to inhibit its spread during the silking and filling period (Ferrero et al., 2023). Corn dwarf disease is a viral disease transmitted by the gray leafhopper. There is no specific drug for treatment at present. Prevention is the only option: choose disease-resistant varieties, remove weeds around corn fields to reduce virus vectors, reasonably adjust the sowing period to avoid the peak of gray leafhoppers, and use seed coating (such as seed dressing with prochloraz or imidacloprid) to reduce the infection rate in the seedling stage. Through the above measures, the incidence of the above diseases in the demonstration area has been significantly reduced, and there has been no large-scale epidemic.

In terms of pest control, the demonstration area is mainly threatened by two major pests: corn borer and corn armyworm. Corn borer is one of the most common major pests on corn. Its larvae can eat the tassels, leaves and stems of corn. In severe cases, it will lead to a significant reduction in corn yield or even the whole plant lodging. For corn borer, the demonstration area emphasizes a comprehensive prevention and control strategy with prevention as the main focus: timely clean up the corn stalks in the field after the winter harvest to eliminate the overwintering insect source; in April and May of the following year, when the corn borer larvae hatch and have not yet drilled into the stems, use low-toxic and high-efficiency pesticides for prevention and control. For example, spread trichlorfon granules on the heart leaves, or mix phoxim with fine sand and spread evenly on the heart leaves, and spray appropriate amounts of high-efficiency low-residue insecticides such as emamectin benzoate when necessary; at the same time, combine biological control measures such as releasing the natural enemy of corn borer, trichogrammatid wasps, spraying Bacillus thuringiensis preparations, and minimize the population base of corn borer larvae. In recent years, the occurrence of corn armyworm has become increasingly serious in the local area, with the harmful characteristics of collective overeating. It often breaks out quickly in high humidity and hot weather: the larvae can eat up the entire corn leaf within a few days, posing a major threat to corn production safety. The demonstration area adopts the strategy of "trapping and killing adults+timely treatment of larvae" for green prevention and control of armyworms: on the one hand, insect traps or sweet and sour liquid are set up in the field to trap and kill adults, straw is inserted to attract armyworm adults to lay eggs

and replaced every 5 days, and the straw with eggs is burned in a centralized manner to reduce the number of eggs in the field; on the other hand, once the signs of damage by armyworm larvae are found in the field, high-efficiency and low-toxic biological pesticides or botanical pesticides are immediately sprayed for prevention and control (such as directional spraying of preparations containing chlorpyrifos or phoxim) to promptly curb the spread of insect pests in the early stage (Wang and Huang, 2024). Through the above measures, corn borers and armyworms were effectively controlled in the demonstration field, and no significant loss of fresh ear yield was caused.

6 Problems and Challenges

6.1 Impact of abnormal climate on growth cycle and yield

Significant abnormal climate occurred during the experimental year, including continuous drought and low temperature in spring and high temperature and little rain in summer. Continuous sunny and dry weather and low temperature in March and April caused poor soil moisture, slow recovery of ground temperature, slow and uneven emergence of fresh corn, and early growth of seedlings was hindered; some plots lacked seedlings due to lack of effective irrigation. Entering the middle and late growth period (late July to mid-August), it encountered continuous sunny and hot weather, and the maximum daily temperature was above 35 ℃ for a long time. This abnormally high temperature period coincided with the flowering, pollination and grain filling period of corn. High temperature stress led to reduced pollen vitality and pollination fertilization rate, poor silking of female ears, accelerated filling rate and shortened duration, and ultimately insufficient grain filling. High temperature and drought also aggravated plant water stress. Functional leaves of corn plants in some fields showed premature aging, and the phenomenon of empty stalks and bald grains increased, which seriously affected the formation of yield.

The direct consequence of high temperature and drought stress is the abnormal changes in the growth cycle and yield of fresh corn (Liu et al., 2022). Under the influence of the rapid rise in temperature in the later period, the differences in the growth period of the participating varieties were narrowed, and the full growth days of most varieties tended to be consistent (about 111 days), and the maturity period was too concentrated. In particular, except for the early-maturing 'Jinyin 208' and 'Xuetian 7401', the maturity period of the remaining 8 varieties arrived almost at the same time, reflecting that the abnormally high temperature accelerated the maturity of corn and ended the filling in advance. Although remedial measures such as drought-resistant irrigation were taken during the experiment, the yield and quality of crops were still significantly affected. It was calculated that the high temperature and drought caused the measured yield of fresh corn to be 13.0%~20.9% lower than the normal level, the quality of commercial ears decreased, and the fullness of the grains was poor. At the same time, the unfavorable climate caused different batches of corn to mature at the same time, which not only increased the pressure of harvesting and processing, but also caused the time for fresh ears to be put on the market to be too concentrated, which was not conducive to the peak supply market (Bheemanahalli et al., 2022).

6.2 Threats to quality from frequent pest and disease outbreaks

During the trial, the high incidence of major local corn pests and diseases also posed a threat to the yield and quality of fresh corn. Among them, corn borer is one of the most common and most serious pests. Field surveys found that signs of corn borer damage appeared many times during the growth period of corn, such as larvae eating heart leaves, male ears and leaves, and boring into the stems to cause pith cavities. Plants attacked by corn borers often show weak growth, and in severe cases, the stems break and fall or the cobs are damaged. More importantly, corn borer larvae can also invade female ears and eat grains, causing partial rot of the cobs and grains. Affected by this, the integrity of the ear shape of fresh corn was destroyed, the ears and grains were not arranged evenly, some ears were missing grains and worm holes, and the fullness of the grains decreased significantly. Insect pests directly reduce the appearance quality and commerciality of commercial corn ears. The damaged ears are poor in appearance and easy to mold, and the market acceptance is reduced. At the same time, the flavor and taste of the ears deteriorate after being fed by corn borers or infected by pathogens, which is not conducive to maintaining the sensory quality of fresh corn (Tang, 2024). According to statistical analysis, if corn borers are not controlled in time, the yield of fresh corn may be greatly reduced, and even the harvest may be completely lost in

severe cases. This experimental field also monitored signs of corn borer larvae before and after tasseling, and timely applied pesticides in mid-May for prevention and control. However, corn borers overlap generations and are highly hidden, making prevention and control difficult, requiring multiple continuous medications and field management. The lack of prevention and control awareness and measures by some growers is a weak link in the current green prevention and control of corn borers. The residual insect sources in the field are prone to re-infection in the next season, posing a long-term threat to the production of fresh corn.

In terms of diseases, corn leaf spot and small leaf spot are two leaf diseases that are prone to prevalence in local high temperature and high humidity seasons, and they also pose a threat to the yield and quality of fresh corn. Corn leaf spot generally occurs after corn leaf tasseling, and the environmental conditions suitable for the disease are a temperature of 20 ℃ to 25 ℃ and a relative humidity of more than 90%. When the disease occurs, large water-soaked gray-brown patches first appear on the middle and lower leaves of corn, and then spread upward. In severe cases, large areas of leaves of the entire plant die. Corn leaf spot prefers a warm and humid environment, and is very likely to break out in a rainy climate of 26 ℃~29 ℃. Corn leaf spot can occur throughout the growth period of corn, especially after the tassels emerge, and is most harmful. It manifests as small concentric rings with reddish-brown edges on the ears, leaves and sheaths. When the humidity is high, a black mold layer grows on the lesions (Bhat and Anwar, 2017). Large-scale outbreaks of these two leaf spot diseases will significantly reduce the functional leaf area of corn, premature plant decline, shorten the filling period and poor grain development. In the field, it is often seen that the female ears of infected plants are bald or the grains are shriveled, the ear shape becomes smaller, and the fruiting is poor, which ultimately leads to a decline in the quality of commercial ears and a loss of yield. In particular, small leaf spot can break out in the rainy summer season. If not prevented and controlled in time, it will seriously threaten the high and stable yield of corn (Rizzardi et al., 2022). Corn sheath blight and rough dwarf disease also occur sporadically in the test area. Once the environment is suitable, they may also break out, which will have a potential impact on corn growth and ear quality. The prevalence of diseases will reduce the fullness and edible quality of fresh corn kernels, increase the risk of mildew and toxins, and is not conducive to the commodity value of fresh corn and the taste experience of consumers.

In terms of pest and disease control, the experiment also exposed some difficulties and weak links. First, fresh corn aims to put tender ears on the market, and has high requirements for pesticide residues, which limits the frequency and dosage of chemical pesticides and increases the difficulty of green pest and disease control. Pests such as corn borers need to be prevented as the main method, such as removing field stumps in winter to reduce overwintering insect sources and applying pesticides in time during the heart leaf stage. However, in actual promotion, it is often difficult for small farmers to take unified actions in a timely manner due to their scattered operations. Winter straw treatment and drug use during the critical period are sometimes not in place, making it difficult to completely reduce the insect population base. Secondly, for diseases such as large spot disease and small spot disease, it is required to select disease-resistant varieties, balance fertilization to improve disease resistance, and spray the right pesticides in time for continuous prevention and control 2 to 3 times at the early stage of the disease. However, grassroots growers are often constrained by costs and insufficient technical guidance, and often fail to implement multiple sprayings or completely remove diseased residues according to regulations, leaving room for the spread of diseases. Furthermore, some diseases such as corn dwarf disease currently lack specific pesticides, and can only be reduced by avoiding sowing during the peak period of virus-transmitting insects and controlling vector insects. Preventive measures such as these all show that in the large-scale demonstration and promotion of fresh corn, the high incidence of pests and diseases requires a more complete unified prevention and control mechanism and technical training support. The current prevention and control work still has weak links, which directly threatens the appearance quality and internal flavor safety of fresh corn products.

6.3 Limitations on demonstration and promotion due to issues in sowing and management timing

Whether the planting rhythm and field management timing of fresh corn production are reasonable has an important impact on the effect of new variety demonstration and promotion. In the actual promotion process of this study, it was found that factors such as seasonal climate and labor resources led to certain problems in sowing

and management timing, thus limiting the large-scale continuous demonstration planting of new varieties. Late temperature recovery affects the appropriate sowing period. Spring sowing of fresh corn requires that the soil temperature at a depth of 5 cm is stable above 12 ℃. However, in some years, the spring warming is late, and the time for the open-field soil temperature to reach the standard is delayed. In order to seize the early spring planting window, the experiment adopted measures such as seedling transplanting and arch shed insulation, sowing and seedling raising in early March and transplanting in early April. However, for large-scale promotion, not all planting entities have the conditions for facility seedling raising. If the temperature rises slowly and sowing is forced to be postponed to late April or even May, the growth period of corn will be postponed to the hot and rainy summer. Not only will the flowering and pollination period be easily impacted by high temperature and drought, but the maturity and harvest period may also encounter the risk of autumn rain or early frost. The delay in the sowing period caused the planting time of different farmers' fields to be uneven, and the growth in the field was not synchronized, making it difficult to implement unified field management measures in time, reducing the uniformity and persuasiveness of the overall acceptance of the demonstration field (Guo et al., 2022).

Labor shortage leads to inadequate management. The high-quality and high-yield cultivation of fresh corn requires high timeliness of field management. From seedling transplanting, seedling selection and seedling supplementation to topdressing irrigation, insect prevention and disease prevention, each link requires sufficient labor input. However, at present, there is a general shortage of labor in rural areas, and the contradiction of seasonal labor is prominent. There have been many cases of shortage of manpower during the trial demonstration. For example, corn needs to be top-dressed and soiled in batches during the jointing stage and the large bell mouth stage, but due to limited labor, some demonstration fields failed to complete these operations at the same time in the best period and had to postpone them, affecting the consistency of plant growth. For example, pests such as corn borers require timely and unified prevention and control at the early stage of larvae. When there is insufficient labor, it is difficult to apply pesticides to large areas of fields in a timely manner, resulting in the leakage of pests in individual fields. The lack of labor also limits the promotion of seedling transplanting, an efficient cultivation method. Some farmers give up seedling cultivation and switch to direct seeding because they have no help, which leads to further delays in the sowing period or uneven emergence of seedlings. It can be seen that the labor bottleneck makes it difficult to implement standardized and synchronized field management, weakening the actual effect of demonstration and promotion.

Delayed field preparation affects continuous planting. Carrying out continuous demonstration planting requires that each field in the experimental base can be vacated, prepared and sown in time. However, in reality, the harvest of the previous crop and the progress of field preparation in different fields are often inconsistent. Some plots of land were harvested late in the previous season (such as winter wheat, green manure, etc.), missing the appropriate sowing period for early spring corn; some plots were unable to complete land preparation and sowing as planned due to excessively wet soil or untimely deployment of tillage machinery. In this demonstration and promotion, some farmers' plots failed to catch up with the unified sowing rhythm due to delays in the previous crop cleaning, and had to switch to other crops, affecting the integrity of the demonstration area. Continuous operation requires coordination among farmers in the region, but coordination is difficult in the early stages of promotion: some farmers hesitate and miss the best sowing window; some participate but are not well prepared, resulting in problems such as improper sowing depth or missing basal fertilizer, and late management is not standardized. These inconsistencies in timing make it difficult for the demonstration plot to achieve the ideal effect of simultaneous harvesting of ears, and field management cannot be fully standardized, which is not conducive to the centralized display of new varieties and supporting technical effects.

7 Concluding Remarks

This study systematically evaluated the biological and agronomic traits of new varieties of fresh corn introduced in Linhai City, and screened out a number of varieties with excellent comprehensive performance. These new varieties have the common characteristics of uniform emergence, early maturity and high yield, resistance to lodging and stress, and excellent quality, and have adapted well to the ecological conditions of Linhai City. In the early growth period, the emergence rate and seedling rate of each variety were at a high level, and the seedlings grew robustly, laying the foundation for the final yield.

The growth period is generally short, mostly around 80 days, making it suitable for local planting in spring and autumn. Most varieties have short and compact plant types, low ear positions, and outstanding field resistance to lodging; the ears are large and uniform, with good firmness and minimal bald tips, and the fresh weight of a single ear meets the requirements of commercial corn. In terms of yield, varieties such as 'Caitiannuo 168' and 'Zhetian 19' performed outstandingly, with an output of more than 1 000 kg per mu, significantly higher than the control, and have the characteristics of high and stable yield; 'Jinyin 208' has a medium to high yield but excellent quality, and 'Meiyu 25' has an excellent taste and a decent yield, all of which are types worthy of promotion. Quality testing and sensory evaluation show that sweet corn varieties have high sweetness and strong flavor, while glutinous corn varieties have high viscosity and soft texture, and sweet and glutinous varieties have the advantages of both. In particular, the taste scores of 'Jinyin 208' and 'Caitiannuo 168' are among the best, and consumers have a very high acceptance. In terms of stress resistance, all the main varieties have shown strong resistance to lodging and good drought resistance.

Among them, 'Caitiannuo 168' is resistant to low temperatures and 'Lutiannuo 191' is resistant to salt and alkali, and can still grow and bear fruit normally under adverse conditions. Resistance to diseases and pests is a relative weakness of some varieties. For example, 'Xiantiannuo 88' and 'Ditiannuo 336' are susceptible to some diseases, but through appropriate plant protection measures, they can be controlled to a level that does not affect the harvest. Varieties such as 'Caitiannuo 168', 'Zhetian 19', 'Jinyin 208', and 'Meiyu 25' show comprehensive advantages of high yield, excellent quality, and strong adaptability in the Linhai area, and can be used as leading fresh corn new varieties for demonstration and promotion. Although some other varieties have excellent indicators, their shortcomings are obvious. They can be promoted in small quantities or retained as breeding materials according to specific needs. The comprehensive evaluation results are consistent with the field demonstration cases, indicating that the introduction and screening work has achieved the expected goals, and the introduction of excellent new varieties has provided strong support for the development of the fresh corn industry in Linhai City.

The new fresh corn varieties selected in this study have broad prospects for promotion and application in Linhai City and even similar ecological regions. From an economic perspective, the promotion of these high-quality varieties is expected to greatly improve the benefits of corn planting, achieve the combination of grain and vegetables, and multiple uses of one land, and help revitalize rural industries. From a social perspective, residents can taste fresher and more delicious vegetable corn products to meet the needs of consumption upgrades. At the same time, the promotion of some colorful sweet and glutinous corn can also enrich citizens' leisure agricultural projects such as "picking tours" and "experience farms", which has multiple values. In terms of brand building, Linhai City can rely on the selection of varieties to create a local fresh corn brand (such as "Linhai sweet and sticky corn"), and increase its popularity and expand its sales market through standardized production and publicity. As the scale of the industry expands, processing companies can also intervene to develop diversified products such as vacuum-packed fresh corn cobs, quick-frozen corn kernels, and corn beverages to extend the industrial chain and increase added value. It can be seen that the introduction and promotion of new varieties of fresh corn are of great significance to agricultural efficiency and farmers' income.

In terms of follow-up research, there are several directions worth exploring in depth. First, in breeding research, new varieties should be selected and bred in accordance with local needs. For example, in response to the high temperature and high humidity environment in the south, modern molecular breeding technology is used to select sweet and sticky corn hybrids with high disease resistance and high resistance to lodging; gene editing and other means are used to improve corn quality genes to achieve higher sugar content or a softer taste. At the same time, attention should be paid to the nutritional fortification of fresh corn (such as high-vitamin, high-anthocyanin varieties) and the cultivation of functional corn to meet the market demand for healthy food. Secondly, in terms of cultivation research, technical experiments such as dense planting and high-yield cultivation, integrated fertilizer and water management can be carried out to find the optimal cultivation mode for each new variety. For example, in terms of planting system, explore the rotation of "fresh corn+regenerated rice" and "vegetable corn rotation" to improve land utilization. Another example is to develop precise water and fertilizer management solutions and light and simple cultivation technologies for fresh corn to increase yields while reducing inputs and environmental

pressures. Third, in terms of green pest control, it is recommended to further study the occurrence laws of major pests and diseases of fresh corn, and develop biological control or ecological control measures to ensure the green and safe products.

Finally, research and innovation are also needed in product processing and preservation. The bottleneck of the short shelf life of fresh corn after harvest can be broken through by technologies such as vacuum quick freezing and controlled atmosphere storage; at the same time, develop corn leisure and ready-to-eat products, corn deep-processed healthy foods, etc. to improve product diversity. There is still a lot of work to be done around the entire industry chain of new varieties of fresh corn, and scientific research and production need to be closely integrated. Through continuous scientific and technological innovation and promotion practice, Linhai City's fresh corn industry is expected to achieve upgrading and develop in the direction of high yield, high quality, high efficiency, ecology and safety, providing more high-quality "fresh corn" results for regional agricultural development and residents' tables.

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Conflict of Interest Disclosure

The author affirms that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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