Exploration of Early-maturing, High-quality and High-yield Cultivation Techniques for Early Spring Fresh Maize with Plastic Film Mulching in Eastern Henan

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Abstract Based on the ecological conditions and production practices in Eastern Henan, this paper elaborates on key aspects of early spring fresh maize cultivation in the region, including current planting status, variety selection, seed treatment, site selection and land preparation, plastic film mulching and sowing, field management, pest and disease control, and harvesting. The aim is to provide technical support for improving quality and efficiency in the fresh maize industry and increasing growers' income in Eastern Henan.

Key words Eastern Henan; Early spring fresh maize; Plastic film mulching; Early cultivation; High quality; High yield

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Fresh maize, mainly comprising sweet, waxy, and sweet-waxy types, offers excellent taste and rich nutrition, showing strong market demand. It has become an important economic crop in Eastern Henan for adjusting planting structures and increasing farmers' income. Additionally, regular consumption of fresh maize helps prevent vascular sclerosis, lower cholesterol levels, and reduce the incidence of intestinal diseases[1]. Early spring cultivation with plastic film mulching effectively mitigates low-temperature damage, enables earlier sowing and market availability, and captures peak price periods, thereby achieving the goals of "early maturation, high quality, high yield, and high efficiency". In recent years, with the advancement of green agricultural development and the promotion of agricultural machinery and agronomic techniques, new technologies such as fully biodegradable plastic film, side-film sowing, precise water and fertilizer management, and full-process green pest control have been rapidly applied in fresh maize production. These innovations are driving the transformation of traditional cultivation toward simplified, standardized, green, and high-efficiency models. Based on the ecological conditions and production practices in Eastern Henan, this article provides a detailed discussion on key aspects of early spring fresh maize cultivation in the region, including the current planting status, variety selection, seed treatment, site selection and land preparation, plastic film mulching and sowing, field management, pest and disease control, and harvesting, aiming to offer technical support for improving the quality and efficiency of the fresh maize industry in Eastern Henan and increasing growers' income.

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Current Status of Early Spring Fresh Maize Cultivation

Ecological condition characteristics

The Eastern Henan region has an average annual temperature of 14 – 15 ℃, and an accumulated temperature of 4 500 – 5 000 ℃ (≥10 ℃). During early spring (March to April), the average daily temperature ranges from 8 to 12 ℃. The soil temperature at a depth of 10 cm consistently remains above 12 ℃ from late March to early April. Precipitation is relatively low and unevenly distributed. The soil is predominantly fluvo-aquic, characterized by a deep plow layer and moderate fertility, making it suitable for fresh maize cultivation. However, early spring low-temperature damage, periodic drought, and underground pest damage during the seedling stage have become major constraints to early sowing, uniform emergence, and robust seedling growth in fresh maize. Plastic film mulching technology can compensate for these climatic limitations, advancing the growth period by 10 – 15 d and moving the fresh ear market availability to mid-to-late June. It significantly enhances the market premium space.

Current planting situation and existing problems

In recent years, the planting area of fresh maize in Eastern Henan has expanded annually. In 2024, the total planting area exceeded 53 333 hm^2. Sweet maize, waxy maize, and sweet-waxy maize are primarily cultivated using plastic film mulching. However, problems still exist in production, such as blind variety selection, improper sowing timing, non-standard plastic film mulching techniques, extensive water and fertilizer management, and delayed pest and disease control. As a result, the yield of fresh ears is only 12 000 – 15 000 kg/hm^2, with a commodity rate below 75%, representing a significant gap compared with the over 22 500 kg/hm^2 achieved in high-yield demonstration areas. Furthermore, issues such as variety mixing and cross-pollination lead to quality degradation, while delayed harvesting results in poor taste, severely impacting planting efficiency. There is an urgent

need for a standardized cultivation technology system to guide production[2].

Variety Selection

Early spring fresh maize cultivation in Eastern Henan requires varieties characterized by early maturity, high quality, stress resistance, and high yield[3]. Varieties with a fresh ear harvest period of 70 – 80 d from emergence should be selected, ensuring that the growth period aligns with the temperature conditions of early spring plastic film mulching in Eastern Henan, thereby enabling early market entry and capturing market opportunities. Sweet maize varieties with soluble sugar content ≥12% and waxy maize with amylopectin content ≥95% should be selected. They should have a cooking quality score ≥86 points. The ears are required to be uniform, and have plump kernels and no tip baldness, and the varieties should have high market recognition. Varieties with strong low-temperature tolerance, lodging resistance, and disease resistance, particularly resistance to head smut, common smut, and corn borer, are preferred, as they can adapt to the disease occurrence characteristics of low-temperature and high-humidity conditions in early spring in Eastern Henan. Fresh maize varieties with a semi-compact plant type suitable for dense planting and significant yield potential are preferred. Suitable fresh maize varieties for early spring plastic film mulching cultivation in the Eastern Henan region include Zaobai 2017, Zhengnuo 166, Meiyu Jia Tiannuo 25, and Shenke Tiannuo 99.

Seed Treatment

Before sowing, seeds are carefully selected to remove broken, insect-damaged, diseased, and shriveled grains. Seeds with plump kernels, a purity of ≥98%, and a germination rate of ≥ 90% are chosen to ensure uniform seedling emergence. Before sowing, the seeds are sun-dried for 1 – 2 d on sunny days, 3 – 4 h per day, to break dormancy and enhance germination vigor. Seed coating is applied using 300 – 400 ml of 22% thiamethoxam · fludioxonil suspension concentrate per 100 kg of seeds to control underground pests such as white grubs and cutworms, as well as seedling-stage pests such as aphids and small brown planthoppers, while also preventing root rot and head smut, ensuring full emergence after sowing[4].

Site Selection and Land Preparation

Site selection and fertilization

Fields with flat terrain, convenient irrigation and drainage, deep soil layers, and an organic matter content of ≥1.2% should be selected, and the previous crop should not be maize, so as to avoid aggravation of pests and diseases caused by continuous cropping[5]. After the harvest of the previous crop, deep plowing is carried out to a depth of 25 – 30 cm to break the plow pan. Before sowing, shallow plowing of 15 – 20 cm is performed to achieve level ground, fine soil, and the absence of clods. A sufficient base fertilizer is applied in combination with land preparation, following the principle of prioritizing organic fertilizer supplemented by chemical fertilizer. In specific, 30 000 – 45 000 kg/hm^2 of decomposed farmyard manure or 4 500 – 7 500 kg of commercial organic fertilizer is applied per hectare, combined with 450 – 600 kg of ternary compound fertilizer (N-P-K = 15-15-15) and 15 kg of zinc sulfate. The base fertilizer is deeply applied at 15 – 20 cm to integrate soil and fertilizer, providing long-term nutrients for seedling growth.

Plastic film mulching

Polyethylene agricultural film with a thickness of 0.008 – 0.012 mm and a width of 70 – 80 cm is selected, featuring high tensile strength, good light transmission, and aging resistance, with an application rate of approximately 45 – 60 kg/hm^2. If full-film double-ridge mulching is adopted, a film width of 120 cm may be used to enhance soil moisture conservation and warming effects. At 3 – 5 d before sowing, 1 500 – 2 250 ml of 50% acetochlor emulsifiable concentrate is diluted with 450 – 600 kg of water per hectare and evenly sprayed onto the soil surface. Immediately after spraying, the plastic film is laid to form a herbicidal film layer, inhibiting weed germination and preventing competition between weeds and maize for nutrients and water.

Determination of sowing date

The optimal sowing period for early spring fresh maize under plastic film mulching in the Eastern Henan region is mid-to-late March. The critical indicator for sowing is when the 10 cm soil temperature stably reaches ≥10 ℃ for three consecutive days. Plastic film mulching can increase the soil temperature by 3 – 5 ℃, advancing the sowing date by 7 – 10 d compared with open-field sowing. If double-layer mulching with plastic film and small arch shed is adopted, the sowing date can be advanced to early March, further shortening the growth cycle and enabling earlier market availability. The sowing date should avoid late spring cold spells to prevent seed rot caused by low temperatures. In the event of a temperature drop, straw can be covered after sowing for insulation.

Sowing with Plastic Film Mulching

Planting density and methods

The planting density is determined based on variety characteristics. For early-maturing compact varieties (such as Xuetian 7401 and Zaobai 2017), the planting density is 67 500 – 75 000 plants/hm^2. For mid-maturing semi-compact varieties (such as Zhengnuo 166 and Jingketian 618), the density is 57 000 – 63 000 plants/hm^2. A wide-narrow row planting pattern is adopted, with wide rows of 70 – 80 cm and narrow rows of 40 – 50 cm, and a plant spacing of 22 – 30 cm. This pattern provides good ventilation and light penetration, facilitates field management and plastic film mulching, and reduces the incidence of pests and diseases.

On the prepared field, lines are marked according to the wide-narrow row pattern. Holes are punched in the narrow rows using a hole punch, with a depth of 3 – 5 cm. Seeds are sown with two seeds per hole, covered with fine soil, and compacted to ensure close contact between the seeds and the soil. Immediately

after sowing, plastic film is laid, stretched tightly, and flattened. The edges are compacted with soil, and a soil ridge is maded every 2 – 3 m to prevent the film from being lifted by strong winds. The width of soil covering the film edges is not less than 10 cm to ensure the moisture conservation and warming effects of temperature increase. Fresh maize (especially waxy maize) is prone to cross-pollination with common maize, which can lead to quality degradation. Therefore, spatial isolation or temporal isolation should be implemented. Specifically, spatial isolation requires a distance of ≥300 m from other maize varieties, while temporal isolation requires a flowering period difference of ≥20 d to ensure pure quality.

After sowing, the condition of the plastic film covering should be checked promptly. Any film breaks or exposed holes should be immediately sealed with soil to reduce heat and moisture loss. If drought occurs before seedling emergence, irrigation can be carried out by ditching between the films to avoid flood irrigation. In case of rainfall, any water accumulated on the film surface should be cleared promptly to prevent low soil temperature from affecting seedling emergence.

Field Management

Seedling stage management (emergence to 5-leaf stage)

Key points during the seedling stage include breaking the film to release seedlings, checking and replanting, thinning and fixing seedlings, and controlling water and fertilizer, all aimed at cultivating high-quality robust seedlings. After seedlings emerge, timely film breaking and seedling release are carried out during the 2-leaf to 3-leaf stage. A small knife is used to cut a cross-shaped opening in the film to guide the seedlings out, and then fine soil is used to tightly seal the holes to prevent heat damage to the seedlings and moisture evaporation. Field inspection is conducted 3 – 4 d after emergence, and replanting is performed with prepared seedlings when plant missing is oberved. After replanting, watering is carried out to promote survival, ensuring uniform and complete seedling establishment. The seedlings are thinned at the 3-leaf stage, removing weak, diseased, and off-type seedlings. At the 5-leaf stage, final singling is performed, leaving one robust seedling per hill to avoid competition for water and nutrients. During the seedling stage, water is appropriately controlled to promote deep root penetration. If basal fertilizer is sufficient, no additional seedling fertilizer is needed. If soil fertility is poor, 75 – 120 kg of urea is applied per hectare with water to promote vigorous seedling growth.

Ear stage management (6-leaf to tasseling stage)

The ear stage is a critical period for both vegetative and reproductive growth in fresh maize. Key management tasks include emphasizing ear fertilizer application, water management, removal of tillers, and assisted pollination. At the big flare stage (10 – 12 leaf stage), 225 – 300 kg of urea and 150 kg of potassium sulfate per hectare are applied by deep furrowing in wide rows to a depth of 10 – 15 cm, followed by soil covering and irrigation to promote ear differentiation and increase the number of kernel rows and kernels per ear[6]. Water demand is high during the ear stage, and soil relative moisture content should be maintained at 70% – 80%. In case of drought, timely furrow irrigation is carried out. In case of waterlogging, timely drainage is performed to prevent root rot caused by excessive moisture. Fresh maize is prone to producing tillers that consume nutrients. Tillers should be promptly removed when they reach 5 – 10 cm in length, and only the main stem is retained to promote ear development. During the tasseling and silking stage, if high temperatures or rainy weather occur, pollen viability may decrease. Artificial pollination can be carried out between 9:00 and 11:00 a. m. by gently tapping the tassels with a bamboo pole to disperse pollen onto the silks, thereby improving the seed-setting rate and reducing tip baldness.

Grain-filling stage management (tasseling to harvesting)

During the grain-filling stage, the core focus is on kernel development and quality formation. Key management practices include maintaining leaf function, increasing grain weight, and improving quality. Specific measures involve foliar fertilization, water regulation, and removal of ineffective ears. At the early grain-filling stage, foliar spraying is carried out using 750 kg of a 0.2% – 0.3% potassium dihydrogen phosphate solution per hectare, applied every 7 – 10 d for a total of two times. This helps delay leaf senescence and enhances kernel plumpness and soluble sugar content. Soil relative moisture content should be maintained at 60% – 70% to prevent kernel shriveling caused by drought, while also avoiding excessive moisture that may lead to lodging. One to two healthy ears per plant are retained, while weak and malformed ears are removed to concentrate nutrients on the main ear, thereby improving the marketable ear rate.

Pest and Disease Control

The main pests and diseases affecting early spring fresh maize in Eastern Henan include underground pests, corn borers, aphids, head smut, and southern rust. Following the principle of prevention first and integrated management, green control techniques combining agricultural, physical, biological, and chemical measures are adopted to ensure product quality and safety.

Agricultural control

Crop rotation is implemented, rotating with non-gramineous crops such as soybeans and peanuts to reduce the overwintering base of pests and diseases. Reasonable dense planting is adopted to improve field ventilation and light penetration conditions. Diseased plants and residues in the field are promptly removed, taken out of the field, and deeply buried or burned to reduce the risk of pest and disease transmission[7].

Physical control

Frequency trembler lamps and sex pheromone traps are used to attract and kill adult pests such as corn borers and cutworms. Fiftheen frequency trembler lamps are placed per hectare of controlled area. During the corn borer emergence period, 30 – 45 sex pheromone traps are suspended per hectare to attract and kill male moths, thereby reducing egg-laying amount.

Biological control

Trichogramma wasps are released to control corn borer. From the initial to the peak egg-laying period of corn borer, 225 000 – 300 000 wasps are released per hectare every 5 – 7 d for 2 – 3 consecutive times, achieving a parasitism rate of over 80%. *Bacillus thuringiensis* (Bt) emulsifiable concentrate is sprayed to control corn borer larvae, using a 1 000-fold dilution at a rate of 750 kg/hm^2, which is safe and pollution-free.

Chemical control

When necessary, highly effective and low-toxicity chemical pesticides may be selected for control. However, it is important to rotate pesticides with different mechanisms of action to delay the development of resistance[8]. For underground pests, in addition to seed coating, 90 – 120 kg/hm^2 of 5% diazinon granules are applied into the sowing furrow during planting to control white grubs and cutworms. For corn borer control, during the big flare stage, 15 – 30 kg/hm^2 of 1% phoxim granules are mixed with 75 – 150 kg of fine soil to prepare a toxic soil mixture, which is then applied into the flared openings to control larvae during the heart leaf stage. For aphid control, during the seedling to tasseling stage, 300 kg/hm^2 of 10% imidacloprid wettable powder is diluted with 450 kg/hm^2 of water and sprayed, also providing control against planthoppers that transmit viral diseases. Head smut is prevented through seed coating[9]. For rust control, at the initial stage of disease occurrence, 1 500 g of 25% triadimefon wettable powder is diluted with 600 kg of water and sprayed per hectare, repeated every 7 d for a total of two times.

Harvesting

Timely harvesting

The harvesting period for fresh maize is short, requiring strict control of harvest time to ensure taste and quality. Sweet maize is harvested 20 – 22 d after pollination, when the soluble sugar content in the kernels is highest, offering a crisp, tender, and juicy texture. Waxy maize is harvested 22 – 25 d after pollination, when the amylopectin content in the kernels reaches its peak, resulting in a soft, waxy, and delicate texture. Sweet-waxy maize is harvested 23 – 26 d after pollination to balance both sweetness and waxiness[10]. Harvesting criteria: The ear husks should be tender green, the silks dry and brown, the kernels plump and bright in color, and when pressed with a finger, milky sap should flow out with moderate consistency. Harvesting should be carried out in the early morning or evening to avoid high-temperature periods, which may lead to moisture loss and quality degradation.

Post-harvest handling

After harvest, the outer old leaves of the husk are promptly removed, while 2 – 3 layers of inner husk are retained to protect the ear and prevent mechanical damage. Fresh ears should be marketed or processed within 24 h of harvest. If storage is necessary, refrigeration is adopted with the temperature controlled at 0 – 4 ℃, and the storage period should not exceed 7 d to ensure freshness and taste.

Benefit Analysis

Plastic film mulching cultivation advances the harvest period of early spring fresh maize in Eastern Henan by 10 – 15 d, shifting the fresh ear market availability from early July to mid-to-late June. During this period, market supply is limited, and prices are 1.6 – 2.4 yuan/kg higher than those of open-field maize, resulting in an increased income of 12 000 – 18 000 yuan/hm^2. Through standardized cultivation techniques, the fresh ear yield can reach 18 750 – 22 500 kg/hm^2, with a commodity rate exceeding 90%, representing a 30% – 50% increase in yield compared to traditional planting patterns. This results in an additional yield of 4 500 – 7 500 kg/hm^2 and an increased income of 9 000 – 15 000 yuan/hm^2. Through variety selection, isolation planting, and refined management, fresh maize of excellent quality is ensured, with soluble sugar and amylopectin contents meeting standards and good cooking quality, resulting in strong market competitiveness. The effect of high quality and high price is significant, generating an additional income of 3 000 – 4 500 yuan/hm^2.

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