High-quality and High-yield Cultivation Techniques for Summer Soybean

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Abstract Soybeans are rich in protein, fats, vitamins, and minerals, serving as an important source of plant-based protein for humans. Summer soybean is widely cultivated in China, and improving its yield and quality is of great significance for ensuring food security and promoting agricultural economic development. This paper elaborated on the high-quality and high-yield cultivation techniques for summer soybean, including variety selection, seed treatment, field selection and land preparation, sowing techniques, field management, pest and disease control, and harvesting, aiming to provide scientific cultivation guidance for summer soybean growers to achieve both superior quality and high yield.

Key words Summer soybean; High quality; High yield; Cultivation technique

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Soybean is an important oil and grain dual-purpose crop in China, with high nutritional value and a wide range of uses. With the improvement of people's living standards, the demand for soybeans continues to grow. Summer soybean, as one of the primary soybean planting crops in China, has a significant cultivation area in regions such as the Huang – Huai – Hai region[1-2]. However, current summer soybean production faces issues such as low yield and unstable quality, which severely restrict the development of the soybean industry. Adopting scientific and rational cultivation techniques, the yield potential of summer soybean can be fully realized, and soybean quality can be improved. Thus, farmers' income can be increased. Therefore, researching and promoting high-quality and high-yield cultivation techniques for summer soybean is of significant practical importance.

Variety Selection

Selection based on local ecological conditions

Different regions vary in climate, soil, and other ecological conditions, so soybean varieties suitable for the local environment should be selected[3]. For example, in the Huang – Huai – Hai region, varieties with moderate growth periods and strong stress resistance are preferred. Given the region's hot and rainy summers, varieties with good heat and waterlogging tolerance, such as Zhonghuang 37 and Hedou 19, are recommended. These varieties have demonstrated strong adaptability and yield potential in this region.

Consideration of market demand

Soybean varieties can be selected based on market requirements for soybean quality. If there is strong demand for high-protein soybeans, varieties with high protein content such as Shangdou 1310 and Shangdou 2028 should be chosen, as they are suitable for soybean product processing. For markets requiring high-oil soybeans, high-oil varieties like Zheng 9805 are preferable due to their elevated oil content, meeting the needs of oil processing.

Pest and disease resistance of varieties

Selecting varieties with strong resistance to pests and diseases can reduce their occurrence and damage, decrease pesticide usage, and improve soybean yield and quality[4]. For example, certain varieties exhibit high resistance to soybean mosaic virus, making them effective in minimizing disease-related losses in regions where the virus is prevalent.

Seed Treatment

Seed selection

Before sowing, seeds should be carefully selected to remove diseased, insect-damaged, broken, and impure grains, ensuring high purity and cleanliness. Methods such as winnowing, sieving or water flotation can be used for seed selection. This process helps achieve a germination rate of over 95%, providing a strong foundation for cultivating strong seedlings.

Seed coating

Seed coating is an effective measure to control pests and diseases, promote seed germination, and enhance seedling growth[5]. Coating agents containing insecticides, fungicides, and trace elements can be selected for treatment. Insecticides in coating agents help control underground pests such as grubs and wireworms, while fungicides prevent diseases like soybean root rot. During coating, the instructions for the coating agents should be strictly followed to ensure uniform application.

Seed dressing with microelement fertilizer

To meet the microelement requirements of soybean growth, seed dressing with microelement fertilizers can be applied. Commonly used microelement fertilizers include ammonium molybdate

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and borax[6-8]. For ammonium molybdate, approximately 0.5% of the seed weight is dissolved in warm water and evenly sprayed onto the seeds while mixing. After drying, the seeds can be sown. Ammonium molybdate promotes the formation of root nodules and enhances nitrogen fixation, improving soybean yield and quality. For borax dressing, about 0.4% of the seed weight is used. The borax is first dissolved in hot water, and then diluted before being mixed with the seeds.

Field Selection and Land Preparation

Field selection

Flat terrain with convenient irrigation and drainage, fertile soil, and deep topsoil is ideal for summer soybean cultivation. Continuous soybean cropping or alternate cropping should be avoided, as they lead to soil nutrient imbalances, increased pest and disease pressure, and negatively impact soybean growth and yield. Crop rotation with maize, wheat or other crops is recommended to improve soil health and reduce pest and disease incidence.

Land preparation

After harvesting the previous crop, land preparation should be conducted promptly. The tillage depth is typically 20 – 25 cm, and deep plowing or subsoiling is adopted to break up the plow pan and improve soil aeration and water retention. After tillage, the soil should be harrowed immediately to achieve a fine and level seedbed for optimal sowing conditions. In fields with insufficient soil moisture, irrigation should be applied before sowing to ensure adequate moisture for sowing.

Sowing Techniques

Sowing time

The sowing time for summer soybean should be determined based on local climatic conditions and the harvest time of the previous crop. Generally, early sowing should be carried out promptly after the harvest of previous crops such as wheat. In the Huang – Huai – Hai region, sowing typically occurs in early to mid-June when temperatures are favorable for seed germination and seedling growth. Early sowing can extend the growth period of soybean, increase photosynthetic product accumulation, and improve yield. However, sowing too early makes the crop vulnerable to pests and diseases from wheat stubbles, while sowing too late exposes the plants to low-temperature damage during the later growth stages, affecting pod filling and maturity.

Sowing methods

Common sowing methods include sowing in drill, hole sowing, and precision seeding. Sowing in drill involves evenly distributing seeds at fixed row spacing, offering faster sowing speed and easier field management. Hole sowing spaces seeds at predetermined intervals between hills and rows. Typically, 3 – 4 seeds are dropped per hill. It is suitable for fields with lower fertility. During precision sowing, precision planters are empolyed to accurately place seeds at predetermined spacing and seeding rates. Typically, 1 – 2 seeds are dropped per hill. This method saves seeds while ensuring uniform seedling emergence and spacing, facilitating the cultivation of robust seedlings.

Seeding density

Seeding density should be determined based on variety characteristics, soil fertility, and cultivation conditions. Generally, shorter varieties with fewer branches can be planted more densely, while taller varieties with more branches require wider spacing. Fields with higher soil fertility may use lower planting densities, whereas less fertile fields benefit from higher densities. In the Huang – Huai – Hai region, the recommended planting density for summer soybean is typically $(1.8 – 2.7) \times 10^5$ plants/hm^2. The row spacing is generally 40 – 50 cm, while the plant spacing can be adjusted according to the target density. An appropriate planting density optimizes land, light, and nutrient utilization, thereby improving soybean yield.

Sowing depth

The optimal sowing depth typically ranges from 3 – 5 cm. Excessive depth makes seedling emergence difficult, depletes nutrients, and results in weak seedlings. Insufficient depth leads to seed dehydration, adversely affecting germination and emergence. Under adequate soil moisture conditions, shallower sowing is preferable, while deeper sowing is recommended in drier conditions. Post-sowing compaction should be performed promptly to ensure good contact betwen seeds and soil, facilitating water absorption and germination.

Field Management

Seedling inspection and gap filling

After soybean emergence, field inspection should be conducted promptly. If conditions such as inadeque seedlings or gaps are found, immediate reseeding or transplanting should be carried out. Seeds for reseeding should be pre-soaked and germinated to accelerate emergence. Transplanting is best performed on cloudy days or in the evening with soil-attached roots and adequate watering to improve survival rates. Seedling inspection and gap filling ensure complete and uniform stands, establishing a foundation for high yields.

Thinning and final singling

When soybean plants develop their first compound leaf, thinning should be performed by removing weak, diseased, or overly dense seedlings to ensure even seedling distribution. At the stage of 3 – 4 compound leaves, final singling shoudl be performed by keeping seedlings at the predetermined spacing, guaranteeing sufficient growing space and nutrient supply for each plant. During thinning and final singling, the roots of seedlings should be protected from damage.

Intertillage weeding

Intertillage weeding can loosen the soil, improve aeration, and promote root growth, while also removing weeds to reduce competition for nutrients, water, and sunlight. Typically, 2 – 3 rounds of intertillage are carried out during the soybean seedling stage. The first round of intertillage is conducted after soybean emergence, combined with thinning, at a depth of 3 – 5 cm. The

second round of intertillage follows seedling finalization, with a depth of 5 – 7 cm. The third round of intertillage is carried out before canopy closure, at a depth of 3 – 5 cm. This round should include hilling to prevent lodging. During intertillage, weeds can be removed manually or through chemical methods. For chemical weeding, it is necessary to select appropriate herbicides and strictly follow the application instructions to avoid phytotoxicity.

Fertilization management

Base fertilizer Base fertilizer serves as the foundation for soybean growth and should primarily consist of organic fertilizer supplemented with appropriate chemical fertilizers. Generally, 30 000 – 45 000 kg/hm^2 of well-decomposed farmyard manure, 225 – 300 kg/hm^2 of diammonium phosphate and 150 – 225 kg/hm^2 of potassium sulfate can be applied. The base fertilizer should be evenly applied into the soil during land preparation to provide long-term nutrient support for soybean growth.

Topdressing Topdressing for soybeans should be applied according to different growth stages. During the seedling stage, for fields with low fertility or insufficient base fertilizer, an appropriate amount of nitrogen fertilizer can be applied, typically 75 – 120 kg/hm^2, to promote seedling growth. During the flowering and pod-setting stage, when soybean nutrient demand peaks, heavy topdressing should be carried out with 120 – 150 kg/hm^2 of urea and 30 – 45 kg/hm^2 of potassium dihydrogen phosphate[9]. The fertilizers can be applied through furrow or hole application, followed by timely irrigation to improve fertilizer efficiency. Additionally, foliar fertilization can be adopted during the flowering and pod-filling stages. In specific, a 0.2% – 0.3% potassium dihydrogen phosphate solution can be sprayd on the leaves every 7 – 10 d for 2 – 3 consecutive times. It can enhances leaf photosynthesis, promotes grain plumpness, and increases yield.

Water management

Soybeans require substantial water during growth, but the water demand vary according to different growth stages. During the sowing period, adequate soil moisture should be ensured to facilitate seed germination and seedling emergence, with optimal soil water content maintained at 70% – 80%. Irrigation should be conducted promptly if soil moisture is insufficient. At the seedling stage, as soybean roots develop rapidly, water should be moderately controlled to encourage deeper root growth and cultivate strong seedlings. The soil water content during this stage can be maintained at 60% – 70%. Excessive soil moisture can lead to poor root development and excessive vegetative growth. The flowering and pod-setting stage represents the critical water demand period for soybean, when plants are highly sensitive to moisture levels. The soil water content should be maintained at 75% – 85% during this stage. Irrigation should be carried out promptly in case of drought to prevent flower and pod abortion. During the grain-filling stage, certain soil moisture should be maintained to support seed filling. However, the water content should be properly controlled when maturity approaches to prevent delayed ripening and ensure optimal yield and quality.

Pest and Disease Control

Disease control

Soybean root rot Soybean root rot is a common disease that primarily harms the roots of soybean plants. In the early stages of infection, brown lesions appear on the roots and gradually expand, leading to root rot, stunted growth, and yellowing of the plants. The control methods include selecting resistant varieties, choosing crop rotation, using seed coating agents containing fungicides, strengthening field management, ensuring timely drainage, and reducing field humidity. At the onset of the disease, fungicides such as carbendazim or thiophanate-methyl can be applied by root irrigation.

Soybean leaf spot Soybean leaf spot includes diseases such as gray spot and brown spot, primarily affecting the leaves. The symptoms include circular or irregular lesions on the leaves, which may turn yellow and fall off in severe cases. The control methods include selecting resistant varieties, maintaining proper plant spacing to improve ventilation and light penetration, and promptly removing diseased plant debris to reduce pathogen sources. At the onset of the disease, fungicides such as chlorothalonil or mancozeb can be applied for prevention and treatment.

Soybean viral diseases Soybean viral diseases are primarily transmitted by aphids. Infected plants exhibit symptoms such as leaf curling, mosaic patterns, and stunting[10]. The control methods include selecting virus-resistant varieties, promptly controlling aphids to reduce virus transmission, and improving field management to enhance plant resistance. At the onset of the disease, antiviral agents such as Virus A can be applied.

Pest control

Soybean aphids Soybean aphids are one of the major pests of soybean. They cluster on young leaves, stems, and terminal buds to suck sap, leading to leaf curling and stunted growth[11]. The control methods include utilizing natural predators such as ladybugs and lacewings. During the initial infestation stage, when the rate of aphid-infested plants reaches 50% or the aphid count exceeds 1 500 per 100 plants, insecticides such as imidacloprid or acetamiprid can be selected for spray control.

Soybean pod borers Larvaes of oybean pod borer damage soybean pods and seeds, affecting both yield and quality[12]. The control methods involve selecting resistant varieties. During peak adult emergence, dichlorvos fumigation can be adopted. For larval control during hatching periods, insecticides such as lambda-cyhalothrin or deltamethrin can be sprayed.

Soil pests Soil pests such as grubs and wireworms damage soybean seeds and seedling roots, causing plant gaps in rows[13]. The control methods include seed treatment with insecticide-containing coating agents. Before sowing, 30 – 45 kg of phoxim granules mixed with 300 – 450 kg/hm^2 of fine soil can be evenly spread on the soil surface and then plowed into the soil. For active infestations, phoxim emulsifiable concentrate may be applied through root irrigation.

Harvest

Harvesting time

The harvest period occurs when soybean leaves turn yellow and fall off, stems become dry, pods turn brown, and seeds harden to exhibit their characteristic color and shape[14]. At this stage, the grain moisture content typically ranges between 18% and 20%. Premature harvesting results in immature seeds with high moisture content and reduced 100-seed weight, negatively impacting yield and quality. Delayed harvesting increases the risk of pod shattering, leading to yield losses.

Harvesting methods

Currently, soybean harvesting primarily involves two methods: mechanical harvesting and manual harvesting. Mechanical harvesting is highly efficient and suitable for large-scale planting areas[15]. When using a combine harvester, it is essential to adjust the machine's parameters to ensure harvesting quality and minimize losses. Manual harvesting is applicable for small-scale planting areas or fields where machinery cannot operate. During manual harvesting, care should be taken to cut and handle the plants gently to avoid soybean loss. After harvesting, the soybeans should be promptly dried to reduce moisture content to below 13%, followed by threshing, cleaning, and storage.

Conclusions

The high-quality and high-yield cultivation techniques for summer soybean are a systematic project, involving multiple aspects such as variety selection, seed treatment, field selection and land preparation, sowing techniques, field management, pest and disease control, and harvesting. Only by strictly following scientific methods in every step can the yield potential of summer soybeans be fully realized, achieving the goal of high quality and high yield. In actual production, farmers should flexibly apply cultivation techniques based on local conditions, continuously summarize experience, and improve their planting level to contribute to the development of China's soybean industry.

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