Study on Cultivation Techniques of Spring Soybean for High Quality and High and Stable Yield in Huang - Huai Area

Huajun SUN*

Shangqiu Academy of Agriculture and Forestry Sciences, Shangqiu 476000, China

Abstract As an important grain and oil crop, soybean occupies an important position in China's agricultural production. High quality and stable yield of spring soybean is of great significance for ensuring food security and increasing farmers' income. Based on the planting experience and scientific research achievements in many regions, this paper systematically expounded a series of cultivation techniques of spring soybean with high quality and high yield from variety selection, preparation before sowing, sowing techniques, field management to disease and pest control and harvest and storage, aiming to provide scientific and comprehensive guidance for soybean growers and promote the development of soybean industry.

Key words Spring soybean; High quality; High yield; Stable yield; Cultivation technique

DOI:10.19759/j.cnki.2164-4993.2025.02.006

Soybeans are rich in high-quality protein, oil, and various vitamins and minerals, making them an important food source and feed material for humans. With the population growing and the consumption structure upgrading, the demand for soybeans continues to increase. Spring soybean is one of the important crops in China, and the climatic conditions during its growth and development are different from other seasons, so targeted cultivation techniques are needed to achieve high quality, and high and stable yield[1]. Through scientific and reasonable cultivation management measures, we can make full use of light, heat, water and other resources in spring, improve the yield and quality of soybeans, and increase farmers' economic benefits, which is of important strategic significance for ensuring national food security and effective supply of agricultural products.

Variety Selection

The climate and soil conditions in different ecological regions are significantly different, and the adaptability requirements for soybean varieties are different. In the Huang - Huai - Hai region, the climatic conditions are relatively mild, varieties that are medium and early maturing and adapt to local soil fertility and pest environment can be chosen, such as Zhonghuang 301, Shangdou 2001 and Shangdou 2028.

Preparation Before Seeding

Seed treatment

Seed selection Selecting seeds is a key step for ensuring seed quality. Impurities, shriveled grains, diseased grains and damaged grains are removed by screening, wind separation and water separation[2]. For screening, a vibrating screen can be used to separate seeds according to their size. Wind separation relies on wind power to remove light particles and shriveled particles. During water separation, the seeds are put into 5% - 10% salt water, and after stirring evenly, diseased and shriveled seeds will float on the water surface, and the floating objects will be taken out, and the sunken seeds will be full seeds. The selected seeds have high germination rate and orderly emergence, which is conducive to cultivating strong seedlings.

Seed disinfection Seed disinfection is an important measure to prevent seed-borne diseases. Commonly used methods include seed dressing with chemicals and seed coating. When mixing seeds with pesticides, using carbendazim at a rate of 0.3% - 0.5% of the seed weight can effectively prevent and control diseases such as root rot. Seed dressing with phoxim at 0.2% - 0.3% of seed weight can control underground pests.

Seed pregermination Pregermination can shorten the germination time of seeds in soil and improve the emergence rate and uniformity. Specifically, selected seeds are soaked in warm water at 30 - 35 ℃ for 4 - 6 h to make the seeds fully imbibe, and then, they are taken out. After draining, the seeds are wrapped in wet cloth, and put in an environment at 25 - 30 ℃ to accelerate germination. During pregermination, the seeds are rinsed with warm water for 1 - 2 times every day to keep the seeds moist and breathable. After the seeds show white roots, they can be sown. Seeds that have been pregerminated should be sown as soon as possible to avoid the influence of long storage time on vitality.

Land selection and preparation

Soybean has strong adaptability to soil, but in order to achieve high quality, high yield and stable yield, fertile and loose plots with flat terrain, good drainage and deep soil layer should be selected. It is necessary to avoid continuous cropping and planting

Received: October 8, 2024 Accepted: January 10, 2025

Supported by Special Project for the Construction of the National Modern Agricultural Industry Technology System (CARS-04-CES16).

Huajun SUN (1968 -), male, P. R. China, associate researcher, devoted to research about soybean breeding and physiological cultivation.

* Corresponding author.

soybean again after planting another crop, of which continuous cropping will lead to imbalance of soil nutrients, aggravation of plant diseases and pests, and decline of soybean yield and quality[3-4]. After harvest in autumn and before freezing, deep ploughing should be carried out with a depth reaching 25 – 30 cm to break the plow pan and increase the air permeability and water permeability of the soil, which is beneficial to the growth and rooting of soybean roots. After freezing and thawing in winter, the soil structure is further improved, and some overwintering pests and germs can be eliminated. Before sowing in spring, the land is harrowed and ploughed to make the soil reach the standard of "flat, loose, broken and clean".

Sowing Techniques

Sowing time

When the soil temperature at the depth of 5 – 10 cm stably reaches 10 – 12 ℃, it is the suitable sowing period for spring soybean. Early sowing, low soil temperature and slow seed germination are likely to cause pests and diseases and low-temperature chilling injury. Sowing too late shortens the growth period, which affects the yield and quality.

Seeding methods

Drill sowing Drill sowing is a common way of soybean sowing, which has the advantages of uniform sowing, consistent soil covering depth and convenient field management. During sowing, the row spacing is generally 40 – 50 cm and the sowing depth is 3 – 5 cm. In the process of sowing, it is necessary to control the sowing speed and seeding rate to ensure the uniform distribution of seeds. Mechanical drilling has high efficiency and good sowing quality, and is suitable for large-scale planting. Manual drilling is suitable for small plots or areas with complex terrain.

Hole sowing Hole sowing refers to sowing according to a certain row spacing and hole spacing at a rate of 2 – 3 seeds per hole. The row spacing of hole sowing is generally 40 – 60 cm, and the hole spacing is 15 – 25 cm. The sowing depth is the same as that of drill sowing. When sowing in holes, we should sow seeds in the center of holes to avoid sowing seeds at the edge of holes and affecting seedling emergence. Hole sowing saves seeds, and the seedlings emerge neatly. It is convenient for thinning of seedlings and fertilization management, and suitable for middle- and late-maturing varieties and plots with high fertility.

Precision sowing Precision sowing is an advanced sowing technique, which can accurately control sowing rate and sowing position, realizing one seed per hole or two seeds per hole. It can reduce seed waste and improve the quality and uniformity of seedling emergence. Precision sowing requires high seed quality, germination rate above 95% and uniform size. Meanwhile, it is necessary to use a special precision seeder for operation. The seeder is equipped with a precise seed arrangement device, which can accurately sow according to set sowing rate, row spacing and plant spacing. Precision sowing has a broad application prospect in soybean production. It can effectively improve the planting efficiency of soybean.

Seeding density

Influencing factors The sowing density of soybean is influenced by many factors, including variety characteristics, soil fertility, climatic conditions and planting methods[5]. Generally speaking, close planting is suitable for early-maturing varieties with short plants and few branches. Sparse planting is suitable for late-maturing varieties with tall plants and many branches. For plots with high soil fertility and good water conditions, close planting can be adopted. For arid and barren plots with low soil fertility, appropriate sparse planting should be adopted.

Determination of rational density In the plot with medium fertility, when planting with equal row spacing, the sowing density is $(22.5-30)\times10^4$ plants/hm^2 for early-maturing varieties, $(18-22.5)\times10^4$ plants/hm^2 for middle-maturing varieties, and $(15-18)\times10^4$ plants/hm^2 for late-maturing varieties[6]. When narrow row and close planting are adopted, the planting density can be appropriately increased, and is generally 20% – 30% higher than that of planting with equal row spacing.

Field Management

Thinning and final singling

Thinning and final singling are important measures to ensure uniform distribution of soybean plants and rational utilization of nutrients and space. Generally, when soybean seedlings have 2 – 3 true leaves, they should be thinned to remove over-dense, thin and sick seedlings, making sure the seedlings are evenly distributed. When thinning seedlings, attention should be paid to avoiding damage to the roots of reserved seedlings. When the seedlings have 4 – 5 true leaves, final singling is carried out. The number of seedlings retained in each hole or row is determined according to the predetermined planting density and plant spacing. During final singling, we should choose seedlings with strong growth and free of pests and diseases, so as to ensure that the seedlings are neat and strong[7]. Thinning and final singling should be carried out in the afternoon of a sunny day, when the growth of seedlings is obvious, which is convenient for identification and operation.

Intertillage and weeding

Intertillage times and depth Intertillage is an important field management measure in the process of soybean growth, which can achieve the purpose of loosening soil, improving soil aeration, preserving water and fertilizer, promoting root growth, and eliminating weeds at the same time. Generally, intertillage is carried out for 2 – 3 times during soybean growth. The first intertillage is carried out at the seedling stage, with a depth of 3 – 5 cm, so as to break soil hardening, raise the ground temperature and promote the growth of roots. The second intertillage is carried out at the branching stage with a depth of 5 – 7 cm, and hilling is carried out in combination with intertillage to prevent the plants from lodging. The third intertillage is carried out before the flowering stage with a depth of 3 – 5 cm, so as to avoid damage to the root system.

Weeding methods There are many kinds of weeds in soybean

field, such as barnyard grass, green bristlegrass, crabgrass, *Chenopodium album* and amaranth. The growth of weeds will compete with soybean for nutrients, water and light. Chemical weeding is one of the commonly used weeding methods, and herbicides such as acetochlor can be applied to seal the soil before the emergence of soybean seedlings after sowing. Appropriate herbicides can be selected according to the types of weeds after seedling, such as quizalofop-p-ethyl for controlling gramineous weeds and fomesafen for controlling broadleaved weeds. When using chemical herbicides, we should strictly follow the instructions to avoid phytotoxicity.

Water management

Water demand law The water demand of soybean is increasing gradually during the branching stage, so the soil moisture should be sufficient to facilitate the branching and flower bud differentiation, and it should be kept at 60% – 70% of the field water capacity. The flowering and pod-setting stage is the critical period of soybean water demand, and the plants are the most sensitive to the water demand. At this time, the soil water content should be kept at 70% – 80% of the field capacity. If there is a lack of water, it will cause a large number of flower pods to fall off, seriously affecting yield. During the grain filling stage, it is still necessary to maintain a certain amount of soil moisture to ensure the normal development of grains, and the soil moisture content should be 60% – 70% of the field water holding capacity. However, in the later stage, the soil moisture should be controlled appropriately to prevent late ripening and lodging due to excessive moisture.

Irrigation and drainage Irrigation is carried out according to the water demand law of soybean and soil moisture condition. In case of drought, irrigation can be carried out in time, and water-saving irrigation methods such as sprinkling irrigation and drip irrigation can be adopted. Sprinkling irrigation can spray water evenly in the field to avoid water waste and soil hardening caused by flood irrigation. Drip irrigation can accurately control the amount of water, transport water directly to the vicinity of soybean roots, and improve the utilization rate of water resources.

Fertilization management

Base fertilizer The base fertilizer is the basic fertilizer for soybean growth, so it should be applied heavily. Generally, 30 000 – 45 000 kg/hm^2 of decomposed farmyard manure is applied. In the choice of chemical fertilizers, nitrogen, phosphorus and potassium compound fertilizer should be given priority to, and the fertilizing amount should be determined according to the soil fertility status and target yield. Generally, 300 – 450 kg/hm^2 of compound fertilizer with nitrogen, phosphorus and potassium content of 15-15-15 is applied. The application method of base fertilizer generally is spreading followed by deep ploughing, so that the fertilizer is fully mixed with soil and evenly distributed in the plough layer.

Seed fertilizer The seed fertilizer is a fertilizer applied at the same time as seeds when sowing, and its main function is to provide nutrients for seed germination and seedling growth. Generally, 75 – 120 kg/hm^2 of diammonium phosphate or 45 – 75 kg/hm^2 of special seed fertilizer for soybeans is applied. There are two application methods of seed fertilizer: lateral deep application and layered application. Lateral deep application is to apply seed fertilizer to one side of the seeds, 5 – 7 cm away from the seeds, with a depth of 8 – 10 cm. Layered application is to apply seed fertilizer in two layers, of which the upper layer is applied at a distance of 3 – 5 cm from the seeds and the lower layer is applied at a distance of 8 – 10 cm from the seeds, so that the fertilizer can provide nutrients for the seedlings at different levels.

Topdressing The branching stage is the period when vegetative growth and reproductive growth of soybean go hand in hand. At this time, topdressing can promote branching and flower bud differentiation and increase the number of flowers and pods. Generally, 75 – 120 kg/hm^2 of urea or 150 – 225 kg/hm^2 of high-nitrogen compound fertilizer should be applied. The flowering and pod-setting stage is the peak period of soybean fertilizer demand, and topdressing at this time is very important to improving pod-setting rate and yield. Generally, 120 – 150 kg/hm^2 of urea or 225 – 300 kg/hm^2 of high-nitrogen and high-potassium compound fertilizer is applied. Topdressing at the grain filling stage can promote grain fullness and increase grain weight. Generally, 45 – 75 kg/hm^2 of urea is topdressed, or foliar fertilizers such as potassium dihydrogen phosphate are sprayed on the leaves.

Application of chemical control techniques

In the process of soybean growth, reasonable application of chemical control techniques can adjust the growth and development of soybean and improve the yield and quality. In the early stage of soybean growth, if the plant grows excessively, growth regulators such as paclobutrazol can be sprayed to inhibit the vegetative growth of the plant, promote reproductive growth and prevent lodging. The concentration of paclobutrazol is generally 1 000 – 1 500 times dilution of 15% paclobutrazol wettable powder, which is sprayed on the leaves from the branching stage to the early flowering stage of soybean. Spraying foliar fertilizers such as boron fertilizer and molybdenum fertilizer can promote flower bud differentiation and improve pod-setting rate during soybean flowering and pod setting. The boron fertilizer can be borax, which is diluted into 0.2% – 0.3% solution for foliar spraying. The molybdenum fertilizer can be ammonium molybdate, which is diluted to 0.05% – 0.1% solution for foliar spraying.

Control of Diseases and Pests

Control of diseases

Common diseases of soybean in spring include root rot, gray leaf spot and downy mildew. Root rot is a common soil-borne disease of soybean. At the initial stage of the disease, brown spots appear on the roots, and gradually expand and lead to root rot. The aboveground part shows a short plant, yellow leaves and slow growth, and in severe cases, the whole plant dies. When treating seeds, coating them with seed coating agents containing fludioxonil, metalaxyl-M and other ingredients can effectively prevent root

rot. At the early stage of the disease, the roots can be irrigated with metalaxyl, hymexazol and other drugs, which can be applied once every 7 – 10 d for 2 – 3 times continuously, and the dosage for each plant is about 200 – 300 ml. It mainly harms the leaves. At the initial stage, round to oval lesions with gray center and brown edges appear on leaves. In severe cases, leaves are densely covered by disease spots, and they become yellow and fall off, which affects photosynthesis and dry matter accumulation. The key to preventing and controlling gray leaf spot disease is to choose resistant varieties, such as "Zhonghuang 35", which have good resistance to gray leaf spot disease. Measures such as reasonable close planting, keeping good ventilation and light transmission in the field, reducing humidity and reducing disease occurrence conditions can be taken. In the early stage of the disease, when the rate of diseased leaves in the field reaches 10%, fungicides such as carbendazim and thiophanate-methyl are sprayed in time, and after being diluted according to the instructions, the liquid dilution is applied at a rate of 600 – 750 L/hm^2, and sprayed again after 7 – 10 d, for a total of 2 – 3 times[8]. Downy mildew is easy to occur in low temperature and high humidity environments, with irregular yellow-green spots on the front of leaves and gray-white mildew layer on the back. In severe cases, leaves are curled and dried up, and after pods are damaged, internal seeds will also carry the fungi. Downy mildew is likely to occur in low temperature and high humidity environments. Generally, irregular yellow green lesions appear on the front of the leaves, and a gray white mold layer appears on the back. In severe cases, the leaves are curled and dried up, and after the pods are damaged, the internal seeds may also carry the fungi. At the early stage of the disease, metalaxyl mancozeb, dimethomorph and other agents can be sprayed for prevention and control, once every 7 d, and continuously for 2 – 3 times[9].

Control of pests

Common pests include soybean aphids, soybean pod borers, grubs and so on. Aphids suck soybean juice with piercing mouthparts, which causes leaves to curl and shrink, hinder growth, and spread viral diseases, resulting in greater harm. When the occurrence of aphids in the field reaches the control index (generally, the number of aphids per 100 plants is 1 500 – 2 000), chemicals such as imidacloprid and acetamiprid can be sprayed in time. They are diluted according to recommended doses, and sprayed evenly, mainly on the back of leaves[10]. The larvae of borers eat beans and bite them, forming channels or holes, which seriously affects the quality and commodity value of soybeans. In the early stage of larval hatching, pyrethroid insecticides such as beta-cyfluthrin and deltamethrin should be adopted for spray control, and it is necessary to ensure that the pesticides cover the pods evenly when applying them to improve the control effect. White grubs are cockchafer larvae, which eat soybean roots under the ground, causing root damage and poor plant growth. In severe cases, the whole plant dies, and the phenomena of sparse seedlings and vacant ridges may happen. Before sowing, the soil is treated using phoxim granules, with the dosage of 30 – 45 kg/hm^2. In specific, the pesticide is mixed with fine soil, and evenly spread, and the soil is then ploughed. By such, white grubs can be effectively killed. Biological agents such as *Beauveria bassiana* and *Metarhizium anisopliae* can also be used for control. In the early stage of grub occurrence, the biological agents are diluted and then irrigated to the roots, and grubs are eliminated by the parasitic effect of microorganisms. It can reduce the use of chemical pesticides and protect the ecological environment.

References

[1] ZHANG P, GOU SX, XIAO JP, *et al.* Breeding and cultivation techniques of high protein soybean 'Qindou 2014' [J]. Chinese Agricultural Science Bulletin, 2019, 35 (26): 19 – 23. (in Chinese).

[2] WANG YP, LI W, ZONG CM, *et al.* Breeding and cultivation of a new soybean variety Dudou 15 with high yield and high protein[J]. Soybean Science & Technology, 2020(1): 60 – 62. (in Chinese).

[3] GUO QQ. High-yielding cultivation techniques of potato, corn and soybean belt compound planting[J]. Seed Science & Technology, 2024(5): 42. (in Chinese).

[4] LIU JQ, FU JL, LIU BC, *et al.* Discussion on the technical system and benefit of soybean and corn belt compound planting in Huize County[J]. South China Agriculture, 2024(18): 22 – 25. (in Chinese).

[5] DUAN PP. Key points of high-yield cultivation techniques of maize and soybean belt compound planting[J]. Agricultural Technology & Equipment, 2023(8): 172 – 174. (in Chinese).

[6] YU DB, ZHANG MH, MENG FG, *et al.* Effects of density on main agronomic characters and yield of branching soybean variety[J]. Journal of Anhui Agricultural Sciences, 2020, 48(24): 20 – 21. (in Chinese).

[7] ZHU Q, XIE SY, LIU XY, *et al.* Breeding of soybean new variety Yundou 101 and high-yield cultivation technique[J]. Journal of Anhui Agricultural Sciences, 2015, 43(5): 50 – 51. (in Chinese).

[8] LI L. Analysis of soybean planting techniques and pest control methods [J]. Agriculture and Technology, 2019(1): 131 – 132. (in Chinese).

[9] YUE XS. Analysis of soybean planting and pest control techniques[J]. Nong Min Zhi Fu Zhi You, 2020(4): 9. (in Chinese).

[10] ZHAO J. Study on soybean planting techniques and disease and pest control techniques[J]. Xin Nongye, 2020(7): 15 – 16. (in Chinese).

Editor: Yingzhi GUANG Proofreader: Xinxiu ZHU