Key Techniques for High-yield and High-efficiency Cultivation of 'Zhouhua 5' Peanut under Film Mulching

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Abstract With the expansion of peanut planting area year by year, film mulching cultivation has become increasingly important in peanut production due to its unique advantages in enhancing both yield per unit area and overall economic benefits. Based on the varietal characteristics of 'Zhouhua 5' and addressing practical issues in peanut production, this paper summarized key techniques for high-yield and high-efficiency film mulching cultivation of this variety. These techniques cover all critical stages, including land preparation and fertilization, seed preparation, sowing methods, field management, and timely harvesting, providing technical guidance for varietal promotion and peanut production.

Key words Peanut; Zhouhua 5; Film mulching; Key technique

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Peanut (*Arachis hypogaea* L.) is an annual herbaceous plant belonging to *Arachis* in Fabaceae. Originating from Brazil in South America, it is characterized by drought resistance, barren tolerance and strong adaptability. It serves as a significant economic and oilseed crop[1]. Currently, China is the world's largest peanut producer, holding competitive advantages in terms of both planting area and total output. As one of China's primary oilseed crops, peanut accounts for nearly half of the nation's total oilseed production[2]. It has become a key crop in alleviating the shortage of domestic edible oil supply, ensuring food and oil security, optimizing agricultural planting structure, and increasing farmers' income.

Current Development Status

Zhoukou City is situated in the hinterland of the Huang – Huai Plain. With an average annual temperature of 14 – 15 ℃, and the accumulated temperature ≥10 ℃ exceeding 4 700 ℃, and a frost-free period of 219 – 224 d, its short frost period and sufficient thermal resources can fully meet the heat requirements for peanut growth (135 – 145 d). This favorable condition is conducive to timely direct seeding after wheat harvest, enabling a double-cropping system within one year. Its annual precipitation ranges from 700 to 800 mm, and over 50% of the total occurs between June and August, resulting in good natural synchrony between rainfall and thermal conditions. This rainfall pattern highly coincides with the critical peanut growth stages of flowering, pegging, and pod enlargement. However, droughts in late spring and early summer have a frequency of approximately 40%, making supplementary irrigation necessary. The soils are primarily sandy fluvo-aquic soils and mixed soil developed from Yellow River alluvial deposits. The topsoil is loose, well-drained, and aerated, and has a pH of 7.0 – 7.5 and a balanced sand-clay ratio. This soil profile is conducive to pod penetration and expansion while also facilitating mechanical harvesting. The total area suitable for peanut cultivation in the city exceeds 260 000 hm^2. In 2023, the city's peanut cultivation area reached 187 000 hm^2, accounting for 18% of the provincial total and ranking second in the province. The average yield was 3.45 t/hm^2, 7% higher than the provincial average. The value in high-yield demonstration plots achieved 4.8 t/hm^2. The total production was 645 000 t, representing 19% of the province's total production. As a core production area for large-fruit peanuts in eastern Henan, with a commodity rate exceeding 85% and a processing output value surpassing 12 billion yuan, peanut has become the third-largest crop after wheat and corn and a leading industry for increasing farmers' income in Zhoukou[3]. 'Zhouhua 5' is a new peanut variety characterized by high yield, high oil content, and multi-resistance, bred by Zhoukou Academy of Agricultural Sciences. In recent years, the film mulching cultivation technology for 'Zhouhua 5' has been demonstrated and extended across major peanut production areas in Henan Province, achieving the matching of good varieties and methods, and achieving remarkable results.

High-yield Film Mulching Cultivation Technology

Land preparation and fertilization

Land preparation The land is deep-plowed to the depth of 30 – 40 cm in winter, and shallow plowing is carried out after thawing in early spring. After plowing, harrowing and leveling are promptly conducted to preserve soil moisture.

Application of sufficient base fertilizer As a high-oil peanut variety, 'Zhouhua 5' requires emphasis on organic fertilizer and nitrogen fertilizer, adhering to the principle of heavy application of base fertilizer and supplementary application of micronutrients.

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Since topdressing is inconvenient during the growth period of peanuts under film mulching, adequate base fertilizer must be applied during land plowing. The typical fertilization regimen includes the application of over 3 000 kg/hm^2 of high-quality farmyard manure, 450 – 600 kg/hm^2 of ammonium bicarbonate, 600 – 750 kg/hm^2 of calcium superphosphate, and 225 kg/hm^2 of potassium chloride. Alternatively, 750 kg/hm^2 of compound fertilizer special for peanut can be applied. Based on soil nutrient conditions, micronutrient fertilizers such as boron and zinc are applied according to local conditions. Supplementation with 15 kg/hm^2 of boron fertilizer and 7.5 kg/hm^2 of zinc fertilizer is implemented to enhance the fruit setting rate and improve pod plumpness[4].

Seed treatment

Before sowing, pods are sun-dried for 2 – 3 d, followed by shelling. During shelling, kernels are selected. Specifically, kernels that are plump, intact, and of good color are chosen as production seeds. Prior to sowing, seeds are dressed with 50% carbendazim wettable powder (WP) at 0.5% of the kernel weight or with 10 ml of fludioxonil per 5 kg of seeds to control soil-borne diseases such as root rot and stem rot.

Sowing time

The optimal sowing window for spring-sown film-mulched peanut generally falls between April 10 and 25. Sowing is typically initiated when the soil temperature at a 5 cm depth stabilizes at 12.5 ℃ and soil moisture is approximately 70% of field capacity.

Sowing methods

Mulching first, followed by drilling and sowing A herbicide is sprayed on the ridges 5 – 7 d before sowing peanuts, and then plastic film is laid to conserve soil moisture. During sowing, a four-step procedure is employed: drilling holes, watering, placing seeds, and covering with soil.

Sowing first, followed by mulching Seeds are sown on the ridges and then covered with soil, followed by herbicide application and film mulching to conserve soil moisture. This method requires timely perforation of the film to release seedlings. Since intertillage is not possible on peanut ridges covered with film, a herbicide must be sprayed before mulching. In specific, 1 500 – 2 250 ml/hm^2 of 72% metolachlor emulsifiable concentrate (EC) is diluted with 600 kg/hm^2 of water and sprayed evenly. Immediately after spraying, plastic film is laid to cover the field with its edges firmly pressed and sealed[5-6].

Mechanical film mulching and sowing Mechanical film-mulching and sowing offers the advantages of labor and time saving, consistent sowing depth, and uniform plant spacing. It meets the standardization and specification requirements for peanut film mulching and represents the future direction of mulched peanut cultivation. This method should be adopted where conditions permit.

Reasonable close planting

'Zhouhua 5' exhibits a relatively compact plant type, stable growth vigor, and good lodging resistance, making it suitable for close planting. The planting density should be managed such that the rows close canopy during the pod-setting stage. Typically, two rows of peanut plants are planted per ridge, with a row spacing of 35 – 40 cm and a hill spacing of 15 – 18 cm, resulting in a density of 135 000 – 165 000 hills/hm^2, and two seeds are sown per hill.

Field management

Timely seedling release For fields where sowing is followed by mulching, holes are punched to release seedlings as soon as the peanuts emerge, to prevent heat damage from high temperatures under the film. After releasing the seedlings, the film openings are sealed with fine soil to prevent wind damage. Timely inspection and replanting are conducted to ensure a full stand.

Clearing soil and releasing branches During the extension stage of the first pair of lateral branches, soil around the peanut base is promptly cleared to release these branches. Meanwhile, the film openings used for seedling release are sealed with soil.

Water management The peanut stages most sensitive to water demand are the flowering-pegging and pod-setting stages, which also represent the peak water requirement throughout the growth cycle. Supplemental irrigation should be provided promptly during drought. Typically, soil moisture is maintained at 50% – 70% of field capacity. During the pod-filling and maturation stage, if an autumn drought occurs, light irrigation (pod-filling water) should be conducted immediately to enhance pod plumpness. Conversely, if rainfall is excessive during this period, timely drainage is necessary to prevent waterlogging.

Foliar fertilization To prevent premature senescence in the later stage of mulched peanuts, foliar fertilization is initiated from the late pod-setting stage. A solution of 2 250 g of potassium dihydrogen phosphate mixed with 750 kg of water per hectare is applied via spraying. The operation is repeated 2 – 3 times at 7 – 10 d intervals. This practice aims to extend the functional period of leaves and promote fuller peanut kernels.

Timely harvesting Peanuts should be harvested at the appropriate time upon reaching maturity. Harvesting too early results in yield below the expected potential, while harvesting too late increases the risk of pod sprouting and pod drop. Harvesting can be initiated when the entire field meets the following criteria: over 70% of peanut pods have hardened with clear reticulation; over 70% of the spongy tissue inside the shells has been fully absorbed; over 70% of peanut kernels have seed coats that have turned to their mature color; and over 70% of the inner pod walls exhibit dark brown stripes. The late maturity stage of spring-sown peanuts occurs in autumn. During this stage, the middle and lower leaves of the plants gradually yellow and fall, and the pods meet the maturity criteria. Harvesting should be started at this time. Peanut harvesting can be conducted either manually or mechanically, with mechanical harvesting including two-stage semi-mechanized harvesting and fully mechanized harvesting. Two-stage semi-mechanized harvesting involves first digging and uprooting the plants using a digger, followed by manually feeding them into a pod stripper for pod removal and collection. Fully mechanized harvesting completes the entire process including digging, soil

shaking, pod stripping, and collection in a single operation. The adoption of mechanical harvesting for peanuts enhances operational efficiency, reduces labor costs, and achieves cost saving and efficiency improvement[7].

Pest, Disease and Weed Control Techniques

Disease control

Root rot and stem rot Before sowing, seeds are treated by mixing with 70% thiophanate-methyl or 50% carbendazim. During the seedling stage and before flowering, plants are sprayed for disease control with either a 1 000-fold dilution of 50% carbendazim WP or an 800-fold dilution of 70% thiophanate-methyl WP.

Leaf spot Leaf spot is the most prevalent and damaging foliar disease during the mid to late stages of peanut growth. The control method involves foliar application of fungicides such as a 500-fold dilution of 50% carbendazim WP, a 1 500-fold dilution of 43% tebuconazole WP, or a 300-fold dilution of 1.5% polyoxin, which should be applied alternately when the diseased leaf rate reaches 6% – 8%. The application is repeated once every approximately 10 d for a total of 2 – 3 times[8]. These fungicides can simultaneously control multiple peanut diseases and have demonstrated favorable effects on both disease prevention and yield improvement.

Southern blight (white mold) Peanut southern blight (white mold) has shown an increasing trend in recent years, and severe infections often lead to significant yield losses. Control method: During the initial stage of disease development, 50% carbendazim WP or 50% iprodione WP diluted 1 000 – 1 500 times is applied by foliar spray. When southern blight is observed to be prevalent in the field, fungicides such as thifluzamide or thifluzamide · tebuconazole should be selected at the initial stage of disease onset when white mycelia appear. The fungicide solution should be evenly drenched onto the stem bases of the plants and the soil or straw near the ground.

Rust Peanut rust is caused by the fungus *Puccinia arachidis*. Initially, pinpoint-sized rash-like white spots appear on the undersides of leaves. These spots gradually develop into circular pale yellow lesions. As the lesions expand and become raised, they turn yellowish-brown, and their epidermis ruptures to release a rust-colored powder. The lesions are often surrounded by an indistinct yellow halo. At the initial stage of the disease, control can be achieved by promptly spraying with 20% triadimefon · thiram WP diluted 1 000 – 1 500 times, 25% propiconazole EC diluted 1 500 – 2 000 times, or 5% chlorothalonil WP diluted 750 times[9].

Scab Peanut scab is caused by the fungus *Sphaceloma arachidis*. Affected surfaces exhibit corky scab-like lesions. Symptoms are particularly pronounced on new leaves. In severe infections, leaves become twisted and deformed, showing pinpoint-sized circular spots, while lesions on petioles and stems are larger. Under high-humidity conditions, a layer of dark brown velvet will grow on the surface of the lesions. Control can be achieved by spraying with a 500-fold dilution of 70% thiophanate-methyl WP, a 600-fold dilution of 50% carbendazim WP, or a 1 000-fold dilution of 10% difenoconazole WP.

Pest control

The primary pests threatening peanut growth include below-ground species such as root-knot nematodes, white grubs, cutworms, and mole crickets, as well as above-ground species including aphids, cotton bollworms, tobacco cutworms, and thrips. Early-season pest management strategies in peanut fields largely align with disease prevention approaches, encompassing practices such as deep plowing and field sunning, seed coating, and light trapping. The implementation of these measures can significantly reduce the probability of pest infestations. In the event of pest infestations, pesticides characterized by high efficacy, low toxicity, and low residue are selected for control, with application intervals of once every 7 – 10 d, and an alternating or mixed-use strategy is adopted. For below-ground pests, methods such as root drenching with pesticide solutions or incorporating pesticides into the soil for broadcast application around the plant root zone are typically applied. The control of above-ground pests requires spraying evenly and applying sufficient pesticides 1 – 2 times.

White grubs White grub control requires integrated management targeting both adults and larvae. During the peak adult activity period (late June to early July), control measures include the use of insecticidal lamps and insecticides. For the peak larval hatching and early instar stages (mid-July to early August), 3 000 – 4 500 ml/hm^2 of 48% chlorpyrifos EC is applied via spraying[10].

Cotton bollworms, soybean loopers, and tobacco cutworms Prior to the third-instar stage, a spray application of 300 g/hm^2 of 10% *Bacillus thuringiensis* (Bt) insecticide mixed with 900 kg/hm^2 of water is simplemented, followed by a second application 5 d later. At the early flowering stage, spraying with 50% phoxim diluted 1 000 – 1 500 times or 1.8% abamectin diluted 2 000 – 3 000 times is conducted. The use of highly toxic and highly residual pesticides is strictly prohibited in pest control operations.

Aphids and spider mites When the aphid count exceeds 500 per 100 peanut hills, control is achieved by spraying with either a 1 000-fold dilution of 40% chlorpyrifos EC or a 4 000-fold dilution of 10% imidacloprid. For the simultaneous control of both aphids and spider mites, a mixture of 1.8% abamectin EC diluted 1 000 – 1 500 times and 1% emamectin benzoate diluted 1 000 times is applied[11].

Chemical weed and growth control

Due to improved ecological conditions, weed infestation poses a significant challenge in film-mulched peanut fields. After complete peanut emergence, grass weeds are controlled by spraying 450 – 600 ml/hm^2 of 12.5% haloxyfop-R-methyl EC mixed with 450 kg/hm^2 of water, while broadleaf weeds are managed by spraying 45 – 75 ml/hm^2 of 24% lactofen mixed with 450 kg/hm^2 of water. Film-mulched peanuts exhibit rapid early growth and development, making them prone to excessive vegetative growth and

(Continued on page 25)

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(Continued from page 15)

lodging during the initial pod-setting stage. For fields where plant height exceeds 35 cm and shows a tendency toward vigorous growth, chemical growth regulation is implemented. This involves spraying 1 050 – 1 500 g/hm^2 of 5% uniconazole WP mixed with 750 kg/hm^2 of water[12], while avoiding over-application, missed spots, or rainfall shortly after spraying. To reduce costs, growth regulation can be integrated with disease and pest control measures.

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