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The Characteristics and Disease/Insect Control of Bijie White Garlic

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Abstract

To clarify the varietal characteristics and supporting production technologies of Bijie white garlic, and improve its yield, quality and cultivation efficiency, this paper takes Guizhou Bijie white garlic as the research object. By combining literature review and field production practice summary, it systematically studies its species overview, biological characteristics, morphological characteristics and growth and development rules, and puts forward integrated prevention and control measures for main diseases and insect pests. The results show that Bijie white garlic features large bulbs, high quality and strong cold resistance, with a growth period of 250–280 days. The dry garlic yield per mu in monocropping can reach 800–1000 kg. Its growth has staged demands for temperature, light and water, and the bulb expansion stage is the critical period for yield formation. It is mainly affected by diseases and pests such as rust, leaf blight, garlic maggot and thrips. Reasonable regulation of environmental conditions, scientific water and fertilizer management and green integrated prevention and control can significantly improve the yield and commodity value of white garlic. This study can provide theoretical basis and technical support for the standardized cultivation, seed breeding and green production of Bijie white garlic.

Keywords

Bijie White Garlic; Biological Characteristics; Morphological Characteristics; Growth and Development; Disease/Insect Control.

1. Overview of the Species

Bijie White Garlic is a local variety from Bijie City, Guizhou Province. Renowned both domestically and internationally for its large bulbs, thick flesh, pure white color and rich aroma, it is a key cash crop in Bijie City and one of its primary export products, with exports reaching countries such as Japan and Singapore, as well as the Hong Kong and Macao regions of China [1]. Bijie City cultivates over 2,300 hectares of white garlic annually, yielding more than 4,500 tonnes. Planting density has a significant impact on the yield and quality of white garlic, and adopting a reasonable planting density is one of the key measures for increasing its yield [2]. Currently, some garlic farmers in Bijie City blindly increase planting density in pursuit of high yields. Although this increases the yield per unit area, it results in smaller bulb diameters and lower individual bulb weights, leading to poor economic returns. The entire growing season for Bijie white garlic is 250–280 days. The plants reach a height of approximately 0.5 meters, with scapes measuring about 0.5 metres in length. The bulbs are flattened and conical in shape, with a white exterior. When young, the skin around the cloves is white; as they mature, it takes on a slight purple hue, whilst the flesh remains white. The bulbs measure 6–8 cm in diameter and 4–5.5 cm in height, with an average weight of 40–50 g per bulb; larger specimens may exceed 60 g. The cloves are plump, typically numbering around 8 but sometimes as many as 12,

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arranged neatly and firmly attached to the bulb. It exhibits strong cold tolerance, is fertile, disease-resistant, early-maturing and slow to degenerate. When intercropped, the yield of dried garlic is generally around 300 kg per 667 square metres (1 mu). If grown as a sole crop, the yield of dried garlic can reach 800–1,000 kg per 667 square metres, with garlic scapes yielding 200–300 kg, resulting in considerable economic benefits.

2. Biological Characteristics

2.1. Environmental Requirements

2.1.1. Temperature

The growth and development of Bijie White Garlic exhibit distinct stage-specific temperature requirements, well-suited to the mild and humid climate of Bijie, Guizhou: the optimal temperature during the germination stage is 15–20°C; temperatures below 10°C delay germination and result in uneven emergence [7]; The seedling stage exhibits strong cold tolerance, with the plants able to withstand brief periods of temperatures as low as -5°C; the optimal growth temperature is 12–18°C, with lower temperatures promoting robust seedling growth and nutrient accumulation; the bulb enlargement stage is a critical phase, with an optimal temperature of 20–25°C; excessively high temperatures (above 30°C) can lead to premature leaf senescence and poor bulb development, whilst excessively low temperatures will slow the rate of enlargement; After harvest, the crop enters dormancy; storage temperatures of 0–5°C inhibit bulb respiration and extend storage life.

2.1.2. Light

Bijie White Garlic is a long-day plant, and its light requirements vary significantly across different growth stages: during the seedling stage, light duration requirements are relatively flexible, with growth best supported by 8–10 hours of light per day; ample yet gentle light promotes leaf photosynthesis, facilitating nutrient accumulation to foster robust seedlings [5]; Upon entering the bulb differentiation and enlargement stage, a long-day environment of 12–14 hours of light per day must be ensured; this is a key condition for inducing bulb formation and promoting rapid bulb enlargement. If light duration is insufficient, the plants are prone to leggy growth and poor bulb development; Furthermore, adequate light must be maintained throughout the entire growing season, and shading caused by dense foliage in the field must be avoided, as this would reduce photosynthetic efficiency and adversely affect the yield and quality of white garlic.

2.1.3. Water

The water requirements of Bijie white garlic vary significantly across different growth stages and must be managed precisely in accordance with the precipitation patterns of Bijie, Guizhou: During the sowing and germination period, the soil must be kept moist, with moisture content maintained at 60–70% of field capacity, to facilitate water uptake by the garlic seeds, promote germination, and ensure uniform emergence; During the seedling stage, watering should be moderately restricted, with soil moisture content maintained at 50–60% to prevent root rot or disease caused by waterlogging and to promote deep root development; The bulb differentiation and enlargement stage is a critical period for water requirements. An adequate and uniform water supply must be ensured, with soil moisture content stabilised at 70–80% of field capacity to meet the demands of rapid bulb enlargement; water deficiency at this stage will result in small cloves and reduced yields; One to two weeks prior to harvest, watering should be reduced to lower soil moisture, promoting the lignification of the bulb skin and enhancing storage life.

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2.2. Photosynthesis and Nutrient Accumulation

As a typical light-loving, long-day crop, Bijie white garlic exhibits photosynthetic and nutrient accumulation characteristics that are closely attuned to the demands of its growth stages and the climatic conditions of Bijie, Guizhou: during the seedling stage, the photosynthetic rate of the leaves increases with rising light intensity; moderate daylight hours of 8–10 hours promote chlorophyll synthesis, with photosynthetic products being prioritised for accumulation in the root system and leaves, thereby fostering robust seedlings to support subsequent growth; Upon entering the bulb differentiation and enlargement stage, long-day conditions of 12–14 hours induce a shift in the distribution of photosynthetic products, with large quantities of carbohydrates being transported to the bulbs. At this stage, ample light significantly enhances photosynthetic efficiency; conversely, insufficient light leads to reduced accumulation of photosynthetic products, resulting in leggy growth and stunted bulb development; Throughout the entire growing season, the accumulation of photosynthetic products in Bijie White Garlic is positively correlated with the duration and intensity of light exposure. At the same time, appropriate water and fertiliser management can synergistically enhance photosynthetic efficiency, further promoting the accumulation of nutrients such as starch and protein in the bulbs, thereby ensuring both yield and quality.

2.3. Stress Tolerance

2.3.1. Drought Tolerance

Bijie White Garlic exhibits generally low drought tolerance, with significant variations in drought resistance across different growth stages: during the seedling stage, the root system is in its early stages of development and can tolerate short-term, mild drought; however, prolonged water deficiency leads to leaf yellowing and stunted growth; The bulb differentiation and enlargement stage is a critical period for water demand, during which drought tolerance is at its lowest. Water deficiency at this stage directly affects the transport of photosynthetic products and bulb enlargement, resulting in small cloves, low yields and reduced quality; whilst moderate water restriction prior to harvest is beneficial for the lignification of the bulb skin, prolonged drought can cause the skin to crack, thereby reducing storage life. Given the climatic characteristics of Bijie, Guizhou—which is generally rainy but occasionally experiences summer droughts—it is essential to provide timely irrigation during critical growth stages to avoid drought stress.

2.3.2. Cold Tolerance

The cold tolerance of Bijie White Garlic varies by growth stage, but overall it is well-suited to the mild winter climate of Bijie, Guizhou, which is occasionally subject to low temperatures: Cold tolerance is relatively strong during the seedling stage, with the plants able to withstand short-term temperatures as low as -5°C; low temperatures can even promote deeper root penetration and nutrient accumulation, which is beneficial for cultivating robust seedlings; once the bulb differentiation stage begins, cold tolerance declines significantly; if exposed to prolonged temperatures below 0°C, this can easily lead to frost damage to the growing point, affecting normal bulb differentiation; During the bulb enlargement stage, the plant is even more sensitive to low temperatures; cold conditions inhibit the transport of photosynthetic products to the bulb, slowing down the rate of enlargement and reducing both yield and quality.

2.3.3. Disease Resistance

Bijie White Garlic exhibits moderate overall disease resistance, with significant variations in resistance to different diseases, which is well-suited to the high-humidity, foggy climate of Bijie, Guizhou: It possesses some resistance to powdery mildew and leaf blight; however, if the field is overcrowded or humidity remains persistently high, these diseases are still likely to be induced; It exhibits relatively weak resistance to garlic maggots and root rot; these pests and

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diseases frequently occur due to waterlogged soil and continuous cropping, directly damaging the root system and bulbs, leading to premature plant senescence and rotten cloves. Through cultivation management measures such as crop rotation, appropriate planting density, and water control and drainage, its overall disease resistance can be significantly enhanced [6].

3. Morphological Characteristics

3.1. Root System Morphology

Bijie White Garlic possesses fibrous roots without a taproot, exhibiting a shallow and dense root system: the fibrous roots predominantly emerge from the stem base at the bulb's base, are of relatively uniform thickness, and generally measure 15–25 cm in length, primarily distributed within the topsoil layer at a depth of 10–20 cm; The root system has a limited capacity for branching and produces few root hairs, resulting in a restricted range for water and nutrient uptake; this is a key reason for its relatively poor drought tolerance and intolerance to waterlogging. During the seedling stage, root growth is rapid, allowing the roots to quickly occupy the upper soil layer to absorb nutrients; however, root growth ceases during the bulb enlargement stage, and root function gradually declines.

3.2. Characteristics of Stems and Leaves

The stems and leaves of Bijie White Garlic exhibit typical characteristics of Allium species within the Liliaceae family, adapted to the physiological requirements of bulb development: The stems are divided into vegetative stems and flower stems. The vegetative stems are shortened underground to form a stem rosette, serving as the base for the attachment of the root system and leaves. The flower stems (garlic scapes) are cylindrical and hollow, 30–50 cm long and 0.5–0.8 cm in diameter, with a crisp and tender texture; The leaves are flat and strap-shaped, arranged alternately; they are 40–60 cm long and 1.5–2.5 cm wide, with a deep green colour and a waxy coating on the surface to reduce water transpiration. The photosynthetic area of the leaves and the thickness of the waxy layer directly influence the accumulation of photosynthetic products, thereby determining bulb yield.

3.3. Bulb Morphology and Characteristics of Nutrient Storage

The bulbs of Bijie White Garlic are flattened spherical or nearly spherical in shape, with a thin, white or pale purple outer skin. Individual bulbs typically measure 4–6 cm in diameter and weigh 50–80 g. They are composed of multiple cloves arranged closely together on a basal stem disc; the cloves are plump and full, with a firm texture [9]. The bulb serves as the primary organ for nutrient storage. During the early growth stages, nutrients such as carbohydrates, proteins and minerals produced by photosynthesis in the leaves are continuously transported to and accumulated within the bulb. Starch accounts for 60–70% of the dry matter, whilst active compounds such as allicin are also concentrated. The storage characteristics of the bulb are well-suited to cool, dry environments; under conditions of 0–5°C, respiratory consumption is suppressed, thereby extending the storage life and maintaining the stability of nutritional components [4].

4. Growth and Development Stages

4.1. Sowing and Germination Stage

The sowing and germination stage is generally carried out in autumn. Given the climatic conditions of Bijie, Guizhou, the optimal sowing period is from late September to early October [3]. Management during this stage focuses on temperature, moisture and soil conditions: after sowing, soil moisture should be maintained at 60–70% of field capacity, with temperatures controlled between 15–20°C to facilitate water uptake and germination by the garlic seeds; A

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sowing depth of 3–5 cm is recommended to avoid delayed emergence from excessive depth or drought stress from shallow planting; a thin layer of straw may be applied after sowing to retain moisture and provide insulation. Uniform emergence generally occurs 10–15 days after sowing; however, if temperatures fall below 10°C, germination rates slow significantly and emergence uniformity decreases [9].

4.2. Seedling Growth Stage

The seedling growth stage follows immediately after the germination stage and lasts approximately 60–80 days, well-suited to the mild autumn and winter climate of Bijie, Guizhou. The core of management during this stage is to cultivate robust seedlings and promote deep root development [3]: In terms of temperature, seedlings can tolerate short-term temperatures as low as –5°C, with an optimal growth temperature of 12–18°C; low temperatures enhance the seedlings' stress resistance and promote nutrient accumulation; Water management requires appropriate water restriction, maintaining soil moisture at 50–60% of field capacity to prevent waterlogging and root rot; Regarding light, 8–10 hours of moderate sunlight per day is sufficient; ample light improves leaf photosynthetic efficiency and promotes the growth of both leaves and roots; Furthermore, light nitrogen fertiliser can be applied in conjunction with cultivation and soil loosening to support robust seedling growth and lay the foundation for subsequent bulb differentiation.

4.3. Bulb Swelling Stage

The bulb enlargement stage is a critical phase for yield formation, generally occurring from March to April of the following year and lasting approximately 40–50 days. This aligns well with the climatic conditions in Bijie, Guizhou, where spring temperatures rise and sunlight is abundant: the optimal temperature during this stage is 20–25°C, and 12–14 hours of long daylight hours per day must be ensured to facilitate the rapid transport of photosynthetic products to the bulbs; In terms of water management, soil moisture content should be maintained at 70–80% of field capacity. Watering should be uniform, and waterlogging avoided, as water deficiency leads to small cloves and reduced yields. Regarding nutrients, phosphorus and potassium fertilisers should be increased whilst nitrogen fertiliser application is reduced to prevent excessive vegetative growth. Additionally, weeds must be removed promptly to improve ventilation and light penetration, thereby promoting plump bulb enlargement and enhancing quality.

4.4. Harvesting Period

The harvesting period for Bijie White Garlic is divided into two stages: scape harvesting and bulb harvesting, which must be precisely timed in accordance with plant growth and the climatic characteristics of Bijie's spring: Scape harvesting generally takes place during the early stage of bulb enlargement. Harvesting may commence when the scape tip curves into a hook, the bract turns white, and the stem stands erect; this typically occurs in mid-to-late April. Harvesting should ideally be carried out on a sunny morning to avoid damaging the leaves and affecting the accumulation of photosynthetic products; Bulb harvesting takes place 20–30 days after scape harvesting, when the lower leaves have turned yellow and withered, the upper leaves retain 3–4 green leaves, and the bulb skin is firm and white. This usually occurs in early to mid-May. After harvesting, the bulbs must be sun-dried promptly to promote drying of the skin and enhance storage life.

4.5. Seed Saving Period

The seed saving period for Bijie White Garlic must take into account both its growth characteristics and the climatic conditions of Bijie, with particular attention paid to the key stages of seed garlic selection, field management and storage: seed garlic should be selected at

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the time of bulb harvest, choosing high-quality individual bulbs that are plump, free from pests and diseases, have intact outer skins, and conform to the variety's characteristics; these should be harvested separately and sun-dried; After drying, they must be stored in a well-ventilated, dry place until sowing in autumn. The storage environment should be maintained at a temperature of 0–5°C and a relative humidity of 60–70% to prevent the seed garlic from becoming damp and mouldy or suffering frost damage; prior to sowing, a further selection must be carried out to remove rotten or shrivelled bulbs, ensuring uniform emergence and vigorous growth after sowing.

5. Pest and Disease Control

5.1. Major Diseases and Prevention

5.1.1. Garlic Rust

This disease is a common fungal disease affecting Bijie White Garlic during its growing season. It typically erupts in spring when temperatures rise and humidity is high, primarily affecting the leaves and pseudostems. In the early stages of infection, pinhead-sized chlorotic spots appear on the leaf surface, which gradually develop into yellow to orange-yellow pustular rust spots. When these spots rupture, they release a rust-coloured powder (fungal spores). In severe cases, the lesions merge, causing premature senescence and death of the leaves, which impairs the accumulation of photosynthetic products and reduces bulb yield. Control measures must focus on the critical early stage of the disease. Apply a 1,500-fold dilution of 25% triazole emulsion promptly, ensuring the solution evenly covers both sides of the leaves. Spray once every 7 days, repeating the treatment twice, to effectively suppress the spread of the pathogen.

5.1.2. Garlic Leaf Blight

This disease is a fungal infection with a long incubation period, capable of infecting plants from the seedling stage through to bulb enlargement, primarily affecting the leaves. In the early stages, the leaf tips turn yellow with a water-soaked appearance, which subsequently spreads towards the base of the leaf. Irregular brown lesions develop on the affected areas, accompanied by a black mouldy layer; in severe cases, the entire leaf rots and dies. Control measures should be implemented at the onset of the disease. Apply a 600-fold dilution of 75% chlorothalonil wettable powder as a foliar spray, focusing on the middle and lower leaves of the plants. Depending on the progression of the disease, repeat the application every 7–10 days to effectively control the severity of the disease.

5.2. Major Pests and Control

5.2.1. Garlic Maggots

Garlic maggots are the larvae of Diptera (two-winged) flies and constitute the primary underground pests of Bijie white garlic. They feed on garlic seeds, root systems and bulbs. Infected plants suffer root damage and reduced water uptake, with leaves exhibiting symptoms of yellowing and wilting. Once the bulbs are bored into, cavities form, accompanied by rotting and a foul odour; in severe cases, this leads to plant death and a direct reduction in yield. Control measures focus primarily on soil treatment. Before sowing or at the early stage of larval emergence, apply 2 kg of 5% phoxim granules evenly per mu. After application, lightly till the soil to ensure thorough mixing of the pesticide with the soil, which effectively kills the larvae. Alternatively, during the adult egg-laying period, spray a diluted solution of phoxim emulsifiable concentrate to prevent egg hatching [10].

5.2.2. Thrips

Thrips are piercing-sucking pests that primarily damage the leaves and scapes of white garlic. Both adults and nymphs pierce and suck plant sap, causing greyish-white spots or streaks to

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appear on the leaves. In severe cases, the leaves curl, turn yellow and wither; damaged scapes develop scars, affecting market value [11]. Control measures can be implemented at the early stages of infestation by spraying a 2,000-fold dilution of 10% imidacloprid wettable powder. When spraying, focus on the terminal leaves and the undersides of the leaves. Apply once every 5–7 days, repeating the treatment twice, to effectively eliminate both adult and nymph thrips.

5.3. Green Pest Control Techniques

5.3.1. Biological Control

Priority should be given to eco-friendly control methods to reduce the use of chemical pesticides. To combat thrips infestations, predatory mites can be released into the field to control thrips populations through predation. The release rate should be adjusted according to the pest density in the field; generally, releasing 20,000–30,000 mites per mu can maintain long-term pest control efficacy; To combat garlic maggots, Bt emulsion (Bacillus thuringiensis) may be applied via root drenching. Apply 300–400 kg of a 500-fold dilution of Bt emulsion per mu [12] to the plant roots; this effectively infects and kills garlic maggot larvae without harming the soil environment or natural enemies.

5.3.2. Physical Control

Implement physical control measures in conjunction with field management to reduce the baseline incidence of pests and diseases. During the adult emergence period of thrips and seed flies, hang 20–30 yellow sticky traps (20 cm × 30 cm) per mu, positioning them at the same height as the plant tops. This utilises the insects' attraction to yellow to trap and kill adults, thereby reducing egg-laying; In the early stages of disease outbreak, promptly remove diseased plants by hand, remove them from the field for deep burial or incineration, to prevent the spread of pathogens within the field; simultaneously, regularly clear weeds from the field to eliminate habitats for pests.

5.4. Precautions for Chemical Control

During the chemical control of pests and diseases in Bijie white garlic, strict adherence to application guidelines is required: priority should be given to low-toxicity, low-residue pesticides such as imidacloprid and triazole [8]. Pesticides must be applied uniformly in strict accordance with the dilution ratios and dosage specified in the instructions. Additionally, pesticides with different modes of action should be rotated to prevent the development of resistance in pests and diseases; The safety interval for pesticide application must be strictly observed; the use of any chemical pesticides is prohibited 20 days prior to harvest to ensure that pesticide residues in garlic bulbs and scapes comply with national food safety standards [8].

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