Technical Guidance on High-yield Onion Cultivation

World Food Programme Centre of Excellence for Rural Transformation

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Section 1: Biological characteristics of onions

I. Morphological characteristics

(I) Root

The radicle of onion shrinks soon after entering the soil, so there is no main root, and the root is a string-like fibrous root, which is born at the base of the short shrunken stem disc and has no root hairs. The onion root system is weak and shallow, mainly concentrated in the 20-30 cm deep soil layer, so the onion root system is not strong in absorbing fertilizer and drought tolerance is weak.

(II) Stem

During the nutritional growth period, the stem of onion is shortened into a flat conical stem disk. The disc is ringed with cylindrical leaf sheaths and buds at the top and fibrous roots below. The stem disc tissue of mature bulbs dries and hardens into a disc heel, which prevents water from entering the bulb and controls premature root growth or bulb sprouting. During the reproductive growth period, after the plant is subjected to low temperature, the growth cone starts to differentiate flower buds and produce flowering shoots under long daylight conditions.

(III) leaves

The leaves of onions consist of two parts: the leaf blade and the leaf sheath. The leaf blade is slightly curved, green to dark green, tubular and hollow, with a waxy powdered surface and a depressed abdomen. The number and size of the leaf blade is related to the variety, but also with the yield and quality. Generally has the number of leaves 9 to 13, the more the number of leaves the higher the yield. Early varieties have fewer leaves.

Japanese onion varieties are characterized by few leaves and thin leaf tubes due to the low temperature and low sunlight in the early stage of growth. Onion varieties from the United States, the Netherlands, Spain and other countries in the pre-growth period at a suitable temperature and sufficient sunlight, showing more leaves, rapid growth and thick leaf tubes. The lower part of the onion leaves are leaf sheaths, which are cylindrical, light green and hold each other into pseudostems. At the early stage of growth, the base of the leaf sheath is not expanded, pseudostem thickness is similar to the upper and lower. In the middle and late stages of growth, the base of the leaf sheath

accumulates nutrients and gradually expands to form thick scales, and the thick scales are clasped into a bulb. The number of layers and the degree of fatness of leaf sheaths directly affect the size and yield of bulbs, while the number of layers of leaf sheaths is related to the number of leaves.

(IV) Bulbs

In late onion growth to maturity, the outermost 1 to 3 layers of the leaf sheath base due to the stored nutrients moved inward and become membranous scales, to protect the inner scales to reduce transpiration, so that the onion can be stored for a long time. Onion open fleshy scales inside for young buds, each bud generally has 2 to 5 buds, each bud includes several closed scales and growth cones that have not yet extended into leaves. The bulbs of onions are flat, round or ellipsoidal in shape, with red, yellow or white epidermis.

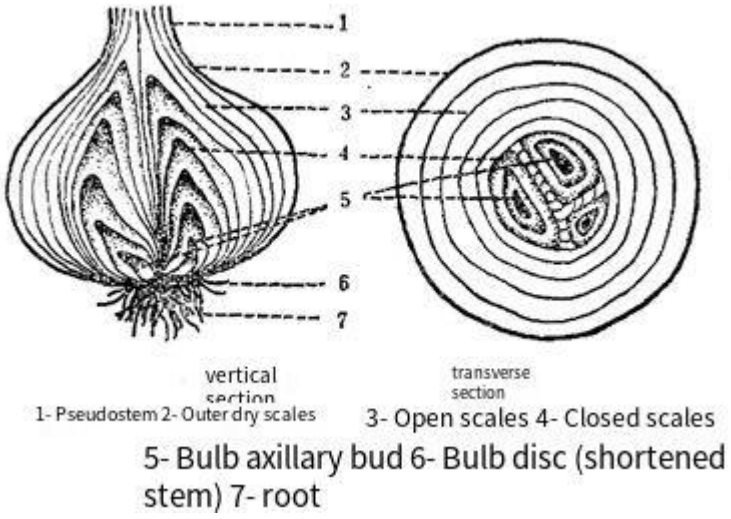

Figure 1 Schematic diagram of onion bulb structure

(V) Flowers

After the onion plant or bulb feels the low temperature for a certain period of time, it starts reproductive growth, growth point differentiation, and flowering in the warm spring and summer under long sunshine conditions. Onion flowering shoots are hollow and tubular, slightly spindle-shaped from the middle to the bottom. The flowering shoots vary in height depending on the variety and cultivation conditions, generally 1 to 1.5 m. The top of the flowering shoots bear umbels with involucre envelopes and many small flowers inside, usually 200 to 300, with many up to 500 or more. One onion mother bulb can produce four to five flowering shoots, more than 10. There are also

individual plants that produce only one flowering stem, and such plants take less seed, but their offspring are less likely to have cleavage.

The general tendency of the flowering process on a flower bulb is to expand outward from the center, but the pattern is not obvious. The pedicel of onion florets is about 2.5 cm long, with 6 petals, white and lanceolate; 6 stamens, arranged in two whorls of 3 each; 1 pistil, the ovary is superior, 3-locular, with two ovules per locule.

The onion is a stamen-first heterogeneous pollinated crop, in 2 to 4 d after flowering, the pistil elongation to the maximum length of about 0.5 cm, is the best period of pollination, generally in 5 d after the loss of fertilization capacity. The pollen of onion is poorly tolerant of moisture, and pollen grains can disintegrate on their own after absorbing water. Therefore, rainfall during flowering is very unfavorable for seed harvesting and can lead to significant yield reduction.

(VI) Fruits and seeds

The onion fruit is a bifid capsule containing six seeds per fruit. The seeds of onions are peltate, angular, flat on the ventral side and deeply depressed at the umbilicus. The seed surface is black and has irregular wrinkles. Onion seeds are 3.1 to 3.4 mm long, 2.3 to 2.6 mm wide, 1.5 to 1.6 mm thick, except for special varieties, less than the above values of small seeds of poor quality. Thousand grain weight 3 ~ 4 g, specific gravity 1.15 ~ 1.17. 1 L full seed weight of about 420 ~ 470 g. If 1 L seed weight in 400 g or less, the quality is poor, germination rate is difficult to exceed 70%.

The outermost layer of onion seeds is the black seed coat, and on the inner side of the seed coat, there is a thin film-like outer endosperm, and inside it is the inner endosperm and embryo, which is located in the middle of the inner endosperm in a spiral shape. The endosperm is rich in protein and fat. The embryo can be divided into the cotyledons, epicotyledons, hypocotyledons and the primordia of the first true leaf. Onion seeds can generally maintain their germination ability for about 1 year at room temperature, and any longer and their germination power will be significantly reduced. However, if such seeds are placed in low temperature conditions, seed germination power can be prolonged substantially. Therefore, if the onion seeds harvested in the current year cannot be sown immediately, they should be put into low temperature cold storage.

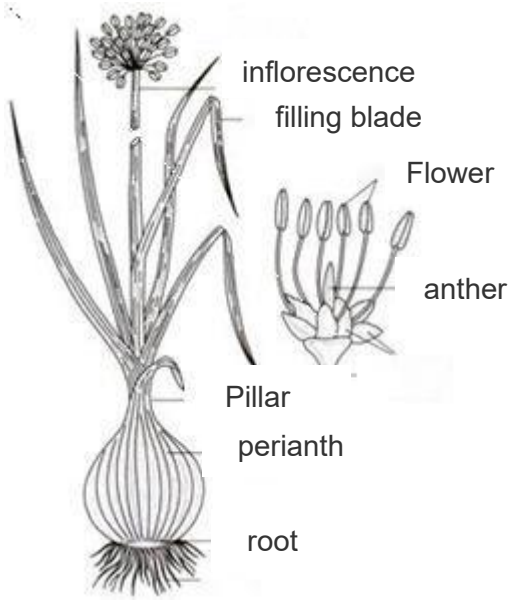

Figure 2 Onion plant morphology

II. The growth and development characteristics

From seed germination to flowering and seed setting, onions not only vary greatly in plant morphology, but also have different requirements for external conditions at different times. According to its growth and development process and combined with the characteristics of farming management, the fertility cycle of onion can be divided into the following periods.

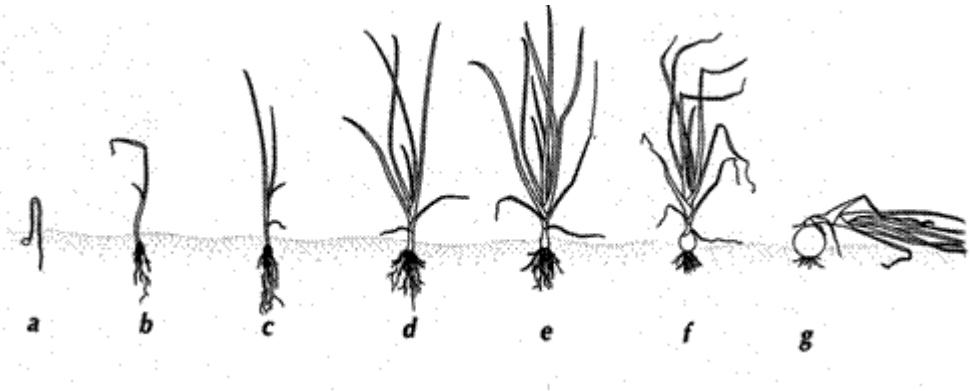

Figure 3 Onion nutritional growth and development process

(I) Germination period

The germination period is from seed germination to one-leaf-one-heart exposure (Figure 2 , a, b). The germination period takes about 12 to 15 d and goes through four stages: seed breakout, rooting, leaf emergence, and straight hook, resulting in a 1-leaf, 1-hearted seedling. The onion seed coat is hard and germinates slowly, emerging about 7 d after sowing and growing mainly on the nutrients stored in the seed embryo. Therefore, the seeds should not be sown too deeply and the soil should be kept moist to

prevent soil caking. After sowing, the seeds need proper temperature (around 20°C) and moisture (soil moisture content greater than 10%) during the period from germination to emergence.

(II) Seedling stage

The period from the appearance of the first true leaves to planting is called the seedling stage (Fig. 2, c). The length of this period varies depending on the sowing and planting period in each region. It takes 55 to 65 d for fall sowing or spring sowing and 180 to 230 d for fall and spring planting. 55 to 65 d after sowing, seedlings can grow to 3 leaves and 1 heart or 4 leaves. Leaf growth is slow in the early stages and rapid in the later stages. The seedling stage is an important stage in the development of onion, and the root growth and development is more important than the above-ground growth. Onions are usually grown as seedlings and then planted in the field when they reach a certain size.

(III) Vigorous growth period of the plant

The growth period after planting and before bulb expansion is called the vigorous growth period (Figure 2, c, d, e). It takes 30-40 d from seedling re-growth to bulb expansion, during which the root system first grows rapidly and then enters the leaf development phase, with the number of leaves increasing rapidly, leaf area increasing and assimilation strengthening, while root activity is also very vigorous and constantly renewed. The leaf sheath base is thickened and the bulb expansion stage is entered.

Before and after planting, if the seedlings are too large and affected by unfavorable conditions such as low temperature (2-10℃) and drought, it may cause some plants to tiller (balling) or preemptively draw shoots, resulting in lower onion commercial rate and reduced yield; if it encounters high soil temperature and drought, it will accelerate the aging of the root system.

(IV) Bulb expansion period

The period from the early stage of bulb expansion when the base of the leaf sheath begins to thicken to the time when the stem leaves begin to wither and collapse and the bulb basically stops growing is called the bulb expansion period (Fig. 2, f, g). When bulbs are formed, they first grow longitudinally and grow slowly laterally, thus forming small elliptical or ovoid bulbs. As the temperature rises and sunshine hours lengthen, leaf growth is inhibited and nutrients begin to be transferred to the lower part and stored at the base of the leaf sheath and in the young shoots, causing the bulbs to thicken

rapidly. When the root and leaf growth are at a standstill, the bulb expansion period is entered. At the end of bulb expansion, the leaves begin to wither, the pseudostem becomes flaccid and collapses, and the nutrients in the outermost 1 to 3 layers of scales are transferred inward and dry and shrink into a membrane, then it enters the harvesting period.

(V) Bulb dormancy period

The stage from bulb maturity to the time when the bulb buds in the bulb just start to sprout is called bulb dormancy. Dormancy is the result of long-term adaptation of onions to adverse environmental conditions such as high summer temperatures and drought in their country of origin. The length of the natural dormancy period varies depending on the variety, the degree of dormancy and the external temperature, and generally takes about 70 to 90 d. After the bulbs are released from their natural dormancy, they can sprout normally if the external conditions are suitable. The length of the dormancy period is directly related to the storage capacity of the onion, and the strength of the storage capacity depends on the dormancy depth of the onion and the continuity of dormancy, but also affected by the temperature. Therefore, in the storage process, we should take advantage of the dormancy characteristics of bulbs, take various technical measures to give appropriate conditions to extend the dormancy period to reduce nutrient consumption in order to extend the storage time and ensure the quality of commercial onions.

(VI) Reproductive growth period

From bud differentiation to seed maturation. After the onion plant has passed the stage of development, the terminal or lateral buds will form flower buds and flowering will take place. Onion bulbs used for seed harvesting are usually planted in autumn after summer and autumn storage, and flowering occurs in the following spring under long sunshine conditions until seed maturity in summer. Generally, each onion head can produce 2-5 flower buds, and it takes 8-10 months from bulb planting to seed maturity, and 60-70 d from flowering to seed maturity.

III. The requirements of environmental conditions

(I) Temperature

Onions are cold-tolerant vegetables and are highly adaptable to temperature. Onion seeds and dormant bulbs can germinate slowly at 3 to 5 ℃, but germination is best at 15 to l8 ℃. Seedling growth temperature of 12 ~ 20 ℃, healthy seedlings can

withstand low temperatures of -6 ~ -7 ℃. Leaf growth temperature is 18 ~ 20 ℃. Onion bulb expansion requires a higher temperature, 15 ℃ below can not expand, 15 ~ 21 ℃ began to expand, 21 ~ 27 ℃ growth is best, the temperature exceeds 27 ℃ growth decline and enter dormancy. Onion for green nutrients through the vernalization of plants, most species in the seedling pseudostem thicker than 0.6 cm or bulb diameter greater than 2.5 cm, at 2 ~ 5 ℃ after 60 ~ 70 d, can pass the vernalization stage, but slightly different between species. The root system grows at a lower temperature than the above ground, and the root system starts to grow when the ground temperature is 5 ℃, 10-15 ℃ is the most suitable for growth, and the growth is slow at 24-25 ℃.

(II) Light

Onions are long-day plants, and bulb formation can be promoted under high temperature and long-day conditions. However, varieties vary greatly, such as short sunshine types are mostly early maturing varieties, which generally form bulbs under 12-13 h sunshine conditions, while long sunshine types are mostly late maturing varieties, which generally form bulbs under 14-15 h sunshine conditions. Therefore, when introducing seeds must pay attention to the fact that if the long sunshine varieties are introduced to the short sunshine area for planting, the bulb formation period is delayed and the onion head is small with low yield. If the short sunshine type varieties are introduced to the long sunshine area for planting, as the plant has not yet grown to a certain size, it has met its requirements for the number of hours of light, thus forming bulbs prematurely and making the yield lower. Therefore, when introducing seeds, we should consider whether the characteristics of the varieties meet the local sunshine conditions, otherwise it will cause losses.

Temperature and light are important conditions for the induction of onion flowering. Onion bulbs in the storage process, after 5 to 10 ℃ low temperature treatment, to the second year whether in long sunshine or short sunshine conditions can be flowering; on the contrary, in high temperature storage of onions, the second year whether in long sunshine or short sunshine conditions can not be flowering.

The light intensity requirements of onions are lower than those of fruit and vegetables, higher than those of leafy and root vegetables in general, and suitable for medium light intensity.

(III) Soil nutrition

Onions are more adaptable to soil, fertile, loose, permeable neutral loam , sandy

loam soil is easy to get high yields, but clay loam soil grows onion bulbs full, good color and storage resistance. Onion roots are weak in fertilizer absorption and require adequate nutrient conditions for high yields. For every 1000 kg of bulbs produced, about 2.0-2.4 kg of nitrogen (N), 0.7-0.9 kg of phosphorus ($P_2 O_5$), and 3.7-4.1 kg of potassium (K_2 O) need to be absorbed. The roots and stems contain more nitrogen during the seedling stage, and the roots contain significantly more nitrogen, phosphorus, and potassium during the leaf growth period. The amount of nitrogen, phosphorus and potassium absorbed per plant is also high during bulb expansion. Onions require high nutritional conditions and need more nitrogen fertilizer during the seedling and bulb expansion periods, but excessive nitrogen fertilization can lead to growth, greening and delayed maturity, resulting in bulbs that are not storage resistant. Phosphorus is necessary for root development. Onions absorb and run phosphorus from the soil very slowly and can be transferred from old leaves to bulbs during the bulb development and maturity stages, so most of the phosphorus fertilizer can be applied before planting and during the bulb development stage. Additional application of phosphorus and potassium fertilizers can improve the utilization of nitrogen fertilizer in onions, promote cell division expansion and nutrient transport and accumulation in the plant, and improve product quality.

(IV) Moisture

Onion root system is not developed, the ability to absorb deep soil moisture is weak, in the germination period, seedlings and bulb expansion period are required to soil moist, when the supply of sufficient water is the key to good yield. But in the seedling stage and before wintering to control moisture, to prevent seedlings from growing and frost damage. Irrigation should be controlled 1 to 2 weeks before harvest to make the bulb tissue full, accelerate maturity, prevent bulb cracking, and improve quality and storage resistance. Soil drought can promote early bulb formation, but the yield is low. Onion tubular leaves are drought tolerant, suitable for 60% to 70% relative air humidity, air humidity is too high susceptible to disease. Bulbs are drought-tolerant organs, stored in drought conditions, can still retain water and maintain the life activities of young shoots.

Section 2: the nutrition of onion

Onions are a delicious addition to people's diets and are highly prized for their unique composition for human health. Onions provide a rich flavor to a wide variety of

foods, but are low in calories. They are naturally fat and cholesterol free. Onions are rich in vitamin C and are a source of dietary fiber. Onions are rich in nutritional value and contain high levels of protein, sugars, vitamins and a variety of minerals such as phosphorus, iron and sulfur. According to analysis, each 100 g of fresh onion contains about 89 g of water, 1 to 1. 8 g of protein, 0.1 g of lipids, 1.7 g of dietary fiber, 23 mg of calcium, 46 mg of phosphorus, 0. 21 mg of iron, 146 g of potassium, 7.4 mg of vitamin C, 0. 05 mg of riboflavin, 0. 08 mg of thiamin and 1.0 mg of carotene; it also contains lauric acid, erucic acid, caffeic acid citrate, polysaccharides and various amino acids (Table 1).

Onions are a rich source of dietary flavonoids and contain three different and highly valuable phytochemicals in perfect proportions: flavonoids, fructans and organosulfur compounds. These compounds are beneficial to human health. Medical research has proven that the flavonoids and organosulfur compounds in onions have antioxidant, hypotensive, hypolipidemic, anticancer, antibacterial and anti-inflammatory health functions.

Table 1 Table of main nutrients of onion bulbs (per 100g)

Nutritional Composition	Unit	Average value	Nutritional Composition	Unit	Average value
Moisture	g	89.11	Magnesium	mg	10
Protein	g	1.1	Phosphorus	mg	29
Lipids	g	0.1	Sodium	mg	4.4
Ash	g	0.35	Selenium	μg	0.5
Carbohydrates	g	0.34	Vitamin C	mg	7.4
Dietary fiber	g	1.7	Vitamin b1	mg	0.046
Total Sugar	g	4.24	Vitamin b2	mg	0.027
Sucrose	g	0.99	Niacin	mg	0.116
Glucose	g	1.97	Vitamin b6	mg	0.12
Fructose	g	1.29	Folic acid	μg	19
Energy	kcal	40	Beta-carotene	μg	1
Calcium	mg	23	Vitamin A	IU	2
Iron	mg	0.21	Vitamin E	mg	0.02
Potassium	mg	146			

Chapter 2: Techniques on High-yield Onion Cultivation

Section 1: The preparation before onion planting

Suitable varieties, land and fertilizers need to be prepared before onion planting. According to the market demand and consumption habits to choose the appropriate good varieties. The onion root system is weak in absorbing water and fertilizer, so you need to choose a neutral loam with fertile soil, good permeability and rich organic matter. The onion is not a heavy crop, so choose a plot that has not been planted with garlic, shallots, onions and other onion plants for 3 to 5 years. Before planting, deep plowing and fertilizing should be done to prepare the land for the border. Apply 4000 kg of well-rotted farmyard manure, 50 kg of calcium superphosphate or 20 kg of diammonium phosphate evenly per 667 m^2 , and you can add 5% phoxim granules 2 to 4 kg/667m^2 or 5% pyriproxyfen granules 5 kg/667m^2 to control underground pests. In Mekong countries, due to the high rainfall, raised beds about 1.2 m wide and 30 cm high can be used to facilitate drainage.

Section 2: Onion seedling

I. Sowing period determination

Choosing the right sowing period is the key to cultivating strong seedlings. Sowing too early or too late can affect the growth of onions, resulting in lower quality and yield. If sown too early, the yield may be reduced the following year due to early shoots; if sown too late, although early shoots will not occur, the overwintering ability will be reduced, which will also affect the yield. The specific sowing period differs from place to place depending on the climatic conditions. The selection of the sowing period should be based on the local temperature, light and the maturity of the selected species. Onions cannot be planted under flooded conditions and should be planted at the end of the rainy season. Generally September to November, the temperature 18 to 20 ℃ when sowing.

II. Seeding

In order to ensure germination, a germination test should be done before sowing, and the paper culture method can generally be used to test. First in the porcelain flat tray or dish bottom flat several layers of absorbent napkins, etc., so that it fully absorb water, the test onion seeds placed on it, can also be covered with moisture-absorbing paper again, and then put the tray or dish into a plastic bag, inflate the bag tightly after moisturizing. The germination rate was investigated at 20-25°C for 5-7 d.

Under normal conditions, the amount of seed used per 667m^2 field is 150-200 g. Considering that 20% of weak and poor seedlings should be eliminated and interspersed,

if the germination rate is less than 70%, the amount of seed sown should be increased as appropriate.

III. Sowing technology

(I) Site selection

The seeds of onions are small, the cotyledons grow slowly when germinating, and it is difficult to emerge from the soil. Therefore, seedbeds should be selected from plots with fertile soil, high ground, strong water retention, and have not been planted with onion and garlic vegetables for 2 to 3 years. Poor drainage and low-lying waterlogging can cause the young roots of onions to rot and grow poorly.

(II) Preparation of borders

Select a plot that is close to the planting cultivation field, with flat terrain, convenient drainage and irrigation, fertile soil, loose soil, and has not been planted with onion and garlic vegetables in the past three years, with neutral loamy soil. Deep plowing and harrowing, remove grass roots and stones, and level the ground and break the soil. It is not easy to apply too much fertilizer to the seedbed to avoid overgrowth of seedlings. Spread 300 kg of high quality organic fertilizer and 15 kg of nitrogen, phosphorus and potassium compound fertilizer evenly per 667 m^2 and turn it into the soil layer of 20 cm. Make a raised bed with a height of 20-30 cm and a width of 1-1.2 m. The distance between two beds is about 30 cm.

(III) Seed treatment and sowing volume

Generally direct sowing, to prevent the occurrence of disease can be treated with 0.3% of the seed amount of 35% methomyl mix. Sow about 500 g of seeds per 100 m^2 of seedbed area. The ratio of seedbed area to planted field is generally 1:15 to 1:20.

(IV) Seeding

Sowing is generally done by spreading. The seedbed will be filled with sufficient water, and when the water is about to seep down, the seedbed will be scraped flat with a wooden board and other tools, and the onion seeds will be mixed with fine sandy soil in the ratio of 1:10 and evenly sown on the seedbed, then covered with sieved fine soil, and the thickness of the mulch is about 1.0 cm. The seeds were not watered again until they had emerged. If the seeds are sown and then watered, it will make the border panel knotted, which is not conducive to the emergence of seedlings.

After sowing, the seedbed can be covered with shade net and straw for shade and moisture. You can also insert small arches to build rain and sun protection facilities,

cover the arches with plastic film of 0.1 mm thickness, then cover with shade net of 50% density, leave a 10 cm ventilation opening between the lower end of the film and the bed ridge, and then fix the film and shade net with a rope. The seedlings started to emerge 5-7 d after sowing, and when the emergence rate reached 60%, the mulch was removed with a small watering.

If the amount of seedlings is large, they can be sown in strips with a special precision seeder and sprinkler irrigation by laying micro-sprinkler belts. Strip sowing or spreading has no significant effect on the quality of seedlings as long as the seeds are sown in appropriate quantities.

a. Sowing b. Strip sowing

Figure 4 Different ways of sowing onions

IV. Seedling management

Watering of seedlings should depend on soil moisture and different sowing methods. Generally, watering is not necessary until the seedlings are ready. For other sowing methods, watering is required before the cotyledons are straight and again during the "straight hook" period, after which watering should be properly controlled until the first true leaf emerges. After removing the mulch, sprinkle water or use sprinklers to water in time depending on the weather conditions to prevent seedbed caking. After the seedlings emerge, keep the soil dry and moist and control the watering appropriately. When two true leaves appear, apply ammonium sulfate 25 kg/667m^2 or urea 10-15 kg/667m^2 in combination with watering. 10d-15d before planting, apply foliar fertilizer according to the growth of onion seedlings, and spray 0.2% potassium phosphate solution. In the middle and late stages, a small amount of urea is applied in combination with watering to cultivate strong seedlings of appropriate age through fertilizer and water control.

In addition, don't rush to interrupt seedlings in the process of raising seedlings, and

be careful against blight and sudden collapse disease until 2 true leaves are produced, then weed and interrupt seedlings before fertilization. If the seedlings grow too big, cut 1/3 of the leaves to control them.

V. Breeding of young balls

The main purpose of growing young bulbs is to avoid unfavorable climatic conditions for onion growth and to ensure normal growth. In tropical and subtropical regions, the cultivation of young bulbs can avoid high summer temperatures and typhoon attacks. In addition, the cultivation of bulbs allows for early harvesting and higher yields. In the first year, grow 2cm diameter bulbs and plant them before winter or in early spring of the following year.

Seedlings can be produced by planting seeds at very high densities of 15,000 to 30,000 plants/ha. Fresh seedlings usually weigh 2 to 3 g and are <25 mm in diameter, and can grow and develop into larger bulbs after replanting.

The young bulbs produced in spring sowing can be planted again in late summer for rapid growth into larger bulbs that can be harvested in December. As a rule, the diameter of the bulbs should be 1 to 2 cm, and those <16 mm in diameter will seldom be seeded. The larger bulbs may crack or pull out, especially if the bulbs are exposed to low temperature of 7-12°C for a long time. Usually, 30 to 80 seedlings are planted per square meter.

Section 3: Onion transplanting and field management

I. Preparation before planting

(I) Land preparation and base fertilizer application

Onions are mostly planted in subtropical areas in high beds to facilitate drainage. According to the custom of different regions, the width of narrow borders is about 1.2 m and the width of wide borders is 1.7 m or more, and the height of the borders is about 30 cm. To facilitate field operations, the two beds should be about 30 cm apart.

The depth of tillage should not be less than 20 cm. To deepen the tillage layer and improve the soil structure, it is better to plow deeper than 30 cm if possible. In combination with the land preparation, apply 60 m^3 to 75 m^3 of well-rotted organic fertilizer, 750 kg of nitrogen, phosphorus and potassium (15-15-15) compound fertilizer and 45 kg of 5% of phoxim granules or 22.5-30 kg of 2% of bifenthrin granules per hectare, rake and level the land, and make borders according to local customs. Water and irrigate the beds before planting, and after the water has seeped under, spray the

beds with suitable herbicides such as dimethoate, and then cover the beds with mulch, which should be laid flat and close to the beds.

(II) Selection of seedlings

In about 3 d before starting seedlings, according to the seedbed moisture can be lightly watered once before starting seedlings, when the bed soil is moderately dry, seedlings with a seedling shovel to start, try to avoid hand-pulling seedlings to prevent injury to the roots, reducing the survival rate. The first thing you need to do before planting an onion is to select the seedlings, eliminate the rootless, no growing point, too short, weak seedlings and leaves are too long for the long-lived seedlings and tiller seedlings, infested with diseases and insects. Seedlings are graded according to size and planted separately to make the plants grow neatly and uniformly in the field and facilitate management. The appropriate standard for strong seedlings is 55-60 d, with three leaves or four leaves, a pseudostem of about 0.6 cm, a plant height of about 25 cm, and a single plant weight of 4-6 g. For large seedlings with a leaf sheath diameter close to 1 cm, the leaf part can be cut off by one-third before planting to reduce the first shoots, but the leaf should not be cut in excess. Seedlings should be kept under moist conditions before planting to protect the root system.

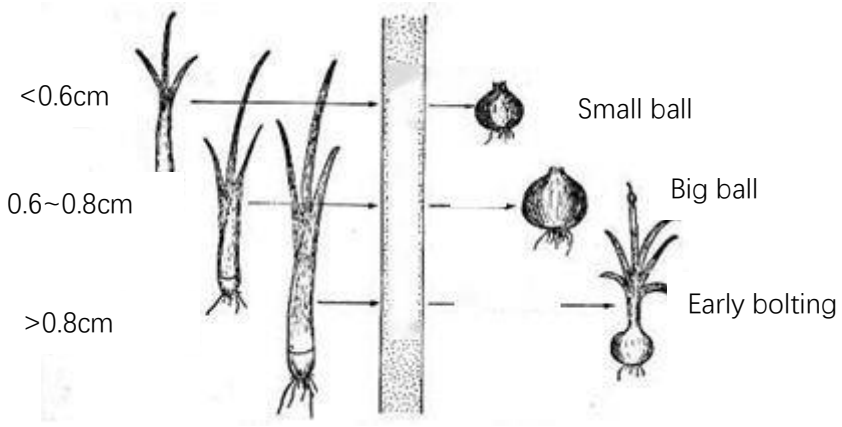

Figure 5 Relationship between onion seedling size and shoots

Section 3: Onion transplanting and field management

I. Planting of onions

(I) Determination of the planting period

The planting period in each region depends on the climate and variety. In late autumn and early winter planting, seedlings must be slowed down and restored to growth before the severe cold, so that the seedlings do not die because the root system has not fully recovered before winter (due to the imbalance of water supply and

demand). The time to plant in the fall to plant the root system to restore growth, safe overwintering is appropriate, generally in the first half of November, the seedling age of 55 ~ 60 d transplanted. If you plant too early, the plants will start to grow and the overwintering seedlings will be too big, and the first shoots will easily occur in the second year; if you plant too late, the root system will not resume growth and will be susceptible to frost damage. Generally, it is appropriate to plant 30-40 d before the arrival of severe cold. Because early varieties of seedlings grow faster but easy to aging, late varieties of slower growth but long seedlings, not easy to aging, so, on the basis of planting at the right time, early varieties of planting period should be slightly earlier than late varieties.

(II) Planting density

Onion plants are upright, with little shade on the leaves, suitable for dense planting. It is a powerful measure to increase yield by appropriately increasing the number of plants to achieve reasonable dense planting. According to the characteristics of the variety of reasonable density planting, planting density of 30,000 to 35,000 plants per $667m^2$ is appropriate. The general suitable planting density is 15 cm x 15 cm. early varieties can be a little denser, late varieties can be a little thinner. When planting, plant the seedlings according to the determined spacing on the film. However, the fertility of the soil is an important guarantee of increased yield for dense planting and must be coordinated with fertilizer and water management. In addition, the planting density needs to be determined according to the requirements of exported onions. For example, in some areas, large and medium sized balls are more popular, and extra large and small sized balls cannot be exported, so the planting density should be increased appropriately, with a suitable plant spacing of 20 cm x 10 cm.

(III) Planting method

The onion seedlings have been damaged part of the root system when starting, after planting to rely on these injured roots to complete the slow seedling, so, before planting to keep the seedlings in moist conditions, planting seedlings also do not make the root system then suffer more damage. In order to preserve moisture and resist frost, it is advisable to plant the seedlings a little deeper in late autumn, but the top of the leaf sheath should be exposed to the ground. Planting too deep, not only is not conducive to the development of roots, slow seedlings, and the future growth of bulbs also have an impact on the expansion. If the planting is too shallow, it will easily fall over and the

bulbs will turn green and affect the quality. Then, according to the predetermined spacing of the plant with bamboo skewers and other perforated film holes, planting depth 2 ~ 3cm or so, the diameter of the hole to just into the onion seedlings appropriate, the onion seedling roots of soil compaction.

(IV) Post-planting management

1、Fertilizer chasing

After planting, the onion first grows in the root system, and thereafter turns to the growth of the above-ground part, and only after the upper part of the ground is fully grown does it enter the period of bulb hypertrophy and growth. According to the growth and development characteristics of the onion, good phasing fertilization is one of the keys to good yield of onion. The first fertilization should be done in the spring after the seedlings are slowed down and in the late fall or early winter after the greening. The first fertilizer should be applied in combination with 150-225 kg of diammonium phosphate and 150 kg of potassium sulfate per hectare, followed by a "seedling fertilizer" to ensure the needs of the above-ground functional leaf growth. Because the size of leaf nutrients is very closely related to the size of bulbs later, promoting leaf growth in the early stage is to lay the foundation for the fat growth of bulbs later. When the plant has 8-10 tubular leaves, the bulb starts to grow fat, after that, 2-3 times of fertilizer should be applied, generally 150-300 kg of ammonium sulfate per hectare. In the later stage, if the nitrogen fertilizer is applied too much, it will affect the harvesting by "greedy green". If the amount of potassium fertilizer in the base fertilizer is not enough, 75-150 kg of potassium sulfate per hectare should be added in the follow-up application of head fertilizer. During the bulb expansion period, potassium deficiency will not only reduce the yield, but also affect the storability of the bulbs.

2、Watering and squatting

Regardless of the season of planting, watering is necessary at the time of planting so that the roots and soil are closely integrated through irrigation. It takes about 10 d from planting to seedling establishment. If the amount of water is too much, it will lower the soil temperature which is not good for the root growth.

If planted in late autumn or early winter, water in early spring after greening. The green water should be poured at the right time and in the right amount when the soil temperature is 10cm deep and stable at 10℃. If the green water is poured too early, the soil temperature is still low for onion growth; too late will inhibit growth, and even

make the leaves dry tip. The spring planting of onions, in the slow period has been watered 2 to 3 times, the need for appropriate water control, squatting seedlings to promote the development of roots, to prevent growth. Thereafter, onions planted in late fall or early spring should not be deprived of water in order to promote above-ground growth. Depending on the climate and soil quality, water every 15 days or so to keep the surface layer of the soil dry and moist and the deeper layer moist. If the above-ground parts do not grow sufficiently due to lack of water during this period, the size and weight of the bulbs will be affected.

After the seedlings reach the full growth height, they will turn to the growth stage with bulb expansion as the main growth stage, during this transformation process, water control is also required to promote the transformation. After about 10 d, the transformation of the growth stage will be completed, after which watering with fertilizer will be carried out, usually every 10 d, to promote the bulb expansion and growth. Watering should be stopped until individual plants in the field start to fall over, otherwise the bulbs will contain too much water, which will not resist storage and will also affect the quality of the product due to excessive water supply causing the outer skin to crumble. Generally, from planting to harvest, water about 10 times, 2/3 of the above-ground growth period and 1/3 of the bulb expansion period.

For late autumn and early winter planting, only about 10 d of squatting before bulb expansion, and for early spring planting, two squatting must be done after slowing down and before bulb expansion. The length of squatting time should be flexible according to the soil, climate and plant growth. When the sandy soil and dry weather, to shorten the squatting period; clay soil and low-lying land, should be properly extended squatting period. Regardless of the conditions, the plant should be judged according to the morphology of the plant, that is, when the mature tubular leaves of onions turn dark green, the flesh of the leaves is thick, the wax on the leaf surface increases and the color of the tender heart leaves deepens, the squatting should be ended and watering should be carried out.

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Chapter 4 Onion major pests and diseases control

Section 1: Principles of onion pest and disease control

Onion pest control should be in accordance with the "prevention-oriented, integrated control" plant protection policy, giving priority to agricultural control, physical control and biological control methods, with the scientific and reasonable use of chemical control techniques, not to use the high toxicity, high residue pesticides and pesticides

that are prohibited and restricted in vegetables. Through the selection of disease-resistant varieties, cultivate strong seedlings, strengthen cultivation management, scientific fertilization, improve and optimize the ecological environment of vegetable fields, to create an environmental conditions conducive to the growth and development of onions.

I. Agricultural control

According to the law of onion pests and diseases and their required conditions, through the phased control of temperature, light, water, air and other environmental factors, as well as the selection of disease-resistant varieties, reasonable crop rotation and a series of measures to improve the resistance of onions, can reduce the pest and disease damage. The main measures include choosing disease-resistant varieties according to local conditions; seed treatment and seedbed disinfection; choosing a suitable sowing period according to local weather forecasts and variety characteristics; deep tilling of the land, applying sufficient well-rotted fertilizer, and reasonable crop rotation and intercropping can reduce the sources of disease and insects.

II. physical control

For example, using warm soup to soak seeds to kill some of the germs and insect eggs carried by seeds, using solar heat disinfection and low temperature in winter to kill germs and insect eggs. Use the tendency of pests to repel or trap, such as using silver gray film to avoid aphids and yellow boards to trap and kill aphids. Use sex attractants and sugar and vinegar to lure and kill pests such as smoke-green insects and small vegetable moths. Use black light to lure and kill ground tiger, night moth and other pests.

III. biological control

Natural enemies of pests and biopesticides are used to achieve the purpose of treating insects with insects and bacteria with bacteria. For example, the use of predatory natural enemies such as ladybugs, syrphid flies, hunting bugs, predatory spiders and mites; the use of microorganisms such as Bacillus thuringiensis (Bt), nuclear polyhedrosis virus (NPV) and microsporidia to kill insects; the use of plant-derived pesticides such as bitter ginseng, nicotine and bisulcine to control a variety of pests; the use of agricultural antimicrobials such as wellbutrin, polycomb, gentamycin and neosporin to control diseases.

IV. Chemical control

In the process of chemical control must be reasonable use of pesticides, and follow the principle of "strict, accurate, appropriate". To choose high-efficiency, low toxicity, low residue pesticide varieties to ensure the safety of onions. In addition to the strict implementation of pesticide safety interval period, suitable for the period of control, the right medicine. To improve the prediction and forecast, to achieve targeted control to meet the standard. No pest control indicators shall not use chemical pesticides, in order to reduce the number of times the use of pesticides and the amount of use; to reach the pest control indicators to timely use of drugs to improve the effectiveness of prevention. According to the law of pests and diseases, accurately select the time of application; according to the distribution of pests and diseases in the field, accurately select the mode of application, dose and number of times, prohibit blindly increase the concentration and dosage of pesticides.

Section 2: Onion major disease identification and control

I. Riparian blight

(I) Onset symptoms

The blight is a seedling disease. The base of the stem of the onion seedling becomes brown, and after a few days the diseased part shrinks and becomes thin, and the stem and leaves wither and die; if it is a slightly larger seedling, it initially wilts in the daytime and recovers at night, but when the spot goes around the stem for a week, the seedling gradually dies and starts to show oval dark brown spots with concentric whorls and light brown spider-like mold.

Figure 6 Root of Riparian blight

(II) pathogenic transmission pathways and pathogenic conditions

The pathogenic fungus is the genus of the subphylum Seminiferous filamentous nucleus. The fungus overwinters with mycelium and nucleus on the residue of the disease plant or in the soil, and can directly invade the onion seedlings; it can be spread over longer distances with the help of rainwater, irrigation water or agricultural operations. The appropriate temperature for the growth of the disease is 24 ℃, the minimum is 13-15 ℃. Generally sowing too densely, seedbed temperature and humidity, etc. are prone to induce disease.

(III) Control technology

1、Onion seedbed soil should be selected from grass crops or paddy soil, and seeds should be disinfected before sowing to prevent seeds from carrying pathogens. The seeds can be disinfected by mixing the seeds with 50% fomesin wettable powder of 0.2% of the seed amount.

2、Before sowing, the ground is sprayed with pharmaceuticals plus neogolipid film to disinfect the soil, while a protective film is formed to prevent the invasion of pathogens and inhibit the reproduction of soil pests and diseases.

3、 Chemical control: At the early stage of the disease, the use of 20% clofentezine 1000-1500 times, 20% methyl risothione emulsion 1200 times, 36% methylthiocarb suspension 500 times, 5% wellbutrin water 1500 times spray control.

II. Sudden collapse disease

(I) Onset symptoms

It occurs mainly in the seedling stage before 2 true leaves. Soon after the onion seedlings emerge from the ground, first in the seedlings close to the surface of the stem base of the occurrence of water-stained dark spots, and then spread around the stem expansion, gradually constricted in a thin line, and collapse sudden death. When the seedbed humidity is high, often dense white cotton wool-like mycelium on the bed surface in or near the diseased seedlings.

Figure 7 Sudden collapse disease occurrence symptoms

(II) pathogenic transmission pathways and pathogenic conditions

The disease is mainly caused by the flagellate subphylum melon fruit rot fungus infestation. The fungus overwinters in the soil with the disease residue, can spread with irrigation water, generally from the stem base invade seedlings. The fungus likes high temperatures, but can also grow at 8 to 9 ℃. In the case of low seedbed temperature and slow growth of seedlings, if high temperatures are encountered, the susceptibility period is elongated, and sudden collapse disease can easily occur. Especially in the seedling encounter rainy weather, light is not enough, the seedling growth is poor, the disease is serious. Sudden collapse mainly occurs in the seedling stage before 2 true leaves, when the seedling grows to 3-4 true leaves, the resistance to the disease is stronger.

(III) Control technology

Same as laminaria.

III. downy mildew

(I) Onset symptoms

Seedlings affected by the disease after poor growth, leaf distortion without luster; spring after the warm spot expansion is fast, and can harm the new leaves, when the air is moist, the spot produced sparse white or gray-purple mold. The disease plant as the center of the disease continues to spread, forming a re-infestation. It mainly affects the foliage and flowering shoots of seed-picking plants.

There are five types of symptomatology.

(1) The surface of the infested part of the leaf is covered with lavender downy mildew.

(2) Long ovate or elliptic yellowish green spots on the leaves, white or grayish purple downy mildew on the surface, withering of the leaves after rain.

(3) Producing yellow spots of different sizes and shapes, but not bearing moldy material.

(4) Oval spots surrounded by a slightly depressed gray-white band 2-3 mm wide.

(5) Under conditions of persistent drought, presenting small grayish-white spots. Later, the disease is often infested with gray or black moldy material by gray mold, black spot and other semi-rotten fungi in the diseased part. After the bulbs are affected, the external scales become soft and crumpled, sometimes mixed with soft rot. The disease is characterized by large, long oval, yellowish-white spots, the spots turn grayish-white after rain, sparse white mold grows on the spots when wet, and grayish-purple mold grows when hot.

Figure 8 Foliar symptoms of downy mildew

(II) Pathogenic transmission routes and pathogenic conditions

The disease is caused by flagellate subphylum downy mildew onion fungus infestation. Mainly with egg cells with the disease residue in the soil survival, autumn infestation of seedlings or seed plant bulbs within the mycelium, forming a systemic infestation. In the southern region because of the warm climate disease can survive in the field with the diseased plant. After that, sporangia grow on the spot and spread by wind and rain, and invade from stomata to form re-infestation. The disease is more

prevalent when it is cold, rainy or often heavy foggy weather. In heavy crops, low-lying land, as well as under heavy irrigation, excessive dense planting and other conditions, the disease is also heavier.

(III) Prevention and treatment technology

Implement a 2-3 year crop rotation, and pay attention to cleaning and burning of diseased tissue. Strictly choose healthy seedlings before planting and eliminate diseased seedlings.

Reasonably dense planting, appropriate amount of watering, and strengthen the drainage of the field in the rainy season. In the early stage of the disease, timely pharmaceutical control, available 25% flumioxazin - azoxystrobin suspension, 68.75% flumioxazin water 800 ~ 1000 times, 68% fine methomyl - manganese zinc water dispersible granules 600 times, 50% enoylmorpholine wettable powder 1000 times, or 72% manganese zinc - fenoxycarb wettable powder 600 times, or 64% maloxyl - manganese zinc wettable powder 600～800 times of liquid, or 72.2% of the water agent 700 times of the spray control, every 7 ~ 10d spray 1, the above agents are used alternately, 2 ~ 3 times of continuous control.

IV. Purple spot disease

(I) Onset symptoms

It mainly affects leaves and pedicels. Initially water-soaked white dots, later become light brown oval or fusiform slightly sunken spots, continue to expand brown or dark purple, the disease grows gray-black with concentric verticillate arrangement of mold, the disease continues to expand, resulting in the whole leaf yellow withered or broken.

Figure 9 Leaf symptoms of purple spot disease

(II) pathogenic transmission pathways and pathogenic conditions

Caused by the fungal infestation of Streptomyces hemiphilus subphylum. Spread by airflow or rain, warm and humid summer incidence of heavy (cloudy and rainy incidence of the heaviest), below 12 ℃ is not easy to develop.

(III) Prevention and treatment technology

Clean the fields and implement crop rotation. Strengthen management, apply more basal fertilizer, increase potassium fertilizer, and timely drainage after rain to make the plants grow strong and enhance disease resistance. Watering during the growth period should not be too diligent, and control watering after the onset of the disease. Early control of onion thrips to prevent wounds and the introduction of disease.

The early stage of the disease spray 10% benzamethizole water dispersible granules 1000 ~ 1500 times, 75% chlorothalonil wettable powder 600 times or 58% oxamyl - manganese zinc wettable powder 600 times or 50% isoxaflutole wettable powder 1500 times can be combined with the control of downy mildew, a variety of pharmaceuticals used in rotation.

V. Mycobacteriosis

(I) Onset symptoms

When the leaf develops, the initial water-stained, and then becomes light brown or gray-white, the shape of the disease spot is variable, and finally turns white and ruptures, the leaf dies and droops. The diseased leaves are cut open and have white cotton wool-like mycelium inside. Under moist conditions, the diseased part is scattered, first creamy white to yellowish brown, and finally becomes a small black nucleus. The same disease develops on the pedicel of the seed plant, which breaks off and droops from the diseased part. The disease is distinguished from other diseases by the production of small black nuclei on the diseased parts.

(II) pathogenic transmission pathways and pathogenic conditions

It is caused by the infestation of garlic nucleus of the genus Nucleus Discus of the subphylum Cysticercus. The nucleus of the pathogen survives for a long time on the disease residue or in the soil. It forms ascospores and ascospores in spring under humid conditions and spreads by air currents. Mycorrhizal nucleus can also produce mycelium for the first infestation, and later expand the infection by mycelium. Generally easy to develop between April and May, in heavy crops, poor drainage and weaker growth is more serious.

(III) Control technology

Severely diseased lots should be rotated with non-onion and garlic crops for 3 to 4 years. Because the disease can be attached to the seeds to spread, when sowing the seeds can be used 50% thiram, 50% carbendazim or 50% thiophanate-methyl wettable powder, at 0.2% of the seed weight for seed dressing. In the early stage of the disease, 75% chlorothalonil wettable powder, 64% alumicide wettable powder, 70% manganese zinc Dyson, 58% methomyl manganese zinc 500 times or 50% isomethylurea wettable powder 1500 times spray control.

VI. gray mold

(I) Onset symptoms

In the field, the disease mainly affects the leaf sheaths, pedicels and bulb necks, forming light brown spots, internal rot, when wet, the disease is full of gray powdery mold. If the disease develops in the leaf tip, first for the white oval spot, 1 to 3 mm in diameter, the spot continues to expand, can be connected into pieces and make onion leaves curled and die, when the humidity can occur gray mold. In the flowering shoots and florets on the disease, and the leaf tip onset of the same. Storage period onset, first in the neck of the boat sunken spots, and then become soft, light brown, gray mold layer between the scales, and later produced brown nucleus. Bulbs are often invaded by soft rot bacteria again after the disease, incurring rot and odor. This disease is characterized by the occurrence of gray mold layer under high humidity conditions, the late disease produces small black-brown nucleus.

Figure 10 Gray mold foliar symptoms

(II) pathogenic transmission pathways and pathogenic conditions

It is caused by the infestation of Staphylococcus onionis of the subphylum Hemiptera. The disease residue left in the field and the nucleus in the soil can survive for a longer period of time. After the initial infestation, a large number of conidia are produced on the disease spot and spread by airflow, rain or irrigation water. After invading from the wound, it then spreads to the neck of the bulb. Low temperature and high humidity are the conditions for disease onset and prevalence. Rain before harvest and failure to adequately dry after harvest will also invite disease.

(III) Control technology

In cultivation management, attention should be paid to the removal of disease residues and timely harvest. At the early stage of the disease, use 43% fluro-oxime suspension 1000 times, 50% rotten mildew wettable powder 1000-1500 times, 50% isomethylurea wettable powder 1000-1500 times, 50% pyrimethanil suspension 800-1200 times and other agents to prevent and control the disease every 7-10 days, 2-3 times in a row.

VII. Epidemic diseases

(I) Onset symptoms

Onion seedlings and plants can be affected, and the most susceptible fertility period is from planting to harvesting. After the plant is infected, the leaf sheath, the body of the leaf appears inconspicuous dark green oil stain spots, spots expand quickly, gradually expanding to about 5 cm of oil-impregnated green-white spots, the central white to gray spots, resulting in the whole leaf or half the leaf wilting and drooping. When the humidity is high, the spot rots and produces a sparse gray-white mold layer on it. Different leaves of the same plant on the spot, in the early stage of the disease more in the same height, is a clear feature to distinguish from gray mold.

Figure 11 Symptoms of onion blight

(II) pathogenic transmission pathways and pathogenic conditions

Infection caused by the flagellate fungus onion blight. The disease is spread by wind and rain, suitable for high temperature and high humidity environment, 12 to 36 ℃, relative humidity above 90 % susceptible to disease. Low-lying terrain, the field is prone to waterlogging, rainy; planting density, poor field permeability, sloppy management, partial application of nitrogen fertilizer, plant growth, or frequent lack of fertilizer, lack of water, plant growth is weak, low disease resistance heavy disease.

(III) Control technology

Crop rotation and crop reversal. Do not plant onion and garlic vegetables for 2 to 3 years to reduce the source of the fungus and reduce the incidence of disease in the field.

Strengthen water and fertilizer management. The onion into the bulb expansion period requires more water, should be small water diligent watering, so as not to cause excessive humidity in the field. The company's main goal is to provide the best possible service to its customers. Choose well-drained plots for planting, plant reasonably densely, remove stagnant water in time after rain, strengthen cultivation management, and use formula fertilizer reasonably to enhance the host's disease resistance. Remove disease residues from the field in time after harvest.

Pharmacological control. You can use 72 % fenoxycarb - manganese zinc wettable powder 800 ~ 1,000 times, 72.2 % fenoxycarb water 800 times, 58 % methomyl - manganese zinc wettable powder 800 times, 69 % enoylmorpholin - manganese zinc wettable powder 1000 times spray, focus on controlling the center of the disease, every

7 to 10 d spray 1, depending on the disease even spray 2 to 3 times. As the outer epidermis of onion leaves is covered with wax, which is smooth, it is not easy for the liquid to adhere to the spread, so organosilicon can be added to the application to improve the control effect of pharmaceuticals.

VIII. Soft rot

(I)Onset symptoms

The disease mostly develops during the bulb expansion period. When the disease develops, the lower part of the outer leaves produce gray-white, translucent spots, softening the base of the leaf sheath and collapse, the neck of the bulb appears water-soaked depression, and soon the internal rot of the bulb, with sap overflow and foul smell. During storage period, the disease mostly starts from the neck of the bulb, and there is a softening sensation when the disease is pressed by hand, and the scales are water-soaked and flow white with foul-smelling sap. The disease is characterized by the bulb neck is water-soaked depression, and cause rotting and odor.

Figure 12 Onion soft rot symptoms

(II) pathogenic transmission pathways and pathogenic conditions

The pathogenic bacteria are the bacteria carrot soft rot Eubacterium. It rots for a long time in the disease residue and soil or overwinters in the bulbs, spreads through rain, irrigation, and invades through wounds. Onion thrips, seed flies and other insects can also be transmitted. Cultivation and management, poor plant growth, continuous crop, low-lying areas are susceptible to disease in case of rain.

(III) Control technology

Pay attention to fertilizer and water management, prevent excessive nitrogen

fertilizer, and remove pests to reduce infestation conditions. Before the onset of the disease or after the discovery of sporadic disease plants, promptly pull them out and spray with 25% copper complex aqueous suspension to 15kg of water. Focus on spraying the base of the plant. Combined with irrigation, every 667m^2 flush 30% methomyl-oxycarbophos suspension 500ml and 25% copper complex aqueous 200ml. In the early stage of disease in the field, control with 50% amber copper sulfate, 46% copper hydroxide aqueous dispersion granules 1000-1500 times, 20% thiram copper suspension 500 times or copper calcium sulfate 600 times or new phytomycin 4000 times, depending on the condition of successive Depending on the disease, carry out 2 to 3 times of control.

IX. rust disease

(I) Onset symptoms

The main sites of disease are leaves and flowering shoots, rarely on the flowering apparatus. At the beginning of the disease, the surface of the disease part is slightly raised with orange-yellow spots in the center, and later the epidermis ruptures and scatters orange-yellow powder. In autumn, the herpetic spots turn dark brown, and after rupture, dark brown powder is dispersed.

Figure 13 Symptoms of rust disease

(II) pathogenic transmission pathways and pathogenic conditions

The pathogenic bacteria are onion stalk rust fungus and onion stalk rust fungus, the former mostly in the cold zone disease. Both belong to the subphylum Streptomyces and the genus Streptomyces. Mainly with winter spores on the disease residue overwintering, and then winter spore germination can produce tamer and tamer spores, spread by airflow. In the southern region, summer spores or mycelium

overwinter on the disease plant in the field and spread by summer spores in the spring of the second year. In the spring and autumn low temperature and rainy period is easy to develop. Insufficient fertility, poor growth of the plant disease is more serious.

(III) Control technology

Increase organic fertilizer, increase phosphorus and potassium fertilizer, cultivate strong plants and increase disease resistance. At the early stage of the disease, spray 15% triadimefon wettable powder 1500-2000 times or 40% flusilazole emulsifiable oil 8000-10000 times or 12.5% alizarin wettable powder 2000-3000 times + 70% dextran manganese zinc wettable powder 800 times or 30% flumioxazol wettable powder 2000-3000 times + 50% clotrimazole wettable powder 400-600 times. 400-600 times, etc. The above agents are used alternately, spraying 1 time every 7d, and control 2 times continuously.

Section 3: onion major pests and control

I. Onion thrips

Onion thrips belongs to the order Thysanoptera, family Thripsidae, and is one of the main pests of onions.

(I) Pest characteristics

Both adults and flies damage the leaves and shoots of onions by filing and sucking mouthparts, causing yellowish-white patches to form. In severe cases, the leaves grow distorted and yellow.

Figure 14 Thrips infesting leaves

(II) Living habits

The larval period is 6-7 d, and the adult life span is 8-10 d. Females can reproduce alone. The newly hatched larvae are concentrated at the base of the leaves and are scattered when they are slightly larger. Adults are very active, good at flying, afraid of sunlight, and feed strongly in the morning, evening or cloudy days. When the temperature is 25℃ and the relative humidity is below 60%, the occurrence of thrips is favorable. Storms can reduce the occurrence. In. High temperature and high humidity are not conducive to its occurrence of infestation, more rain can also reduce the density of insects, field drought, often not watered or less watered plots occur on the heavy side.

(III) Prevention and treatment technology

During the peak of thrips, use the blue color of thrips to set up blue sticky boards in the field to trap and kill the adults. In the peak of the occurrence of the worm, spraying 10% imidacloprid wettable powder 2000-2500 times, 2.5% polymyxin suspension 1200 times, 2% methomyl emulsion 2000 times or 50% bataan soluble powder 1000 times, every 7-10 d spray 1 time, alternately, 2-3 times in a row.

II. Onion leaf diving fly

(I) Pest characteristics

Larvae in the leaf tissue in the formation of gray-white curve-like sinuous submerged channel, serious when into a mess, submerged channel in tandem with each other, throughout the leaf, resulting in leaf yellowing.

Figure 15 Leafminer infesting leaves

(II)Living habits

The larvae pupate in moth-eaten tunnels and the adults are active and roost on the plants. Overwintering or summering with pupae, adults are active during the day and

tend to sugar.

(III)Prevention and treatment technology

Good field hygiene, timely removal of residual plants, weeds, can depress the next generation and overwintering insect source base. Overwintering generation of adult feathering period, using its tendency to sugar, available sweet potato, carrot juice at 0.05% plus crystal trichlorfon made of traps, according to the ratio of 1 trap per square meter spray traps, can be sprayed every 3-5d 1 time, a total of 5-6 times. When the larvae start to harm, promptly use 40% octreotide emulsion 1000 times, 1.8% avermectin emulsion 1500 times or 10% imidacloprid emulsion 1500 times spray control.

III. Onion ground seed fly

(I)Pest characteristics

Onion ground seed fly belongs to the order Diptera, the family of flower flies, commonly known as onion maggots or root maggots. Mainly larvae damage, the larvae from the seedling stage to begin to infest, eroding bulbs, causing rot. And lead to above-ground leaf yellowing and even withering death, serious cause planting ground lack of seedlings and broken monopoly and even destroy the seed, often forced to change the seed.

Figure 16 Ground seed fly infesting onion pseudostems and bulbs

(II)Living habits

The adults lay their eggs in the topsoil around the leaves or plants at a depth of about 1cm during the bloom period, and the hatching larvae soon enter the soil to make their homes.

(III)Control technology

Promote the use of green biotechnology for integrated control of onion ground

seed flies.

Strengthen water and fertilizer management, and do not use unripe organic fertilizer. In plots where onion maggots have occurred, irrigation should be diligent, and if necessary, flooding can be used to stop the seed flies from laying eggs, inhibit the activities of onion maggots and drown some larvae.

The adult insects can be trapped and killed with sugar and vinegar solution during the peak season. The booby-trapping liquid is 0.5kg of brown sugar, 0.25kg of vinegar, 0.25kg of wine, 0.5kg of water, mixed with a small amount of trichlorfon. Choose the leeward and sunny lot, put a large bowl every 8-10m, 10-15 bowls per 667m^2 to trap and kill and as a forecast of the insect situation. Within 10 d after the bloom of adult insects, it is the right time to control eggs and larvae. It can be used to irrigate the roots with 1000 times of 40% octreotide emulsion or 5000-6000 times of 25% thiamethoxam aqueous dispersible granules or 3000 times of 75% methomyl wettable powder or 1250 times of 25% thiamethoxam aqueous dispersible granules. You can also use 1.8% abamectin emulsifiable oil 300~400mL, 40% octinoxate emulsifiable oil 700~1000mL per 667m^2 , and irrigate the roots with watering.

Production machinery is in urgent need of research and development, and has a broad development prospect.

Chapter 4: Harvesting and storage of onions

Section 1: Onion harvest

In the late stage of bulb expansion and growth, the plant collapses from the base of the leaf sheath. This is because the scales formed in the bulb no longer have new leaves to fill the leaf sheath and become hollow, and collapse occurs when it cannot bear the weight of the leaves. In case of rain, wind, or hot and dry weather, it will prompt early collapse. Inversion is a symbol of bulb maturity, in a sense, it is a prelude to the bulb going into dormancy and a sign of harvesting.

The harvesting period of onions varies greatly from region to region, so it depends on the growing conditions of the onions. Also, the weather conditions at the time should be taken into consideration, and it is best to have a few sunny days after the harvest for drying. For varieties with short dormancy and poor storage resistance, the harvesting period should be appropriately early, when 30% to 50% of the plants are down. For medium and late maturing varieties with long dormancy, the harvesting period is suitable when the natural fall rate reaches about 70%, the first and second leaves have

died, and the tips of the third and fourth leaves turn yellow. If the harvest is too early, the bulbs will accumulate less nutrients and affect the yield and quality; if the harvest is too late, the sprouting will be early and the decay rate will be higher.

Try not to touch the bulbs when harvesting, and not to break the leaves, so that it is easy to braid or tie, but also to reduce the infection of the wound during storage and cause rot.

Section 2: storage of onions

I. Braid collection

This method can be chosen for storage by farmers who grow scattered, small areas and small quantities. Reducing the water content of the bulbs is important for their storage. In a dry sunny place will be harvested onion plant stems and leaves facing up, onion head down diagonally dense arrangement together, so that each row of stems and leaves just cover in the front row of onion head part, and not make the hot sun directly on the onion head. 2 ~ 3 d turn 1 time, and then 2 ~ 3 d. In the case of sunny and dry climate, drying 4 ~ 6 d to the leaves yellow, soft can braid when can. If the drying time is too long, the leaves are yellow and brittle easy to break, braid a certain degree of difficulty, and once wet by the rain, but also easy to cause rot.

Onion drying to nearly dry, in order to avoid rainfall wet, or due to the lack of manpower can not be timely braid, you can first choose a dry place, in about 20 cm from the ground with Panicum straw and other shelves, and then the onion head outward layer by layer pile, so that the middle is higher than 4 weeks, and then in the pile covered with 2 to 3 layers of reed mat is better.

The dried scallions are then selected, the yellowed and flimsy leaves are removed and braided into long braids of about 80 cm from each other. The two braids are knotted together to form a pendant. Generally, there are 60 scallions per hanging, weighing about 5 kg. If the dried onion leaves are few and short, and cannot afford to braid, add some wet straw and other common braid.

After braiding, the onion also needs to be spread on the ground and continue to dry for 5-6 d for sun "braiding". The standard for drying is when the green color of the onion leaves has completely faded, the onion head is fully dry, the stem is completely fleshy, and the outer skin of the bulb has a crisp sound. The most important thing to remember is that you can't be afraid of the rain during the "braid"

period, because it has been knitted together and once it is wet by the rain, it is not easy to dry out even if it is sunny again, and the damp onions are easily rotten in storage. Therefore, in the sun "braid" to pay attention to the climate change and rain work. When the sun is strong at noon, it is best to use a reed mat to cover a little while before uncovering it to dry.

After the sun "braid" onion for long-term storage, should choose a high terrain, well-drained place, lay - layer of straw or straw bedding bottom moisture. Then pile the onions one after another to a height of 1.5 m or so. After the pile is finished, cover the top with 3 to 4 layers of reed mats, surrounded by two layers of reed mats, and then tied with string horizontally and vertically. This can avoid direct sunlight and prevent rainwater infiltration. It is not necessary to cover it when it is stored indoors, but it should be well ventilated. If it is hung under the eaves, because in a dry, ventilated, rain-free environment, storage effect is better. In addition to the above fresh storage methods, fresh onion head can also be used without "braid' boxing storage method. That is, after the selection of onion head, directly in the wooden box or stacked on the shelves, and keep the warehouse ventilation cool. This can also receive good results.

II. the stack collection

Onion in the harvest after the first in situ yard, so that the latter 1 row of leaves just cover the first 1 row of bulbs, do not make the bulbs directly exposed to the sun. After 2 to 3 d, the leaves are already wilted and soft, and the leaves are braided (stacked and hidden) or tied into small bundles (stacked and hidden, etc.); when braiding or tying, the onions that have suffered mechanical damage, pest bites, diseases, cracked balls and early shoots are picked out. When braiding, each braid has 25 to 30 heads, and every two braids are combined into one hanging, so as to facilitate handling and yarding. If the leaves are damaged, straw can be used to prevent the bulbs from falling off after braiding. After braiding, make the bulb face down and the leaf braid face up, and continue to dry one braid after another. After 6-7 d, when the braid turns from green to yellow and the outer skin of the bulb has dried, it can be stacked up. In order to fully dry, it should be piled into small piles (covered with reed mat or old plastic film), and after 10 d, choose a sunny day to spread out and dry again, so that after repeatedly drying 3 times, it can be formally stacked on the pile of storage. In order to prevent the accumulation of moisture emitted after stacking, small pallets should be put on first. Small pallets are temporary, generally 1m high and 2m long, and the width is the length

of the braid. Small pallets below with wooden purlins pad up, the top layer of dry Panicum straw (sorghum stalks) or reeds, and then the braided onion 1 layer put well, so that the end of the braid facing outward, covered with reed mats and other things to avoid rain or dew. The official stack (on the big stack) storage, stack width 1.2 ~ 1.5m (about and two onion braid length equivalent), about 1.5m high, about 8m long, so 1 stack can be stored onions about 5000 kg. to choose high terrain, good drainage place, first in the ground to do about 1m high ridge, ridge spacing 0.6 ~ 0.7m. in order to reduce the sun ridge, should be east-west direction, onion stack for the north-south direction. Direction After laying a 20cm thick pad of dry Panicum or reeds on the ridge, the bottom of the stack is ready for palletizing. In order to reduce the temperature inside the pile, it is best to choose a sunny day in the middle of the night or before dawn to palletize, if the daytime palletizing, the temperature is high and easy to rot after the sun. When palletizing, the tips (ends) of the onion braid should be lap each other, layer by layer palletizing neatly, hold lightly, try to avoid bumping, so as to facilitate the sealing of the pallets. After the pile is ready, surrounded by two layers of reed mats, the top of the pile should be covered with 5-6 layers of reed mats, or lay a layer of plastic film or asphalt linoleum under the seat to prevent leakage of rain, and then seal the pile with a rope bundle. In some cases, dry straw is laid on the top of the stack, and then the soil is pressed and mud is smeared, which is more economical than using reed mats. After sealing the pallets, as long as it is not a serious leakage of rain, it is best not to reverse the pallets, because the reverse pallets often prompt onion sprouts. After the continuous rainfall or shade rain, when the weather is clear, you can remove 1 layer of the mats around and dry the stack, and then seal it again.

III. pile collection

The onions are first tied into small piles without braiding after 5-6 d of drying, then select a place with high terrain, pad about 20 cm of dry straw on the ground as the bottom of the pile, and pile the tied onions into round piles on top, with a diameter of 1.5-2 m and a height of about 1.5 m. Each pile can store 800-1000 kg of onions. Generally choose indoor ventilation and dry place, with thicker wooden poles as uprights, surrounded by thick corn stalks to form a fence, width 1 ~ 1.3 m, high 1.5 ~ 2 m, length can be determined according to the storage volume. The bottom of the fence in accordance with the pile collection of good soil ridge, or pad prismatic wood, and then lay on dry corn straw, so that the onion and the ground isolation, so as not to get

wet. Then you can load the onion bulbs after drying and chopping off the leaves, after filling the fence, so that the middle part of the fence is higher than the surrounding area, and then lay corn straw or reed mat on top, and then cover the top with plastic film or sheeting to prevent rain before rainfall.

IV. Hanging Collection

After the onion harvest by drying, when the weight is reduced by about 20%, according to each weight of about 4kg tied, a small amount can be hung under the eaves. Generally 2.6 m high, 2.8 m wide, 7 m long hanging storage library, can store 3500 kg. in the indoor rack for hanging storage, hanging storage of the main management work is ventilation. According to Xuzhou experience: when there is a northwest and southwest wind, open the windows to ventilate, cool down and disperse moisture; when there is a southeast wind and northeast wind, to close the doors and windows. In addition, you must always prevent rain and cull individual rotten onion bulbs. This method has good ventilation and less decay, but the effect of bud suppression is poor and the storage period is short.

V. cold storage storage

To promote dormancy and prevent decay of the bulbs after harvest, hot air drying treatment was carried out, especially in years when there was a lot of rain during the harvest period. In other words, the drying process was carried out at 40 to 45 ℃ for 12 to 16 h with continuous air supply to reduce the moisture of onion bulbs by about 10%. When the hot air drying treatment is carried out, close attention should be paid to the change of temperature, if the high temperature above 45 ℃ is endured for too long, the quality of onion bulbs will be adversely affected. It is more economical to enter the cold storage at a later stage of physiological dormancy. If the storage time is late, it will affect the storage effect. The storage can be done in wooden boxes or net bags. The appropriate temperature for storage in the library is 0 ~ 2 ℃. The temperature of the storage environment before storage as the starting point for temperature change after storage, generally according to the degree of 0.5 ℃ per day to gradually cool down. Ventilation time is generally 16 h per day, the practical ventilation volume of onions is 0.7 ~ 1m^3 /min. In short, hot air drying treatment and daily ventilation management after storage, is the key to good cold storage storage.

VI. gas storage

Atmospheric storage is to reduce the oxygen within the storage environment by

artificial measures under airtight conditions, and further regulate the ratio of oxygen and carbon dioxide content to reduce the respiratory intensity of onion bulbs to maintain a normal and minimum metabolic level, thus extending the storage period and preventing sprouting. According to the test and demonstration, it is proved that the use of air conditioning method for onion storage, controlling oxygen at 1% to 3% and carbon dioxide at 5% to 10%, is effective in inhibiting onion bulb sprouting.

The specific operation method is: first lay a piece of polyethylene film with an area of 4.5m×2.5m and a thickness of 0.25 mm on the ground, put the stored onion bulbs in baskets (boxes) and then place them according to the expected specifications. After the yard is ready, the polyethylene plastic film cover (generally 3.5 m, 1.5 m and 1.65 m in length, width and height, respectively) is used to cover, and then the bottom edge of the cover is tightly rolled together with the four sides of the plastic film laid at the bottom of the stack, and buried with soil to make the cover airtight. The oxygen inside the hood is more when it is just closed, and the oxygen inside the hood will be gradually reduced through the respiration of onion bulbs, and the carbon dioxide content will be increased accordingly, so that the respiration can be inhibited and the storage period can be extended. To prevent decay, 100 ml of oxygen per 50 kg of onion bulbs can be filled every 1 day. In addition, in order to prevent the formation of an unfavorable environment of extreme hypoxia, the cover should be opened every 2-4 d during storage for aeration. If conditions permit, several air-regulating holes with sleeves are hot-fitted on the sides of the hood to allow for ventilation, inflation and air extraction; 3.5 kg of soda lime per 500 kg of onion should be placed inside the hood to absorb carbon dioxide and water. This can be done by taking the gas sample in the hood, after analysis to fill the nitrogen method of regulation, so that the content of oxygen and carbon dioxide in the hood are accurately controlled at 1% to 3% and 5% to 10%, respectively, the storage effect is more ideal.

Chapter 5: onion mechanization cultivation development

Section 1: tillage machinery and field management machinery

Onion is a deep-rooted underground crop, deep plowing generally more than 30 cm, must ensure that the soil permeability and soil flat and soft, requiring a flat, neat, broken, even effect. At present, most of the soil deep plowing and leveling equipment to achieve, this type of machinery for field general machinery, mainly including rotary tiller, deep plowing and turning plow, deep pine machine, disc harrow, etc.. This kind of machinery

operation efficiency is high, but there are unreasonable matching ratio with power equipment, working parts such as plow blade harrow blade broken or wear serious problems, resulting in power and equipment waste or inadequate and poor working results.

Figure 17 Mechanical rototilling and border making

Onion irrigation mainly uses large water diffusion, partly using mobile sprinkler machinery and laying drip irrigation pipe water and fertilizer integration equipment. Large water diffusion irrigation is a serious waste of water resources, water and fertilizer integration to achieve the integrated use and management of water and fertilizer, so that water and fertilizer in the soil in an optimal combination of state supply to the plant to absorb and use, worth promoting, but the initial investment is large.

Figure 18 Sprinkler and drip irrigation

Section 2: seeding machinery

A small number of seedlings can be sown by hand, but if the planting area is large,

the use of mechanical sowing seedlings is a way to save labor and effort. Onion sowing for large field seedling method, there are small seed special sowing machine. This type of machine sowing uniform, high efficiency, sowing specifications, easy to start seedlings later. Onion seedlings are small, light and easy to transport, but easily withered. For cavity seedlings there are fully automatic seeding machines for cavity trays, which shorten the slowing period, improve the survival rate and facilitate mechanized transplanting. However, onions must be single planted and single harvested, so the seeds must be sown in a single spot, which is extremely demanding in terms of seed quality, otherwise it will produce empty holes, lack of seedlings and reduced yield.

Figure 19 Precision seeder

Figure 20 Automatic cavity tray seeder

Section 3: transplanting machinery

Onion planting is mainly transplanting method, onion seedlings transplanting requires basic vertical to the ground, the maximum tilt does not exceed 30 °, plant spacing, row spacing and planting depth should be uniform, no leakage and empty planting, no injury to seedlings.

Currently, the main mechanized production model in this segment is the onion transplanter. Onion transplanting machinery is divided into clamp type, chain clamp

type, seedling guide tube type and duckbill type according to the form of planters. At present, the main model visible in the market is the traction type semi-automatic transplanter, which requires manual picking up and setting up of seedlings, and is limited by the speed of manual setting up, and the walking speed of the machine is slow. At present, most of the fully automatic transplanters for onions are Japanese products, but there are problems such as small size, low efficiency, strict soil requirements and high cost of cavity tray seedlings.

Figure 21 Automatic and semi-automatic transplanters

Figure 22 Various types of transplanting machinery (from left to right, clamp type, seedling guide tube type, chain clamp type)

Section 4: harvesting machinery

Harvesting is one of the most important and tedious aspects of onion production, using a large amount of labor, and its operational quality directly affects onion production and growers' economic returns. It is characterized by strong seasonality, short operating time and large workload. At present, onion harvesting is mainly done manually, and only a few regions have adopted mechanical harvesting such as digging shovels or plows, garlic excavators, and potato excavators, because these harvesting equipment are not designed for onion growing characteristics, and there are problems such as high energy consumption, low digging net rate, and high loss rate. The harvesting equipment developed in Europe and the United States is biased toward multi-function, automation and combined operation, while the harvesting equipment

developed in Asia is biased toward small and medium-sized combined operation. Among them, onion harvesters produced by ASA-LIFT in Denmark are the most used in the market at present, covering more than 60 countries in the world, and have achieved serialization and standardization of onion harvesting, mainly including three categories of de-seeders, diggers and pickers. Countries such as Iran, India and the Philippines combine their national conditions and onion cultivation status to develop harvesting machines that favor miniaturization and simplification of operations. Denmark and the United States and other countries have been very mature onion harvesting machinery research. The lack of onion harvesting machinery and the low level of technology have seriously affected the development of onion industry. At the same time, by natural conditions and planting patterns and other factors, onion harvesting machinery needs to be combined with the national planting agronomy and mode of independent research and development.

Onion harvesting equipment is a large one-time investment and currently only large growers choose these harvesting equipment to complete their onion harvest. Onion growing regions have different climatic environments and have very different functional requirements for onion harvesters. Therefore, it is especially important to design suitable harvesting machines specifically for the onion harvesting characteristics of a region. Onion harvesting mechanization is constrained by many reasons. First, most farmers have small land areas that are not suitable for mechanized operation; and the market also lacks machinery for harvesting small areas of land. Secondly, the low harvesting efficiency of harvesting machines with high breakage rate cannot meet the demand of harvesting. Then, farmers' understanding and awareness of agricultural mechanization is not high enough for various reasons are affecting the popularity of agricultural mechanization and the development of agricultural machinery.

Figure 23 Onion walking harvester

Figure 24 Onion picker

Section 5: onion mechanization development prospects

In recent years, although the change from unilateral adaptation of agricultural machinery to agronomy to the integration of agricultural machinery and agronomy has been achieved, the depth of integration is still far from enough. The topography of each country is complex, and the agronomy and patterns of onion cultivation differ from region to region, so it is obviously not enough to rely solely on the adaptation of agricultural machinery to agronomy. For this reason, we should strengthen the communication with the agricultural management departments of the main onion producing areas and between the large planters, develop a standardized and machine-friendly planting pattern that meets the local requirements, create conditions for mechanized harvesting operations by changing the way of planting agronomy under the premise of ensuring the yield is not reduced, promote the research and development of machinery through the adjustment of agronomy, reduce the type and quantity of machinery development, and improve the adaptability of machinery.

According to the different planting patterns and land conditions in each production area, different types of machinery should be developed by region. In the

small area planting area, we can give priority to the segmented harvesting method, and develop the series of harvesting machinery with better versatility and adaptability for seedling removal, digging harvesting and picking (with optional functions of grading and bagging). In large planting areas can explore the research and development of onion joint harvesting machinery, and the machine, electricity, liquid, gas and many other technologies into, to achieve onion to seedling, digging, soil, bagging integrated operations.

In recent years, labor prices have been rising, onion planting costs have increased, and comparative benefits have declined year by year, limiting the further development of the onion industry. The link of onion labor is concentrated in the onion transplanting and planting and harvesting stages. According to statistics, onion production investment costs in labor costs can reach 40 to 45% of the total cost, and even have increased the trend. At present, in onion production, the Mekong countries are not yet more suitable, special onion machinery. In Japan, the United States and other developed countries have been commonly used onion seeding, planting, harvesting and other machinery to achieve high production efficiency high and low production costs. In order to promote the scale and standardized production of onion industry, effectively reduce costs and ensure that growers increase production and income, the whole process of onion mechanization dedicated.