

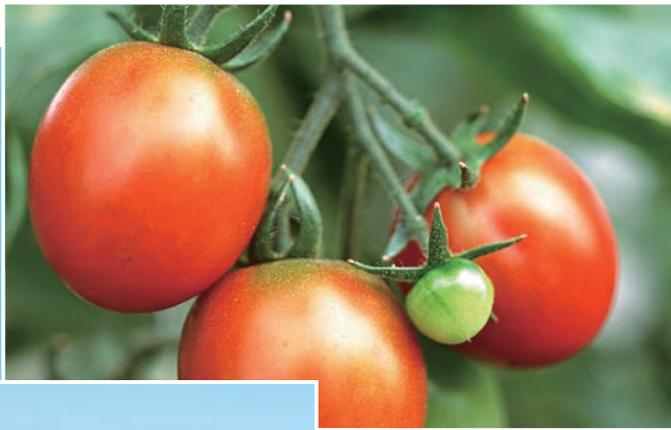
# 農業技能測定試験

Agricultural Skill Assessment Test

テキスト 耕種農業全般  
text : General Crop farming

English

英語版  
English Edition



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## Preface

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Labor shortages in Japanese agricultural workplaces have become a serious problem. For this reason, as a new framework for accepting foreign human resources (Foreigners for Agricultural Support) who can work immediately in Japanese agricultural workplaces, the “Specified Skilled Worker” designation has been established. Along with the Technical Intern Training Program, expectations are high of this mechanism to support and develop Japanese agriculture. In order for foreigners to work in agricultural workplaces through this project, they need to meet the requirements specified by the Japanese government, such as knowledge and skills concerning agriculture.

The National Chamber of Agriculture has therefore received aid from the Ministry of Agriculture, Forestry and Fisheries, and has decided to start examinations (Agriculture Skill Assessment Test) from FY2019, to confirm and evaluate the knowledge and skills of foreigners concerning agriculture, etc. before entering Japan. As part of these examinations, tests on two subjects will be carried out: 1. general crop farming and 2. general livestock farming.

This text is organized in an easy-to-understand manner using photographs and illustrations on the knowledge and techniques that should be learned by those who take the examinations on general crop farming. We hope that it will be helpful for learning and that the examinees will utilize it.

In addition, the examination on general crop farming includes questions to confirm and evaluate whether the examinees have the necessary Japanese abilities to engage in Japanese agriculture. For the examination, please also use the text for learning Japanese, separately prepared by the National Chamber of Agriculture.

Finally, in creating this text, we received great cooperation from each member of the Agriculture Skill Assessment Test Planning Committee Crop Subcommittee, including former Professors of Utsunomiya University Yoshikazu Yamaki (fruit tree cultivation), Yukio Ohashi (Greenhouse Horticulture), Tadashi Nagashima (rice cultivation), and Tomomi Hirasawa (crop cultivation). We are deeply grateful for their support.

October 2019

National Chamber of Agriculture

# Table of Contents

## 1 General Japanese agriculture

---

- |   |                        |   |   |                              |   |
|---|------------------------|---|---|------------------------------|---|
| 1 | Rice cultivation ..... | 1 | 3 | Fruit tree cultivation ..... | 1 |
| 2 | Vegetable .....        | 1 |   |                              |   |

## 2 General crop farming

---

- |   |  |    |    |   |    |
|---|--|----|----|---|----|
| 1 | Growth of each organ ...                   | 2  | 10 | Fertilizer application ...                        | 19 |
| 2 | Cropping system<br>and cropping type ..... | 4  | 11 | Ridging .....                                     | 21 |
| 3 | Sowing .....                               | 5  | 12 | Pinching, defoliation<br>and fruit thinning ..... | 22 |
| 4 | Raising of seedlings<br>and planting ..... | 6  | 13 | Artificial pollination ...                        | 23 |
| 5 | Irrigation (Watering) ...                  | 8  | 14 | Training, supporting ...                          | 23 |
| 6 | Soil for growing crops ...                 | 10 | 15 | Harvest .....                                     | 24 |
| 7 | Improvement of soil fertility ...          | 12 | 16 | Utilization of covering material ...              | 25 |
| 8 | Replant failure .....                      | 15 | 17 | Knowledge of pest<br>and weed control .....       | 27 |
| 9 | Fertilizer .....                           | 16 |    |   |    |

## 3 Health and safety

---

- |   |   |    |   |   |    |
|---|---|----|---|---|----|
| 1 | How to use agricultural<br>machinery safely ..... | 30 | 3 | Handling power<br>supplies and fuel oil ... | 34 |
| 2 | Pesticide spraying .....                          | 32 | 4 | Keeping things in order ...                 | 36 |
|   |   |    | 5 | How to use stepladders safely ...           | 37 |

## 4 Rice cultivation work

---

- |   |                                |    |   |   |    |
|---|--------------------------------|----|---|---|----|
| 1 | Seed preparation .....         | 38 | 5 | Preparation and shipping ...                    | 42 |
| 2 | Raising of seedlings ...       | 39 | 6 | Management of<br>paddy fields after harvest ... | 42 |
| 3 | Management of paddy fields ... | 40 |   |   |    |
| 4 | Harvest .....                  | 42 |   |   |    |

## **5 Upland field work for crops and vegetables**

---

- |   |   |
|---|---|
| <b>1</b> Characteristics of cultivated crops ..... 45 | <b>2</b> Cultivation management of upland crops and vegetables ... 51 |
|   | <b>3</b> Seeds ..... 52   |

## **6 Facility horticulture work**

---

- |  |  |
|--|--|
| <b>1</b> Characteristics of crops in facility horticulture ... 55    | <b>4</b> Equipment in facilities ... 60  |
| <b>2</b> Types and structures of facilities ..... 57                 | <b>5</b> Environmental management ... 62 |
| <b>3</b> Facility coating materials and their characteristics ... 58 | <b>6</b> Growth diagnosis ..... 64       |
|  | <b>7</b> Nutriculture ..... 65           |
|  | <b>8</b> Seedling methods ..... 66       |

## **7 Fruit tree cultivation work**

---

- |   |  |
|---|--|
| <b>1</b> Definitions and species of fruit trees ... 68  | <b>4</b> Facility cultivation of fruit trees ... 85                            |
| <b>2</b> Features of fruit tree cultivation ... 68      | <b>5</b> Characteristics of main fruit trees and cultivation management ... 85 |
| <b>3</b> Cultivation management of fruit trees ..... 71 | <b>6</b> Agricultural materials and machinery used for fruit trees ... 87      |

## **8 Terms used in farm work** ..... 90

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### **List of photographs (vegetables, covering materials and fruits)**

---

- |                   |                           |                 |
|-------------------|---------------------------|-----------------|
| Vegetables ... 94 | Covering materials ... 95 | Fruits ..... 95 |
|-------------------|---------------------------|-----------------|

# Introduction

## Precautions when entering Japan

When you enter Japan and engage in agriculture, you must follow the following rules to prevent the invasion of livestock infectious diseases and pests.

- Please do not touch livestock within a week before coming to Japan.
- As a general rule, please do not enter a barn or its surroundings for 1 week after entering Japan (including re-entry).
- Do not bring dirty work clothes, work shoes, or boots used overseas.
- Meat products such as meat, ham, sausage, and bacon must not be brought into Japan without an inspection certificate.
- Please tell your family and friends not to send meat products to Japan in small packages or small mail (international mail).
- In addition, let's work safely according to the instructions of the manager of the farm.

## 1 Rice cultivation

Rice cultivation means growing rice plants.

There is Asian rice and African rice. The former is widely cultivated around the world especially in Asia.

Asian rice is classified roughly into Indica and Japonica subspecies and most of the rice plants cultivated in Japan are Japonica rice.



Brown rice of the Indica subspecies



Brown rice of the Japonica subspecies

The grains of a rice plant which has had the hulls removed are called “rice.”

Rice for processing use such as rice powder, and rice for livestock feed are also cultivated.

The work involved in rice cultivation such as tillage, transplanting, harvesting (reaping), threshing and preparing is mechanized.

## 2 Vegetables

Vegetables are actively grown by facility cultivation using vinyl houses as well as by open field cultivation.

There are root vegetables whose roots and rhizomes are used, leafy vegetables whose leaves are used, and fruit vegetables whose fruits are used.

Higher quality vegetables have been produced by improvements in breeding and cultivation technology.

The popularization of facility cultivation and the availability of covering materials have also enabled the same kind of vegetable to be produced throughout the year. This is called year-round cultivation.

## 3 Fruit tree cultivation

For evergreen fruit trees, there are citrus fruits such as Satsuma mandarin, loquat, etc.

For deciduous fruit trees, there are apples, grapes and pears, etc.

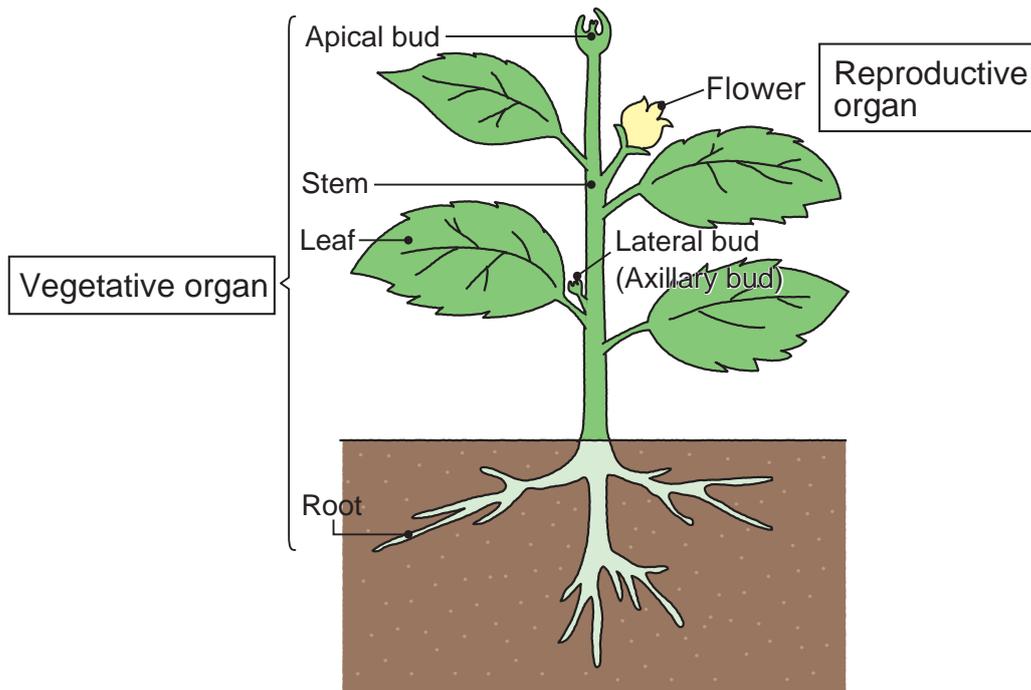
Apples are mainly grown in areas where the winters are cold, whereas Satsuma mandarins are grown where the winters are warmer.

## 1 Growth of each organ

### (1) Crop body

Leaves, stems and roots are the organs for growth. They are called the vegetative organs.

Flowers and fruits are the organs that leave offspring. They are called the reproductive organs.



### (2) Vegetative growth and reproductive growth

Growth is divided into vegetative growth and reproductive growth.

Vegetative growth means the growth of the vegetative organs such as leaves, stems, and roots.

Reproductive growth means the growth that produces fruits and seeds.

The conditions and appearances to shift from vegetative growth to reproductive growth depend on the crops.

### (3) Photosynthesis

Crops carry out photosynthesis.

Photosynthesis requires light, carbon dioxide ( $\text{CO}_2$ ), and water ( $\text{H}_2\text{O}$ ).

Crops synthesize carbohydrates by photosynthesis.

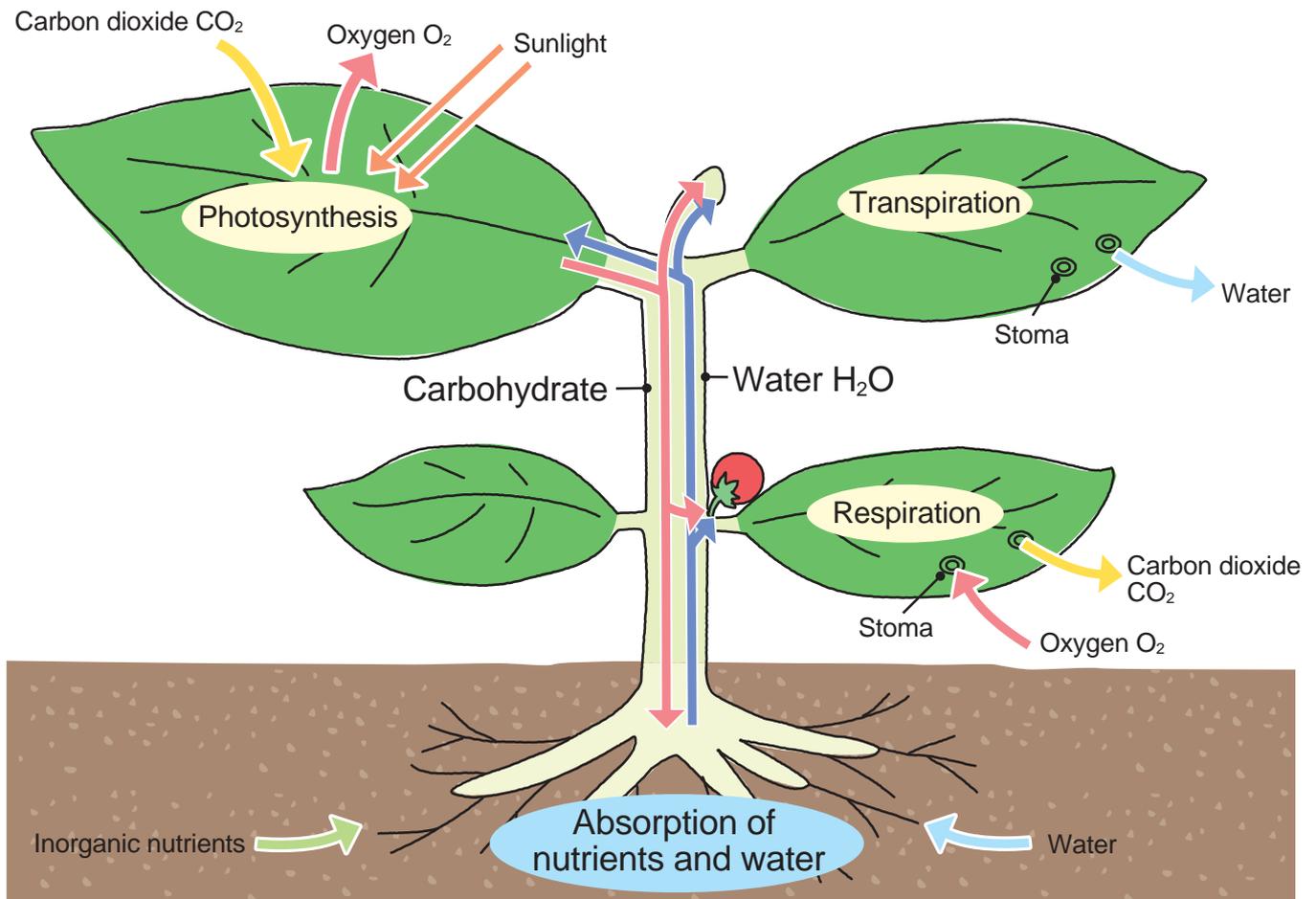
Generally, stronger light will produce more photosynthesis.

## (4) Respiration

Crops carry out respiration.

Respiration increases when crops are rapidly growing and when the temperature is high.

When the temperature at night is high, respiration increases and the carbohydrates that were made during the daytime are consumed in large amounts, resulting in less accumulation in the crops.



## (5) Transpiration

Crops drain moisture from leaf stomata. This is called transpiration.

## (6) Absorption of nutrients and water

Crops absorb nutrients and water in the soil through their roots.

## (7) Formation of flower buds

When vegetative growth has progressed to some level, reproductive growth begins and flower buds are formed. This is called flower bud differentiation.

There are two types of flower bud differentiation.

- ① A type that grows to some extent and then differentiates regularly.

Example: tomatoes.

- ② A type that differentiates under the influence of environmental changes such as temperature and day length.

Example: Radish and spinach.

Short-day plants are plants that differentiate flower buds when the dark time is longer than a certain time (decrease in the length of the light time). Strawberries, chrysanthemums, and so on.

Long-day plants are plants that differentiate flower buds when the dark time is shorter than a certain time (increase in the length of the light time). Spinach and so on.

Some plants differentiate flower buds when the temperature is low. Radish, cabbage, broccoli, and so on.

## 2 Cropping system and cropping type

- ① Cropping system

A cropping system is a system that handles the species of crops grown in the fields and the order of cultivation.

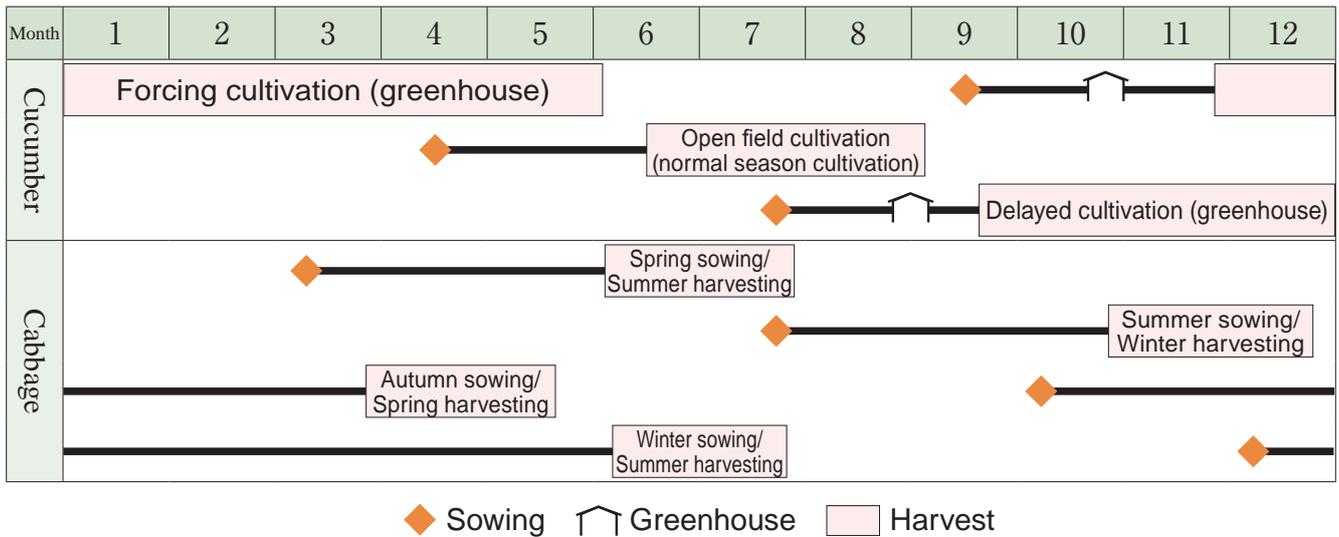
- ② Cropping type

Even with the same crop, the cultivation season and method may be different. This is called cropping type.

For example, in leaf vegetables and root vegetables such as cabbage and radish, there are spring sowing cultivation, summer sowing cultivation, and autumn sowing cultivation, which differ in seeding and harvesting periods.

In addition, tomatoes and cucumbers are also grown by forcing cultivation method which advances the harvest time compared to open field (normal season) cultivation, and also by delayed cultivation method which delays the harvest time.

### Example of cropping type



## 3 Sowing

### (1) Sowing

The work of sowing seeds is called sowing.

Moisture, temperature and oxygen are all essential for the germination of seeds. These are the **three conditions required for germination**. The seeds are covered with soil to ensure the three conditions for germination.

Some seeds germinate easily when exposed to light (photoblastic seed), while others germinate poorly when exposed to light (negative photoblastic seed). Photoblastic seeds should be covered thinly with soil. Negative photoblastic seeds should be covered thickly with soil.

### (2) Direct sowing

Direct sowing means sowing directly into the field.

Root vegetables such as radish and carrot are directly sown.

### (3) Agricultural tools and machinery for sowing



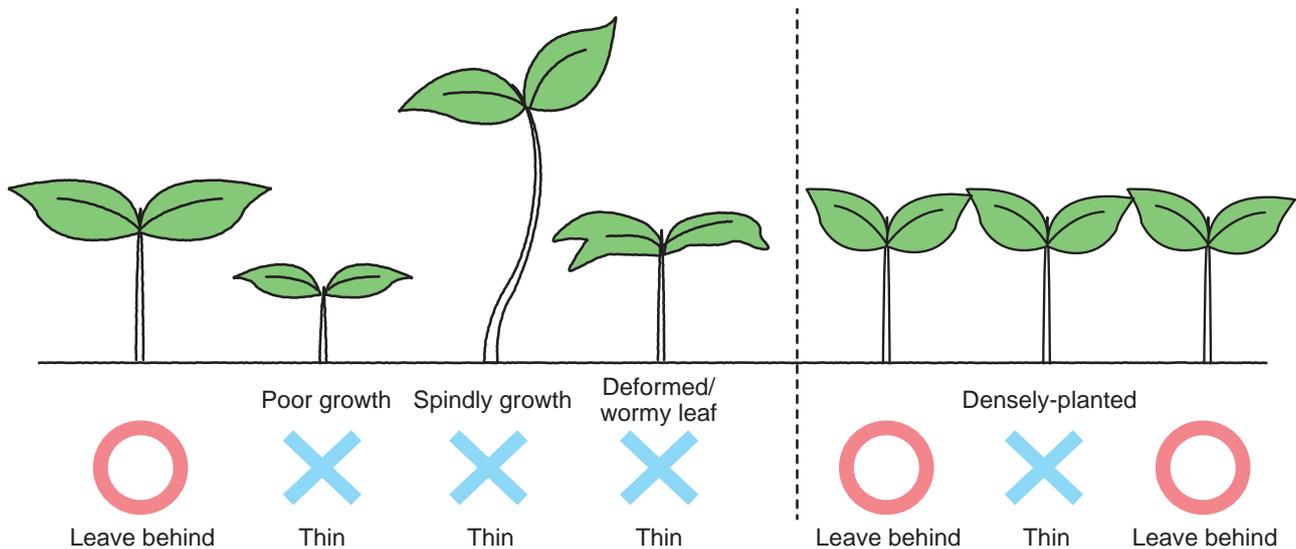
Hand seeder



Seeder

## (4) Thinning

In direct sowing cultivation, thinning is carried out. Thinning is to create a proper space between the seedlings by removing any seedlings that are damaged by pests, deformed seedlings and extra seedlings.



## 4 Raising of seedlings and planting

### (1) Raising of seedlings

Sowing and growing seedlings in a different place from the field is called the raising of seedlings. The place where seedlings are raised is called a nursery bed.

Raising of seedlings is used for fruit vegetables (tomatoes, cucumbers, etc.) and leafy vegetables (cabbage, lettuce, etc.).

#### Advantages of raising of seedlings

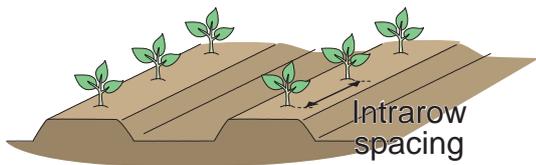
- We can protect seedlings from weather changes such as rain and wind, diseases and pests.
- We can prepare healthy and evenly grown seedlings.
- We can grow other crops in the field by shortening the cultivation period of a crop.
- You can raise seedlings efficiently in a small area.

### (2) Planting

Planting is to plant seedlings in a field.

The growth stage suitable for planting and the space between seedlings (intrarow spacing) differ among crop species.

There are two methods of planting: using a machine and by hand.



Transplanter



Hand planting

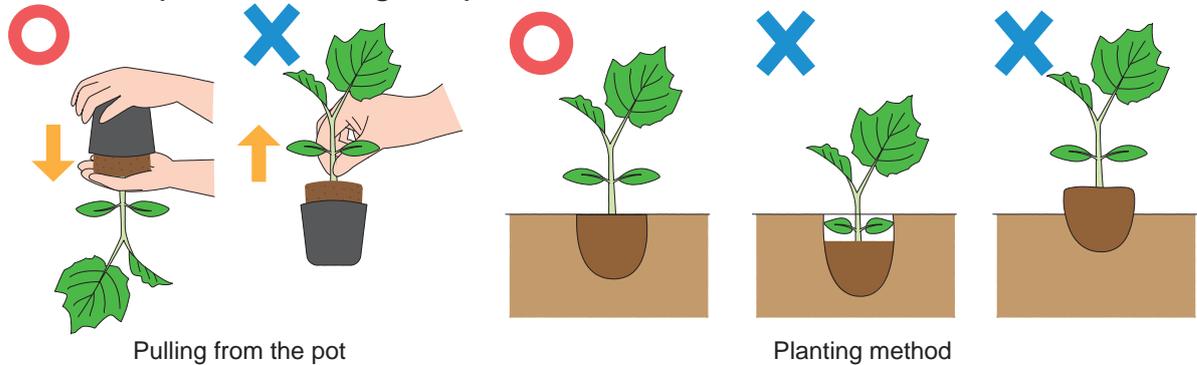
### The characteristics of machine planting and hand planting

- The method using a machine (transplanter)
  - Advantage: You can plant seedlings over a large area in a short time.
  - Disadvantage: Advanced techniques, such as uniform seedling growth, are required.
  
- The method of planting by hand
  - Advantage: You can plant seedlings reliably. It doesn't cost anything.
  - Disadvantage: It takes time to plant and requires hard work to bend down.

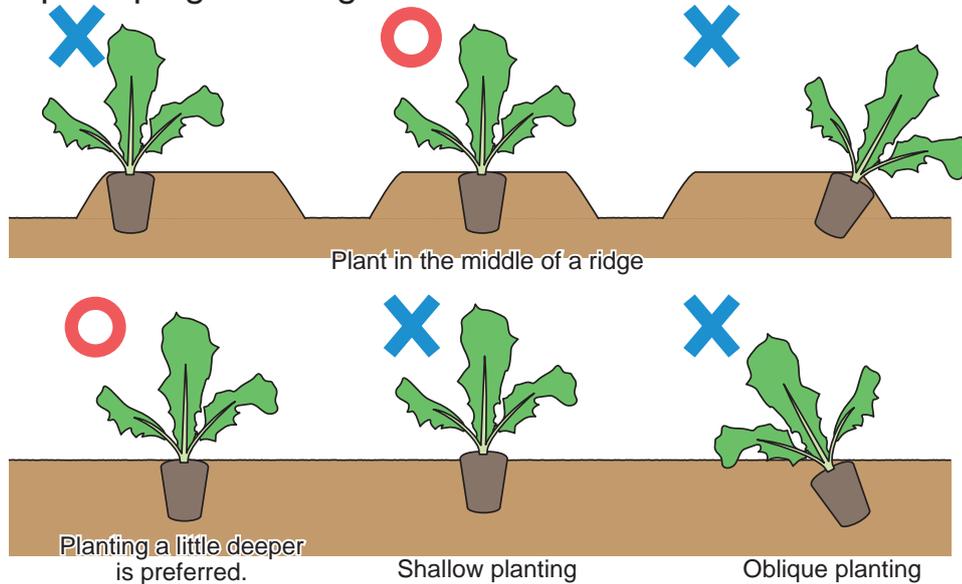

**Practical skill**

- Understand the proper planting method of seedlings.

### How to plant seedlings in pots



### How to plant plug seedlings



## 5 Irrigation (Watering)

### (1) Irrigation

Irrigation (watering) is also important work.

Irrigation must be done while observing the growth of the crops and the soil condition.

The amount of water required depends on the temperature and humidity. Excess water may cause root rot.

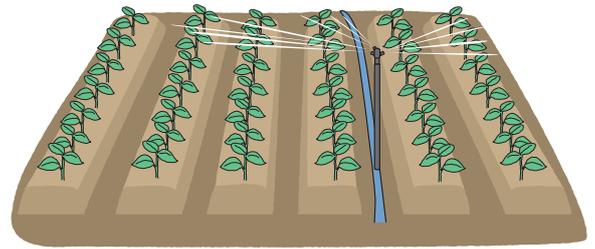
Irrigation is mainly performed in the morning and evening.

## (2) Methods of irrigation

### ① Overhead irrigation

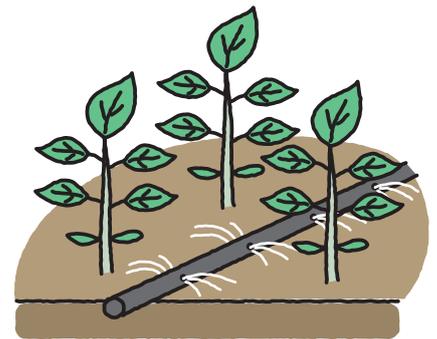
A general method that sprays water down onto the crops. Hoses with a rose or sprinkler, watering tubes, etc. are used.

Watering should better be avoided in the daytime in midsummer.



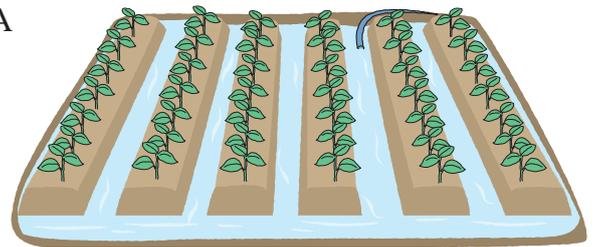
### ② Plant foot irrigation

A method that gives water to the roots of the crop. Tools such as drip irrigation tube are used. Water can be saved using this method.



### ③ Furrow irrigation

A method that floods the furrows with water. A large amount of water is necessary.



## (3) Tools used for irrigation



Rose



Sprinkler



Irrigation tube



Drip irrigation tube


**Practical skill**

- Understand the main irrigation tools.
- Understand the time required for irrigation.
- Understand the irrigation equipment such as drip irrigation tube and irrigation tube.

## 6 Soil for growing crops

### (1) Classification of soil texture

In Japan, the soil texture is divided into five types according to the proportion of clay.

Fertilizer response (also called fertilizer retention), drainage, etc. differ greatly depending on the soil texture.

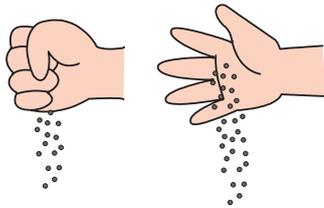
Soil texture	Percentage of clay	Fertilizer retention	Drainage
Clay	50.0% or more	Good	Bad
Clay loam	37.5 to 50.0%	Good	Slightly bad
Loam	25.0 to 37.5%	Good	Good
Sandy loam	12.5 to 25.0%	Slightly bad	Good
Sand	12.5% or less	Bad	Good

Loam and clay loam, which contain a moderate amount of sand and clay, are suitable for the cultivation of many crops.


**Practical skill**

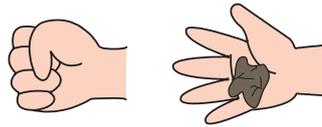
- Learn to identify soil texture by looking at soil samples.
- Understand a simple method to identify soil texture.

The soil will not harden even if you hold it



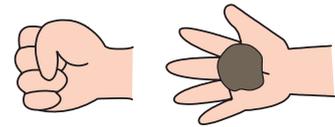
Sand - sandy loam

The soil will harden slightly but will crack



Loam - clay loam

The soil has hardened



Clay

- Understand the characteristics of each soil texture (fertilization and drainage).

## (2) Soil type

In Japanese farmland, unique soils are distributed according to the geographical features.

### Major soil groups

#### ① Andosol

It is widely distributed on plateaus and hills. It is mainly volcanic ash and contains a lot of humus. It is a black soil layer. Half of the crop fields in Japan are andosol.

#### ② Brown lowland soil

It is distributed in natural levees in alluvial lowlands, etc. All or almost all layers are tawny soil layers. It is used for crop fields.

#### ③ Gray lowland soil

It is distributed in alluvial fans and plains with good drainage. It is a gray soil layer. It is used for paddy fields.

#### ④ Gley soil

It is distributed in alluvial depressions. It is a blue-gray soil layer. It is used for paddy fields.

## (3) Crumb structure of soil

A crumb means a cluster of soil particles.

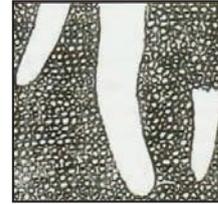
Soil with a large amount of crumbs (crumb structure soil) is soft and suitable for the cultivation of crops.

The opposite of crumb structure is single-grain structure. Soil of single-grain structure is dense with particles and is a hard soil. To increase crumb structure, add compost and organic matter.

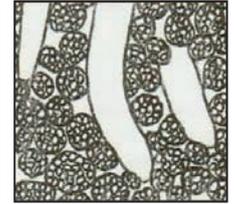
### Characteristics of soil with many crumbs

- There are spaces in the soil.
- It adsorbs fertilizer nutrients and retains fertilizer.
- It has high air permeability and water holding capacity that make crops grow well.

Single-grain structure



Crumb structure



### Characteristics of single-grain structure soil

- It has low air and water permeability that prevent crops from growing well.

#### Practical skill

- Understand crumb structure and single-grain structure.

## (4) Three-phase structure of soil

Soil is composed of solid (soil particles, organic matter), liquid (moisture), and gas (air) phases. These three are called **three-phase structure of soil**.

The balance of solid, liquid, and gas phases influences crop growth.

Good soil has a percentage from 30% to 40% for each of solid, liquid and gas.

## 7 Improvement of soil fertility

### (1) Soil fertility

Soil fertility means the overall soil productivity.

Soil with soil fertility is able to grow crops well and yields a large amount of crops.

Improving the properties of soil to enhance soil fertility is the basics of agriculture.

### Characteristic of soil with soil fertility

- ① It has thick and soft soil layer, high air permeability, and high water holding capacity.
- ② It appropriately contains nutrients necessary for crops and the soil acidity is within the proper range.
- ③ It contains appropriate amounts of soil organic matter, and soil microorganisms are active.

## (2) Improvement of soil properties

### ① Tillage (plowing): Improvement of physical properties

Tillage means digging up the soil.

Air enters into the soil and makes it soft.

Tillage improves air permeability and drainage.

Plowing the soil deeply is called deep tillage.

### ② Improvement of acidity: Improvement of chemical properties

Japanese soil is generally very acidic.

The acidity needs to be adjusted to a level suitable for the crops.

To improve acidic soils, spread an appropriate amount of lime or dolomite.

### ③ Replenishment of organic matter: Improvement of microflora

To propagate and activate soil microorganisms, spread soil amendment such as compost and organic matter.

## (3) Appropriate pH

pH (pH and hydrogen ion concentration index) indicates the acidity of soil.

pH 7 is neutral, higher than 7 is alkaline, and lower than 7 is acidic.

Soil with a pH less than 7 is called acidic soil, and soil with a pH greater than 7 is called alkaline soil.

Many Japanese crops are suitable for growing at pH 5.5 to 6.5.

### Crop species and suitable pH for growth

6.5 ~ 7.0	Spinach	5.5 ~ 6.0	Sweet potatoes
6.0 ~ 7.0	Japanese radish, cabbage, tomato	5.0 ~ 6.5	Potatoes
6.0 ~ 6.5	Eggplant, lettuce	4.5 ~ 5.5	Tea, blueberry
5.5 ~ 6.5	Strawberries, onions, carrots		

## (4) Instruments for measuring the acidity and pH of soil

A soil acidity meter is an instrument to measure soil acidity.

Other types of pH meters include those that measure pH using a colorimetric table (colorimetric pH tester), those that measure pH by putting them into soil, and those that display numerical values digitally.



Acidity meter

### Practical skill

- Understand the measurement of acidity of soil.

How to use a soil acidity meter

It is a simple measuring instrument to measure the approximate acidity by inserting it directly into the soil.

- ① First, water is sprinkled on the soil to be measured to make it sufficiently wet. (To the extent that it hardens with your hands.)
- ② Insert it into the soil so that all the electrodes of the metal part are filled. (so that the soil tightly adheres to the metal surface.)
- ③ After 1 minute, when the number becomes stable, read it.

## (5) Agricultural tools and machinery for “tillage”

- ① Agricultural tools



Grub hoe [hiraguwa]



Fork hoe [mannouguwa]



Scoop (shovel)

## ② Agricultural machinery



Riding tractor



Plow



Rotary harrow



Walking tractor (cultivator)

\* The tractor is used for tilling with a rotary and plow mounted.

\* In addition to tillage, with farm working machinery mounted, a tractor is a general-purpose machine which can be used for harvesting, pest control, sowing, transport, etc. Ride-on tractors are usually called tractors, and walking tractors are called tillers or cultivators.

## 8 Replant failure

### (1) Replant failure

Repeated cultivation in the same field is likely to cause the occurrence of pests which leads to poor growth and may decrease the yield. This is called **replant failure**.

Causes of replant failure

- Increase of pathogens in soil
- Increase of pests such as nematodes
- Lack of specific nutrients
- Increase of substances that hinder the growth of crops

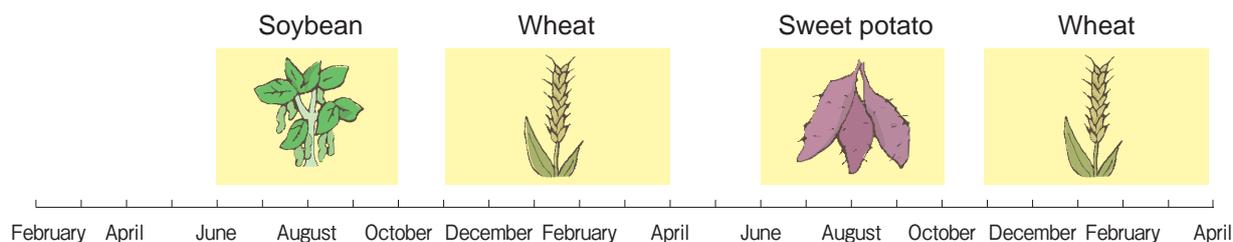
### (2) Countermeasures against replant failure

A preferred countermeasure against replant failure is crop rotation.

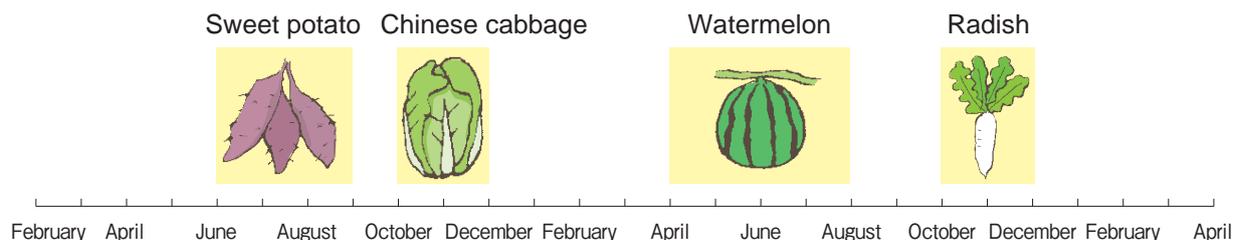
Crop rotation means cultivating different kinds of crops periodically in the same field.

In addition, there are also methods such as using grafting, using disease-resistant varieties, improving soil by introducing compost, and soil disinfection using chemicals or sunlight.

An example of a 2-year and 4-cycle crop rotation with a combination of summer crops and winter crops



An example of a 2-year and 4-cycle crop rotation with a combination of summer crops and autumn crops



## 9 Fertilizer

### (1) Three elements of fertilizer

Fertilizer is necessary for crop growth. It is because soil itself does not contain enough nutrients for crops.

Nitrogen, phosphorus, and potassium are the **three elements of fertilizer**.

Elements essential for the growth of crops are called essential elements. There are 16 essential elements.

The element symbols for the three elements of fertilizer are nitrogen: N, phosphoric acid: P, and potassium: K.

Trace elements are calcium (Ca), magnesium (Mg), sulfur (S), manganese (Mn), boron (B), iron (Fe), copper (Cu), zinc (Zn), chlorine (Cl), and molybdenum (Mo).

Carbon (C), hydrogen (H), and oxygen (O) are obtained from air and water and are fixed by photosynthesis. Oxygen (O) and hydrogen (H) are absorbed as water from roots, and carbon (C) is absorbed as carbon dioxide from air through leaves.

### (2) Characteristics of the three elements of fertilizer

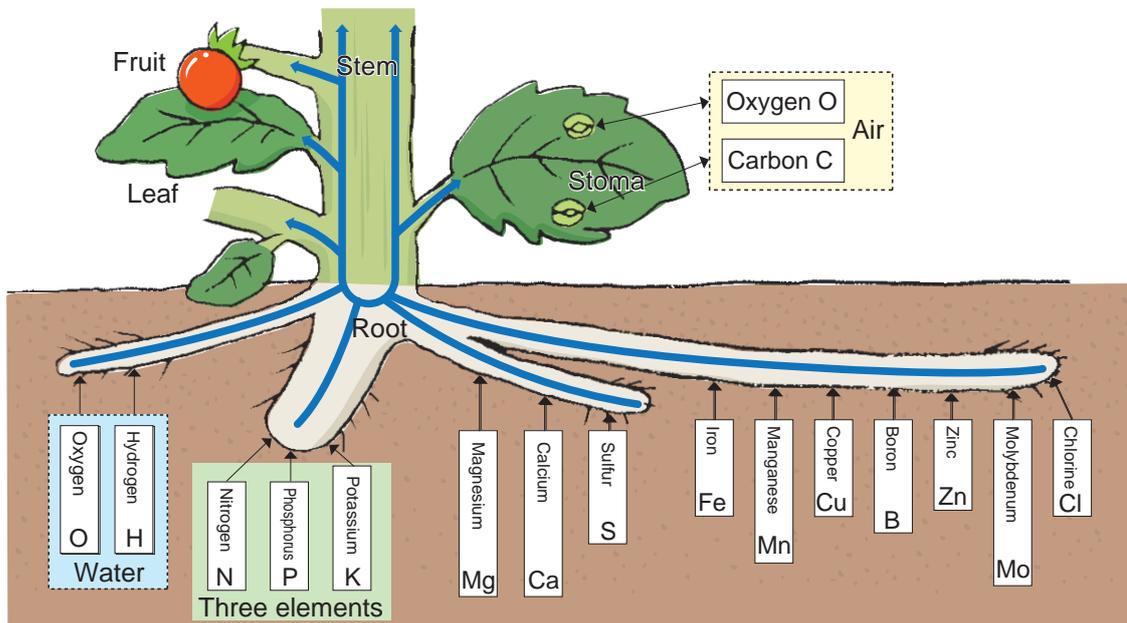
Nitrogen (N): Associated with crop growth and yield.

Nitrogen mainly elongates stems and leaves and makes color of leaves darker.

Excess nitrogen makes crops flaccid.

Phosphorus (P): Affects mainly blooming and fruiting.

Potassium (K): Affects mainly blooming, fruiting, and root development.



Inorganic nutrients necessary for crops

### (3) Types of fertilizer

#### ① Chemical fertilizer (inorganic fertilizer)

A chemically synthesized fertilizer. Also called inorganic fertilizer.

The fertilizer effect appears quickly with chemical fertilizer.

Straight fertilizer contains only one element of the three.

Compound fertilizer contains two or more elements of the three. Compound fertilizers include complex fertilizers and mixed fertilizers.

Mixed fertilizer is mainly made by mixing of straight fertilizers of the chemical fertilizer. It contains 2 or more elements among nitrogen, phosphoric acid, and potassium, and the total content is guaranteed to be 10% or more. Most mixed fertilizers contain organic fertilizer.

#### Classification of fertilizers

##### ○ Straight fertilizer

Nitrogen fertilizers Ammonium sulfate, urea, etc.

Phosphate fertilizers Superphosphate, fused phosphate, etc.

Potassic fertilizers Potassium sulfate, Potassium chloride, etc.

### ○ Compound fertilizer

Complex fertilizers [Rin-shou-an-kari] Ammonium nitrate, calcium phosphate, potassium sulfate / [Rin-ka-an] Ammonium, potassium phosphate / [Ryu-ka-rin-an] Ammonium nitrate, potassium sulfate, ammonium phosphate / NK fertilizer / PK fertilizer

Mixed fertilizers BB fertilizer, mixed fertilizer which contains organic matter

High-analysis complex fertilizer, one of the complex fertilizers, contains 2 or more elements among nitrogen, phosphoric acid, and potassium and the total amount is 30% or more. Complex fertilizer that contains less than 30% is low-analysis complex fertilizer.

### ② Organic fertilizer

A fertilizer made from organic substances derived from animals and plants.

There is fish meal, rapeseed meal, bone meal, etc.

The fertilizer effect appears slowly with organic fertilizer.

### ③ Compost

Compost is made with fermented cattle manure, chicken manure, swine manure, bark, fallen leaves, etc.

Depending on the type of main material, there is cattle manure compost, swine manure compost, chicken manure compost, bark compost, fallen leaves-compost, rice straw compost, etc.

Compost not only has a soil improvement effect but also a fertilizer effect.

### ④ Liquid fertilizer

It is a liquid form fertilizer. Even if the original form is a solid such as powder or granule, if it is dissolved into a liquid at application, it should be classified as liquid fertilizer.

### ⑤ Quick acting fertilizer, slow release fertilizer, and delayed release fertilizer

#### i Quick acting fertilizer

The effect will appear soon after fertilization. The effect lasts up to 30 days.

Includes liquid fertilizer, complex fertilizer, etc.

#### ii Slow release fertilizer

The effect lasts for a long period. The effect lasts for 30 to 120 days.

Includes fertilizer covered with a film and response-controlled fertilizer whose dissolution is regulated and the like.

#### iii Delayed release fertilizer

It takes a long time for the effect to appear until degraded by microorganisms.

Includes rapeseed meal, bone meal, etc. Some chemical fertilizers are effective for a year.

#### (4) Form of fertilizer and the lik

Fertilizer is processed into various forms for ease of use and effectiveness. Forms include powdery, granular, liquid, or pelleted fertilizer that is processed into a cylindrical solid (pellet).

Recently, there are fertilizers made by mixing organic fertilizers into chemical fertilizers.



Granular fertilizer



Powdery fertilizer



Pelleted fertilizer



Liquid fertilizer

#### Practical skill

- Understand the main types of fertilizer.
- Understand chemical fertilizer, organic fertilizer and compost.
- Understand the form and classification of fertilizers.

Granular fertilizer, powdery fertilizer, pelleted fertilizer, liquid fertilizer

## 10 Fertilizer application

### (1) How to use fertilizers

Giving fertilizer to crops is called fertilizer application.

For fertilizer application, there is basal fertilizer and additional fertilizer.

Basal fertilizer is a fertilizer given before planting crops.

Apply mainly **slow release fertilizer** whose effect is mild and lasts for a long time.

Additional fertilizer is a fertilizer additionally given to crops according to their growth, etc.

Use **quick acting fertilizer** (complex fertilizer, liquid fertilizer, etc.) which exert an effect immediately.

Liquid fertilizer can also be used to spread on leaves.

Fertilizers must not directly touch the seeds or roots when given. Otherwise the crops may die.

In addition, excess fertilizer can increase the salt concentration in the soil and impair the growth of crops.

This is called salt injury.

Salt concentrations are measured by electrical conductivity (EC). Soil with a high EC value has a lot of fertilizer left.

Apply fertilizer according to the recommended rate of fertilizer application for each crop.

## (2) Agricultural machinery used for fertilizer application



Fertilizer broadcaster



Manure spreader



Lime sower

### ○ Look at the fertilizer bag and understand the fertilizer components.

- The meaning of “10-8-8” stated by a complex fertilizer

The fertilizer components are nitrogen: 10%, phosphoric acid: 8% and potassium: 8%. Since the total amount of components is less than 30%, this belongs to low analysis compound fertilizer.

- The weight of the components in 20 kg (per bag) of a fertilizer stating "10-8-8"

Nitrogen  $20 \times \frac{10}{100} = 2$ ; that is, the fertilizer contains 2 kg of nitrogen.

Phosphoric acid  $20 \times \frac{8}{100} = 1.6$ ; that is, the fertilizer contains 1.6 kg of phosphoric acid.

Potassium  $20 \times \frac{8}{100} = 1.6$ ; that is, the fertilizer contains 1.6 kg of potassium.

### ○ You should be able to calculate the required amount of fertilizer based on the recommended rate of fertilizer application.

**Question:** How to calculate the amount of fertilizer that satisfies the recommended rate of fertilizer application

A Recommended rate of fertilizer application for vegetables (application amount of fertilizer per 10 a)	Fertilizer used (component content rate)
Nitrogen (N)            21 kg	Ammonium sulfate        (N: 21%)
Phosphoric acid (P)   23 kg	Calcium superphosphate (P: 46%)
Potassium (K)         18 kg	Potassium chloride       (K: 60%)

Application amount of fertilizer  
 =  $\frac{\text{amount of fertilizer based on the recommended rate of fertilizer application}}{\text{component content rate}} \times 100$

**(Answer)**

Calculation formula

$$\text{Ammonium sulfate: } \frac{21}{21} \times 100 = 100 \text{ (kg)}$$

$$\text{Calcium superphosphate: } \frac{23}{46} \times 100 = 50 \text{ (kg)}$$

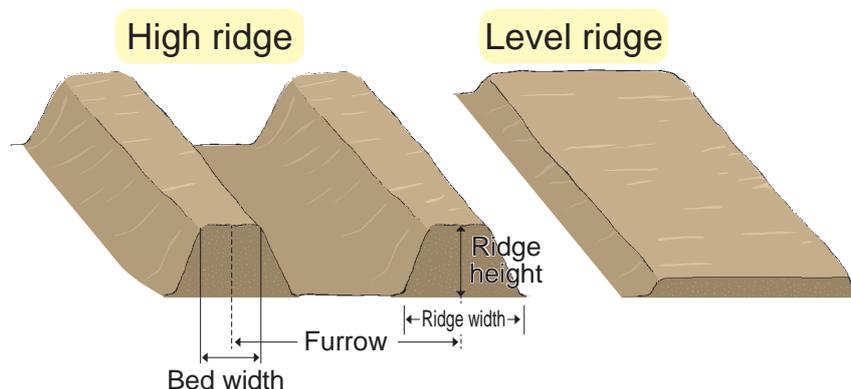
$$\text{Potassium chloride: } \frac{18}{60} \times 100 = 30 \text{ (kg)}$$

**11 Ridging****( 1 ) Ridge shape**

A ridge is a cultivation bed with mounded soil. The aim is to improve drainage and air permeability.

The work of making a ridge is called **ridging**. It is carried out before sowing or planting seedlings.

In a field with a high groundwater level, the ridge should be a high ridge with a raised bed.

**Practical skill**

- Understand the type of the ridge.  
High ridge, level ridge
- Understand the name of the ridge.  
Ridge width, ridge height, furrow, bed width

## (2) Agricultural tools and machinery for ridging

When ridging by hand, a hoe, etc. is used.

When ridging using machines, we work using a tractor or a cultivator mounted with a ridger or hiller, etc.



Small ridge forming machine



High ridge hiller

## 12 Pinching, defoliation and fruit thinning

### (1) Pinching

Pinching is the work of cutting off the tip of the stem.

Pinching will feed nutrients to the leaves and fruits.

It also makes cultivation management and harvesting easier.

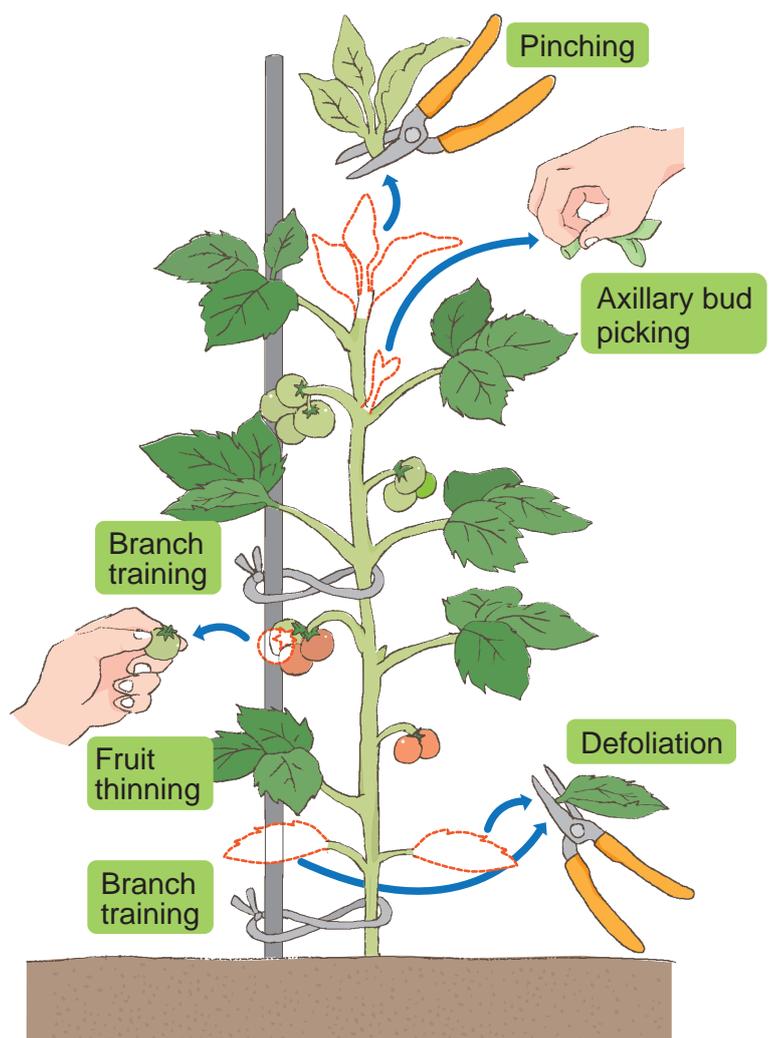
### (2) Axillary bud picking

Axillary buds sprout from the axil of the leaf. Remove them to prevent excess fruiting and over-luxuriant growth of the leaf, and to catch more sunlight.

### (3) Defoliation

Defoliation is the work of removing diseased leaves and crowded leaves.

Defoliation supplies good ventilation and a large amount of sunshine.



## (4) Disbudding, flower picking and fruit thinning

Disbudding, flower picking and fruit thinning are work that picks excess flower buds, flowers and fruits, respectively. Remove excess flower buds, flowers and fruit, fruit damaged by pests and deformed fruit, etc.

Fruit thinning enables to grow high quality fruit by concentrating nutrients and moisture into the remaining fruit.

Generally, it is performed in fruit cultivation, but also performed in vegetable cultivation such as watermelon, melon and tomato.

### Practical skill

- Understand the work of pinching, axillary bud picking, defoliation, and fruit thinning.

## 13 Artificial pollination

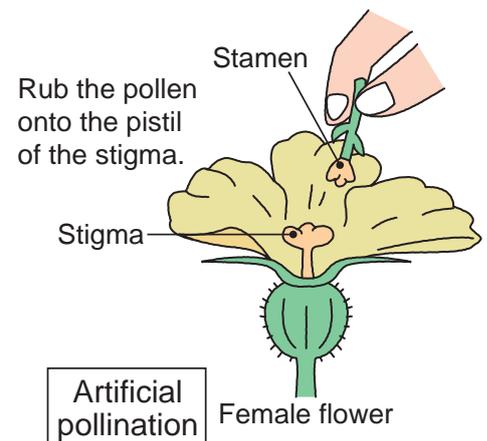
The process by which pollen is transferred to the stigma of a pistil is called pollination.

In circumstances where pollination does not occur easily, artificial pollination is carried out, which involves transferring the pollen onto the pistil artificially.

In greenhouses, insects such as honeybees and bumblebees are used.

Honeybees are mainly used to pollinate strawberries.

With watermelon, melon and pumpkin, artificial pollination is performed to ensure fruiting.

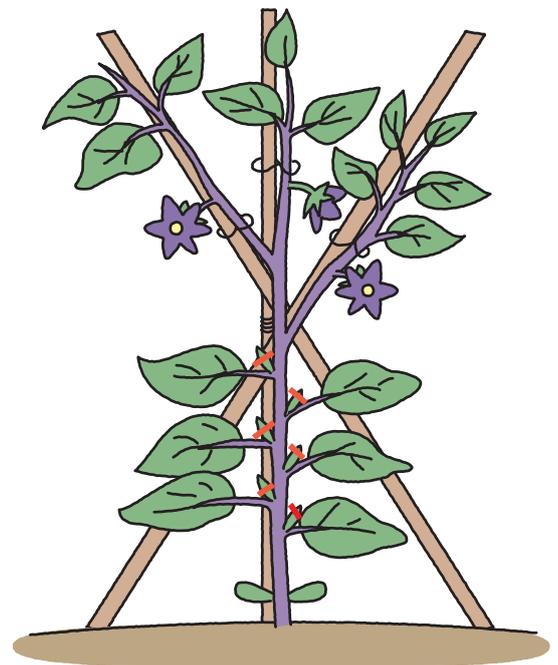


## 14 Training, supporting

### (1) Training

Training is the trimming of branches to adjust their number and arrangement.

Training increases the yield and makes maintenance easier.

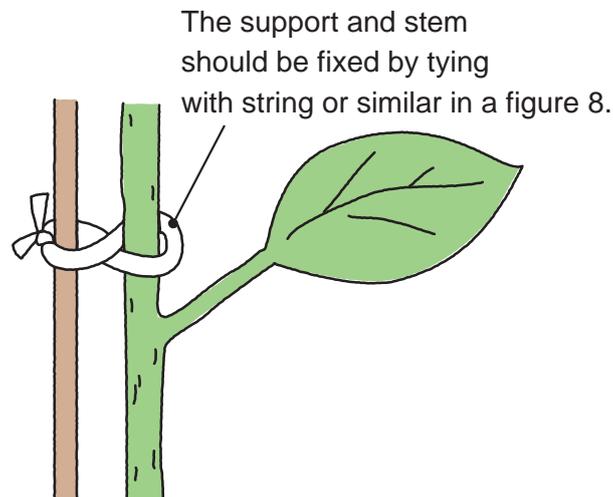


## (2) Supporting

Supporting is work that trains the branches to be appropriately arranged.

Supporting protects the plant from dropping and prevents the branches from being crowded. The plant will be well-exposed to the sun and easy to maintain.

When supporting tomatoes, eggplants, cucumbers, etc., branches such as the main stems and lateral branches are bound to the supports and taped.



## 15 Harvest

### (1) Harvest

Harvesting is the work of ingathering crops.

Harvesting must be done at just the right time (optimum stage).

For example, the indications to harvest are: tomato = coloring, spinach = plant height, cucumber = length of fruit.

Most of the harvesting of vegetables, flowers, and fruit is performed manually, but mechanization has made progress for carrots, potatoes, etc.

### (2) Agricultural tools and machinery for harvest

#### ① Agricultural tools



Harvest scissors



Container



Harvest bag

## ② Harvesting machines



Combine harvester (rice)



Vegetable harvesting machine (green onion)



Digging harvester (potato)

## (3) Precooling

Pre-cooling is to cool harvested vegetables and fruits.

The purpose is to maintain freshness.

Harvesting early in the morning gives a precooling effect.

Vacuum precooling is a major precooling method, and there are also forced draft methods.

Vacuum precooling is a system in which vegetables are placed in a vacuum state in the equipment, and the heat from the vegetables is removed so that they are cooled. Vegetables are cooled quickly and the pre-cooling time is shortened.

## 16 Utilization of covering material

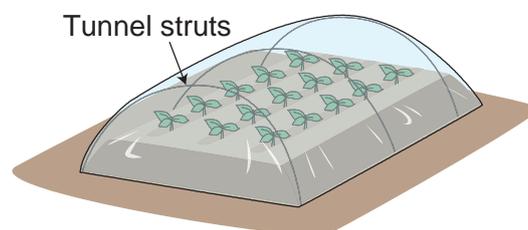
### (1) Tunnel cultivation

Tunnel cultivation is a method of cultivation that covers the ridges with covering materials in the form of a tunnel.

Tunnel struts and covering materials are used.

The effect of tunnel cultivation is to keep the warmth, to prevent wind, rain and pests.

Covering materials include polyvinyl chloride (PVC), polyethylene film for agriculture (PE), nonwoven fabric, cheesecloth and insect screens, which should be selected according to the purpose.



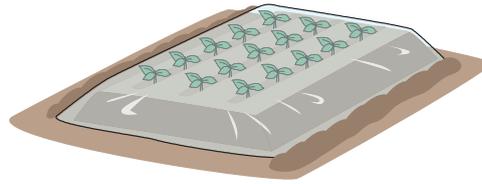
### (2) Cultivation with floating row covers

Cultivation with floating row covers is a method of cultivation that covers the crops directly in touch with the covering material or with the material somewhat floating above the crops.

The effect of a floating row cover is to stabilize germination, improve initial growth, protect

from the wind, rainfall, pests, etc.

Covering materials include nonwoven fabric, cheesecloth.



### (3) Mulching

#### ① Mulching

Mulching (mulch) means to cover the surface of the soil with rice straw, plastic film, etc. The effect of the mulch is as follows.

- Adjusts the soil temperature and improve the growing condition
- Keeps the soil soft and prevents runoff of moisture and fertilizer
- Prevents diseases and harmful insects
- Prevents weeds



Rice straw mulch



Film mulch

#### ② Mulching materials and their characteristics

Covering materials include rice straw and plastic film.

There are various materials and colors for plastic film.

The effect depends on the color of the film.

#### Film colors and their effects

Transparent	Most effective in raising soil temperature
Green	The effect of raising the soil temperature is intermediate between transparent and black, and it also prevents weeds.
White	Prevents the soil temperature from rising
Black	Prevents weeds

There are also bilayer films that combine white and black (suppression of increase of soil temperature), silver films that reflect sunlight (use of reflected light, suppression of soil temperature rise, insect control), perforated films that have holes for planting, and biodegradable films that are degraded by microorganisms (labor saving in waste disposal). Except perforated films, the films prevent percolation of rain water in the soil.

### ③ Agricultural machinery for mulching



Rotary mulch for level rows

## (4) Disposing of film

Care must be taken in disposing of film used for tunnels and mulching. Be sure to ask a specialist for disposal.

Burning in the field is forbidden by law. There is a risk that it may generate toxic gas.

## 17 Knowledge of pest and weed control

### (1) Pest control

#### ① Basic way of thinking

Create an environment where pests hardly occur.

Detect them at an early stage and control them as soon as possible before they spread.

#### ② Control with chemical pesticide

Chemical pesticides used for the prevention and control of diseases are called fungicides.

Chemical pesticides used for the prevention and control of pest insects are called insecticides.

#### ③ Pest control using other than chemical pesticides

##### i Cultural control method

Use varieties that are resistant to diseases and pest insects (disease resistant varieties).

Cultivate plants that suppress the generation of pests and diseases. For example, the density of soil nematodes decreases when cultivating marigold.

The density of Cucurbitaceous *Fusarium oxysporum* is reduced by planting genus *Allium* at the root.

- ii Use of natural enemies  
Insects and microorganisms that prey on and kill harmful insects are used.
- iii Use of sex pheromone  
Use pheromone traps to control harmful insects.  
Using pheromone dispensers, interfere with insect mating (communication disturbance) and reduce harmful insects in the next generation.
- iv Use of visual sense  
Apply reflective tape to the aphids.  
Illuminate with yellow light to prevent harmful insects.  
Trapping with adhesive tape.
- v Physical pest control  
Prevent invasion of harmful insects using an insect screen.

## (2) Weed control

### ① Basic way of thinking

Do not bring weed seeds into the field.

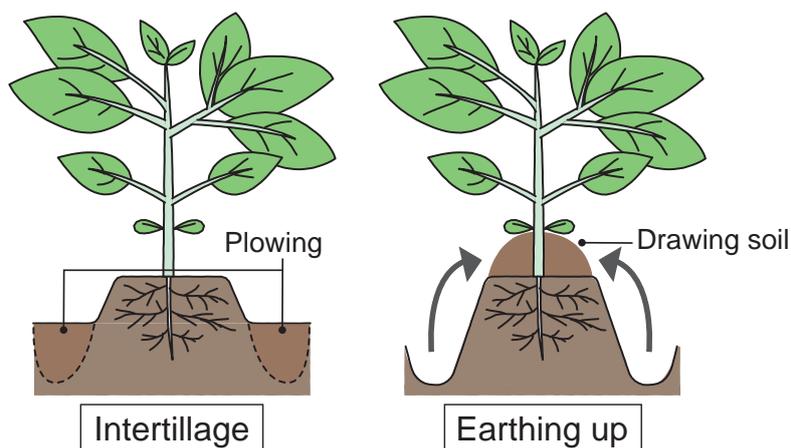
Remove the weeds as soon as possible before they drop their seeds.

### ② Herbicide

Chemical pesticides used for weed control are called herbicides.

### ③ Control other than herbicides

- i Mulch with a light-blocking material.
- ii Intertillage (plowing the soil between ridges) and earthing up (piling soil up around the base of a plant) should be carried out during cultivation.
- iii Fields without crops should be plowed.



④ Notes on using herbicides

- i Use the herbicides which are effective for each weed. Do not use herbicides intended for non-crop areas which are not registered for crop fields.
- ii Obey the usage standards of the herbicides (applicable crops, time of application, concentration, etc.) and apply them at the appropriate time.
- iii The tools for herbicide application should not be used for pest control.
- iv If there are crops nearby, use a special nozzle or cover and take care not to disperse (drift) around the chemical agent.



Nozzles commonly used in herbicide spraying



Nozzles commonly used in insecticide spraying

(3) Agricultural tools and machinery for pest control and weed control

① Pest control



Knapsack sprayer



Power sprayer



Speed sprayer (SS)

② Weed control



Grass mower



Walking type hammer knife mower



Riding mower

# 3

## Health and safety

### 1 How to use agricultural machinery safely

#### (1) Preparation before work

Understand the operation procedure of the machine well by reading the instruction manual, etc. before use.

Understand how to start the engine, how to operate the break, and how to stop the engine.

#### (2) Daily inspection

Daily inspections will help maintain the machine's abilities, prolong the life of the machine, and prevent farm accidents.

Inspect for abnormalities before, during, and after machine operation.

When checking, be sure to stop the engine except for any operational checks required during operation.

#### (3) Caution during machine operation (common to all machines)

##### ① Common to machines

- When temporarily interrupting machine operation, be sure to stop the engine.
- Always stop the engine when unjamming machinery.

##### ② Riding tractor

- Get on and off from the left side of the tractor.
- Work with the safety frame set up.
- While the tractor is running, connect the left and right brake pedals.
- After the work, the work machine attached to the tractor is removed or lowered down to the ground after cleaning.
- After the work, fill up the fuel tank.
- You need a license to drive on the street.



Safety frame



Connection of the brake pedal

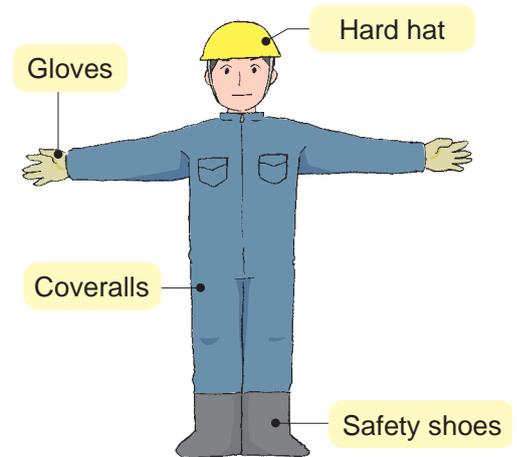
#### (4) Reasonable work plan

Fatigue can affect attentiveness and may cause accidents. When you are tired, machine work is dangerous.

In addition, since machine operation after taking alcohol is dangerous, never do it.  
Take a break between tasks.

## (5) Safety clothing

Wear suitable clothes for work that will not get caught in the machinery or a rotating belt.



○ Understand how to use the agricultural machinery safely.

○ **Understand how to start and stop the engine of the cultivator and grass mower.**

• Start and stop the cultivator

**Start**

- Confirm that the main clutch lever and tilling clutch lever are "OFF" and that the main shift lever is in neutral.
- Turn on the engine switch.
- Pull the recoil handle firmly to start the engine.

**Stop**

- Using the accelerator lever, reduce the engine speed, turn off the main clutch lever, and stop the machine.
- Set the main shift lever to neutral and turn off the engine switch.



Main clutch lever OFF



Engine switch ON



Pull the recoil handle

- Start and stop of the grass mower

### Start

- Open the throttle lever (1/3 to half).
- Push the rubber bulb (primer pump) several times to send the mixed gasoline to the carburetor.
- Set the choke lever to "Close". (reduce the amount of air entering the carburetor)
- Pull the string (recoil starter knob) vigorously.
- Turn the choke to "Open" when the engine starts.
- If the engine does not start, repeat this step.
- When the engine starts, return the throttle lever to the position of the lowest speed and warm it up.



Primer pump



Choke/string

### Stop

- Return the throttle lever to the position of the lowest speed.
- Press the stop switch until the engine stops.

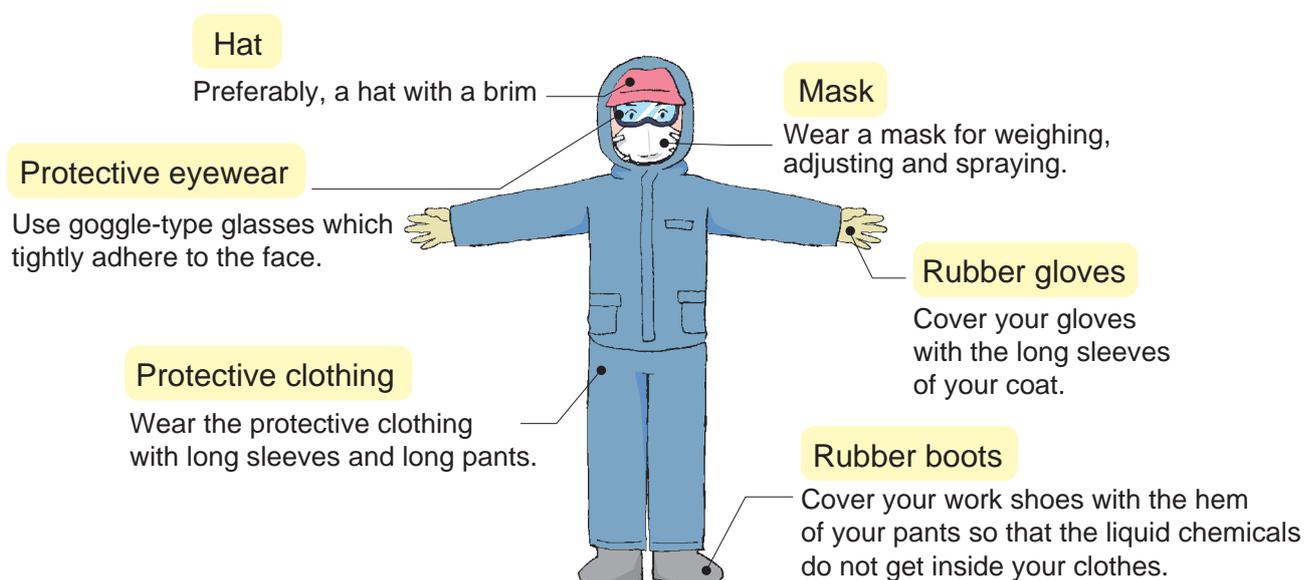
## 2 Pesticide spraying

### (1) Clothing

Pesticide spraying must be done in appropriate clothing to avoid exposing the skin to chemicals.

Wear a hat, protective clothing with long sleeves and long pants, rubber boots, an agricultural mask, protective eyewear and rubber gloves. Do not use cotton work gloves because they get wet.

Cover your gloves with the sleeves of your protective clothing jacket and cover your rubber boots with the hem of the pants.



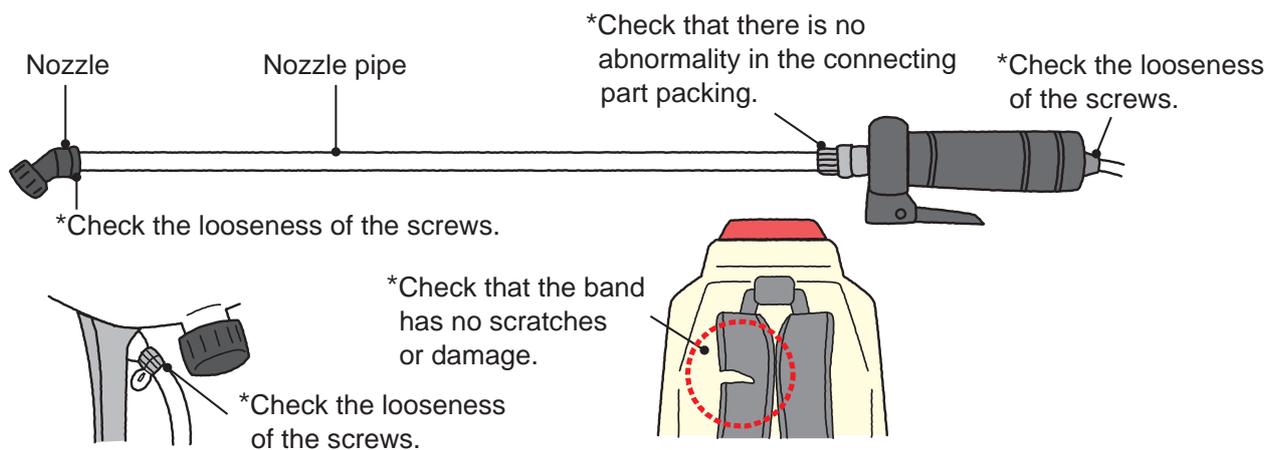
## (2) Strict observance of usage standards

For agricultural chemicals, usage standards such as the concentration to be used, amount used, time of use and number of times are all decided so that we are safe when we eat the crops that have had these chemicals applied.

When using pesticides, carefully read the labels on the product and always observe the usage standards.

## (3) Inspection of pest control machines

Check each connection of the sprayer for looseness, etc.



## (4) Correct spraying

When spraying pesticide, be careful not to disperse (drift) it around.

Spraying must be done on a day with light winds and must be stopped if the wind becomes strong. Spray in the cool hours of the morning or the evening as much as possible.

Spraying should be done with your back to the wind. Avoid direct contact with the chemicals.

Do not spray for a long time. If you need to spray for a long time, take appropriate breaks.

If you feel anything unusual in your body such as dizziness or nausea in the middle of the spraying work or afterwards, you must see a doctor immediately.

All the prepared pesticide must be used up in the field. Do not throw into waterways, etc.

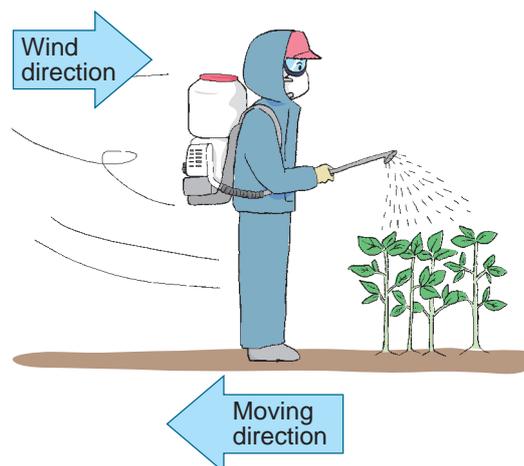
### (5) Treatment after spraying

Wash the tools well after spraying. Wash your hands and gargle.

### (6) Storage of pesticides

Record the use of the pesticides and store them in a dedicated place (such as a cabinet) that can be locked.

Pesticides corresponding to poisonous and deleterious substances must be stored in a separate warehouse from those corresponding to ordinary substances, and must be locked up after being labeled.



#### Practical skill

- Learn to wear protective clothing correctly.
- Understand how to check the safety of the sprayer, how to use it, and what to do after spraying.

#### ● Understand how to dilute disinfectant solution.

How many milliliters of pesticide would be needed to make a 1,000 fold diluted disinfectant solution in a 10-liter foot dip?

Adding 999 mL of water to 1 mL of pesticide makes 1 L of 1,000 fold diluted disinfectant.

10 liters (10,000 mL) of 1,000 fold diluted disinfectant solution is 10 times the disinfectant, so that 10 mL of pesticide is needed.

## 3 Handling power supplies and fuel oil

### (1) Handling power supplies

For agricultural power supplies, alternating current (AC) 100 volt and three-phase AC 200 volt are often used.

A 200 volt power supply is used for dryers, motors, heaters, etc.

It is dangerous to touch the switchboard and leading wires with your bare hands. In particular, handling the electrical plug with wet hands will lead to an electric shock accident.

## Outlet shape for 200 volt and 100 volt



Three-phase alternating current 200 volt



Alternating current 100 volt



## Notes on three-phase alternating current

- Handle with care as the voltage is high.

## (2) Types of fuel oil

Fuel oils for agricultural machinery include gasoline, heavy oil, light oil, heating oil, mixed oil, etc. Depending on the machine, the type of fuel oil is different.

Gasoline	Cultivator, transplanter, etc.
Light oil	Tractor, combine harvester, etc.
Mixed oil of gasoline and oil	Grass mower (2-stroke engine)
Heavy oil/heating oil	Grain dryer, hot air heater, etc.

## (3) Precautions when handling fuel oil

- Check the type of fuel oil such as gasoline or light oil and use the one suitable for each agricultural machine. If you use a fuel oil that does not match the machine, it may cause a malfunction.
- When fueling, be sure to stop the engine.
- During refueling, make sure there is not a fire in the surroundings. In particular, gasoline easily catches fire, so be careful.
- When fueling, be careful not to let the fuel overflow from the tank.

## (4) Storage of fuel

The containers for gasoline and light oil are restricted by law. Gasoline should be stored in metal containers.

It is prohibited to store gasoline in plastic containers for kerosene (20 liters).

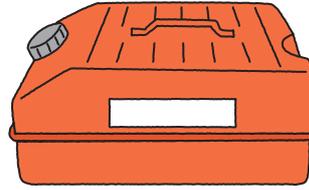
Light oil can be stored in plastic containers if it is 30 liters or less.

Fire is strictly prohibited in the storage place, and a fire extinguisher should be installed.

Fuel deteriorates when it is stored for a long time. Do not use the deteriorated fuel, as it may lead to mechanical failure.



Metal container



(Notes) Release the pressure and open the cap.

**Practical skill**

- Understand the fuel for each agricultural machine.

#### 4 Keeping things in order

Handle tools such as saws and scissors correctly, and keep them safely.

An inspection before use and correct care after use should also be carried out.

## 5 How to use stepladders safely

Check for cracks, breaks, bends, etc., before use.

Make sure you put the stepladder up so that it is stable.

Spreaders (chains or stoppers) should be locked or hooked properly.

Do not ride or straddle the stepladder top, work while standing on the step.

Practical  
skill

### ○ Understand how to use the stepladder safely.

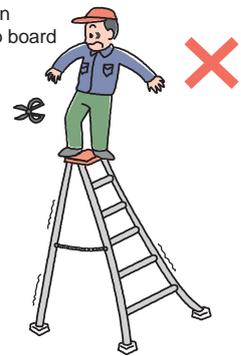


#### Dangerous action

- Leave the chain or clasp unhooked



- Ride on the top board



- Straddle the top board



- Hang out of the tripod post



# 4

# Rice cultivation work

In Japan, transplanting cultivation is generally carried out using a rice transplanter.

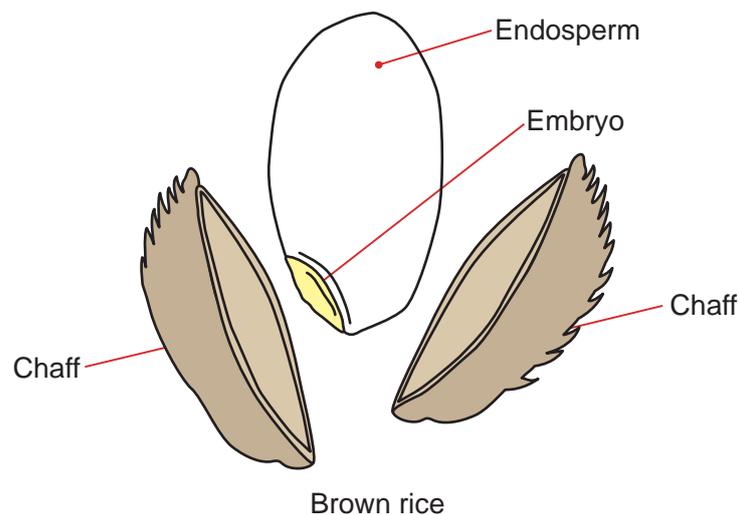
March	April	May	June	July	August	September
	Sowing					
	Rice transplanting	Start period of the tillering stage			Heading time	Time of maturity
			Young-ear formation stage	Booting stage		
Seed soaking/hastening of germination	Raising of seedlings	Herbicide spraying	Midsummer drainage			Harvest
	Basal fertilizer/puddling			Ear manuring		

Growth stage of rice and outline of main work (cropping season for early maturing varieties)

## 1 Seed preparation

### (1) Structure of the seed

Seed rice consists of brown rice, which is made up of embryos and endosperm, and rice husks, which protect it. The embryo has organs that become leaves and roots after germination, and the endosperm stores nutrients necessary for their growth.

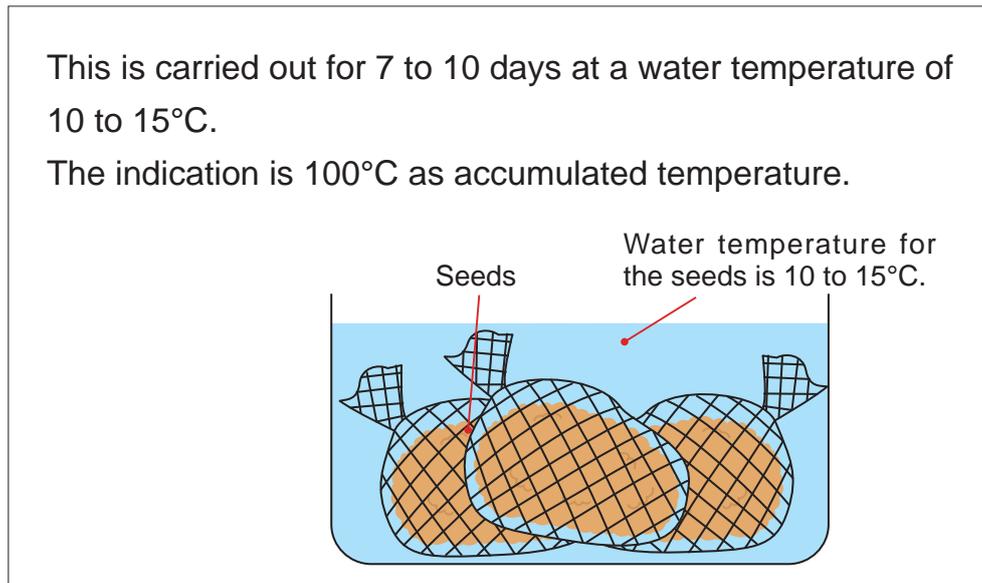


### (2) Seed disinfection

Disinfects diseases attached to the rice seed such as rice white-tip nematode, bakanae disease, rice bacterial grain rot and rice blight.

### (3) Seed soaking

Soak rice seeds in water for roughly 10 days to let the seeds absorb enough water.

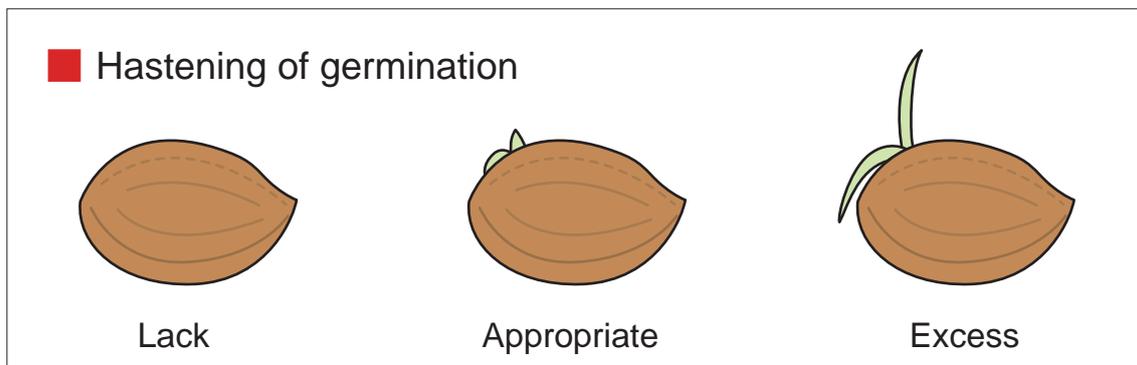


Soaking of seeds

### (4) Hastening of germination

Warm up to 30-32°C so they sprout on the day before sowing.

Create a state known as pigeon breasts where the buds come out about 1 mm.



Rice seeds in the pigeon breast state

## 2 Raising of seedlings

Making seedlings for transplanting cultivation using a rice transplanter is called raising of seedlings.

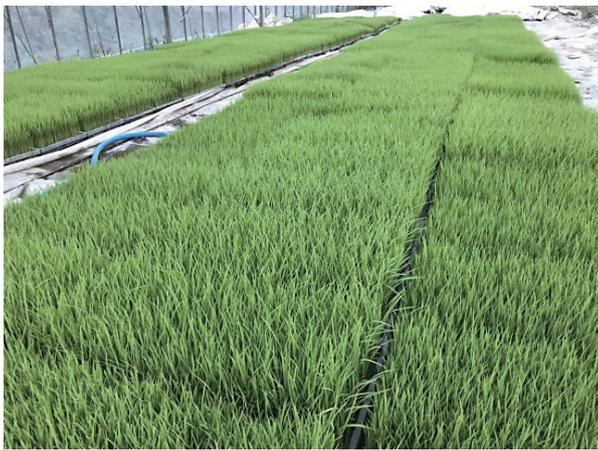
To raise seedlings, put the fertilizer-containing soil (culture soil) in a nursery box 60 cm long, 30 cm wide and 3 cm thick, and after watering, sow the rice seeds and cover them with soil.

After covering with soil, let them germinate by covering with a heat-retention material in a nursery chamber or in a vinyl house (greenhouse).

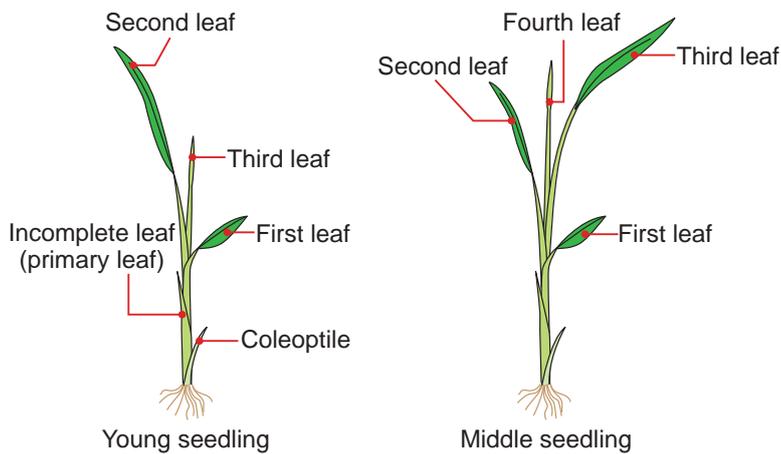
After germination, arrange them in a vinyl house (greenhouse) and cover them until the seedlings turn green.

Water the seedlings while paying attention to the temperature in the vinyl house, then seedlings called young seedlings grow in 20 to 25 days of the nursery period, and those called middle seedlings grow in 30 to 35 days.

#### 4 Rice cultivation work



Nursery boxes arranged in a vinyl house (greenhouse)



Types of seedlings

### 3 Management of paddy fields

#### (1) Preparation of paddy fields

Plow the paddy field with a tractor (rotary) and make it even. After irrigation, agitate the soil to make it soft. This is called puddling.



Puddling with a tractor

#### (2) Fertilizer application

Spread fertilizer across the whole surface of the paddy field before puddling. There is another method of fertilizer application, which can be done simultaneously with rice transplanting.



Transplanting with a ride-on type transplanter

### (3) Rice transplanting

Rice planting is carried out using 2 to 8 rows rice transplanters. With a rice transplanter, the interrow space (or the furrow) should be 30 cm. The intrarow spacing is adjusted by the rice transplanter. It is usually set at 10 to 30 cm.

### (4) Water management

After transplanting, introduce water (referred to as beginning irrigation) to protect the seedlings. When new roots and leaves appear, make the water shallow to increase the number of new stems (called tillers).

After that, drain (called midsummer drainage) or add water according to the amount of growth.

### (5) Spraying herbicide

Spray herbicide after transplanting. There are different kinds of granules and flowables, etc.

### (6) Pest control

Control diseases such as rice blight and leaf blotches.

In areas where pest insects that eat leaves and ears occur after transplanting, control them.



Rice blight (leaf blight)



Stink bug (*Stenotus rubrovittatus*)

### (7) Additional manure

Apply additional nitrogen and potassium (Ear manuring) 15 to 25 days before heading to increase the differentiation of the glumose flowers and to suppress degeneration. Note that a glumose flower refers to the flower of a gramineous plant.

## 4 Harvest

The panicles differentiate when vegetative growth transfers to reproductive growth. The period when the panicles differentiate is called the young panicle formation stage.

The panicles develop in roughly 30 days after differentiation of the young panicles. This is called heading. Harvest time will be 30 to 60 days after the heading.

Harvest is done using combine harvesters in most areas. Combine means “a machine with a reaper and a threshing machine combined.” In Japan, a “head-feeding combine” is generally used.



Harvest using a head-feed combine

## 5 Preparation and shipping

The moisture content of unhulled rice immediately after harvest is as high as 20 to 27%, so dry with heated-air to reduce the moisture to 14 to 15%.

After drying, brown rice is prepared by hulling which removes the chaff. Next, brown rice is prepared to ship by removing any rice fragments and then packing in 30 kg rice bags and flexible containers.



Grain dryer

## 6 Management of paddy fields after harvest

After harvesting, plow the paddy field with a tractor (rotary) and bury any stumps of rice, straws and weeds.

## ● Regarding low-cost rice cultivation

Methods of low-cost rice cultivation include ① direct sowing and ② sparse planting.

### ① Direct sowing

Direct sowing cultivation is a method that cultivates rice by sowing seeds directly in paddy fields without transplanting. Since there is no operation for raising seedlings, the work time is shortened and materials for raising seedlings are unnecessary.

Sowing methods include direct sowing in flooding paddy field and that in well-drained paddy field.

Direct sowing in flooding paddy field is a method that sows in the soil or on the surface of the soil after plowing and puddling. Seeds coated with calcium peroxide (Calper) or iron are used to improve budding.

In direct sowing in a well-drained paddy field, seed rice is sown in paddy field under dry condition and the plants are left in field condition after germination, and then flooded. It is possible to share the machines, such as the sowing machine, with wheat crops.

### ② Sparse planting

Sparse planting is a cultivation method that reduces planting density by widening the intrarow spacing set by rice transplanters.

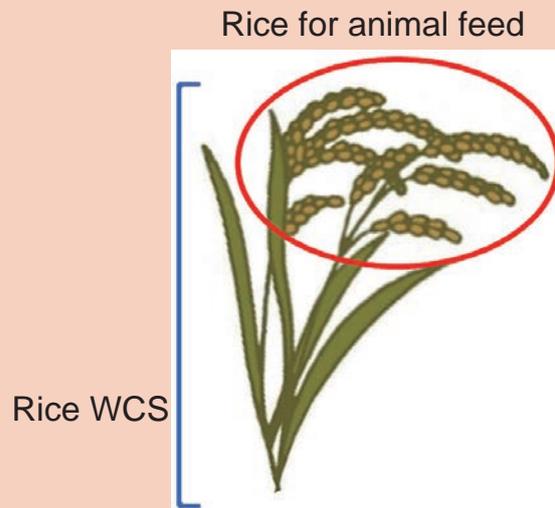
If the conventional 30-cm interrow space and intrarow spacing is widened from 15 cm to 28 cm, the number of nursery boxes decreases by more than 40%. This reduces production costs for seeds and seedling materials and labor hours.



Direct sowing cultivation (A multipurpose rice transplanter equipped with a sowing machine)  
Photo: cited from "Nousagyou benri-cho" (agricultural work handbook)

● Regarding rice for livestock feed

When rice is used for livestock feed, there are two types; that is, seed of rice that is utilized for livestock feed and rice WCS that utilize ears and forage concurrently harvested.



Cooperation between rice farmers and livestock farmers is also necessary for cultivation.

Rice fermentation roughage (rice WCS) is a silaged roughage that is harvested before the rice grain is fully matured. Specialized varieties of high yielding stems and leaves have been developed.

To improve the quality of silage, it is harvested around the "yellow ripe stage".

Rice for animal feed is an excellent feed that can be produced by utilizing paddy fields. Rice for animal feed can be produced using the same cultivation method and agricultural machinery as rice for staple food.

In addition to using conventional cultivars, special forage rice cultivars have been developed. They are characterized by ① high yield, ② cultivation characteristics (It doesn't fall easily and is easy to raise), ③ many varieties that are resistant to diseases, ④ not affected by the taste of rice cooked or the quality of brown rice, and ⑤ many varieties with large grains.

Rice for animal feed needs to be produced at low cost because its unit selling price is lower than that of rice for staple food. It is necessary to devise ways to reduce production costs and increase yields, using techniques such as direct sowing cultivation, sparse planting cultivation, and the compost produced by livestock farmers.

## 1 Characteristics of cultivated crops

### (1) Grain

Grains include wheat and barley, pulses, etc.

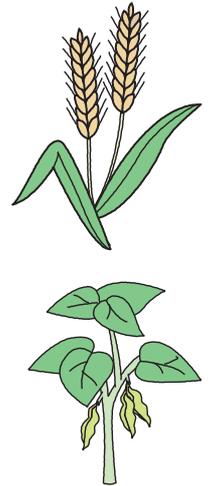
#### ① Mugi (in Japanese)

There is wheat, barley, rye, oats, etc.

#### ② Pulses

There are soybeans, adzuki beans, etc.

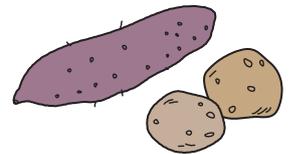
Immature soybeans are classified as a vegetable called edamame.



### (2) Potatoes

There is sweet potato, potato, etc. These are used as raw materials for starch, etc.

Those eaten fresh are classified as vegetables.



### (3) Vegetables

#### ① Kinds of vegetables

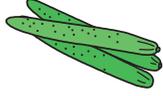
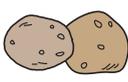
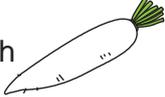
There are about 150 species of vegetables cultivated in Japan.

Potatoes, sweet potatoes, radishes, cabbages, Chinese cabbage, and so on have a large cultivation area. In addition, onions, carrots, and spinach are also popular.

The classification system for vegetables includes a natural classification based on botany and an artificial classification based on available organs.

In natural classification, plants of the same family have common properties.

**Natural classification**

Family	Major vegetables			
Cucurbitaceae	Cucumber 	Melon 	Watermelon 	Squash 
Solanaceae	Eggplant 	Tomato 	Green pepper 	Potatoes 
Liliaceae	Onion 	Welsh onion 		
Asteraceae	Lettuce 	Burdock 	Shungiku 	
Chenopodiaceae	Spinach 			
Brassicaceae	Cabbage 	Chinese cabbage 	Radish 	
Apiaceae	Carrot 			
Araceae	Taro 			
Gramineae	Corn 			
Convolvulaceae	Sweet potatoes 			
Rosaceae	Strawberry 			

## Classification by organ of use

Leafy vegetables:  
eating leaves



Spinach

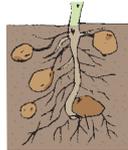


Chinese cabbage

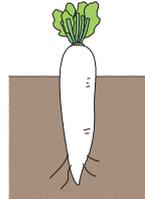


Cabbage

Root vegetables:  
eating roots and rhizomes



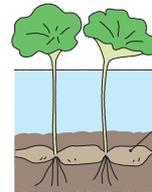
Potatoes



Radish



Carrot



Lotus

Lotus root

Fruit vegetables:  
eating fruits and seeds



Cucumber



Tomato



Eggplant



Green pepper



Edamame

## ② Characteristics of representative vegetables (by artificial classification)

### i Leafy vegetables

#### a Cabbage

Suitable for cool climates.

Grown by transplant cultivation.

It is used not only for raw consumption but also for various edibles.



#### b Chinese cabbage

An autumn vegetable used for pickles and an essential ingredient in Japanese Nabe (hot pot). Grows well in cool climates.

Usually grown by transplanting cultivation but also cultivated by direct sowing depending on the region.

There is head type, loose-head type and non-head type.



### c Lettuce

There are many varieties: leaves with a ball-like head, without a head, crispy, etc.

Grows well in cool climates.

Grown by transplant cultivation.

The seed is a photoblastic seed. It is weak to acidity.

Differentiates flower buds at high temperatures.



### d Spinach

Harvested in one and a half to two months after sowing. A vegetable that is easy to grow. Harvested at a plant height of about 25 cm.

Usually grown by direct sowing, but recently also grown by transplanting cultivation.

Breeding improvement has enabled year-round cultivation.



## ii Root vegetable

### a Onion

The edible round ball is an overlapping part of the leaf and stem, but it is a root vegetable.

Grown by transplant cultivation.



### b Radish

Autumn radish, harvested from autumn to winter, was mainstream but the production of spring radish and summer radish has also increased meaning it is now cultivated throughout the year. Tunnel cultivation is also employed during the cold season.

Grown by direct sowing.

Flower buds differentiate in continued low temperatures.



### c Potatoes

In addition to being eaten as fresh potatoes, also used as raw materials for starch and processed foods.

Cultivation starts with planting seed potatoes in the field.



### d Sweet potato

The enlarged root is the edible part.

Grows well even in soil with poor fertility. Excess fertilizer makes the leaves and stems larger but the roots remain small.

Cut the buds that sprout from the seed sweet potatoes and plant them in the field as seedlings.



### e Carrot

Contains high beta-carotene. In addition to cooking, also used for juice.

Grows well in cool climates, but is cultivated anywhere in Japan.

Grown by direct sowing. Difficult to germinate in dry conditions.



## iii Fruit vegetables

### a Tomatoes

There are many varieties including those for cooking. Mini tomatoes with high sugar levels are also popular.

Grown by transplant cultivation. Grown by grafting.

To grow single stem tomatoes, prune the axillary buds while they are small, which is called “axillary bud picking.” In addition, carry out pinching and fruit thinning.



## b Cucumber

The immature green fruit is the edible part. Used for salads and pickles.

Harvested throughout the year not only by open field cultivation but also by facility cultivation.

Harvested when the fruit length (fruits) is about 20 cm.

Grown by transplant cultivation. Grafting is also applied.



## c Eggplant

There are many varieties including many region-specific varieties.

Because of the long cultivation period, enough fertilizer is needed.

Grown by transplant cultivation.

As they grow up, use support, and perform bud picking/ supporting and branch training.



## (4) Industrial crops

Industrial crops require advanced processing.

There is tea, konjac, peanuts, rush, tobacco, sugar beet, sugarcane, etc.

### a Tea

Tea is the leaves of the tea tree. Since it is an arboreal crop, once planted it can be harvested for many years. A field of tea trees is called a tea field.

For easier harvesting work, tea trees are arranged to reach waist height.

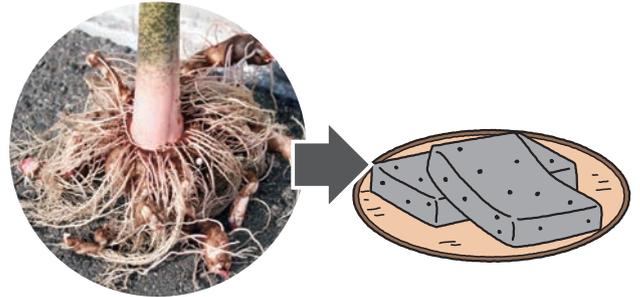


## b Konjac

Harvest konjac potatoes, a rhizome, and process them into konjac products.

Grown on flat land with good drainage or sloping land.

Cultivation starts with the seed konjac potatoes.

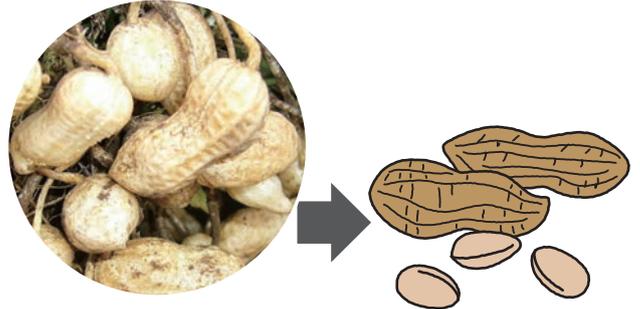


## c Peanut

Peanut is a legume plant.

After fertilization of the flowers above the ground, the pedicel grows down into the soil and the tip develops into a pod. Dig up the pods from the soil to harvest.

Cultivation starts with seeding in the field.



## (5) Forage crop

Forage crops are crops that serve as feed for livestock. Includes pasture grass, rice, corn, sorghum, and oats.

Raw grass, hay, and silage are given to livestock.

The ears, stalks, and leaves of grass, rice, or corn are harvested together and stored in a tightly closed state free of oxygen (air); this is a fermented feed called silage.

Harvesting is done when the nutrition value of crops is high.

## 2 Cultivation management of upland crops and vegetables

### ① Temperature

Crops have the optimum temperature range for growth depending on the species and growth stage. There are crops that prefer low temperatures and those that prefer high temperatures.

Breeding and ingenious cultivation methods have expanded the cultivable area.

Even crops that grow well at high temperatures can be grown in cold areas by using a greenhouse, tunnel cultivation, floating row covers, etc.

## ② Light intensity and photosynthesis

Crops grow by photosynthesis.

Generally, the stronger the light, the more effected the photosynthesis. There is a light saturation point that reaches a plateau when the light exceeds a certain intensity.

The intensity of light required differs depending on the crop.

Vegetables that need strong light include tomatoes, melons, corn, and carrots.

Japanese honewort and Japanese ginger grow with weak light.

## ③ Moisture

The growth of crops depends on the moisture condition of the soil.

If there is not enough water, it will wilt and suffer nutrient deficiency.

On the contrary, if there is too much water, oxygen becomes deficient and the roots may rot.

To measure soil water content, use a soil moisture meter and a tension meter. The value of water content can be expressed as a percentage or as a pF value. Appropriate soil water content ranges from 35 to 55%.

# 3 Seeds

## (1) Seeds

### ① Germination

Moisture, temperature, and oxygen are necessary for the seeds to sprout (germinate). These are the three conditions required for germination.

Excess water causes a lack of oxygen and decreases the germination percentage.

### ② Photoblastic seeds and negative photoblastic seeds

Seeds that germinate easily when exposed to light are called photoblastic seeds.

Example: carrots, lettuce, etc.

Seeds that have difficulty germinating when exposed to light are called negative photoblastic seeds.

Example: Radish, tomato, watermelon, etc.

### ③ Lifetime of seeds and storage method

Seeds have a lifetime. The lifetime is different depending on the species of the crop or vegetable, and there are short ones and long ones.

Seeds should be stored in cool and dry conditions.

Improper storage conditions shorten the lifetime of seeds.

## Life span of vegetable seeds

1-2 years: carrot, corn, spinach

2-3 years: welsh onion, onion, radish, cabbage

3-4 years: tomato, eggplant

### ④ Processed seeds

Processed seeds have increased in number and feature easy sowing, good germination, and disease prevention.

- Coated seeds: processed uniformly spherical
- Naked seeds: seeds stripped of their hard skins and denuded (Spinach)
- Disinfected seeds: seeds having undergone disinfection
- Seed tape: A tape with seeds placed at regular intervals.

### ⑤ F1 (F one) seeds

It is also called seed of first filial generation.

It is a seed with excellent ability of parents using heterosis.

Currently, F1 seeds are used for many vegetables.

In addition, seeds of true breed have been inherited from their parents' superior abilities. Local specialty vegetables such as Kyoto vegetables and Kaga vegetables are true breeds. They can be maintained by home seed-raising.



#### Practical skill

- You should be able to imagine the species of vegetables by looking at their seeds.
- You should be able to recognize the processed seeds.
- Understand the storage method of seeds.
- Understand the difference of the life span of seed depending on the species of vegetables.
- Understand the major types of photoblastic seeds and negative photoblastic seeds.

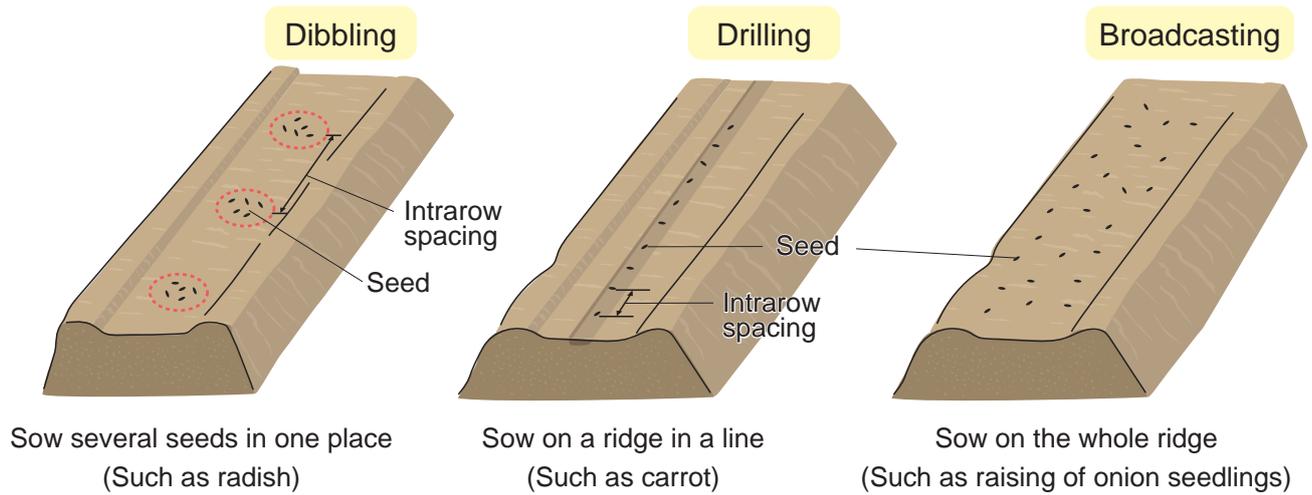
## (2) Sowing

Sowing includes broadcasting, drilling and dibbling.

Seeding should be done in a suitable way for each vegetable.

Putting the soil on the seeds after sowing is called soil covering.

For photoblastic seeds such as carrot, overly thick soil cover lowers the germination rate, so the soil cover should be thin.



○ Understand how to sow.

## 1 Characteristics of crops in facility horticulture

### (1) Vegetables

#### ① Tomatoes

Tomato is a solanaceous plant.

It has many cropping types and is cultivated throughout the year.

It grows well at slightly higher temperatures, but grows even at low temperatures.

It requires strong light for growth.



#### ② Strawberries

Strawberry belongs to the rosaceae family.

Elevated bench cultivation where you can stand working is becoming more common.

It reproduces itself through vegetative propagation. After flowering/fruiting, a runner occurs and the daughter plants that form at the tip of the runner are used for propagation.

Seeding methods that accelerate differentiation of the flower bud are now common and so forcing cultivation has become usual.



#### ③ Cucumber

Cucumber is a cucurbitaceous fruit vegetable (using young fruits).

A diclinous plant which cross-fertilizes, but has a nature that produces fruit without pollination or fertilization (parthenocarpy).

Most cultivation uses support.



#### ④ Others

Many vegetables such as spinach (Chenopodiaceae/leafy vegetables), eggplant (Solanaceae/fruit vegetables), green peppers (Solanaceae/fruit vegetables) are cultivated in the facility.



Spinach



Eggplant



Green peppers

## (2) Flowers

Flowers are also actively grown using facility cultivation. Regulation of the flowering period allows production of high quality cut flowers and pot flowers.

### ① Chrysanthemum

Chrysanthemum is a perennial plant.

Raise seedlings by herbaceous cutting.

The chrysanthemum that blooms in the autumn is a short-day plant. To delay flowering, light cultivation is carried out by lighting up at night.

There are many varieties including those that bloom in the summer and it is shipped throughout the year.



### ② Rose

Used for cut flowers of flower trees.

Facility cultivation is carried out and the flowers are shipped throughout the year.



### ③ Lily

Raised from bulbs and used for cut flowers.

There are many kinds such as Easter lily, Asiatic hybrids, Oriental hybrids, etc. It is shipped throughout the year using low temperature treatment, etc.



#### ④ Carnation

Carnation is a perennial plant and used for cut flowers.

Cropping of the spray type, that blooms many flowers per stem, is roughly 70%.



## 2 Types and structures of facilities

### (1) Types

Depending on the covering material used, facilities can be divided into glass greenhouses and plastic greenhouses.

#### ① Glass greenhouse

A greenhouse made of glass.

The light transmits easily. It can also be used for many years because of its durability.

Construction cost is higher than plastic.

#### ② Plastic greenhouse

A facility using soft and hard film that is light and easy to handle. Durability is inferior compared to glass. Has recently increased due to development of long usable film and low construction cost.

#### ③ Rain protection greenhouse

This is a plastic house with only its roof covered with film.

Since crops are not directly exposed to the rain, it is effective in preventing diseases/harmful insects and fruit cracking.



### (2) Structure

#### ① Type

##### a Detached type

Type that has a single roof. Strong against the wind and snow, and has good ventilation and plenty of sunshine.

##### b Connected type

A house that is multiple single houses connected. The efficiency of heating is better than that of the detached type. The interior is wide and workability is good, but there are drawbacks such as reduced light in the connected parts.

## ② Shape of the roof

## a Gable-style roof

There are slopes on both sides of the roof and it has the shape of a house.

## b Dome-style roof

The roof has a round shape.

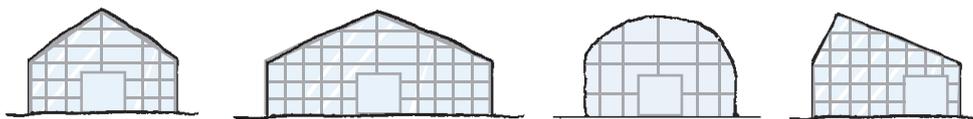
## c Uneven span type

One of the two roof segments is narrow.

## d Venlo type

A large house with high eaves developed in the Netherlands.

## Detached type



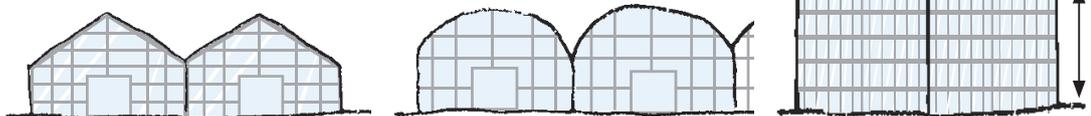
Gable-style roof

Gable-style roof (large type)

Dome-style roof

Uneven span type

## Connected type



Gable-style roof connected type

Dome-style roof connected type

Venlo type

Eaves height

### 3 Facility coating materials and their characteristics

#### (1) Sheathing material

## ① Glass

Flat glass is used. It transmits light well.

## ② Soft film

“Noubi” (vinyl chloride film for agricultural use) and “Nou PO” special film (Special polyolefin films for agricultural use) are available.

## Characteristics

- i Noubi (vinyl chloride film for agricultural use)  
A film that allows light to pass through easily and has high heat retention.  
The materials are heavy. It is sticky and easily gets dirty. It also has the property of being easy to tear.  
It needs to be replaced in 1-2 years. When burned, toxic gas is produced.
- ii Nou PO special films (special polyolefin films for agricultural use)  
It is lighter than Noubi. There is no stickiness, and stain resistance.  
Usually it resists extension for 2 to 3 years and certain types resist longer, extension for 3 to 5 years.

### ③ Rigid film

Fluorine film for agriculture is available. It has durability of more than 10 years.  
There is also an acrylic plate type which can be used for more than 10 years.

## (2) Lining material

### ① Soft film

Transparent films such as Nobi, Nou Poly (polyethylene film for agricultural use), Nou Sakubi (ethylene vinyl acetate copolymer resin film for agricultural use), and Nou PO special film are also used for lining. The film for lining is thinner than the outside film.

Among soft films, nou poly is poor in heat retention.



### ② Nonwoven fabric

It is used as a thermal curtain for lining. Light transmission is lower than that of transparent films, but it has moisture permeability and water permeability.

### ③ Cheesecloth

It blocks light and has air permeability.



Nonwoven fabric



Cheesecloth


**Practical skill**

- Understand the types of covering materials and their main purposes of use.

## 4 Equipment in facilities

### (1) Heating system

There are hot air systems and hot water systems for heating. Hot air systems are used a lot because they are easy to install.

The fuel used is mostly heavy oil and kerosene. Some heating systems use electricity, gas, or wood pellets.

Solar heat and heat pumps are also being introduced.



### Unheated greenhouse

Unheated greenhouse is a procedure that uses no heaters. It is suitable for crops that are resistant to low temperatures. The advantage is that there is no fuel cost.

If you use a tunnel at the same time, it effectively blocks the heat loss at night.

### (2) Ventilator

The inside of the facility will be hot due to the heat of the sun during the daytime. Ventilate and introduce outside air so that the temperature inside does not rise too high.

There are two ventilation methods.

#### ① Natural ventilation

Introduce outside air by opening a ventilation window and part of the covering material. This method is affected by the weather.

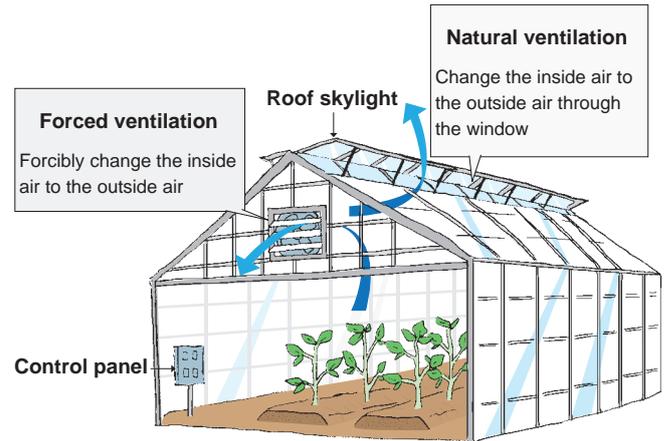
#### ② Forced ventilation

Turn on the ventilation fan and forcibly introduce outside air. This method requires power and the effect depends on the abilities of the ventilator.

### ③ Order of ventilation

Ventilation should be done from natural ventilation. The order of natural ventilation is to open the lining first and then open the roof skylight. If the temperature is still high, open the sides.

If the temperature does not drop by natural ventilation, forced ventilation should be performed.



#### Practical skill

- Understand how to ventilate and the order of ventilation.

### (3) Carbon dioxide generator

Carbon dioxide (carbon-rich gas) promotes photosynthesis in crops. A shortage of carbon dioxide may occur in a closed facility. By supplying carbon dioxide using a carbon dioxide generator, photosynthesis can be promoted.



Carbon dioxide generator

### (4) Pest control equipment

Because the inside of the facility is very humid and warm, pests tend to occur easily and may spread rapidly. Pesticide spraying in the facility is done by using equipment that automatically spreads pesticides such as “self-propelled sprayers” to reduce labor and ensure worker safety. There are also methods that do not use chemical pesticides, such as yellow light “insect repellent light systems.”



Self-propelled sprayer



Insect repellent light

## 5 Environmental management

Open field cultivation is greatly influenced by the weather and the climate.

Facility cultivation allows to regulate the above-ground environment (temperature, humidity, light, etc.) and the underground environment (soil temperature, soil moisture, nutrient concentration, etc.).

### (1) Temperature management

#### ① Temperature control

Control the temperature in the facility according to the optimum growth temperature of the crop.

The temperature inside the facility may be too high during the daytime. Reduce the temperature using ventilation. In summers with high humidity, the temperature may be lowered using a cooling device. In summers when the temperature is high, the temperature may be lowered using a cooling device.

In the early morning and at night in cooler seasons, increase the temperature using heating devices.

#### ② Instruments to measure temperature

A bar thermometer that encapsulates colored alcohol (displays the current temperature), a maximum and minimum thermometer that encapsulates mercury (displays the current temperature and the maximum and minimum temperature since the last reset), and a digital thermometer that displays the current temperature digitally (displays the maximum and minimum temperatures recorded since the last reset).



Bar thermometer



Maximum and minimum thermometer



Digital thermometer

#### ③ Heat retention methods

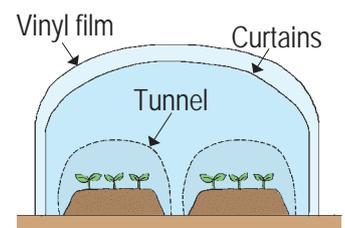
The effect of heat retention depends on the number of sheets of covering material (multiplexing/multilayer) and the type of material.

If it is the same material, the greater the number of sheets, the more effective for heat retention.

It is also effective to prevent gaps and improve air tightness.

There are 2 ways of lining to improve heat retention. 1. Fix the heat retention material with a little space inside the Sheathing material, 2. Movable curtains that can be opened and closed.

There is also a way to install a single-layered tunnel or a double-layered tunnel in a greenhouse.

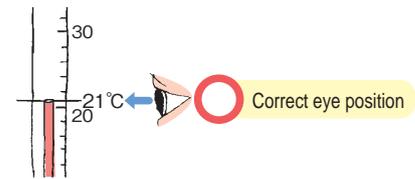


### Practical skill

- Understand the type and usage of the thermometer.

Celsius is used in Japan.

When using the thermometer, read the figure from just beside the liquid. The units are degrees or °C.



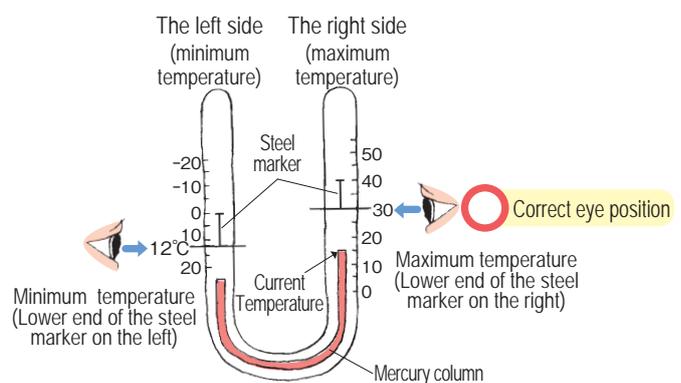
### Practical skill

- Understand how to use a maximum and minimum thermometer.

The maximum temperature, minimum temperature, and current temperature can be measured simultaneously.

The maximum temperature is measured at the lower end of the steel marker (temperature index inside the liquid) on the right.

The minimum temperature is measured at the lower end of the steel marker on the left side.



## (2) Moisture

The growth of crops depends on the moisture condition of the soil.

If there is not enough water, it will wilt and suffer nutrient deficiency.

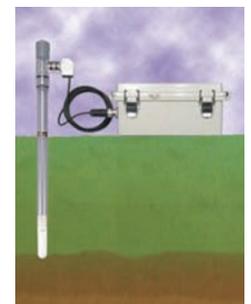
On the contrary, if there is too much water, oxygen content is too low and poor growth and root rot may occur.

To measure soil water content, use a soil moisture meter and a tension meter. The value of water content can be expressed as a percentage or as a pF value.

Appropriate soil water content ranges from 35 to 55%.



Soil moisture meter



Tension meter

## (3) Humidity

In the facility, humidity tends to be high due to heat retention and warming.

In particular, during winter nights, this humid tendency may cause disease. It is necessary to lower the humidity and prevent condensation.

#### (4) Complex environmental control

The simultaneous management of several environmental factors such as temperature, humidity, light, and carbon dioxide is called complex environmental control.

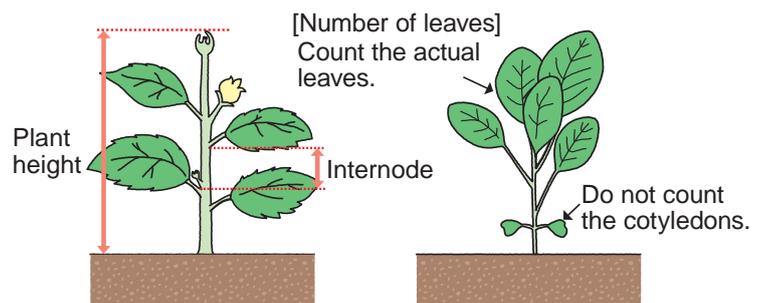
Computers enable automatic control of ventilation and heating systems.

## 6 Growth diagnosis

Look at the growing conditions of the crop when watering and applying fertilizer. To understand the growing conditions, observe the number of leaves, the interval between nodes (internode length), plant height, leaf color, etc.



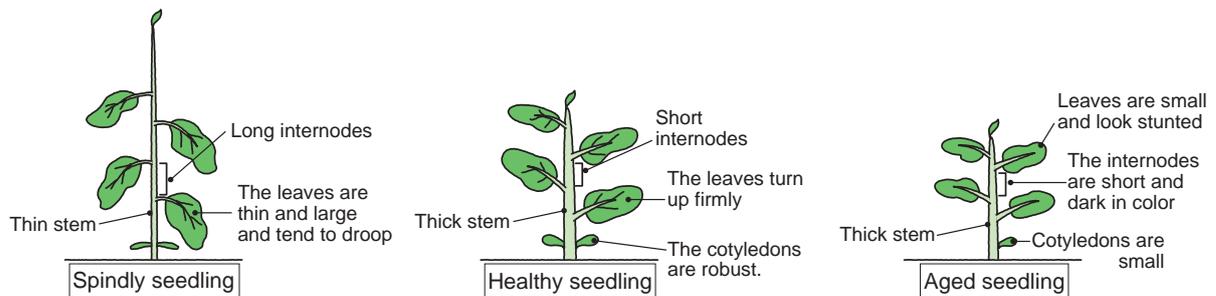
- Learn how to measure plant height and internode length.
- Understand the number of leaves.



**Practical skill**

- You should be able to judge healthy seedlings.

Unhealthy seedlings are characterized by spindly growth, blotches and feeding marks on leaves and stems (bearing traces of being eaten by pests), etiolation between veins, lacking cotyledons, and senescence of leaves and stems.



- You should be able to find out the cause of growth failure.

- Water shortage: the tip of the stem falls and leaves wilt.
- Lack of fertilizers
  - Lack of calcium: develops a physiological disorder (bottom rot).
  - Iron deficiency: etiolation of new leaves.
- Lack of sunlight: thin stems, long internodes, thin and large leaves.



Bottom rot of tomato

## 7 Nutriculture

### (1) Nutriculture

Nutriculture is a method to grow crops in a culture solution in which nutrients are dissolved in water without using soil.

There are two ways of nutriculture, using solid medium and not using solid medium.

Solid media include rock wool, palm husk, peat moss, gravel, and so on.

The methods without using culture media are hydroponic culture and hydroaeronic culture.



Hydroponic cultivation



Rock wool cultivation



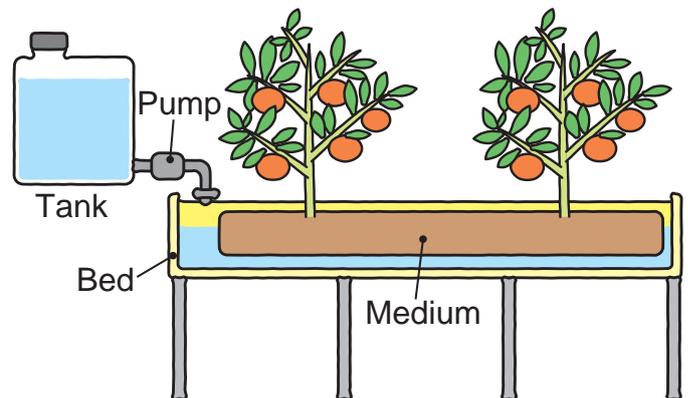
Gravel cultivation

## (2) Characteristics of nutriculture

- There are few outbreaks of diseases transmitted from soil
- Improvement of soil property, irrigation, and weeding can be eliminated
- There is no waste of fertilizers
- There is no replant failure
- Management is easily automated
- Facilities cost for construction

## (3) Nutriculture system

Nutriculture needs a tank to store the culture solution, a bed for cultivation, and a pump to send the culture solution to the bed.



## 8 Seedling methods

### (1) Seedling methods

#### ① Seedlings in ground seedbeds

Prepare nursery beds and sow the seeds. There are the hot beds and the cold beds. No special materials are required for the cold beds. With the hot beds, set heating wires to warm the bed soil.

#### ② Nursery box

Sow seeds in the nursery box. A nursery box is required.

#### ③ Pot seedling

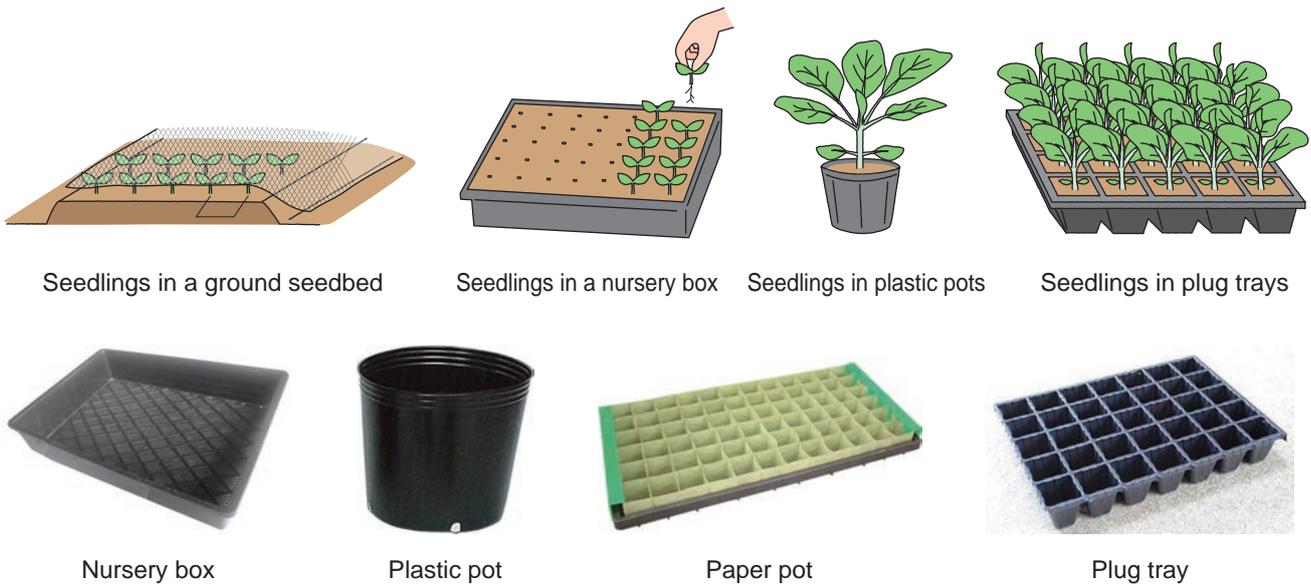
Sow seeds in the plastic pot. Plastic pots come in various sizes.

#### ④ Paper pot seedling

Sow seeds in the paper pot that decomposes in the soil.

#### ⑤ Plug seedling

Sow seeds in a dedicated plug tray. The number of cells in the plug tray corresponds to each vegetable.



## (2) Grafted nursery plant

A grafted nursery plant is a seedling made by grafting a scion onto a stock.

Grafting is employed for eggplant, cucumber, tomato, watermelon, etc.

For stocks, use varieties that are resistant to diseases and pest insects.

For scions, use superior varieties with high yields and high quality.

The advantage of grafting the nursery seedlings is that they are strong against diseases and pests, and the yields increase.

## (3) Healthy seedling

Good seedlings have short internodes, thick stems and are solid.

Excess water and controlling at high temperatures make the seedlings spindly (seedlings with elongated branches and stems).

Lack of light also makes spindly seedlings.

Shortage of nitrogen fertilizer makes the lower leaves turn yellow and discourages the seedlings.

## 1 Definitions and species of fruit trees

### (1) Definition of a fruit tree

Fruit tree refers to “timber” (“tree” in this text) cultivated to harvest fruit.

We also harvest fruit from melon, watermelon and others, but because they are “grass” that die within a year, they are classified as vegetables.

The fruit is called kajitsu or “mi” in Japanese.

### (2) Types of fruit trees

Deciduous fruit trees are trees that lose their leaves in the winter. There is apple, grapes, pear, peach, persimmon, chestnut, etc.

Evergreen fruit trees are trees with leaves that are present throughout the year. There is Satsuma mandarin, yuzu, loquat, etc.

### (3) Why do we grow fruit trees?

Sweet and fragrant fruits enrich our dietary life.

High quality fruit can be sold at a high price, resulting in a lot of income even from a small arable field.

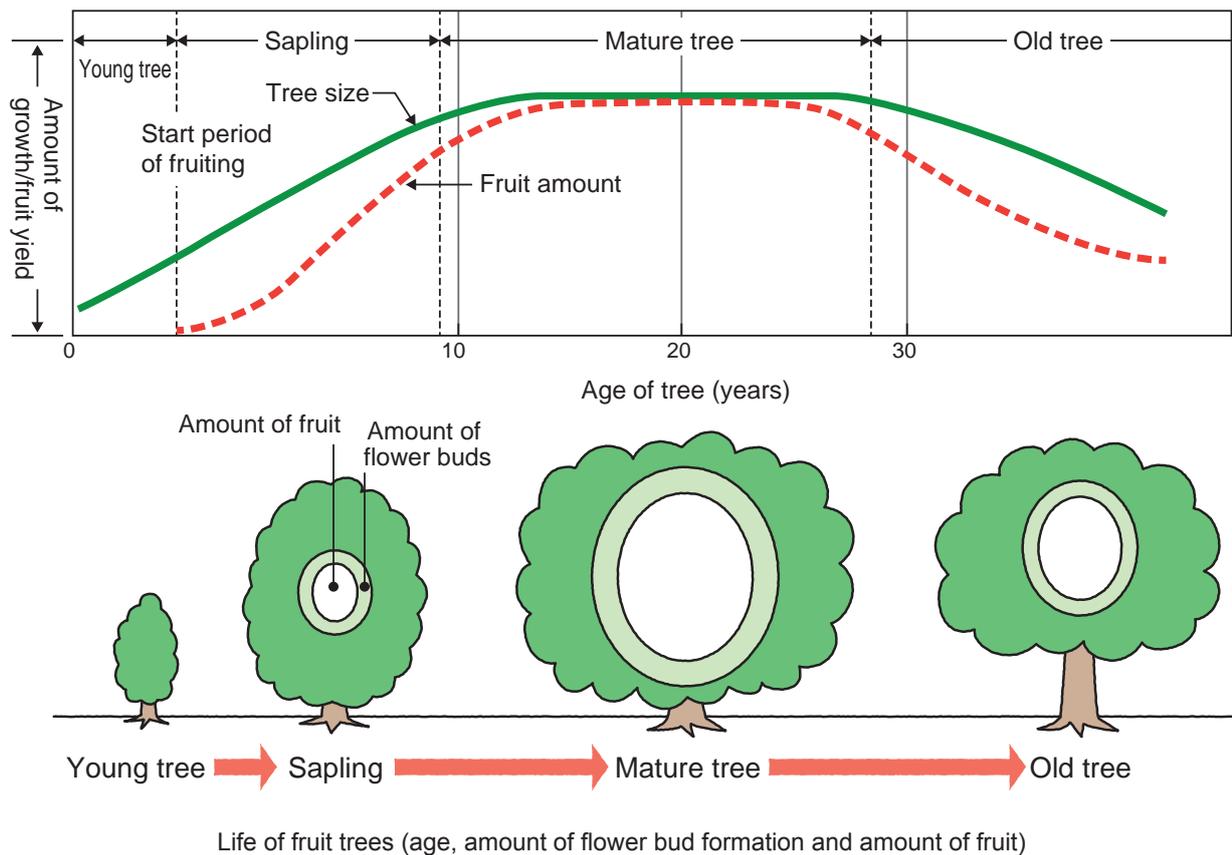
## 2 Features of fruit tree cultivation

### (1) The life of fruit trees

After planting the nursery stock, the tree should be grown larger for several years without letting it fruit.

Once the tree grows, let the tree produce fruit and harvest it.

After that, depending on the species, you can harvest every year over 20 to 40 years.



## (2) Growth of fruit trees

### ① Formation of leaf buds and flower buds

There are two kinds of fruit tree buds: a “leaf bud” from which the leaves emerge, and a “flower bud” from which the flower blooms and which bears the fruit.

Depending on the species of fruit tree, flower buds are formed in different seasons. With many fruit trees, flower buds are formed in the year before the year when the flowers bloom and they bear fruit.

There are two types of flower bud formation. Peach and yellow peach form flower buds on the branches that grew last year. Apple, pear and grapes form flower buds on new branches that have grown this year. Satsuma mandarin has both types.

Depending on the position of the flower buds, the way of pruning is different.

#### Factors that aid differentiation of flower buds

- Reduce the effect of nitrogen fertilizer.
- Perform light pruning.
- Avoid excessive fruiting.
- Reduce the soil moisture slightly.

## Period of flower bud differentiation

Most deciduous fruit trees differentiate flower buds in June-August. Grapes differentiate in late May, and Satsuma mandarin from October to December.

### ② Growth and maturation of fruit

After blooming, as flower pollen reaches the pistil to pollinate, bearing occurs and the fruit begins to grow. Like Satsuma mandarin, some fruit trees grow fruit without pollination.

The growth of fruits without fertilization is called parthenocarpy. In addition to Satsuma mandarin, figs and Hiratanenashi persimmon produce fruits by parthenocarpy. When grapes are treated with gibberellin, they become seedless fruits.

### ③ Growth and maturation of fruit

The fruit grows gradually, accumulates sugar and most fruit become sweet at maturity. Then the cells change to become soft.

The growth of fruit occurs by first increasing the number of cells, then by enlarging the cell volume.

## (3) Cultivation environment for fruit trees

### ① Temperature, irradiation, precipitation, wind

Appropriate air temperature, day length and precipitation are necessary for growth of the current shoots (= newly growing branches) and fruit.

Strong wind either damages or makes the fruit fall so it is necessary to protect it from wind.

Pears are grown by trellis training to protect the fruit from damage and dropping due to strong winds such as typhoons.

### ② Nutrition

In addition to nitrogen, phosphorus and potassium, balanced nutrients are required for the growth of fruit trees.

It is also important that the season and the amount of fertilizer applied are appropriate.

### ③ Soil

In order for fruit trees to spread their roots, and absorb nutrients and moisture, proper improvement of soil fertility is necessary.

It is important that the fertilizer does not run off easily, and that the water holding capacity (water retention) and water permeability (drainage) are favorable.

### 3 Cultivation management of fruit trees

#### (1) Management of trees

##### ① Production and raising of nursery stocks

Fruit tree nursery stock is usually made by “grafting” a “scion” to a “stock”.

Select a variety of stock that spreads roots well and is resistant to diseases.

Select a superior variety of scion that bears high quality fruit.

Grafting includes scion grafting and bud grafting.

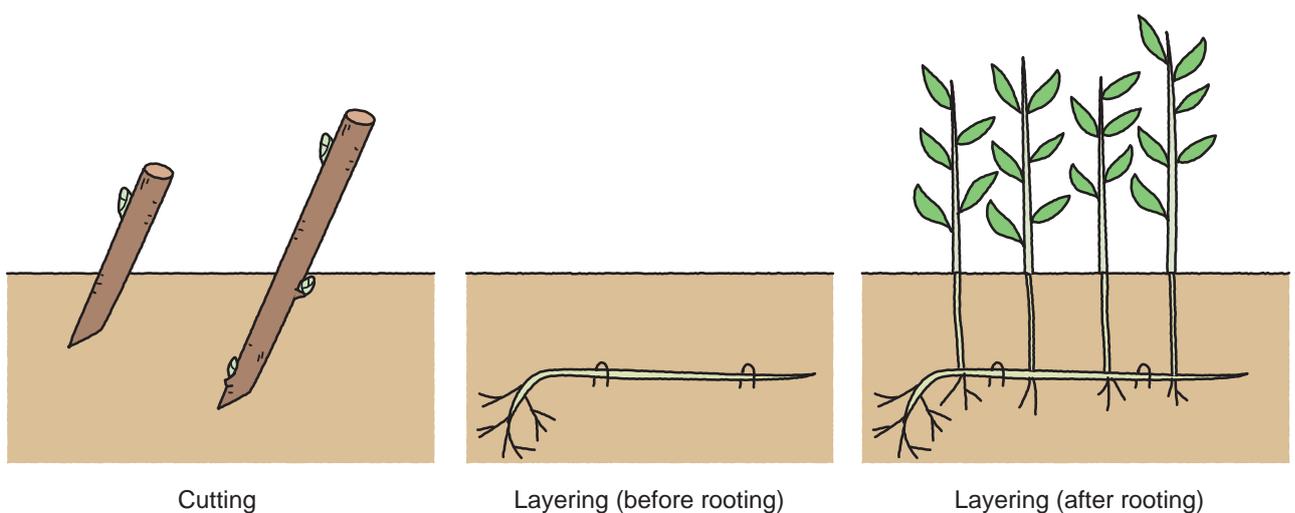
Grafting the branch onto the stock is called “scion grafting.”

As methods of scion grafting, there is veneer grafting, cleft grafting and side grafting.

Grafting the bud to the stock is called “bud grafting.”

As methods of bud grafting, there is T-budding and chip budding.

Production method	Explanation	Characteristics
Propagation by grafting	Graft the scion onto the rootstock.	For fruit trees in general
Propagation by cutting	Cut a part of the branches or the leaves, place them in soil or culture soil, and let them bud and root to use as seedlings.	Grapes, figs, etc.
Propagation by layering	Bend a part of the branch and fill it in the soil, and when the root comes out cut it apart to prepare the seedlings.	Apple, etc.
Sexual propagation	Prepare seedlings by sowing seeds.	How to produce rootstocks



Production of nursery stocks includes vegetative propagation (Grafting, etc.) and seed propagation.

A seedling propagated by sowing seed is called a seedling by sexual propagation. Seed propagation is utilized when growing rootstocks and breeding new varieties. Good nursery stocks have well developed fine roots and are not affected by pests. Use scions that are not damaged by pests.

### Purpose of grafting

- ① Breed the individuals of the same variety and phylaxis.
- ② Hasten the start period of fruiting.
- ③ Renew varieties in a short period by top-grafting.
- ④ Reduce the damage of pests and diseases using resistant rootstocks.

#### Practical skill

- Understand the nursery stock of main fruit trees.

Evergreen  
fruit tree



Citrus

Deciduous  
fruit tree



Persimmon



Grape

Practical skill

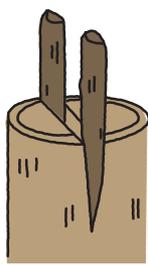
○ Understand the method of scion grafting and bud grafting.

《Scion grafting》



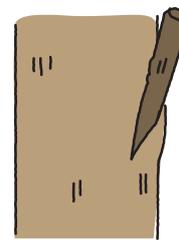
Veneer grafting

Insert the scion by putting the cambium layer of the scion and rootstock together.



Cleft grafting

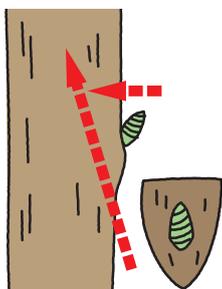
Break the stock and insert a wedge-shaped scion. Mainly used to regenerate the main branch.



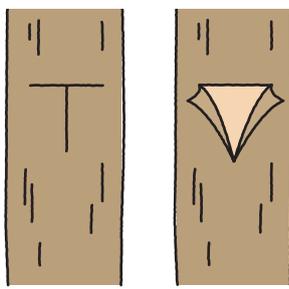
Side grafting

A method of grafting the scion in between without cutting the branches or stems.

《Bud grafting》



① Cut out one sprout.



② Make a T-shaped cut in the rootstock.



③ Insert the sprout.



④ Roll the tape with the sprout exposed.

○ Understand the necessary tools for grafting.



Knife (for cutting out)

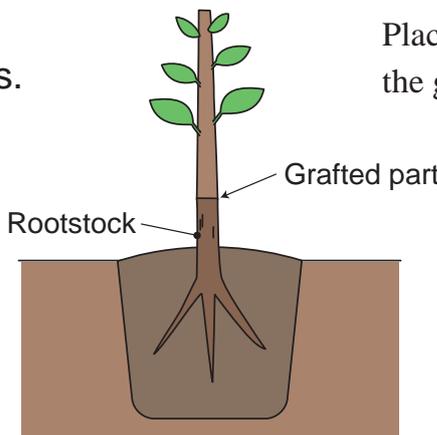


Grafting tape



Grafting wax

○ Understand how to plant grafted nursery stocks.

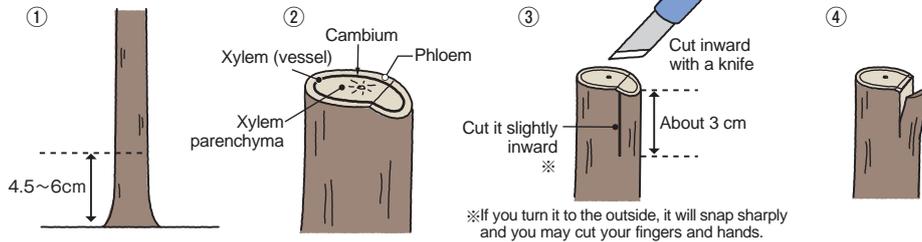


Place the grafted part above the ground.

Practical skill

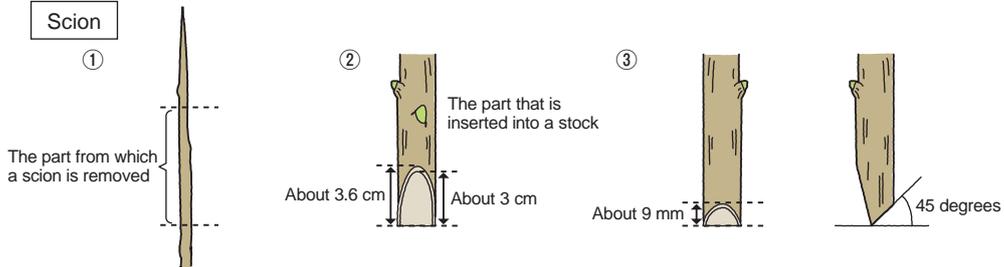
○ Understand how to do scion grafting.

Rootstock



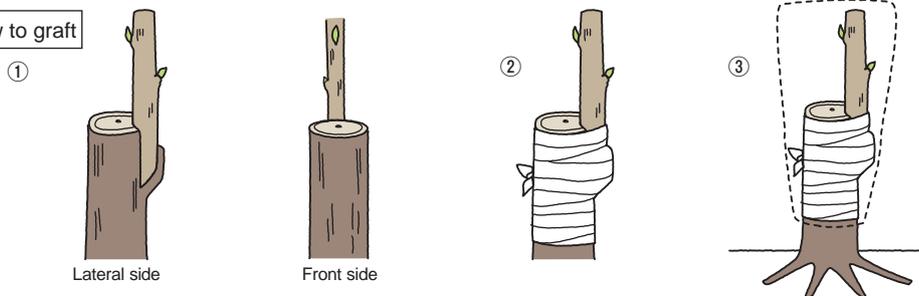
- ① Cut the rootstock at a height of 4.5 - 6 cm above the ground surface.
- ② Remove the shoulder by cutting upward at a 45 degree angle.
- ③ Cut right below at the slanted part.
- ④ Graft the scion before the cut is dry.

Scion



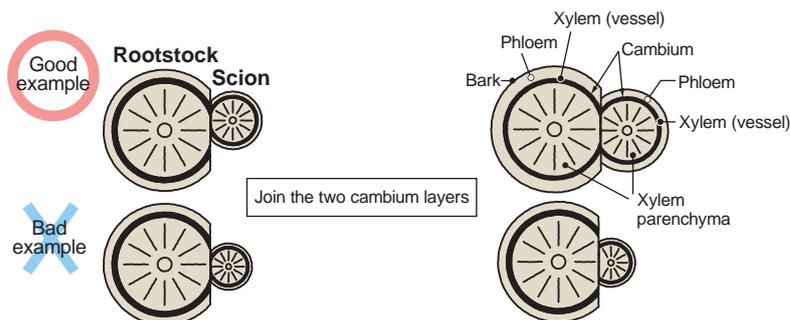
- ① For scion, use the central part of the branch where the buds are fulfilling.
- ② Remain 1 - 3 buds and cut down diagonally and thinly about 3.6 cm length.
- ③ Cut off about 9 mm diagonally from the back at an angle of about 45 degrees.

How to graft



- ① Insert the scion by putting the cambium layer of the scion and rootstock together.  
Since the cambium cannot be seen with the naked eye, join the outside of the xylem (vessel).  
Apply wax to the top of the rootstock.
- ② Firmly fix with tape.
- ③ Cover the rootstock and the scion with a polyethylene bag or the like.

How to join rootstocks and scions (Note) Be careful not to make a gap between the rootstock and the scion.



## ② Training, pruning

“Training” is the work of arranging the shape of the tree by cutting and training branches.

“Pruning” means cutting branches.

The purpose is to harvest better fruit stably by increasing the flowers and making the work easier.

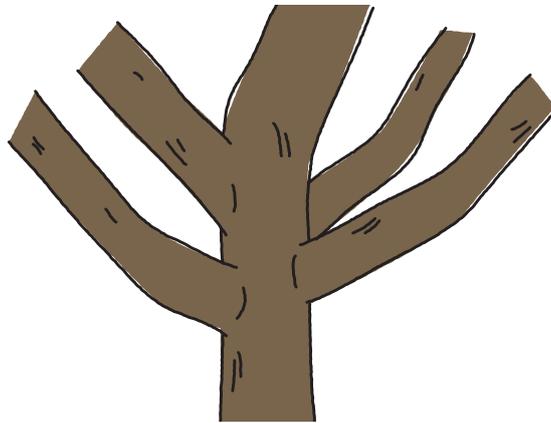
Depending on the extent of the branches cut, there is “heavy pruning” and “light pruning.”

Heavy pruning encourages vegetative growth. Light pruning weakens vegetative growth and encourages reproductive growth.

Fruit trees have a specific training method (tree form) for each species and variety.

Central leader type is used for dwarfing cultivation, etc. of apple and peach, modified leader type is used for apple and persimmon, etc., open center type is used for peach, etc., trellis training is used for grapes and Japanese pear, etc.

When training, be careful not to make a “whorl of branches” where the main branches sprout from one place of the main stem.



Whorl of branches

The pruning is mainly done in winter, called "winter pruning". "Summer pruning" is done adjunctively.

There are 2 types of pruning: "heading back pruning" and "thinning-out pruning".

“Heading back pruning” is to cut newly grown branches in their middle, and it promotes the growth of new branches (branches that newly shoot).

“Thinning-out pruning” is to cut unnecessary branches, leaving necessary branches. It improves ventilation and sunlight.

 Practical skill

○ Understand the principle of pruning.

Before pruning, observe the whole tree and decide which branch to prune by considering the arrangement of the main and secondary branches, the degree of crowding of branches, and the position to produce fruit.

Start with the main branch. Cut unnecessary branches from the tip to the base.

Saw off unnecessary thick branches from their base (Thinning-out pruning).

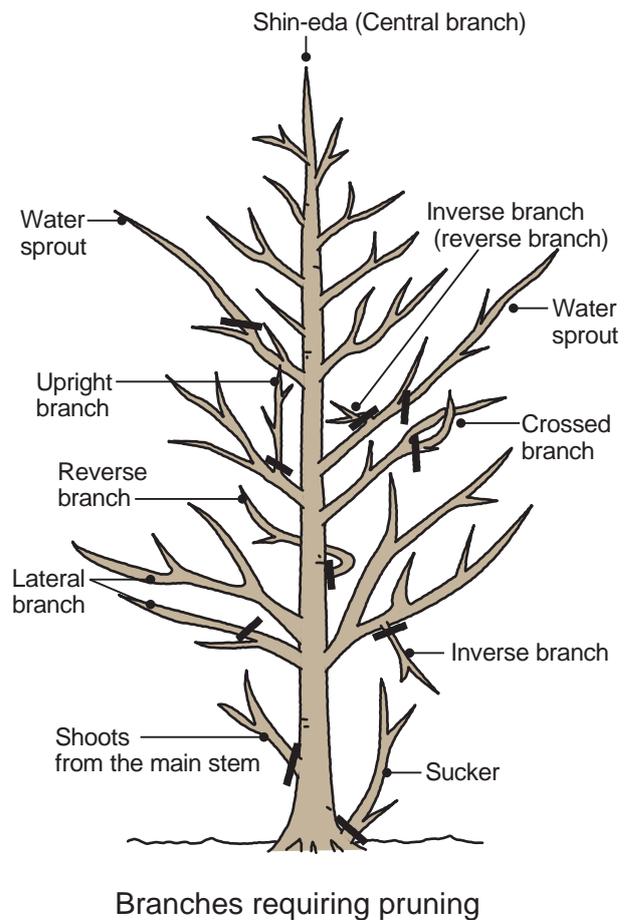
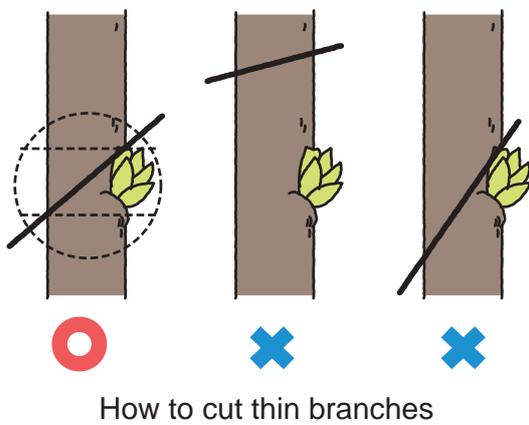
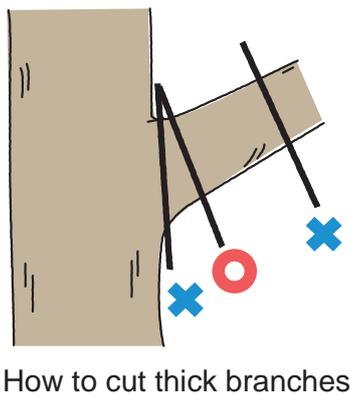
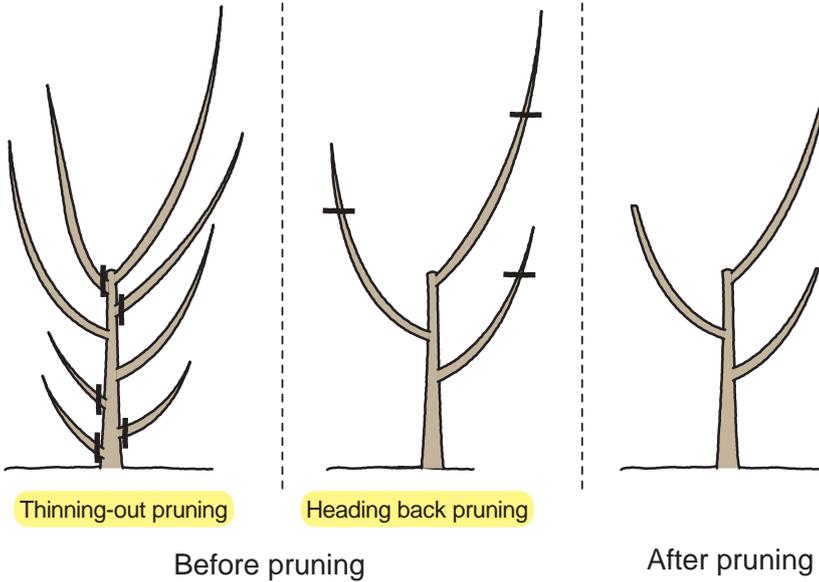
Cut the thin branches to remain, on top of the leaf buds in the direction you intend to extend them (Heading back pruning).

Cut off unnecessary small branches from their base with scissors (Thinning-out pruning).

Practical skill

○ Understand how to prune branches.

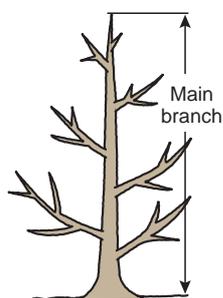
Cut the new branches shooting from the main stem



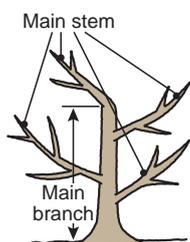
Water sprouts, upright branches, reverse branches, lateral branches, inverse branches, crossed branches, shoots from the main stem, suckers, etc. are pruned. Do not cut the central branch.


**Practical skill**

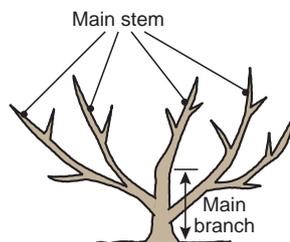
- Understand training method (tree form) and the types of fruit trees.



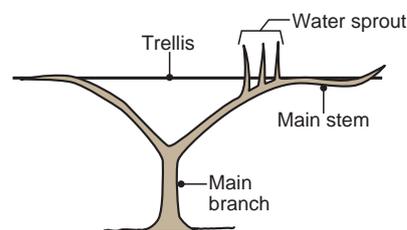
Central leader type  
(Apple, peach)  
(Dwarfing cultivation)



Modified leader type  
(Apple, persimmon)



Open center type  
(Peach, plum, Japanese plum (Ume))



Trellis training  
(Grape, pear)

### ③ Supporting

Supporting is carried out to arrange the growing direction of young branches of Japanese pear and grapes, etc.

### ④ Fruiting management

From before flowering to harvest, the following work is carried out.

#### i Disbudding, flower picking

Pick excess flower buds and flowers to grow higher quality fruit and to facilitate flowering next year.

#### ii Pollination (fertilization)

When flowers bloom, put pollen onto the pistil using artificial pollination.

Sometimes insects such as bees are used.

To facilitate fruiting, plant a different variety called a “pollinizer.”

**Practical skill**

**Deciduous fruit tree**

- Understand the tools used for artificial pollination.



Hand pollinator



Hand pollinator



Bonten  
(a fluffy-ball type tool used like a pollinating brush)

**iii Fruit thinning**

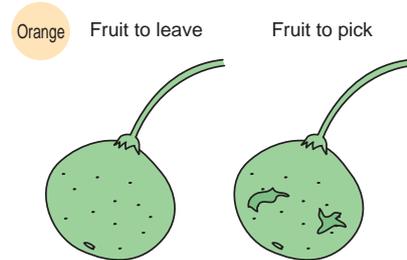
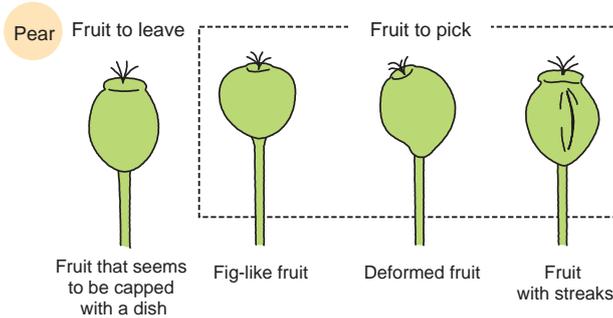
Pick young excess fruit in order to harvest higher quality fruit and to facilitate flowering next year.

**Practical skill**

**Common**

- Understand the fruit to be picked.

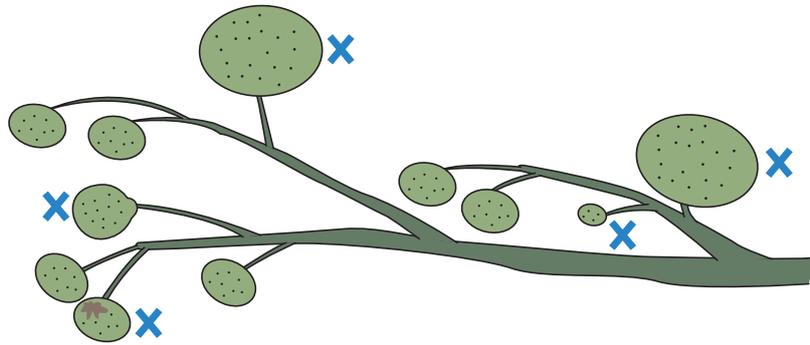
- ① Fruit with damage or injury by pests
- ② Slow developing or deformed fruit
- ③ Fruit in positions where bagging will be difficult





## Evergreen fruit tree

- Understand the fruit thinning of Satsuma mandarin.



### iv Bagging

Wrap the fruit with bags to prevent pests and to make clean fruit.



## Deciduous fruit tree

- Understand how to apply basic bagging.

## Practical skill

## Deciduous fruit tree

- Understand the bag types for main fruit trees and how to bag the fruits.

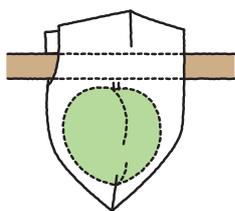


For peach

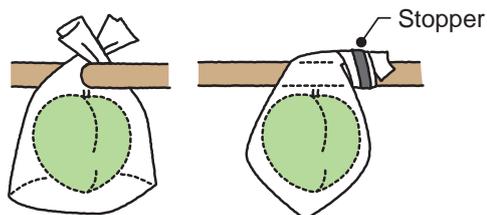


For grapes

## Peach

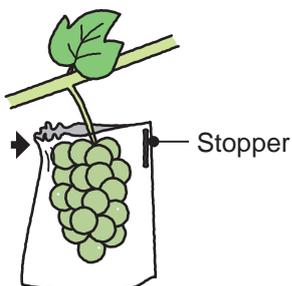


Inflate the bag, put a branch in the cut of the bag, and make sure the fruit is placed in the center of the bag.

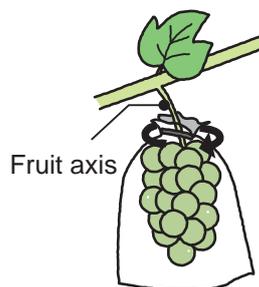


Gather the top of the bag to one side and fold it toward the base of the branch, and tie them together with the wire that is attached to the bag and tighten firmly.

## Grape



Inflate the bag, put the fruit cluster in the center of the bag and gather the top of the bag (the side without the wire).



Gather the other side with the wire and fold the wire to tie it around the fruit axis and tighten the mouth firmly.

- 【Common matter】**
- ① Make sure the fruit is in the middle of the bag.
  - ② Be careful not to crush the fruit axis and branches when winding the stopper tightly.

## ⑤ Harvest

Apple, Japanese pear, citrus fruits, etc. are harvested after the fruits have matured.  
Pear, kiwi fruit, etc. are stored to ripen (ripening) after harvest.

## Harvest period of major fruit trees

Satsuma mandarin	Mid-October to early December
Apple	Early September to mid November
Pear	Mid-August to late November
Grape	Mid-August to early October
Peach	Late June to late August
Persimmon	Late September to early December



## Evergreen fruit tree

- Understand how to harvest Satsuma mandarin.



▲ Disconnect it from the branch so that the cutting edge does not hurt the fruit. Removing by pulling will hurt the fruit.

▼ Cut it twice and cut off the long part of the "axis (fruit axis)."



## (2) Renewal of variety

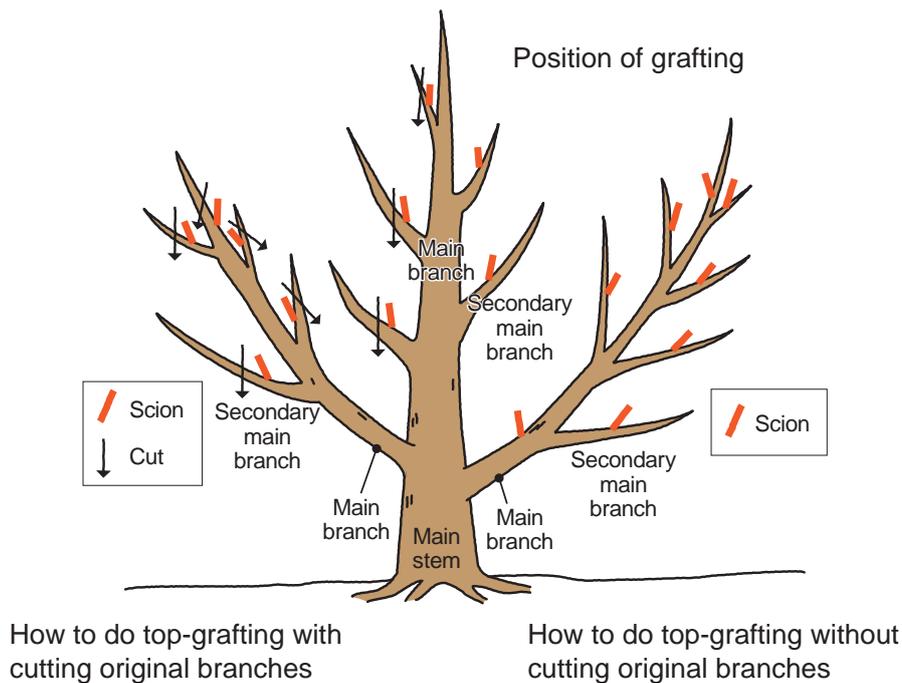
## ① Replanting

Old trees with low tree vigor and yields, and garden sites with poor varieties are replanted with new seedlings, called "replanting".

## ② Top-grafting

It's a method of grafting new variety of branches to the branches of fruit trees. There are 2 types, one is to cut the original (fruit-tree) branch and the other is to leave it as the largest branch.

It is grafted to the middle of the main or secondary main branch.



### (3) Soil management

#### ① Management of the surface soil

To manage the surface of the soil, there is: ① the method of not letting weeds grow, ② the method of laying rice straw or grass, ③ the method of always keeping grass, and ④ a combination of any of the above.

In an orchard with many hills, method ① is not suitable because the soil flows.

#### ② Conservation and improvement of soil

Drain ditches are made to protect the soil from run-off due to heavy rain.

Stone walls are also built to prevent the soil from collapsing.

Plowing the soil deeply (deep tillage) and adding organic matter improves the water retention and air permeability, resulting in the healthy growth of roots.

Depending on the fruit tree, the pH of the soil suitable for cultivation (hydrogen ion exponent) will be different.

Since there is a lot of acidic soil in Japan, adjust the pH with alkaline calcareous materials, etc.

### Soil pH suitable for growth of major fruit trees

Types of fruit trees	Range suitable for the growth	Range for the best growth
Satsuma mandarin	4.2 ~ 7.0	5.4 ~ 6.3
Apple	4.6 ~ 7.1	5.5 ~ 6.6
Grape	5.0 ~ 7.9	6.1 ~ 7.4
Japanese pear	4.3 ~ 6.7	5.3 ~ 6.2
Peach	4.3 ~ 6.7	4.8 ~ 5.9
Persimmon	4.5 ~ 7.0	5.5 ~ 6.6
Chestnut	4.1 ~ 6.1	4.6 ~ 5.5
Loquat	4.3 ~ 6.5	5.1 ~ 6.0
Fig-tree	5.5 ~ 7.5	6.1 ~ 7.2

### ③ Management of moisture

Adjust the timing and amount of watering according to the species of the fruit tree and its growth.

In addition, it is important that the water holding capacity (water retention) and water permeability (drainage) are favorable.

### ④ Fertilizer application

Fertilizer is applied several times a year as “basal fertilizer” and “additional fertilizer,” which have different roles.

“Basal fertilizer” supplies the nutrients that become the basis for the growth that year.

“Additional fertilizer” is only applied when the nutrients in the basal fertilizer are not enough.

The basal fertilizer is given during the dormant period before the growth starts. For deciduous fruit trees, apply it in December to January, and for evergreen fruit trees, apply it in March to April.

For adult trees, fertilizer is usually applied to the surface of the soil, called "broadcasting of fertilizer". In addition, in some cases, "total layer application" that supplies to all layers together with organic matter in deep tillage, and "foliar application" that sprays fertilizer dissolved in water over the entire tree, are performed.

Additional fertilizers include spring applied fertilizer, summer applied fertilizer, and fall applied fertilizer, and quick acting fertilizer is used.

- Spring applied fertilizer: for growth of shoots, branches, and leaves. It is also called fertilizer for sprouting (Medashi-goe).
- Summer applied fertilizer: for growth of fruits. It is also called fertilizer for ripening (Mi-goe).
- Fall applied fertilizer: for restoring tree vigor and for increasing stored nutrients. It is also called fertilizer after harvest (Orei-goe).

### (4) Other management

The weather disasters that fruit trees are likely to be affected by are strong winds, the cold, heavy

rain, drought, heavy snow, hail, etc.

In areas that are prone to damage, various measures are taken.

## (5) Shipping and storage

Select the harvested fruit according to size, taste, appearance, (visual aspect) etc., and then ship them. There is a technology that prolongs storage life and enables systematic shipping.

Before storage, citrus fruits undergo “pretreatment” to dry a few percent of the moisture.

Cool apples in a refrigerator, reduce the oxygen, increase the carbon dioxide and put them in long-term storage (CA storage).

## 4 Facility cultivation of fruit trees

### (1) Type of facility

Some fruit trees such as grapes, Satsuma mandarin, edible cherries (Japanese cherries) are cultivated in the facility.

For cultivation facilities, there are glass greenhouses, vinyl houses and rain protectors.

There is also a cultivation method that uses a heater to raise the temperature inside the facility.

### (2) Cultivation management

As the temperature differs greatly from the outside, appropriate cultivation control is needed in the facility.

In addition, because there is no rainfall, moisture management is also important.

## 5 Characteristics of main fruit trees and cultivation management

### (1) Citrus

Citrus fruits are cultivated in warm regions.

70% of citrus cultivated in Japan is Satsuma mandarin.

Satsuma mandarin is native to Japan and the representative varieties are Miyagawa wase (21%), Aoshima unshu (14%), and Okitsu wase (13%).

Citrus fruits are particularly vulnerable to cold and strong winds, so care must be taken in management.

From year to year, cycles tend to occur where there will be years with many fruit and other years with less fruit (alternate bearing).



Flowers of Satsuma mandarin

## (2) Apple

Apples are cultivated mainly in areas with cold winters.

Representative varieties are Fuji (52%), Tsugaru (13%), and Orin (8%).

Artificial pollination work is carried out to transfer the pollen to the pistil, and also disbudding, flower picking, fruit thinning work, etc. should be done.

Because pest damage tends to occur, appropriate control is necessary. Sometimes bagging is used.

For apples, dwarfing cultivation using dwarfing rootstock is carried out. Central leader type trees are planted closely. This cultivation method aims to increase yield early and save labor by lowering tree height (height of the tree).

## (3) Grapes

Grapes are widely cultivated throughout Japan.

Representative varieties are Kyoho (35%), Delaware (19%), and Pione (16%).

Spread the branches horizontally and train on a trellis. Because they are vulnerable to wind and diseases, also cultivated in facilities.

Using the plant hormone “Gibberellin,” seedless grapes are also cultivated.

### How to produce seedless grapes

The cluster is soaked in a solution of gibberellin twice, before and after flowering.

It is important to keep the timing to use gibberellin and the concentration of the solution.



## (4) Persimmon

Japanese persimmons come in both sweet and astringent varieties.

Typical varieties of persimmon are Fuyu (Sweet persimmon, 25%), Hiratanenashi (astringent persimmon 17%), and Tonewase (astringent persimmon 15%).

Sweet persimmon is a native of Japan and cultivated in warm regions.

Half of the persimmons being cultivated are astringent persimmon. Astringent persimmons undergo a process to remove the astringency.

From year to year, cycles tend to occur where there will be years with many fruit and other years with less fruit (alternate bearing).

## (5) Pear

Pears are grown in various places because they are suitable for the warm and rainy climate of Japan.

Representative varieties are Kosui (40%), Hosui (27%), and Niitaka (10%).

Pears are cultivated in cool, dry areas.

Since pears require pollen from other varieties to pollinate, it is necessary to ensure pollination.

Because the fruit of a Japanese pear tends to fall in the wind, it is trained on a trellis.

## (6) Peach

Peaches are mainly cultivated in cool areas.

Representative varieties are Akatsuki (19%), Hakuho (16%), and Kawanakajima Hakuto (14%).

Growth of the saplings is fast, and it fruits in 3 years and becomes a large tree in 7 or 8 years.

In addition to disbudding and fruit thinning, bagging is carried out to prevent pests and to improve the appearance.

# 6 Agricultural materials and machinery used for fruit trees

## (1) Agricultural materials

Materials used in orchards include materials used for vinyl houses and trellis, nets to protect against strong winds, birds, pest insects, etc. and sprinklers for control and irrigation.

In addition, there are insects such as bees that help pollinate, chemicals for pest control, plant growth regulators that work on growth (chemicals with the same effect as plant hormones).

Sometimes frost protection fans are used to prevent damage by frost.

Sometimes sprinklers are used to prevent damage by freezing.

## Intended use of plant growth regulators in major fruit trees

- To prevent peel puffing: Satsuma mandarin
- To make seedless fruits: Grape
- To prevent fruit drop before harvest: Apple, Japanese pear
- To hasten maturation: many fruit trees
- To promote development of roots and branches: apple, etc.

### Practical skill

- Understand the main materials for fruit trees and their purposes.

Bird proof nets, insect proof nets, mulching materials, reflective sheeting, and other materials



Bird/insect proof net



Mulch



Reflective sheeting

### Mulching material

How to use: Place on the ground around the roots of fruit trees.

Purposes: To prevent soil erosion. To prevent water evaporation. To prevent weeds.

### Reflective sheeting

How to use: Cover the ground under fruit trees at harvest time.

Purpose: To improve coloring of fruits by reflecting sunlight.

## (2) Agricultural machinery

Agricultural machines include those that cultivate the soil, those that spread agents, those used for weeding, those to control fruiting, and those for transportation. In addition to those common machines, the following are also used for fruit tree cultivation.

Control: Speed sprayer (SS)



Cultivation management:

Machines for work in high places



Transportation: Monorail



Transportation: Transporter



## (3) Agricultural tools (only those often used in fruit tree cultivation)

Pruning scissors



Stepladder



Practical  
skill

- Understand the main agricultural tools and agricultural machinery for fruit tree cultivation.

- Fall fertilizing (Reigoe in Japanese)** .....applying fertilizer after harvesting fruit to increase the storage of nutrients
- Underdrainage** .....a drainage method that lays earthen pipes in the soil
- Raising of seedlings**.....preparation of seedlings by sowing in nursery beds instead of the fields
- Ridging**.....work that builds up the soil in a field to create places to plant crops (ridges)
- Flower bud** .....a bud that will form the flower and fruit in the future
- Drought damage**.....damage to crops because of no rainfall
- Irrigation (watering)** ..... giving water to the crops
- Tillage (plowing)** .....work of plowing the soil in the field to soften and improve the air permeability
- Photosynthesis**.....crops produce starch, etc. from water and carbon dioxide from light
- Hastening of germination**.....creating the condition where buds come out about 1 mm on the day before sowing
- Cropping type** .....a method of cultivation which combines cultivation techniques according to variety, season and environment
- Grafting** .....a method of cutting part of a tree such as the branches, placing them in soil to let them bud and root, and growing them as nursery stocks or rootstocks
- Weed control** ..... preventing weeds using chemicals, mulching or other methods
- Direct sowing** .....sowing directly into the field soil
- Facility horticulture** .....a type of cropping that grows crops inside facilities (such as vinyl houses and greenhouses)
- Training** .....a tree shape appropriate for the different species and varieties of fruit trees

- Gibberellin treatment** ...use of gibberellins in normal varieties to let them be seedless and in seedless varieties to promote fruit enlargement
- Harvest**.....work to pick and collect fully grown vegetables, seeds and fruit from fields and trees
- Pretreatment of seeds** ....a series of work done before sowing to let the germination and growth after germination go smoothly. It includes “seed selection,” “disinfection,” “soaking of seeds” and “hastening of germination” (described as “preparation of seeds” in the text)
- Disinfection**.....controlling seed-borne diseases and pest insects using “seed disinfection”
- Weeding (removing weeds)** .....removing weeds in paddy fields and upland fields, orchards, footpaths in the paddy fields and pathways
- Paddling**.....making the soil soft by plowing the paddy soil after introducing water suitable for planting rice seedlings
- Artificial pollination** .....artificially transferring pollen to the pistil of the flowers that need pollination
- Soaking of seeds**.....promoting germination by letting seeds absorb enough moisture to germinate
- Flooding damage** .....Injury and diseases in crops caused by heavy rain
- Drilling**.....sowing seeds on the ridges in line
- Training**.....cutting off extra branches and training branches to arrange the shape of crops and trees suitable for fruit production
- Land grading** .....work that levels the field soil after tillage
- Seed selection**.....removing defective seeds, selecting seeds using difference in specific gravity, “seed selection using a salt solution”
- Pruning** .....cutting branches
- Forcing cultivation**.....a type of cropping that cultivates crops earlier than open field (normal season) cultivation using facilities, etc.

- Rootstock** ..... a plant or tree which has roots when grafting
- Removing astringency** ..... artificially changing soluble tannins to an insoluble state (do not dissolve in water)  
(Shibunuki in Japanese)
- Sowing (seeding)** ..... work that sows crop seeds
- Intertillage** ..... work to lightly plow the surface soil of the field during crop cultivation
- Additional fertilizer** ..... applying fertilizer during crop growth
- Grafting** ..... a method that cuts off a part of the plant or the tree such as a branch or a sprout and grafts it onto the rootstock or another tree
- Planting** ..... work to plant the seedlings grown in nursery beds
- Flower picking** ..... picking excess flowers
- Fruit thinning** ..... selecting and leaving the fruit to be grown and picking other fruit
- Pinching** ..... cutting the tip of a stretched stem or branch
- Defoliation** ..... removing excess leaves
- Disbudding** ..... removing excess flower buds
- Dibbling** ..... a method of sowing several seeds in one place at set intervals
- Midsummer drainage** ... drying a paddy field during the growth of the rice plant by draining for a short period
- Scattering** ..... sowing on a whole field or ridge (also called Sanpa in Japanese)
- Pest control** ..... protecting from pest insects and diseases using chemicals, etc.
- Soil covering** ..... covering seeds with a thin layer of soil
- Scion** ..... shoots, seedlings or branches which are flowering or fruiting when  
(also called Tsugiho in Japanese) grafting
- Thinning** ..... selecting and leaving the seedlings, nursery stocks or branches to be grown while picking or cutting others
- Mulching** ..... covering the surface soil with film, straw, etc.

**Basal fertilizer (basal manure)** ..... applying fertilizer to the soil before planting crops or before the buds of a fruit tree to be activated

**Supporting** ..... regulating the direction of extension by binding the branches of crops to wires or supports

**Delayed cultivation** ..... the opposite of forcing cultivation, a type of cropping that cultivates crops later than open field (normal season) cultivation

**Crop rotation** ..... after harvesting a crop, raising another species of crop in the same field

**Cool weather damage** .... crop damage caused by low summer temperatures due to abnormal weather

**Replant failure** ..... reduction of growth and yield caused by cultivating the same crop after harvesting

**Open field cultivation** ..... a type of cropping that grows crops under natural conditions, not in facilities

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# List of photographs (vegetables, covering materials and fruits)

## Vegetables

### Major vegetables and classification

#### 1. Leafy vegetables



Cabbage  
[Brassicaceae]



Chinese cabbage  
[Brassicaceae]



Lettuce  
[Asteraceae]



Spinach  
[Chenopodiaceae]

#### 2. Root crops



Onion  
[Liliaceae]



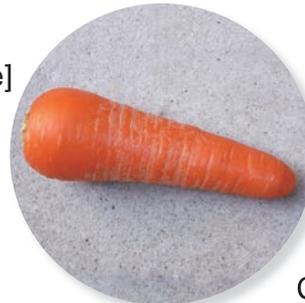
Radish  
[Brassicaceae]



Potato  
[Solanaceae]



Sweet potato  
[Convolvulaceae]



Carrot  
[Apiaceae]

#### 3. Fruit vegetables



Tomato  
[Solanaceae]



Eggplant  
[Solanaceae]



Cucumber  
[Cucurbitaceae]

## Covering materials



Vinyl chloride



Polyethylene film for agriculture (PE)



Nonwoven fabric



Cheesecloth



Insect screen

## Fruits



Apple



Grape



Persimmon



Pear



Peach



Chestnut



Kiwi fruit



Blueberry



Satsuma mandarin



Yuzu



Loquat

Support project to properly accept foreigners for agricultural support

**Agricultural Skill Assessment Test**  
**Text: General crop farming**  
**English Edition**

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