REF. NO.8 MARCH 1995

REF. NO.8 CULTIVATION AND EVALUATION OF VEGETABLE PGR GENETIC RESOURCES PROJE

CULTIVATION AND EVALUATION OF VEGETABLE PGR

TECHNICAL ASSISTANCE ACTIVITIES FOR GENETIC RESOURCES PROJECTS

JAPAN INTERNATIONAL COOPERATION AGENCY

Published

REF. NO. 1	Preservation of Plant Genetic Resources
REF. NO. 2	Exploration and Collection of Plant Genetic Resources Part I Seed-propagated Crops
REF. NO. 3	Exploration and Collection of Plant Genetic Resources Part II Vegetatively Propagated Crops
REF. NO. 4	Evaluation and Classification of Plant Genetic Resources
REF. NO. 5	Utilization of Plant Genetic Resources for Crop Improvement
REF. NO. 6	Cryopreservation of Plant Genetic Resources
REF. NO. 7	Cultivation Methods for the Evaluation of Characteristics of Genetic Resources and Evaluation of Genetic Resources (Cereal, Pulse and Root Crops)

Editorial Office: Agriculture, Forestry & Fisheries Technical Information Society (AFFTIS)
6F Seifun-kaikan, 15-6 Kabuto-cho, Nihonbashi,
Chuo-ku, Tokyo 103, JAPAN

CONTENTS

I. Cabbage
- I-1. Cultivation of cabbage PGR 3
- I-2. Evaluation of characteristics of cabbage PGR 6

II. Spinach
- II-1. Cultivation of spinach PGR 15
- II-2. Evaluation of characteristics of spinach PGR 18

III. Onion
- III-1. Cultivation of onion PGR 25
- III-2. Evaluation of characteristics of onion PGR 27

IV. Lettuce
- IV-1. Cultivation of lettuce PGR 35
- IV-2. Evaluation of characteristics of lettuce PGR 36

V. Cucumber
- V-1. Cultivation of cucumber PGR 47
- V-2. Evaluation of characteristics of cucumber PGR 51

VI. Melon
- VI-1. Cultivation of melon PGR 63
- VI-2. Evaluation of characteristics of melon PGR 67

VII. Tomato
- VII-1. Cultivation of tomato PGR 77
- VII-2. Evaluation of characteristics of tomato PGR 80

VIII. Strawberry
- VIII-1. Cultivation of strawberry PGR 91
- VIII-2. Evaluation of characteristics of strawberry PGR 94

IX. Radish
IX-1. Cultivation of radish PGR 107
IX-2. Evaluation of characteristics of radish PGR 109

X. Carrot
X-1. Cultivation of carrot PGR 119
X-2. Evaluation of characteristics of carrot PGR 120

Introduction

In 1994, we published PGR manual REF. No. 7 which described the methods for the cultivation and evaluation of characteristics of PGR of cereals, pulses and root crops.

This year, the editorial board of GRP REF sponsored by Japan International Cooperation Agency (JICA) decided to publish PGR manual REF. No. 8 to outline the methods for the cultivation and evaluation of characteristics of PGR of vegetables.

The editorial board held consultations with Dr. Hiroaki Yoshikawa, Director of Department of Vegetable Breeding, NIVOT (National Research Institute of Vegetables, Ornamental Plants and Tea, MAFF). Dr. Yoshikawa selected ten representative vegetables as follows: leaf vegetables: cabbage, spinach, onion and lettuce, fruit vegetables: cucumber, melon, tomato and strawberry, and root vegetables: radish and carrot.

Strawberry is classified into fruits in some countries, but, in Japan it is considered as a vegetable, because the method of cultivation are similar to those applied to vegetables.

As in REF. No.7, each descriptor is grouped into three classes, primary, secondary and tertiary and also categorized into essential or optional items. Thus, descriptors appear in a systematic order.

In the next volume of this series, methods of cultivation and descriptors of fruit trees will be dealt with.

Torao Goto
AFFTIS

I. Cabbage

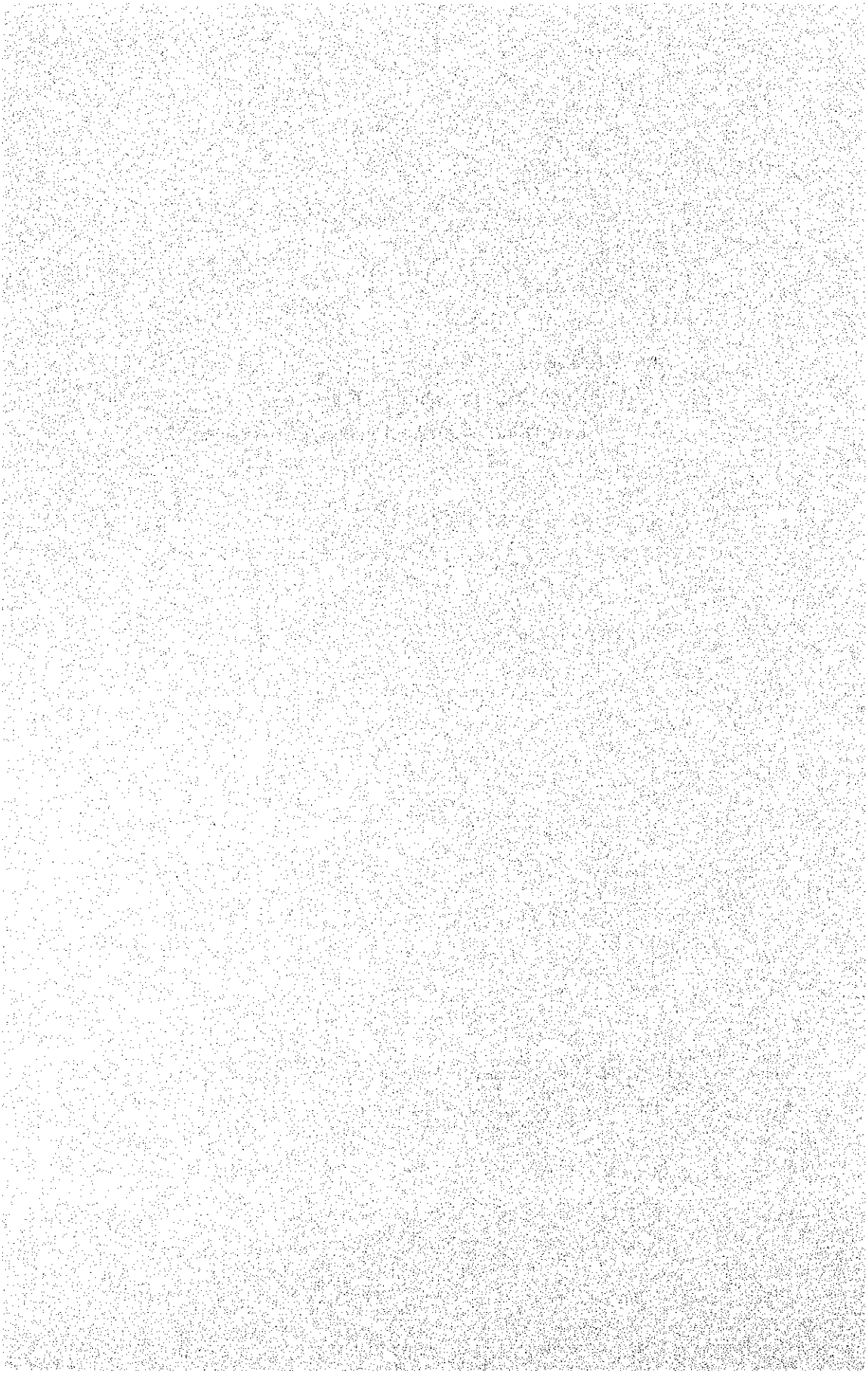
I-1. Cultivation of cabbage PGR

I-2. Evaluation of characteristics of cabbage PGR

by

Ken'ichi Hida

National Research Institute of Vegetable, Ornamental Plants and Tea, MAFF, Ano, Mie 514-23 JAPAN



I-1. Cultivation of cabbage PGR

1. Experimental plan

Randomized complete block design with three replications is generally recommended. Two outer rows and plants at both ends of rows are set up to protect test plants and are not included in the evaluation. Local standard varieties are added to the entries.

2. Preparation of seedlings

Seed disinfection

Seeds are soaked in hot water at 50°C for 25 minutes and then in 1% sodium hypochlorite solution for 10 minutes (recommended by AVRDC), or well-dried seeds are heated at 70°C for three days. The former procedure is effective for most pathogens. The latter is convenient but less effective. As these procedures may reduce the longevity of seeds, only seeds for immediate use should be treated.

Preparation of pots or flats

Flats (garden pan) or pots (9 cm diameter) with drainage holes are used for growing seedlings. Culture medium with proper nutrient and water holding capacity needs to be prepared. Culture medium is poured into the pots or flats, leaving some top space to hold water while watering. When pots are used, they are placed on boards or flats to hold the water flow and to confine the root system in the pots.

Sowing

Holes 0.5 ~ 1 cm deep are made on the culture medium and 2 ~ 3 seeds are sown in a hole. Seeds are covered with fine medium and water is supplied carefully with sprinklers. Entries are arranged in the same way as in the layout in the field.

Protection

Seedlings are covered with plastic film for early spring sowing while temperatures are low. For early summer sowing, seedlings are covered with nets, when severe pest attack or heavy rainfall is expected.

Irrigation

Irrigation is carried out evenly using sprinklers. Although cabbages require an ample supply of water, excessive moisture should be avoided because it might cause damping-off, especially in the case of young seedlings. When additional watering is necessary in the afternoon, it should be applied while sunshine is sufficiently strong to prevent plants from getting wet after dark.

Thinning

When the seedlings reach the two true leaf stage, they are thinned to the best one per seeding

spot by cutting hypocotyls with nails or scissors. Too vigorous or off-type seedlings must be rogued. Pesticides and fungicides are sprayed after thinning.

Hardening

Irrigation is reduced at about five days before transplanting to alleviate transplanting shock of the seedlings, and just before transplanting, an ample supply of water is given. Pests and diseases are controlled thoroughly before transplanting.

2. Land preparation

Field preparation

Soil pH needs to be adjusted between 5.5 ~ 7.5 by the application of calcium fertilizer. Organic manures are broadcasted. The fields are tilled at a depth of 20 cm. When soil is too dry or too wet, tillage should be avoided.

Fertilizer application

Basal fertilizers are applied by broadcasting or in rows. When applied in rows, fertilizer should be applied at a depth of 20 ~ 30 cm below the surface of seed beds. The amount of fertilizers should be adjusted according to the growth conditions and projected yield. The standard total amount of fertilizer for autumn-sowing in Japan is N: 15 ~ 20, P: 8 ~ 12, K: 12 ~ 15 kg/10a, and the amount of basal application is N: 8, P: 8, K: 8 kg/a.

Bed formation

Except for dry areas, seed beds are formed by plowing at a depth of 20 ~ 30cm. The distance between the center of adjacent furrows is set at 70 to 100 cm for single rows and 120 to 150 cm for double rows. In areas with heavy rainfall, furrow systems are designed carefully to drain excess water out of the field.

3. Transplanting

Transplanting holes

Holes are dug at 40 ~ 50 cm intervals. Small amount of chemical fertilizer may be applied to the holes as a starter. When soil is not sufficiently wet, water is applied to the transplanting holes before transplanting.

Transplanting

The 6 ~ 8 leaf stage is optimum for transplanting. When temperatures are high, seedlings are transplanted in the late afternoon. Seedlings are set in the holes and the root system of seedlings is covered with soil to the level of the bed surface. Seedlings are pressed and water is applied to the soil surface to promote root adhesion to soil and support plants. Preemergence herbicides are applied after transplanting.

Mulching

Mulching is applied to improve plant growth and control weeds. Beds are covered with black plastic mulch before transplanting or covered with straw mulch after transplanting. The latter method is suitable for hot environment.

4. Management until harvest

Top dressing

First top dressing is applied when rosette leaves start vigorous expansion. The second one is applied at the early stage of heading. Delayed application may promote cracking. Where tipburn occurs, it is preferable to use NO_3-N compared to NH_4-N for top dressing.

Irrigation

Water supply is necessary to secure the normal formation of heads. If the soil is dry, furrows or beds are watered before wilting occurs. Ample supply of water at a lower frequency is desirable. Where irrigation water is scarce, drip-watering is recommended.

Insect and disease control

Chemicals are applied according to the official recommendations in the area. Enough care is necessary for the timing and order of insecticide application. Otherwise, chemicals may only decimate natural enemies of cabbage. Where insecticides are not effective, early growth of seedlings can be secured by the use of protection nets. Tipburn may occur under highly evaporative conditions with low soil moisture. In that case, calcium, a large amount of organic materials and water should be applied properly. Surplus nitrogen should be avoided because it might exacerbate physiological disorders, as well as soft rot disease, particularly under humid conditions.

Harvest

Firmness of apparently well-formed heads is examined by pressing their shoulders with both hands. If they are firm, they have already reached the stage of harvestable maturity for evaluation. If wrapping leaves or heads are split by pressing, they are overmature.

I-2. Evaluation of characteristics of cabbage PGR

Characteristics of each entry are examined when 50% of the heads become harvestable, if not indicated otherwise. For harvest time, refer to the chapter on cultivation methods. Items relating to the morphology of nonwrapping leaf are examined for the largest nonwrapping leaf. The following abbreviations are used in this text for some representative and check cultivars - JW: Jersey Wakefield, YS: Yellow Succession, SE: SE cross, NB: Nambu, FB: Fuyudori B, OG: Oogosho, K1: Kandama No.1, FW: Fujiwase, KK: Kinkei 201, RB: Ruby Ball, SS: Shoshu, SK: Savoy King, BR: Banchu Riso, Y5: YR 50 days.

1. Primary characters

<Essential items>

Plant attitude

Plant attitude is classified into 3: erect, 5: intermediate, 7: spreading. Ex.- 3: JW, 5: YS, SE, 7: NB, FD.

Shape of nonwrapping leaf

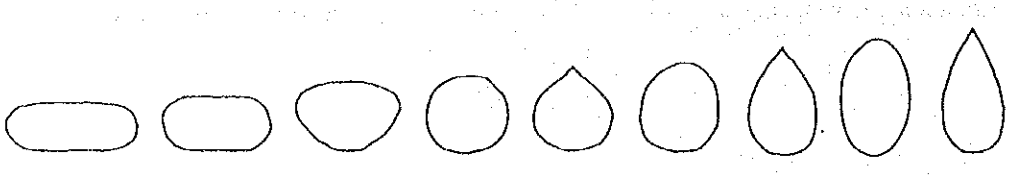
Shape of the largest nonwrapping leaf is classified into 3: broad circular, 5: circular, 7: obovate. Ex.- 3: YS, OG, 5: CM, 7: JW.

Color of nonwrapping leaf

The basic color of nonwrapping leaves is classified into 1: yellowish green, 3: light green, 5: green, 7: dark green, 9: grayish green. Ex.- 1: YS, 3: CM, SE, 5: FW, KK, 7: NB, FB. For red cabbage, classify the color into 3: light purple, 5: purple, 7: dark purple. Ex.- 5: RB.

Head shape

Head shape is classified into 1: flat, 2: semi-flat, 3: reverse short conic, 4: circular, 5: pointed circular, 6: elliptic, 7: pointed elliptic, 8: long elliptic, 9: pointed long elliptic. Ex.- 1: OG, 2: YS, SE, 3: NB, 4: CM, 7: JW. See Fig. 1.



1. Flat 2. Semi-flat 3. Reverse short conic 4. Circular 5. Pointed circular 6. Elliptic 7. Pointed elliptic 8. Long elliptic 9. Pointed long elliptic

Fig. 1 Head Shape.

Head length

Measure head length (vertical size of head) (in centimeters).

Head width

Measure head width (maximum horizontal size of head) (in centimeters).

Wrapping

Count the number of exposed wrapping leaves of heads.

Maturity

Count the number of days from transplanting to the day when 50% of the heads become harvestable.

<Optional items>

Number of nonwrapping leaves

Count the number of nonwrapping leaves (fallen leaves are not counted).

Anthocyanin pigmentation induced by low temperature

Except for red cabbage, the degree of anthocyanin pigmentation of nonwrapping leaves induced by low temperature is classified into 1: absent, 3: light, 5: intermediate, 7: deep. Ex.– 3: FW, 5: OG, 7: NB, K1.

Blooming

Degree of blooming of nonwrapping leaves is classified into 1: absent, 3: slight, 5: intermediate, 7: pronounced. Ex.– 3: FW, SS, 5: YS, SE, 7: NB, FB.

Undulation of leaf margin

Degree of undulation of the marginal area of nonwrapping leaves is classified into 1: absent, 3: slight, 5: intermediate, 7: pronounced. Ex.– 3: K1, 5: OG, 7: SS.

Undulation of whole leaves

Degree of undulation of whole area of nonwrapping leaves is classified into 1: absent, 3: slight, 5: intermediate, 7: pronounced. Ex.– 3: YS, 5: SE, 7: FW, KK.

Blistering

Degree of blistering of nonwrapping leaves is classified into 1: absent, 3: slight, 5: intermediate, 7: pronounced. Ex.– 7: SK (Savoy cabbage)

Distinctness of veins

Degree of distinctness of veins of nonwrapping leaves is classified into 3: negligible, 5: intermediate, 7: prominent. Ex.– 3: JW, 5: YS, SE, 7: NB.

Size of nonwrapping leaf

Size of the largest nonwrapping leaf is classified into 3: small, 5: intermediate, 7: large. Ex.– 3: CM, 5: YS, SE, 7: NB, FB.

Petiole length

Measure petiole length of the largest nonwrapping leaf (in centimeters).

Petiole shape

Petiole of the largest nonwrapping leaf is cut into half at the center and the shape of the transverse section is classified into 3: flat, 5: intermediate, 7: round. Ex.– 5: YS, BR, 7: FW, KK.

Stem length

Measure stem length from the ground level to the bottom of the head (in centimeters).

Shape of head top

Shape of head top is classified into 1: flat, 3: semi-flat, 5: round, 7: pointed. Ex.– 1: YS, OG, 3: NB, BR, 5: CM, 7: JW.

Shape of head bottom

Shape of bottom of head is classified into 3: flat, 5: round, 7: obovate. Ex.– 3: YS, SE, 5: CM.

Color of head top

Except for red cabbage, basic color of head top is classified into 1: yellowish green, 3: light green, 5: green, 7: dark green. Ex.– 3: FW, SS, 5: NB, Y5.

Core length

Measure core length (in centimeters).

Solidity

Solidity is evaluated by the amount of space in head occupied by leaves observed in the vertical section and classified into 3: loose (space over and around the core is not filled), 5: intermediate (only the space around the core is not filled), 7: dense (almost filled), 9: very dense. Ex.– 7: SS, 9: RB.

Exposure

The degree of exposure of heads from surrounding nonwrapping leaves is classified into 1: not exposed, 3: slightly exposed, 5: intermediate, 7: widely exposed. Ex.– 1: BR, 3: NB, FB, 5: FW, KK, 7: CM.

Cracking

Based on the duration from the optimum date of harvest to 10% head cracking, the earliness of cracking is evaluated and classified into 3: early, 5: intermediate, 7: late. Ex.– 3: FW, KK, 5: YS, SE, 7: NB, BR.

Premature bolting

Calculate the frequency of premature bolting (in percentage).

2. Secondary characters

<Essential items>

Resistance to *Fusarium* yellows

Resistance to *Fusarium* yellows is classified based on natural infecion or artificial inoculation into 1: low, 5: Type-B high, 9: Type-A resistant. Ex.– 1: OG, 9: Y5.

Resistance to clubroot

Degree of resistance to clubroot is classified based on natural infection or artificial inoculation into 3: low, 5: intermediate, 7: high.

Resistance to viruses

Degree of resistance to viruses based on natural infection or artificial inoculation into 3: low, 5: intermediate, 7: high.

Resistance to soft rot

Degree of resistance to soft rot is classified based on natural infection or artificial inoculation into 3: low, 5: intermediate, 7: high.

Resistance to black rot

The degree of resistance to black rot is classified based on natural infection or artificial inoculation into 3: low, 5: intermediate, 7: high.

<Optional items>

Resistance to diamondback moth

Degree of resistance to diamondback moth is classified based on natural infecion into 3: low, 5: intermediate, 7: high.

Resistance to aphids

Degree of aphid resistance is classified based on natural infection into 3: low, 5: intermediate, 7: high.

Shelf life

Shelf life is evaluated based on the duration of the period during which marketable quality of harvested heads is maintained at room temperature and classified into 3: short, 5: intermediate, 7: long. Ex.- 3: SS, 5: YS, SE, 7: NB, FB.

Heading ability at high temperature

Head formation and solidity at high temperatures is classified into 3: low, 5: intermediate, 7: high. Ex.– 5: YS, 7: SS.

Low temperature tolerance

Low temperature tolerance is classified based on the degree of low temperature injury into 3: low, 5: intermediate, 7: high. Ex.– 3: SS, 5: YS, 7: NB, FB.

Heading ability at low temperature

Heading ability at low temperatures is classified based on head formation and head solidity at low temperatures into 3: low, 5: intermediate, 7: high. Ex.– 3: SS, 5: YS, 7: NB, OG.

Tolerance to excess soil water

Tolerance to excess soil water is classified based on the degree of retardation or abnormality of growth into 3: low, 5: intermediate, 7: high. Ex.– 3: CM, 5: FW.

3. Tertiary characters

<Essential items>

Head weight

Nonwrapping leaves of five medium size heads are trimmed into marketable conditions and these heads are weighed (in grams).

Brix value

Squeeze juice from outer three heading leaves of five heads and measure Brix value of juice with a Brix meter.

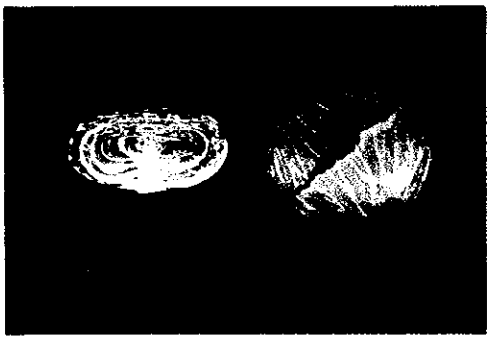
<Optional items>

Processing suitability

Degree of suitability to a certain type of processing is classified into 3: low, 5: intermediate, 7: high. The type(s) and procedure(s) of processing must be recorded.

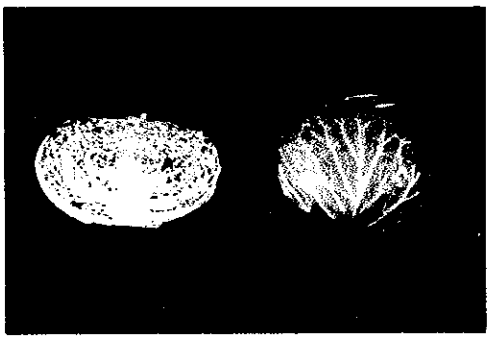
Taste

General taste quality is classified by sensorial evaluation into 3: poor, 5: intermediate, 7: good.



No. 1

No. 3



No. 2

No. 4

Photo. 1 Head shape and solidity.
Head shape: 1-flat, 2-semi flat, 3-circular, 4-pointed elliptic.
Solidity: 1-loose, 2-intermediate, 4-loose.

II. Spinach

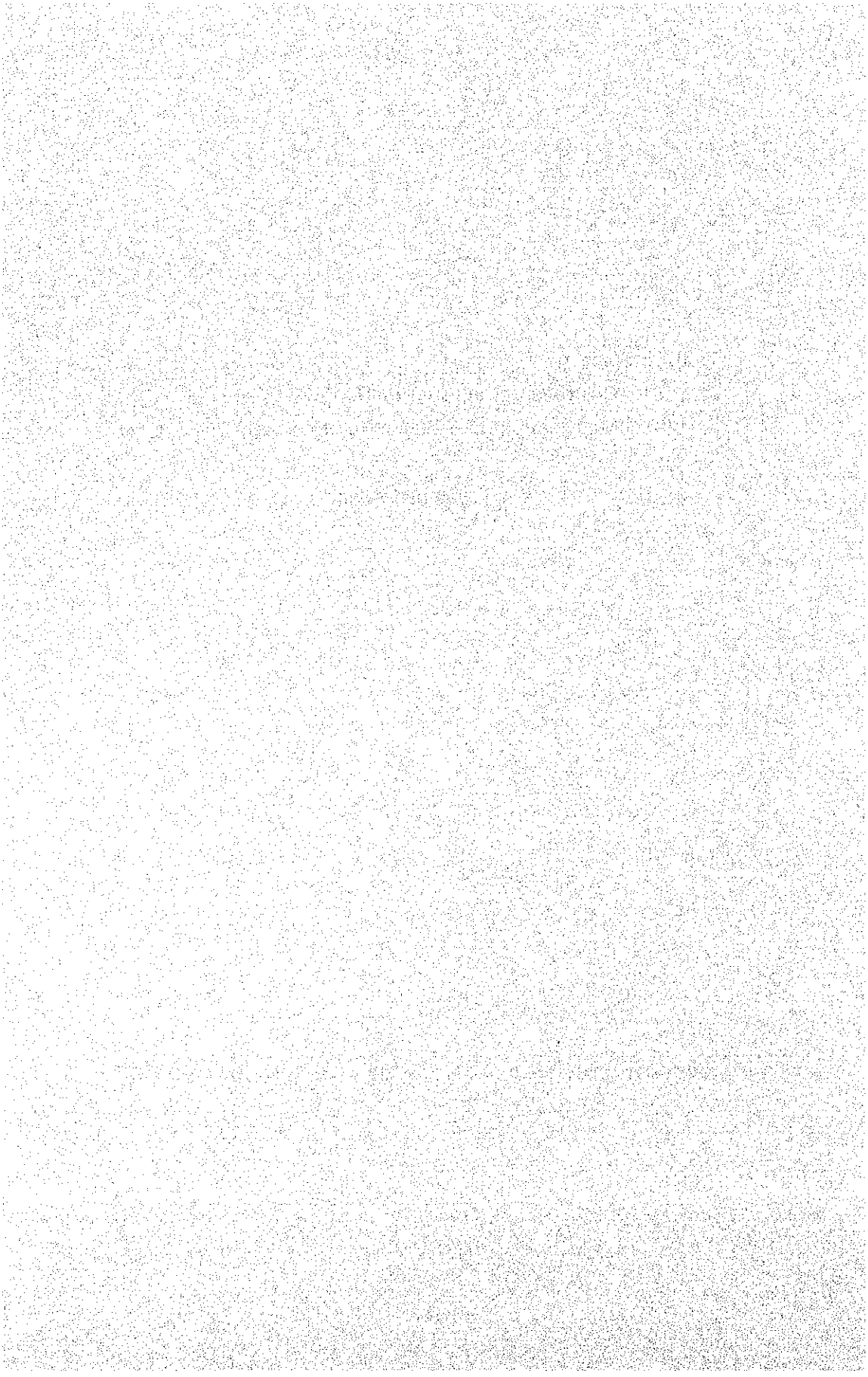
II-1. Cultivation of spinach PGR

II-2. Evaluation of characteristics of spinach PGR

by

Toyamasa Anan

National Research Institute of Vegetables, Ornamental Plants and Tea, MAFF, Ano, Mie 514-23 JAPAN



II-1. Cultivation of spinach PGR

1. Cultivation patterns and methods

Spinach is a hardy crop in cool-season. Optimum temperatures for growth and germination of spinach are in the range of 15 ~ 20°C. Although seeds of spinach germinate well even at a temperature lower than 5°C, it takes around 24 days. High temperatures lead to spinach bolting, especially under long day conditions.

Spinach is a short-duration crop, which matures within 6 to 7 weeks, depending on the climatic conditions. If spinach is sown in the late season, growth of spinach is retarded, and plastic covering may become effective.

In a hot and rainy season, spinach in open-field cultivation is frequently damaged by diseases or rain. Therefore, during this season, spinach is grown in a greenhouse or under plastic covering, although growth is reduced by high temperatures.

Enough care should be taken for the control of ventilation to lower temperatures inside the houses. So-called rain sheltering cultivation is being practiced extensively.

2. Preparation of fields

Spinach can grow on a wide range of soils, but optimum yield is obtained on heavy loam. Setting of drainage and supply of organic materials are necessary. Plowing at a depth of at least 20 cm and thorough harrowing are necessary for field preparation. In irrigated cultivation, levelling of seed beds is necessary to enable water to flow evenly.

3. Fertilizer application

Spinach is very sensitive to the acidity of soil. Spinach is severely injured at pH below 5.0. Spinach cannot grow well on acid soil with a pH below 5.5. Soil should be kept in a range of pH 6.5 ~ 7.0 for normal growth. For the correction of soil acidity, lime can be applied.

Recommended application rates of N, P and K range from 20 to 25, from 10 to 15 and from 15 to 20kg/10a, respectively.

4. Sowing seeds

Seeds are sown on flat rows or low ridges in areas with relatively scarce rainfall or in fields with good drainage. However, in areas with frequent rainfall, seeds are sown on high ridges.

In ridge planting, ridge 70 ~ 80 cm wide with paired row seeding and interrow space of 20 ~ 25 cm is recommended. Intrarow space should be 3 ~ 5 cm, and row length more than 3 m.

To get uniform emergence, seeds are immersed (for 24 hours) in water for forced sprouting. Sowing depth is usually 7 ~ 8 mm, and depth of soil covering varies with soil types and soil conditions.

More than two replications of experimental plots are necessary.

5. Irrigation and drainage

Spinach roots are shallow. If irrigation is not available in a dry season, spinach experiences water stress. For the germination of spinach, ample supply of water is necessary.

As spinach is sensitive to over-watering or water-logging, setting of drainage is necessary at the time of seed bed preparation or tillage.

6. Control of insect pests and diseases

<Insects>

Aphids (*Myzus persicae, Aphis gossypii*) injure spinach plants by sucking. Injury leads to curling of leaves and stunting. Aphids also injure spinach as carrier of mosaic virus. Winged forms of aphid fly into spinach fields and produce the successive generations.
Effective aphid control is carried out by dusting or spraying of chemicals, when the infestation is not severe. Malathion is currently used. The control of weed hosts is recommended.

<Diseases>

Downy Mildew, caused by *Peronospora effusa* and known as blue mold, may cause serious losses under foggy or rainy weather. When the symptoms appear, the disease can be controlled by the spray of zineb or maneb.

Mosaic blight is a virus disease and young inner leaves of affected plants become mottled, crinkled, and yellowish, and eventually die. The virus is transmitted by aphids. Therefore, control of aphids is important.

Damping-off is caused by several species of soil fungi (*Pythium* spp. and others). Very young seedlings die due to this disease, resulting in failure to extrude from seeds. This disease can be controlled by seed treatment.

To achieve rapid germination without damage, seeds should be soaked in water for 24 hours, dried, and then dusted with thiram (34%), captan (1%), or dichlone (1%). Sowing of these seeds should be carried out without delay. Spray of Mepronil or captan is also effective at sowing or sprouting time.

II-2. Evaluation of characteristics of spinach PGR

1. Primary characters

<Essential items>

Shape of seed

Shape of seed is observed for 100 grains and classified into 1: smooth-seed, 3: ratio of smooth-seed and prickly-seed is about 3:1, 5: ratio of smooth-seed and prickly-seed is about 1:1, 7: ratio of smooth-seed and prickly-seed is about 1:3, 9: prickly-seed.

Plant attitude

Plant attitude is observed during the growth period, and classified into 3: close, 4: rather close, 5: intermediate, 6: rather spreading, 7: spreading. The observation is carried out for 30 plants.

Number of leaves

Number of leaves is counted at harvest stage, and the average values of 20 plants are recorded.

Length of leaf

Length of the largest leaf blade is measured at harvest stage. Average values of 20 plants are expressed in cm.

Width of leaf

Width of the largest leaf blade is measured at harvest stage. Average values of 20 plants are expressed in cm.

Color of leaf

Color of the largest leaf blade is observed and classified into 1: extremely light green, 2: lighter green, 3: light green, 4: rather light green, 5: green, 6: rather dark green, 7: dark green, 8: darker green, 9: extremely dark green. The observation is carried out for 20 plants at harvest stage.

Wrinkles of leaf

Wrinkles of the largest leaf blade are observed and classified into 0: absent, 1: extremely few, 2: considerably few, 3: few, 4: rather few, 5: intermediate, 6: rather many, 7: many, 8: considerable number, 9: very large number. The observation is carried out for 20 plants at harvest stage.

Lobation of leaf margin

Lobation of largest leaf margin is observed and classified into 0: absent, 1: extremely shallow, 2: considerably shallow, 3: shallow, 4: rather shallow, 5: moderate, 6: rather deep,

7: deep, 8: considerably deep, 9: extremely deep. The observation is carried out for 20 plants at harvest stage.

Shape of leaf

Shape of the largest leaf is observed and classified into 2: Nippon type, 3: Ujoh type, 5: King of Denmark type, 7: Novel type, 8: Yuugiri type (Fig. 1). The observation is carried out for 20 plants at harvest stage.

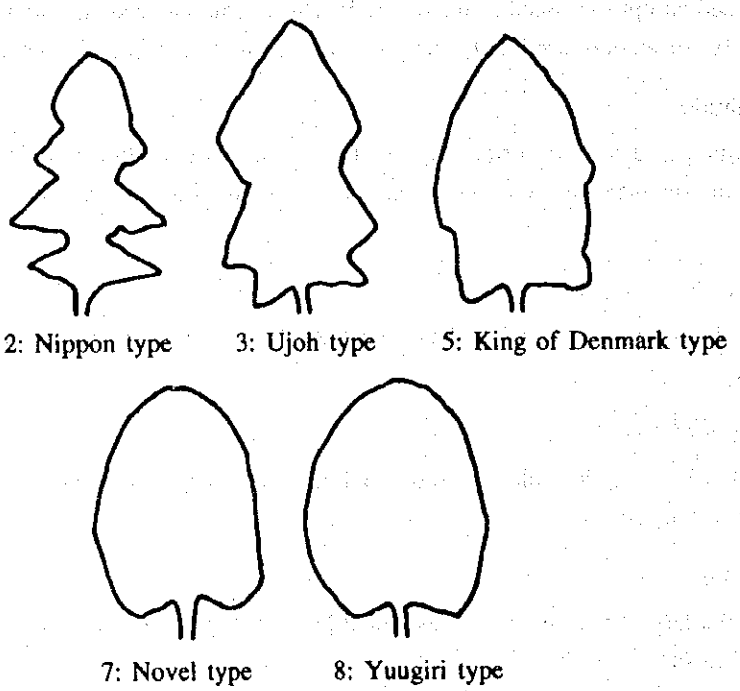


Fig. 1 Shape of leaf.

Color of main root

The pigmentation due to the presence of anthocyanin on the main root is observed and classified into 0: absent, 1: extremely light, 2: considerably light, 3: light, 4: rather light, 5: intermediate, 6: rather deep, 7: deep, 8: considerably deep, 9: extremely deep. The observation is carried out for 20 plants at harvest stage.

<Optional items>

Luster of leaf

Luster of the largest leaf blade is observed and classified into 1: extremely low, 2: considerably low, 3: low, 4: rather low, 5: intermediate, 6: rather high, 7: high, 8: considerably high, 9: extremely high. The observation is carried out for 20 plants at harvest stage.

Shape of leaf tip

Shape of tip of the largest leaf is observed and classified into 1: sharp, 3: rather sharp, 5: intermediate, 7: rather round, 9: round. The observation is carried out for 20 plants at harvest stage.

Length of petiole

Length of petiole of the largest leaf is measured at harvest stage. The average values of 20 plants are expressed in cm.

Thickness of petiole

Thickness of petiole of the largest leaf is measured at harvest stage. The average values of 20 plants are expressed in mm.

Color of proximal part of petiole

The pigmentation due to the presence of anthocyanin on the proximal part of petiole is observed and classified into 0: absent, 1: extremely light, 2: considerably light, 3: light, 4: rather light, 5: intermediate, 6: rather deep, 7: deep, 8: considerably deep, 9: extremely deep. The observation is carried out for 20 plants at harvest stage.

Thickness of mesophyll

Thickness of mesophyll is observed and classified into 1: extremely thin, 2: considerably thin, 3: thin, 4: rather thin, 5: intermediate, 6: rather thick, 7: thick, 8: considerably thick, 9: extremely thick. The observation is carried out for 20 plants at harvest stage.

2. Secondary characters

<Essential items>

Earliness of growth

Number of days from sowing to harvest is counted, and the average values of 30 plants are recorded.

Earliness of bolting

Beginning of bolting is observed and classified into 1: extremely early, 2: considerably early, 3: early, 4: rather early, 5: intermediate, 6: rather late, 7: late, 8: considerably late, 9: extremely late. The observation is carried out for 30 plants.

Resistance to downy mildew *(Peronospora effusa)*

Resistance to downy mildew is evaluated based on the presence of symptoms induced by natural infection or inoculation test, and classified into 1: extremely low, 2: considerably low, 3: low, 4: rather low, 5: intermediate, 6: rather high, 7: high, 8: considerably high, 9: extremely high. The observation is carried out for 30 plants.

<Optional items>

Number of tillers

Number of tillers per plant is counted at harvest stage, and the average values of 30 plants are recorded.

Cold tolerance

Cold tolerance is evaluated based on the degree of tip burn of leaves, the extent of peeled leaf surface and the degree of elongation of leaf, and classified into 1: extremely low, 2: considerably low, 3: low, 4: rather low, 5: intermediate, 6: rather high, 7: high, 8: considerably high, 9: extremely high. The observation is carried out for 30 plants.

Resistance to virus diseases

Resistance to virus diseases is evaluated based on the presence of symptoms induced by natural infection or inoculation test, and classified into 1: extremely low, 2: considerably low, 3: low, 4: rather low, 5: intermediate, 6: rather high, 7: high, 8: considerably high, 9: extremely high. The observation is carried out for 30 plants.

Tolerance to molybdenum deficiency

Tolerance to molybdenum deficiency is evaluated based on the degree of natural occurrence, and classified into 1: extremely low, 2: considerably low, 3: low, 4: rather low, 5: intermediate, 6: rather high, 7: high, 8: considerably high, 9: extremely high. The observation is carried out for 30 plants.

3. Tertiary characters

<Essential items>

Weight of hill

Weight of hill is measured at harvest stage, and the average values of 30 plants are expressed in g.

<Optional items>

Taste

Two minutes after boiling, the tenderness, fibrousness and sweetness are scored by the sensory test. From the comprehensive evaluation of the above-mentioned parameters, taste is classified into 1: poor, 2: rather poor, 3: suitable, 4: rather good, 5: good, 6: rather superior, 7: superior, 8: considerably superior, 9: extremely superior. Tests are carried out for 30 plants.

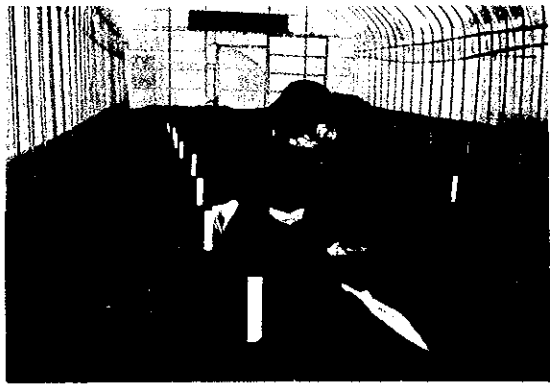


Photo. 1 Hill seeding of spinach.

Photo. 2 Sprouting of spinach (about two weeks after sowing).

Photo. 3 Developed spinach (just before harvest; about 6 weeks after sowing).

III. Onion

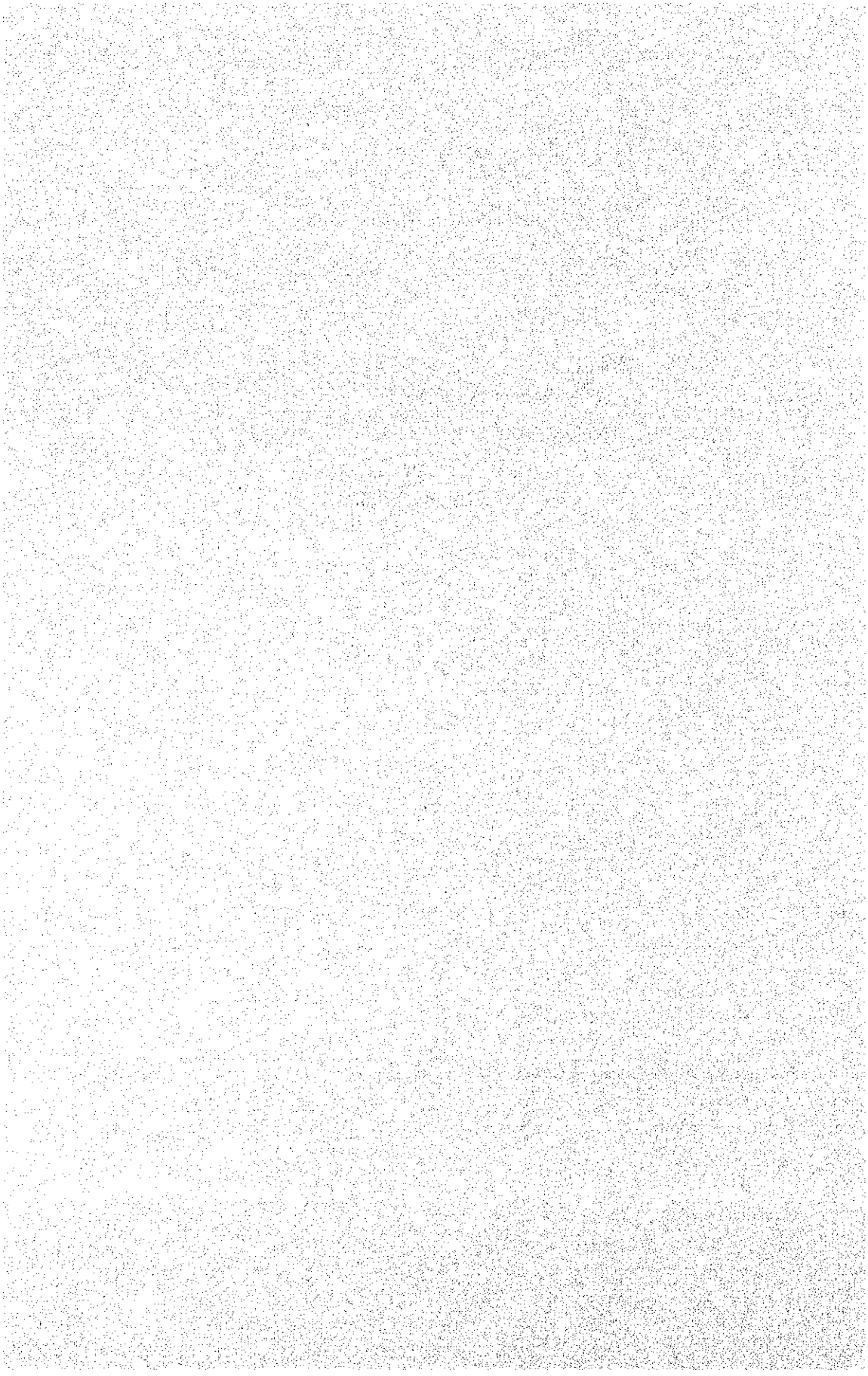
III-1. Cultivation of onion PGR

III-2. Evaluation of characteristics of onion PGR

by

Yutaka Satoh

Hokkaido National Agricultural Experiment Station, MAFF, Sapporo 062 JAPAN



III-1. Cultivation of onion PGR

Sowing seasons for onions are fall or spring. In subtropical areas, onion is defined as a short-day or intermediate-day crop; onions are sown in fall and harvested in spring or summer. There are three methods of cultivation of onion: sowing seeds, planting seedlings, and planting dry sets.

Higher yield with reliable seedling establishment can be obtained by transplanting than by direct sowing.

I. Preparation of seedlings

Preparation of bed soil

Seed bed 400 ~ 500 m^2 in size is necessary for an onion field of one hectare. Nitrogen, 1.8 ~ 2.3 kg/a, phosphorus, 1.5 ~ 2.3 kg/a and potassium, 1.0 ~ 1.5 kg/a are applied to the seed beds.

Sowing

About 4 ~ 7 liters of seeds are necessary for one hectare of onion field. Seeds are sown in rows 6 to 8 cm apart.

Nursing management

Following gemination, seedlings are thinned to 1.2 to 1.3 cm apart. Fifty to 70 days after sowing, seedlings reach approximately a height of 25 ~ 30 cm, a thickness of 0.6 ~ 0.8 cm at the pseudostems and a weight of 4 ~ 6 g.

2. Preparation of open field

Field is plowed while the soil is moist. Then, field is harrowed to obtain fine soil for the seed bed. If the pH of soil is lower than 5.5, lime is broadcasted at a rate of 1 t/ha. Well-fermented poultry manure is applied at a rate of 20 t/ha. The preparation of the field should be completed two weeks before transplanting. Nitrogen at the rate of 150 ~ 250 kg, phosphorus at the rate of 200 ~ 250 kg and potassium at the rate of 150 ~ 250 kg per hectare are applied at final tillage.

3. Transplanting

In fall sowing, seedlings are transplanted to the field from October to December. In spring sowing, seedlings are transplanted as early as possible in spring depending on the weather conditions. Seedlings with pseudostems approximately 0.6 ~ 0.8 cm thick and weighing 4 ~ 6 g are suitable for transplanting. Plants are spaced 12 to 15 cm apart, with a row distance of 25 to 30 cm (250,000 ~ 350,000 plants per hectare). Base of stems of seedlings is set at 2 to 2.5 cm below the soil surface.

4. Management of open field

watering

In tropical and subtropical areas, watering is recommended after transplanting.

Control of diseases and insects

Downy mildew, *Alternaria* leaf spot, gray-mold neck rot, rust, *Phytophthora* blight, smut, *Fusarium* basal rot, bacterial soft rot and yellow dwarf are serious problems. To control airborne diseases, some kinds of fungicides are sprayed in combination with insecticides.

Weed control

The most effective method of weed control is the implementation of a combined program, consisting of conservative use of herbicides and rotation with other crops.

5. Harvest

Onions are pulled by hand when 60 to 70% of foliage of the plants have decayed. Bulbs are laid in row in the field. If the soil is damp, onions are pulled and soil is removed to prevent rerooting. Bulbs are left in rows 1 to 2 weeks before collection. After drying, leaves are removed and onions are packed into nets or boxes.

6. Storage

Bulbs are kept in a storage room at 3 ~ 5°C

III-2. Evaluation of characteristics of onion PGR

I. Primary characters

<Essential items>

Shape of full-grown bulbs

Classify the bulb shape into 1: T, 2: 0T, 3: 0, 4: 0A, 5: A, 6: H (Fig. 1). Bulb shape is also characterized in terms of bulb height and diameter. Calculate the height/diameter ratio (shape index).

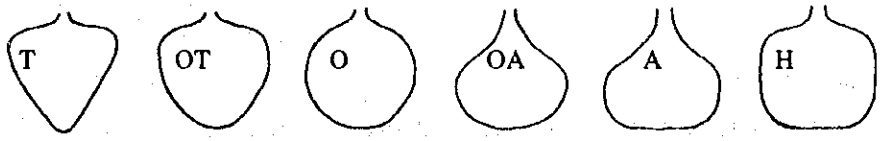


Fig. 1 Shape of onion bulbs.

Bulb skin color

Classify color of onion bulb skin into 3: yellow, 5: red, 7: white.

Bulb firmness

Classify firmness of onion bulb into 3: soft, 5: intermediate, 7: hard.

Plant height

Measure the plant height for 20 plants at the bulbing stage.

Leaf number

Count the number of leaves for 20 plants at the bulbing stage.

Date of bulbing

Examine the date when 40 ~ 50% of the plants are bulbing. Bulbing stage corresponds to the time when the diameter of the bulb becomes twice as large as the diameter of sheath.

<Optional items>

Sheath diameter

Measure the sheath diameter for 20 plants with calipers.

Plant type

Classify the plant type into 3: spreading, 5: intermediate, 7: erect.

Date of top down

Examine the date when 40 ~ 50% of the plants are falling down.

Bolting rate

Count the number of bolting plants among 90 ~ 100 plants and change into percentage.

Thickness of bulb skin

Evaluate thickness of bulb skin into 1: thin, 2: intermediate, 3: thick.

Flesh color of bulb

Classify flesh color of bulb into 1: white, 2: pale yellow, 3: pale yellow ~ pale purple, 4: pale red.

Uniformity of bulb

Evaluate uniformity of bulb into 3: low, 5: intermediate, 7: high.

Scale number

Measure the number of scales of 10 bulbs.

2. Secondary characters

<Essential items>

Storability

Store 90 ~ 100 bulbs and three or six months later, count the number of marketable bulbs after removing sprouting bulbs, rooting bulbs and rotten bulbs. Based on the percentage of marketable bulbs, classify the storability into 3: low, 5: intermediate, 7: high.

<Optional items >

<RESISTANCE TO LEAF DISEASE>

Based on the symptoms in a field infected with leaf diseases, classify resistance to downy mildew (*Peronospora destructor*), leaf rot (*Botrytis squamosa, B. cinerea*) and purple blotch (*Alternaria porri*) into 3: low, 5: intermediate, 7: high. Symptoms of the respective leaf diseases are as follows.

Downy mildew *(Peronospora destructor)*

Leaves of infected plants bend outward. Leaf lesions are long with a pale yellow, glazed appearance; sporulation on these lesions produces a thick grey to purple felt of conidiophores (R. B. Maude, 1990).

Leaf rot *(Botrytis squamosa)*

Severe symptoms include the die-back of onion leaf tips and leaves. On these necrotic tissues conidiophores and conidia are produced (R. B. Maude, 1990).

Purple blotch *(Alternaria porri)*

Small white sunken spots develop on leaves. These spots enlarge and become zonate. Under moist conditions, they turn purple and are surrounded by a broad chlorotic margin (R. B. Maude, 1990).

<RESISTANCE TO INSECT PESTS>

Based on the degree of damage in the field caused by insect pests, classify resistance to onion fly (*Delia antiqua*) and onion thrips (*Thrips tabaci*) into 3: low, 5: intermediate, 7: high. The damage caused by the respective insect pests is described as follows.

Onion fly *(Delia antiqua)*

The first sign of damage consists of wilting of leaves, which become yellowish and flaccid. Eventually, the whole plant collapses and dies. The onion fly emerges later (S. K. Soni and P. R. Ellis, 1990).

Onion thrips (*Thrips tabaci* Lindeman)

Thrips cause highly characteristic damage, such as silvery patches and streaks on leaves and pseudostems, which shine in the sun (S. K. Soni and P. R. Ellis, 1990).

<RESISTANCE TO ROOT DISEASE>

Based on the symptoms in a field infected with root diseases, classify resistance to white rot (*Sclerotium cepivorum*), Fusarium basal rot (*Fusarium oxysporum*), pink root (*Phoma terrestris*) and onion smut (*Urocystis colchici*) into 3: low, 5: intermediate, 7: high.
The symptoms of the respective root diseases are follows.

White rot *(Sclerotium cepivorum)*

Infection leads to the wilting of young plants and the symptoms are similar to those of onion fly. As the plants become larger, the wilt may be confined to the older leaves. If plants are subjected to water deficit, foliar symptoms develop even in large plants. Characteristically, the tips of the older leaves turn yellow and lose turgor, and eventually the plant dies (A. R. Entwistle, 1990).

Fusarium basal rot *(Fusarium oxysporum)*

Emergence of seedlings is delayed. The symptoms consist of damping off of seedlings, stunted growth and basal rotting in growing plants, accompanied by premature maturation and basal rotting in growing plants (A. R. Entwistle, 1990).

Pink root *(Phoma terrestris)*

The roots show a characteristic pink discoloration. The number and size of leaves are reduced, and bulbing starts early, resulting in final bulbs with a small size. Foliar symptoms are similar to those of drought stress. Chlorotic leaf dies back and wilts (A. R. Entwistle, 1990).

Onion smut *(Urocystis colchici)*

Dark streaks are formed within cotyledons and foliage leaves and later the host tissues rupture releasing masses of dark teliospores. The bulbs of infected plants fail to reach a marketable size (A. R. Entwistle, 1990).

<RESISTANCE TO STORAGE DISEASES>

Store 90 ~ 100 bulbs and examine rotten bulbs three months later. If rotten bulbs are detected, cut the bulbs and observe the symptoms on a cross section. Based on the percentage of diseased bulbs, classify the resistance into 3: low, 5: intermediate, 7: high.
The symptoms of the respective storage diseases are as follows.

Neck rot *(Botrytis allii)*

Necks of infected bulbs become soft and a mass of black sclerotia (1 to 5 mm diameter) develops beneath the skin of onion. Conidiophores of fungus produce a gray mold on the lateral part of bulbs below sclerotia. The cross section of infected tissues is brown (R. B. Maude, 1990).

Bacterial rot *(Pseudomonas alliicola)*

When diseased bulbs are cut, some of the main storage scales are brown and water-soaked, with a cooked appearance. When pressure is applied to the base of the bulbs, the center of the core may be ejected, hence the name "slippery skin".

Bacterial rot *(Pseudomonas cepacia)*

P. cepacia attacks only the outer storage scales of onion. The infected scales are yellow and slimy. Bulbs show a vinegary and sour smell, hence the term "sour skin" (R. B. Maude, 1990).

Fusarium basal rot *(Fusarium oxysporum)*

Basal rot affects roots, basal plates and the storage tissues of the lower part of bulbs. Basal rot produces a whitish mold which grows upwards in the storage tissues of bulbs. No sclerotia are produced, in contrast to white rot (R. B. Maude, 1990).

White rot *(Sclerotium cepivorum)*

White rot, unlike neck rot, affects the base of onion bulbs where it produces a white mycelium containing numerous small black sclerotia, 0.3 to 0.5 mm in diameter (R. B. Maude, 1990).

3. Tertiary characters

<Essential items>

Dry matter percentage

Transverse sections one cm thick across the center of five bulbs are dried until the weight becomes almost constant at 70°C in a forced draught oven. Measure the weight after cooling in a desiccator. Calculate the ratio of dry matter to fresh weight.

Pungency

Pungency is classified into 3: weak, 5: intermediate, 7: strong.

References

Entwistle, A.R. (1990) Onions and allied crops. Editors, Haim D. Rabinowitch, James L. Brewster. Vol. 2 pl03-154.

Maude, R.B. (1990) Onions and allied crops. Editors, Haim D. Rabinowitch, James L. Brewster. Vol. 2 pl73-189.

Soni, S.K. and P.R. Ellis (1990) Onions and allied crops. Editors, Haim D. Rabinowitch, James L. Brewster. Vol. 2 p213-271.

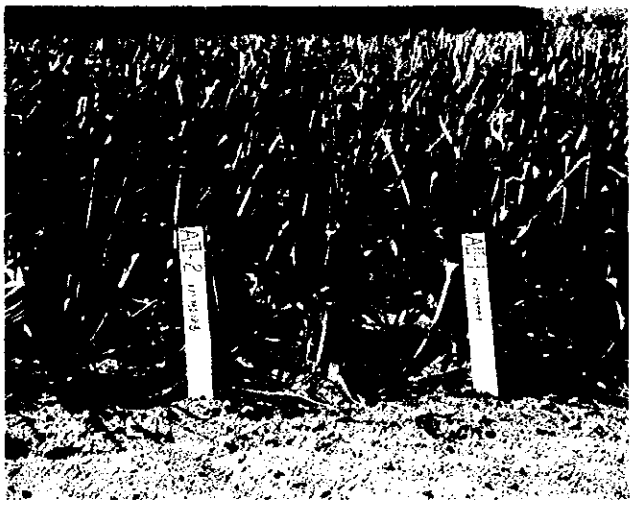


Photo. 1 Onion genetic resources in the evaluation field.

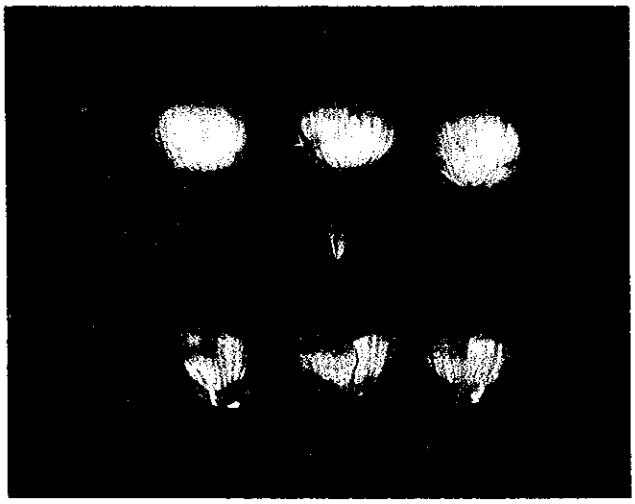


Photo. 2 Varietal differences in the storability of onion.

IV. Lettuce

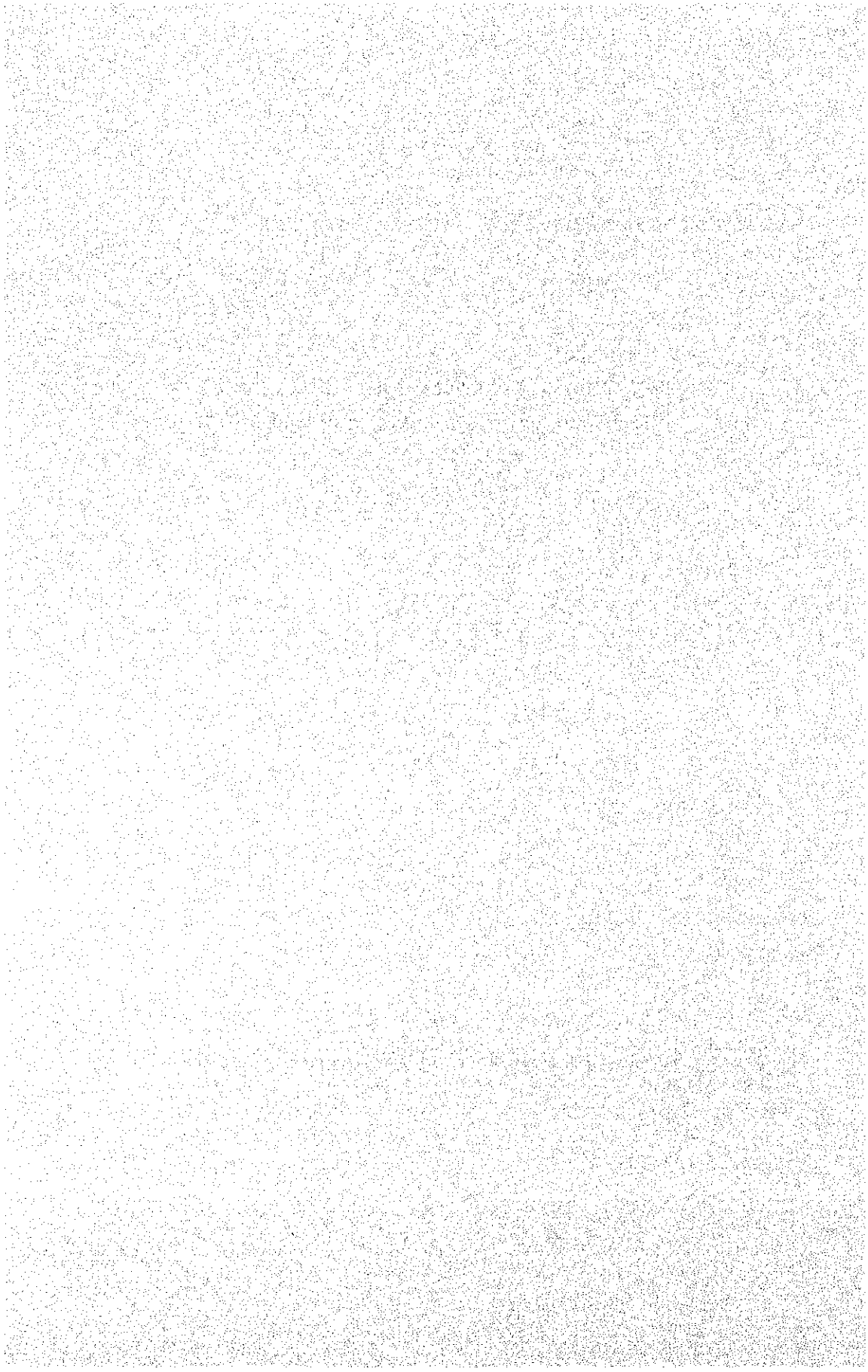
IV-1. Cultivation of lettuce PGR

IV-2. Evaluation of characteristics of lettuce PGR

by

Isamu Igarasi

Morioka Branch, National Research Institute of Vegetables, Ornamental Plants and Tea, MAFF,
Morioka 020-01 JAPAN



IV-1. Cultivation of lettuce PGR

1. General properties

Lettuce is a cool season crop. Daytime temperature in the range of 15 ~ 20°C and night temperature in the range of 10 ~ 15°C are suitable for the growth of lettuce. Daytime temperatures above 25°C cause severe deterioration of quality, such as, early seedstalk formation, deformation and decay.

2. Sowing and nursery preparation

Optimum sowing season is from March to April in the warmer region of Japan and from April to May in the cooler region. However, it is important to identify varietal differences in the bolting behavior by late time sowing in each region.

In order to achieve uniform germination, sowing should be performed on fine soil, and the temperature after sowing needs to be below 25°C, because germination is inhibited above 26°C.

Transplanting is carried out at the first leaf half opening stage in paper pots 3.5cm in width and 3.8cm in height.

3. Planting

Planting is carried out at the 3 ~ 4 leaf stage on two rows at a spacing of 27cm between plants using black mulching film, at a distance of 110cm between beds. Fifteen kg/10a of N, P_2O_5, K_2O by net content are applied.

4. Size of plot and plant protection

Evaluation is carried out using ten plants of each accession with 2 ~ 3 replications. Soil insecticides are applied for the prevention of soil worms just after planting. Fungicides and insecticides are applied periodically after July, when bacterial, fungal diseases and larvae of moths prevail.

IV-2. Evaluation of characteristics of lettuce PGR

1. Primary characters

<Essential items>

Leaf shape

The largest leaf from heads is classified at harvest into 1: acute oblong, 2: oblong, 3: round, 4: scallop shape, 5: oblate. Aka Kakichisha is classified into 1, Parris Island Cos into 2, White Boston into 3, Salad Bowl into 4, Great Lakes 366 into 5. Refer to Fig. 1.

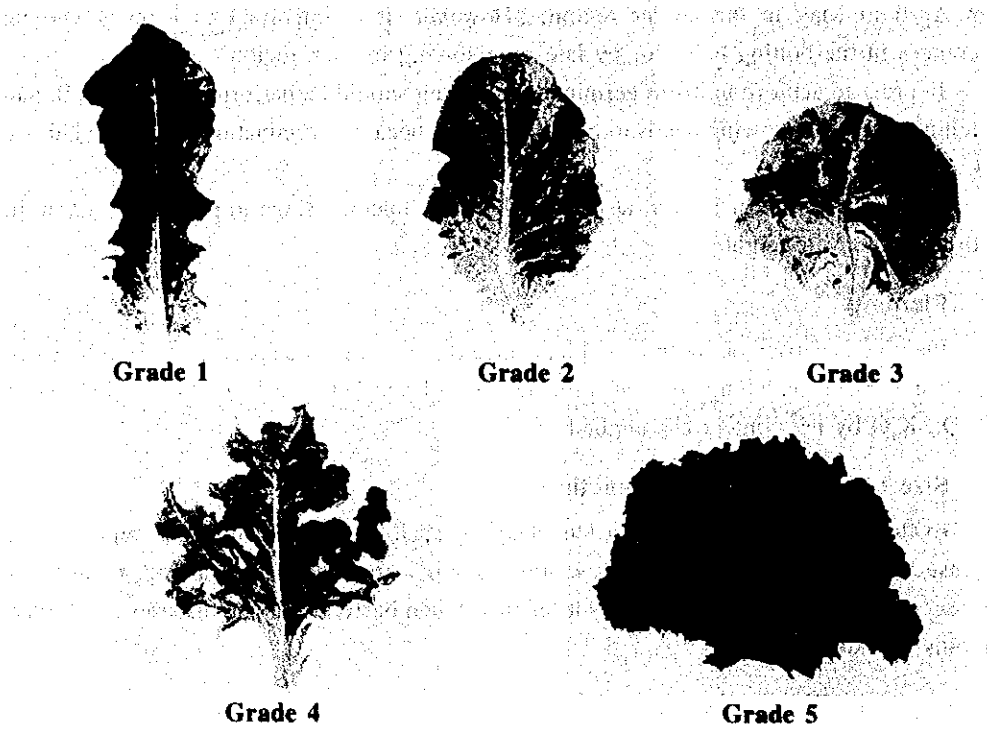


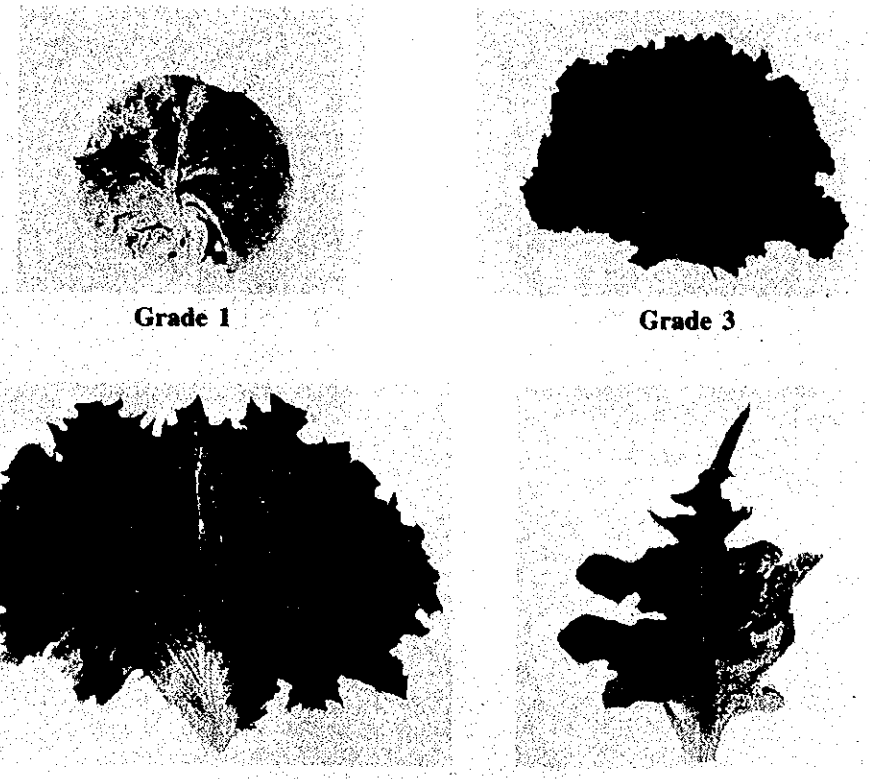
Fig. 1 Leaf shape.

Leaf color

Leaf color is classified at harvest (color chart indication should also be recorded) into 1: yellow, 2: light green, 3: green, 4:dark green. Black Seeded Simpson is classified into 1, White Boston into 2, Olympia into 3, Parris Island Cos into 4.

Lobe of leaf

Lobe of leaf is classified at harvest into 1: absent, 3: shallow, 5: intermediate, 7: deep. White Boston is classified into 1, Great Lakes 366 into 3, Ithaca into 5, Oak Leaf into 8. Refer to Fig. 2.



Grade 1 Grade 3

Grade 5 Grade 8

Fig. 2 Lobe of leaf.

Leaf texture

Leaf texture is classified by the sensory test into 2: crisp, 4:intermediate, 6: soft.

Head formation character

Heading character is classified at harvest into 1: non-heading, 2: half-heading, 3: heading. Prize Head is classified into 1, Parris Island Cos into 2, Great Lakes 366 into 3.

Head shape

Head shape is classified at harvest into 3: flat, 5: globular, 7: cylindrical. Mikado Great 3204 is classified into 3, Calmar into 5, Parris Island Cos into 8. Refer to Fig. 3.

Grade 3

Grade 5

Grade 8

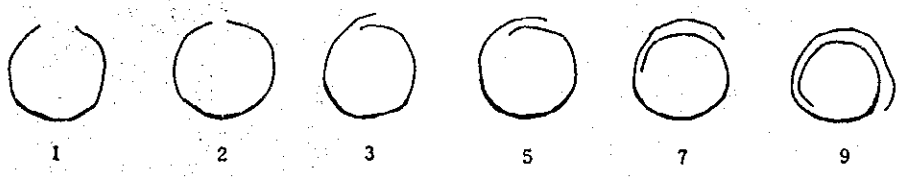
Fig. 3 Head shape.

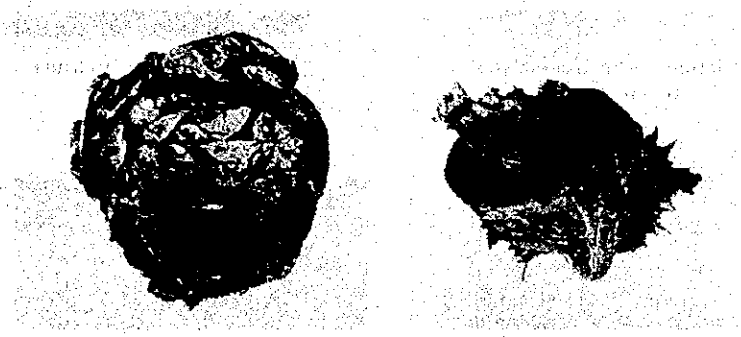
Head weight

Measure the weight of head and classify into 3: light (>400g), 5: intermediate (400g ~ 499g), 7: heavy (500g). Olympia is classified into 3, Great Lakes 366 into 5, Vanguard into 7.

Overlapping of head

Overlapping of head is classified at harvest into 1: absent, 2: shallow, 3: intermediate, 4: deep. White Boston is classified into 1, Olympia into 4. Refer to Fig. 4.





Grade 1 **Grade 4**

Fig. 4 Overlapping of head.

Core length

Measure length of core at harvest.

Earliness of maturity

Earliness of maturity is classified at harvest into 2: early, 4: intermediate, 6: late. White Boston is classified into 2, Olympia into 4, Vanguard into 6.

<Optional items>

Growth type

Growth type is classified at harvest into 1: cutting, 2: stem, 3: cos, 4: leaf, 5: butterhead, 6: crisphead. Aka Kakichisha is classified into 1, Celttuce into 2, Parris Island Cos into 3, Grand Rapid into 4, White Boston into 5, Great Lakes 366 into 6. Refer to Fig. 5.

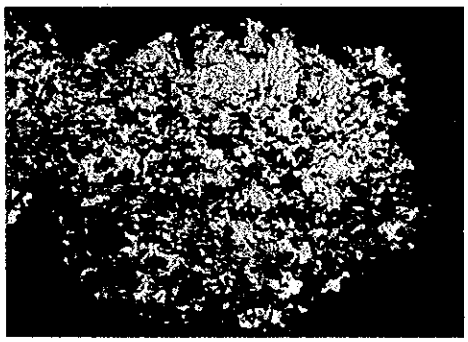
Plant attitude

Plant attitude is classified at harvest into 3: standing, 5: intermediate, 7: opening. Parris Island Cos is classified into 3, Black Seeded Simpson into 5, White Boston into 7.

Cutting lettuce 'Aka Kakichisha'
(Grade 1)

Stem lettuce 'Celttuce'
(Grade 2)

Cos lettuce 'Parris Island Cos'
(Grade 3)



Leaf lettuce 'Grand Rapid'
(Grade 4)

Butterhead lettuce 'White Boston'
(Grade 5)

Crisphead lettuce 'Great Lakes 366'
(Grade 6)

Fig. 5 Growth type.

Anthocyanin pigmentation of leaf

Anthocyanin pigmentation of leaves is classified at harvest into 1: absent, 3: light, 5: intermediate, 7: deep. Great Lakes 366 is classified into 1, Big Boston into 3, Prize Head into 7.

Glossiness of leaf

Glossiness of leaves is classified at harvest into 3: slight, 5: intermediate, 7: pronounced. Okayama Saradana is classified into 3, Prize Head into 5.

Ruffleness of leaf margin

Ruffleness of leaf margins is classified at harvest into 1: smooth, 3: slight, 5: intermediate, 7: pronounced. Oak Leaf is classified into 2, Salinas into 3, Celttuce into 5, Black Seeded Simpson into 7. Refer to Fig. 6.

Grade 3 **Grade 5** **Grade 7**

Fig. 6 Ruffleness of leaf margins.

Waviness of leaf

Waviness of leaves is classified at harvest into 1: absent, 3: slight, 5: intermediate, 7: pronounced. White Boston is classified into 1, Great Lakes 366 into 3, Ithaca into 7. Refer to Fig. 7.

Grade 3 **Grade 5** **Grade 7**

Fig. 7 Waviness of leaf.

Leaf length

Leaf length is measured at harvest.

Leaf width

Leaf width is measured at harvest.

Petiole width

Petiole width is classified at harvest into 3: narrow, 5: intermediate, 7: wide.

Petiole height

Height of petiole is classified at harvest into 3: low, 5: intermediate, 7: high.

Tactual sense of leaf

Tactual sense of leaves is classified at harvest into 1: stiff, 2: brittle, 3: elastic. Aka Kakichisha is classified into 1, Great Lakes 366 into 2, White Boston into 3.

Head color

Head color is classified at harvest into 3: light green, 5: green, 7: dark green. Great Lakes 366 is classified into 5, Parris Island Cos into 7.

Solidity of head

Solidity of head is classified at harvest into 1: loose, 3: fairly loose, 5: intermediate, 7: tight, 9: extremely tight. Parris Island Cos is classified into 3, White Boston into 5.

Diameter of head

Diameter of head is measured at harvest.

Head height

Height of head is measured at harvest.

Number of outer leaves

Number of outer leaves is counted at harvest.

Number of head leaves

Number of head leaves is counted at harvest.

Head distortion

Head distortion is classified at harvest into 3: minimal, 5: intermediate, 7: pronounced. Salinas is classified into 7.

Stem width

Width of stem is measured at harvest and classified into 3: small, 5: intermediate, 7: large. Great Lakes 366 is classified into 5.

Bolting date

Bolting date is classified into 3: early, 5: intermediate, 7: late. Prize Head is classified into 3, Great Lakes 366 into 5, Olympia into 7.

2. Secondary characters

<Essential items>

Seed dormancy

Seed dormancy is evaluated based on the germination rate induced by the acceleration treatment at 25°C, using two months old seeds after harvest.

Resistance to bacterial rot

Resistance to bacterial rot is classified into 3: low, 5: intermediate, 7: high.

Resistance to virus diseases

Resistance to virus diseases is classified into 3: low, 5: intermediate, 7: high.

Resistance to soft rot

Resistance to soft rot is classified into 3: low, 5: intermediate, 7: high.

<Optional items>

Seed thermodormancy

Seed thermodormancy is evaluated based on the germination rate induced by the acceleration treatment at 30°C, using two months old seeds after harvest.

Heat tolerance

Heat tolerance is classified into 3: low, 5: intermediate, 7: high. Olympia is classified into 5.

Cold tolerance

Cold tolerance is classified into 3: low, 5: intermediate, 7: high. Great Lakes 366 is classified into 5.

Drought tolerance

Drought tolerance is classified into 3: low, 5: intermediate, 7: high. Olympia is classified into 5.

Tolerance to excess soil moisture

Tolerance to excess soil moisture is classified into 3: low, 5: intermediate, 7: high. Great Lakes 366 is classified into 5.

Resistance to *Sclerotinia* disease

Resistance to *Sclerotinia* disease is classified into 3: low, 5: intermediate, 7: high.

Resistance to downy mildew

Resistance to downy mildew is classified into 3: low, 5: intermediate, 7: high.

Resistance to insect pests

Resistance to insect pests is classified into 3: low, 5: intermediate, 7: high.

Resistance to physiological injury

Resistance to physiological injury is classified into 3: low, 5: intermediate, 7: high.

3. Tertiary characters

<Essential items>

Brix value

Brix value is measured at harvest.

Bitterness of leaf

Bitterness of leaf is tested by a panel and classified into 3: light, 5: intermediate, 7: strong.

<Optional items>

Latex content

Latex content is classified at harvest.

Browning of cut stem

Browning of cut stem is classified at harvest.

Carbohydrate content

Carbohydrate content is classified by measurement at harvest.

Protein content

Protein content is classified by measurement at harvest.

Fat content

Fat content is classified by measurement at harvest.

Content of minerals

Content of minerals is classified by measurement at harvest.

Content of ascorbic acid

Ascorbic acid content is classified by measurement at harvest.

Content of vitamin A

Content of vitamin A is classified by measurement at harvest.

V. Cucumber

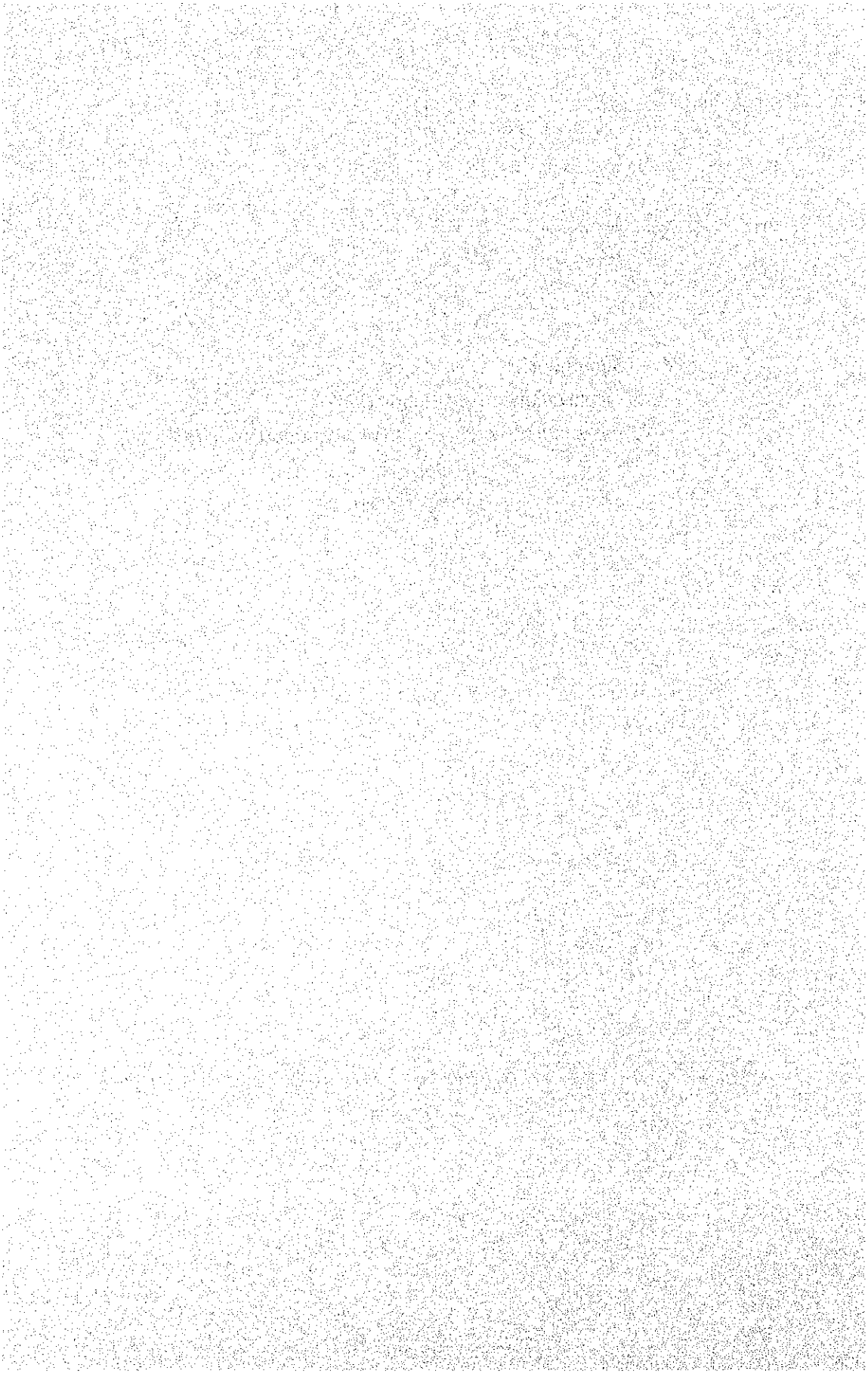
V-1. Cultivation of cucumber PGR

V-2. Evaluation of characteristics of cucumber PGR

by

Denji Ishiuchi

National Research Institute of Vegetables, Ornamental Plants and Tea, MAFF, Ano, Mie 514-23 JAPAN



V-1. Cultivation of cucumber PGR

Cucumber, a member of the Cucurbitaceous family, is considered to have originated in India, which extends from lat. 8°C N to lat. 37°C N. As the native area is located at low latitudes, cucurbitaceous plants generally require short days to form female flowers. Therefore, at high latitudes like in Japan, it is necessary to consider carefully the growing season, particularly the day length.

Cultivation under plastic film using supporting stakes is recommended to grow accessions for evaluation and for prevention of genetic contamination.

1. Raising of seedlings

Transplanting cultivation is preferable to direct seeding, because by transplanting it is possible to select suitable seedlings and to evaluate the characters at the seedling stage. Seedlings are usually grown in greenhouse or under plastic film.

Preparation of soil

The soil for the germination box or pot is prepared by mixing clay with manure. The ratio of manure to clay is 1:1 (volume). Ingredients should be mixed six months before use. Sieved soil is disinfected by steam or chemicals to prevent the occurrence of soil-borne diseases such as Fusarium wilt. Chemical fertilizers are added after soil disinfection. The amounts of N, P_2O_5 and K_2O elements are usually 130 ~ 260g, 320g and 130 ~ 260g, respectively per cubic meter of soil.

Sowing

Seeds should be disinfected before sowing. Chemicals such as antiformin (sodium hypochlorite sol.), hymexazol, captan, benomyl or other fungicides are used for disinfection. Seeds are usually sown in seeding boxes. However, in case of important PGRs, seeds are sown on wet filter papers in petri dishes to accelerate germination, then transferred to boxes when root tips just appear (Fig. 1).

Growing in pot

Young seedlings at the first true leaf stage are transplanted from seedling boxes into pots. Black soft plastic pots 10 cm in diameter are commonly used. Temperatures during growth in pots must be kept above 18°C.

Space between pots is adjusted in proportion to plant growth to prevent succulent growth. When seedlings grow up to the 5th ~ 6th true leaf stage, seedlings are transplanted into the field. Plants in pots can also be used for the evaluation of resistance to diseases and pests (Fig. 1).

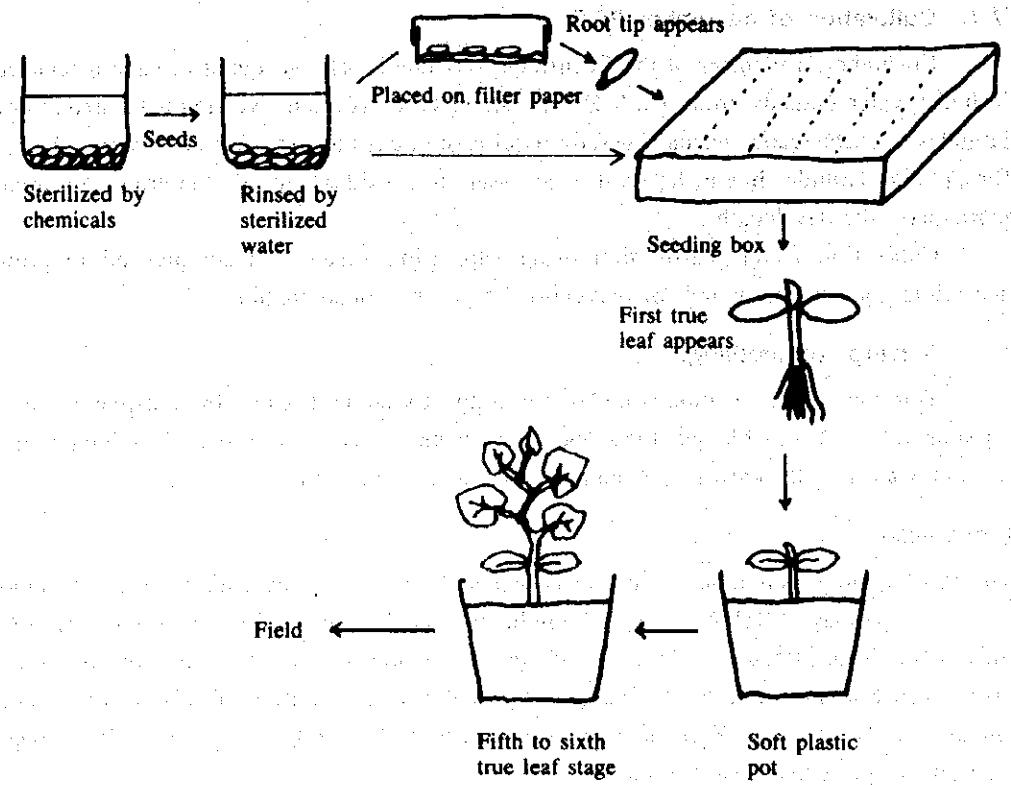


Fig. 1 Scheme of raising seedlings of cucumber.

2. Cultivation in field

Land preparation

Soil infected with soil-borne diseases *e.g.* Fusarium wilt should be disinfected using chemicals such as methyl bromide or chloropicrin.

Barnyard manure, about two tons, with 10kg of N, P_2O_5 and K_2O, respectively, and 200kg lime per 10a are applied before tillage. After tillage, rows 1.4 ~ 1.8m in width, 2.2 ~ 2.6 m for the center to center distance and 15 ~ 25cm in height are formed by ridging.

Mulching is effective for the control of weeds and prevention of soil water deficit. Usually a plastic film 0.05 mm in thickness is used. In case of cultivation in greenhouse or under plastic film, irrigation tube should be set before mulching. Stakes for supporting vines are also set.

Planting space

Cucumbers are planted in two rows on each ridge. Interval between rows ranges from 100 to 120 cm, and intrarow spacing ranges from 40 to 50 cm (Fig. 2).

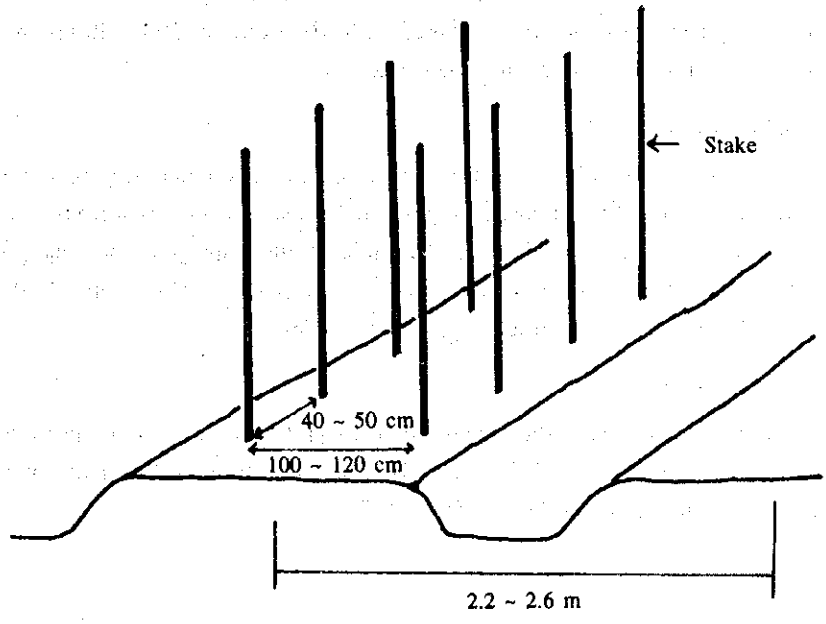


Fig. 2 Land preparation and planting space.
Plastic film, 0.05 mm in thichness is used for mulching.

Training

There are three types of branching habit in cucumber, i.e., no branching (main stems only), lateral shoots only from some nodes, and long lateral shoots from every node. In addition, there are several types of flowering habit. Therefore, the training of lateral branches is an important operation.

In case female flowers appear at every node of main stems, lateral shoots can be removed. On the other hand, in order to maintain the vigor, a small number of lateral shoots should remain. If female flowers appear only on lateral shoots, some lateral shoots should remain to set fruits. Usually, shoot tips of main stems are pruned, when vines reach the top of the stakes.

Pollination and change in sex expression

Since cucumber is generally of a parthenocarpic nature, pollination is not necessary. However, in some cultivars, pollination is necessary for fruit setting.

For the multiplication of accessions, self pollination is obviously necessary. If an accession is gynoecious, young seedlings should be sprayed with silver nitrate (200 ~ 300 ppm) two or three times to change female flowers into male ones.

Pest and disease control

Resistance to pests and diseases is essentially evaluated in plants which are not subjected to control measures. However, if the damage by pests and diseases becomes serious, protection of plants is essential even for the evaluation of ordinary traits. Spray of chemicals, such as insecticides and fungicides is an effective measure, especially, for the control of aphids (vectors of virus diseases), downy mildew, powdery mildew, etc.

Environmental conditions

For the cultivation of cucumber, the maximum critical temperature and optimum daily temperature are 35°C and 23 ~ 28°C, respectively. Since the minimum critical temperature is 8°C, night temperatures must be kept above 10°C.

V-2. Evaluation of characteristics of cucumber PGR

1. Primary characters

<Essential items>

Seed shape

Seed shape is expressed as the ratio of width to length of seeds.

Shape of cotyledon

The ratio of width to length of cotyledons is measured at the first true leaf stage.

Hypocotyl length

Distance from the soil surface to the base of cotyledons is measured (in centimeters) at the first true leaf stage.

Plant type

Growth of the main stem is classified into 1: dwarf, 2: self-pruning, 3: normal.

Plant height

Distance from the soil surface to the shoot tip of the main stem is measured (in centimeters) at the 20th leaf stage or five days before the main stem is pinched. All entries should be measured simultaneously for comparison when the most entries have reached the above mentioned stage.

Internode length

Average length of internode from the 10th node to the 15th node is measured (in centimeters).

Leaf shape

Leaf shape is classified into 3: round, 5: roundish pentagonal, 7: sharp pentagonal.

Leaf size

Width of fully unfolded leaf at the 15th node is measured (in centimeters).

First female flower bearing node

Order of node which bears the first female or bisexual flowers is classified into 0: not bearing, 1: extremely low, 2: considerably low, 3: low, 4: rather low, 5: intermediate, 6: rather high, 7: high, 8: considerably high, 9: extremely high.

Sex of flower

Sex expression of flower is classified into 1: androecious (♂), 2: monoecious (♀+♂), 3: hermaphroditic and monoecious (☤+♀+♂), 4: hermaphroditic and androecious (☤+♂), 5: hermaphroditic and gynoecious (☤+♀), 6: gynoecious (♀), 7: hermaphroditic (☤).

Fruit shape at maturity for table use

Fruit shape at maturity for table use is classified into 1: globular (round), 2: ovoid, 3: obovoid, 4: spindle-shaped, 5: elliptical, 6: cylindrical, 7: sickle-shaped, 8: snake-shaped (Fig. 3).

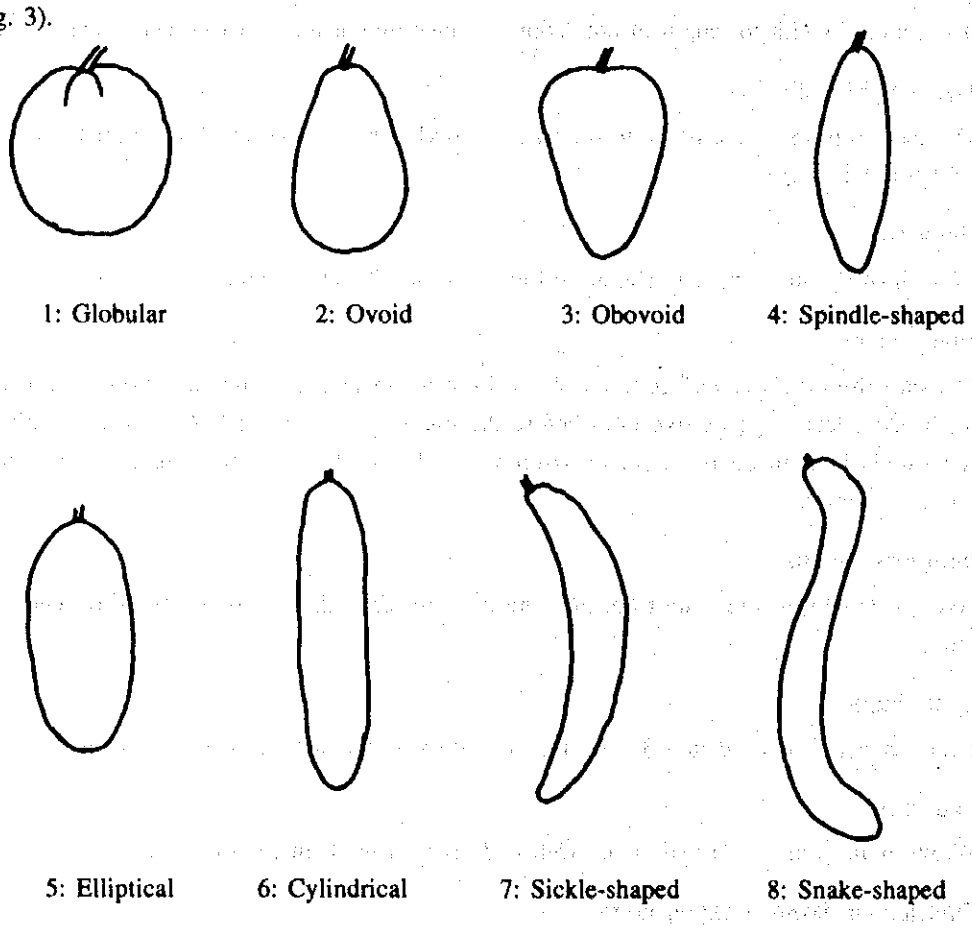


Fig. 3 Fruit shape of cucumber.

Fruit length at maturity for table use

Fruit length at maturity for table use is measured (in centimeters) when fruits grow up to the size suitable for marketing for fresh consumption or for making pickles.

Fruit width at maturity for table use

Fruit width at maturity for table use is measured (in centimeters) when fruits grow up to the size suitable for marketing for fresh consumption or for making pickles.

Fruit color at maturity for table use

Fruit color at maturity for table use is classified into 1: white, 2: yellow, 3: partly white, 4: light green, 5: medium green, 6: dark green.

Wart size of fruit at maturity for table use

Wart size of fruit at maturity for table use is classified into 0: no worts, 1: extremely small, 2: considerably small, 3: small, 4: rather small, 5: intermediate, 6: rather large, 7: large, 8: considerably large, 9: extremely large.

Fruit spine color at maturity for table use

Fruit spine color at maturity for table use is classified into 0: no spines, 3: white, 5: brown, 7: black.

Fruit color at maturity for seed harvest

Fruit color at maturity for seed harvest is classified into 1: white, 2: yellow, 3: yellowish green, 4: reddish brown, 5: brown, 9: others.

Net formation at maturity for seed harvest

Net formation at maturity for seed harvest is classified into 0: absent, 1: extremely sparse, 2: considerably sparse, 3: sparse, 4: rather sparse, 5: intermediate, 6: rather dense, 7: dense, 8: considerably dense, 9: extremely dense.

<Optional items>

Seed size

Length of seeds is measured as seed size (in millimeters).

Size of cotyledon

Length of cotyledons is measured (in centimeters) at the first true leaf stage.

Thickness of hypocotyl

Diameter of hypocotyl is measured (in millimeters) at the first true leaf stage.

Thickness of stem

Diameter of the main stem at the 10 ~ 15th nodes is measured (in millimeters) when the plant height is measured.

Number of lateral shoots

Number of primary lateral shoots is counted from about the sixth to 15th nodes.

Internode length of lateral shoots

The first internode of lateral shoots from about the sixth to 15th nodes of the main stem is measured (in centimeters).

Depth of sinus of leaves

Depth of sinus of leaves is classified into 0: no sinus, 1: extremely shallow, 2: considerably shallow, 3: shallow, 4: rather shallow, 5: intermediate, 6: rather deep, 7: deep, 8: considerably deep, 9: extremely deep.

Degree of serration of leaves

Degree of serration of leaves is classified into 0: absent, 1: extremely scarce, 2: considerably scarce, 3: scarce, 4: rather scarce, 5: intermediate, 6: rather prominent, 7: prominent, 8: considerably prominent, 9: extremely prominent.

Leaf color

Leaf color is classified into 3: light green, 4: rather light green, 5: green, 6: rather dark green, 7: dark green.

Length of petiole

Length of petioles of leaves from about the 10 ~ 15th nodes is measured (in centimeters) when the plant height is measured.

Multi-flowering of pistillate flowers

Number of pistillate flowers per node is counted and classified into 1: one, 2: two, 3: more than three.

Shape of stem-end of fruit at maturity for table use

Shape of stem-end of fruits at maturity for table use is classified into 1: depressed, 2: rather depressed, 3: flattened, 4: rather rounded, 5: rounded, 6: rather pointed, 7: pointed (Fig. 4).

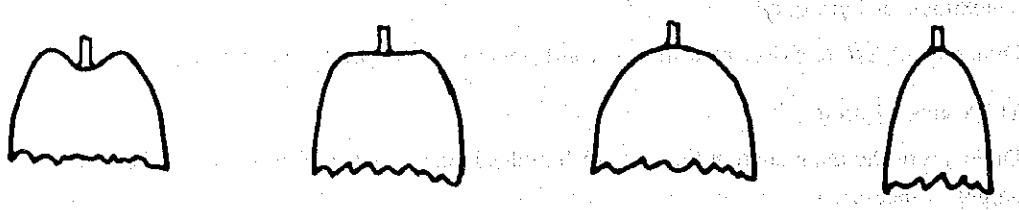
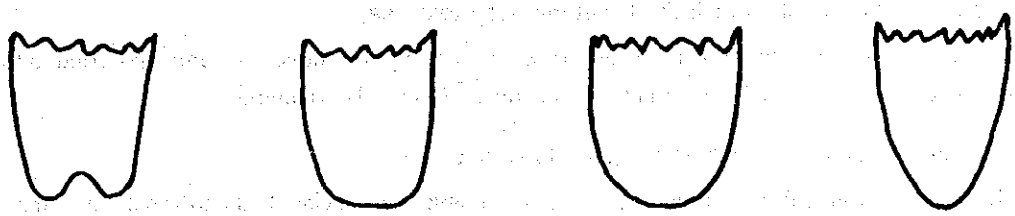


Fig. 4 Shape of stem-end of fruit.

Shape of blossom-end of fruit at maturity for table use

Shape of blossom-end of fruits at maturity for table use is classified into 1: depressed, 2: rather depressed, 3: flattened, 4: rather rounded, 5: rounded, 6: rather pointed, 7: pointed (Fig. 5).



1: Depressed 3: Flattened 5: Rounded 7: Pointed

Fig. 5 Shape of blossom-end of fruit.

Depth of furrow on fruit surface at maturity for table use

Depth of furrow on fruit surface at maturity for table use is classified into 0: no furrows, 1: extremely shallow, 2: considerably shallow, 3: shallow, 4: rather shallow, 5: intermediate, 6: rather deep, 7: deep, 8: considerably deep, 9: extremely deep.

Pattern of fruit surface at maturity for table use

Pattern of fruit surface at maturity for table use is classified into 0: absent, 1: faded yellow stripes, 2: yellow stripes on less than 1/3 of fruit length at blossom-end, 3: yellow stripes approximately on 1/2 of fruit surface, 4: yellow stripes on more than 2/3 of fruit surface, 5: faded with white spots, 6: white spots, 7: faded chintzy, 8: chintzy, 9: others.

Glossiness of fruit skin at maturity for table use

Glossiness of fruit skin at maturity for table use is classified into 0: absent, 1: extremely weak, 2: considerably weak, 3: weak, 4: rather weak, 5: intermediate, 6: rather prominent, 7: prominent, 8: considerably prominent, 9: extremely prominent.

Degree of bloominess of fruit at maturity for table use

Degree of bloominess of fruit at maturity for table use is classified into 0: absent, 1: extremely weak, 2: considerably weak, 3: weak, 4: rather weak, 5: intermediate, 6: rather prominent, 7: prominent, 8: considerably prominent, 9: extremely prominent.

Density of warts of fruit

Density of warts of fruits is observed at maturity for table use and classified into 0: no warts, 1: extremely low, 2: considerably low, 3: low, 4: rather low, 5: intermediate, 6: rather high, 7: high, 8: considerably high, 9: extremely high.

Spine size of fruit at maturity for table use

Spine size of fruits is observed at maturity for table use and classified into 0: no spines, 1: extremely small, 2: considerably small, 3: small, 4: rather small, 5: intermediate, 6: rather large, 7: large, 8: considerably large, 9: extremely large.

Shape of cross section of fruit at maturity for table use

Shape of cross section of fruit is observed at maturity for table use and classified into 1: rounded, 2: triangular and round, 3: triangular, 4: sharply triangular.

Thickness of flesh of fruit at maturity for table use

Thickness of flesh of fruit is observed at maturity for table use and classified into 1: extremely thin, 2: considerably thin, 3: thin, 4: rather thin, 5: intermediate, 6: rather thick, 7: thick, 8: considerably thick, 9: extremely thick.

Flesh color of fruit at maturity for table use

Flesh color of fruit is observed at maturity for table use and classified into 3: white, 4: white to milky green, 5: milky green, 6: milky green to light green, 7: light green.

2. Secondary characters

<Essential items>

Resistance to Fusarium wilt *(Fusarium oxysporum* f. sp. *cucumerinum)*

When accessions are infected severely with this disease, evaluation of other traits becomes impossible. Therefore, accessions are usually grown after disinfection of soil for this pathogen (*Fusarium oxysporum* f. sp. *cucumerinum*). To evaluate the resistance to Fusarium wilt, an artificial infection, by the so-called root dipping method is carried out. Roots of young seedlings at the first true leaf stage are dipped in the aqueous suspension of spores (10^6 ~ 10^7 spores per mm^3), and seedlings are transplanted into disinfected soil. About one week after the inoculation, symptoms become visible. Degree of resistance is estimated about three weeks after the inoculation and classified into 1: extremely low, 2: considerably low, 3: low, 4: rather low, 5: intermediate, 6: rather high, 7: high, 8: considerably high, 9: extremely high.

Resistance to downy mildew *(Pseudoperonospora cubensis)*

Since this disease frequently appears in wet fields, artificial inoculation is not necessarily applied. According to the appearance and expanding pattern of the lesions, the degree of resistance is classified into 1: extremely low, 2: considerably low, 3: low, 4: rather low, 5: intermediate, 6: rather high, 7: high, 8: considerably high, 9: extremely high.

Resistance to powdery mildew *(Sphaerotheca fuliginea)*

Since this disease frequently appears in dry fields, artificial inoculation is not necessarily applied. According to the appearance of the lesions, the degree of resistance is evaluated and classified

similarly in the same way as in the case of downy mildew.

Resistance to virus diseases

Cucumbers are attacked by various viruses, such as cucumber mosaic virus, cucumber green mottle mosaic virus, watermelon mosaic virus, zucchini yellow mosaic virus, etc. Therefore, the inoculation with a specific virus is necessary for the exact evaluation of the resistance to viruses. However, since the identification of the viruses is not easy in fields, the degree of resistance to virus diseases is usually evaluated based on natural infection and classified in the same way as other diseases.

Resistance to nematodes *(Meloidogyne* sp.*)*

After evaluation of other traits, roots of accessions are dug out and knots on roots are examined. Depending on the amount of knots, the degree of resistance is evaluated and classified in the same way as diseases.

Duration of growth

Duration from planting to harvest of the first fruit for table use is calculated and classified into 1: extremely early, 2: considerably early, 3: early, 4: rather early, 5: intermediate, 6: rather late, 7: late, 8: considerably late, 9: extremely late.

<Optional items>

Resistance to bacterial spot (*Pseudomonas lachrymans*)

Resistance to gummy stem blight (*Mycosphaerella melonis*)

Resistance to scab (*Cladosporium cucumerinum*)

Resistance to phytophthora rot (*Phytophthora melonis*)

Resistance to aphid (*Aphis gossypii*)

Resistance to *Aulacophora femoralis*

Degree of resistance to the above diseases and pests is usually evaluated under natural conditions in the field and classified in the same way as the diseases described above.

Resistance to high temperature

Injury by high temperature affects the leaf color, growth rate and some other physiological traits. Degree of resistance is evaluated by observing these traits, and classified into 1: extremely low, 2: considerably low, 3: low, 4: rather low, 5: intermediate, 6: rather high, 7: high, 8: considerably high, 9: extremely high.

Resistance to low temperature

Cucumbers are killed by frost. Therefore, the degree of resistance to low temperature is estimated by exposing accessions to moderately low temperatures. Injury of cucumber accessions is estimated based on the change of leaf color (yellowish), retardation or interruption of growth and dropping of fruits. The resistance is classified into 1: extremely low, 2: considerably low, 3: low, 4: rather low, 5: intermediate, 6: rather high, 7: high, 8: considerably high, 9: extremely high.

3. Tertiary characters

<Essential items>

Fruit bearing habit

According to the position of pistillate flowers on vines, fruit bearing habit is classified into 1: on the main stem only, 2: on the main stem and lateral shoots, 3: on lateral shoots only.

Fruit weight

Weight of fruits is measured at maturity for table use.

Intensity of bitterness of fruit flesh

At maturity for table use, intensity of bitterness of fruit flesh is classified into 0: not bitter, 1: extremely low, 2: considerably low, 3: low, 4: rather low, 5: intermediate, 6: rather high, 7: high, 8: considerably high, 9: extremely high.

<Optional items>

Fruit re-bearing of node

Commonly one node bears one pistillate flower, and when one node has several pistillate flowers (multi-flowering of pistillate flowers), flowers from one node open consecutively. However, pistillate flowers sometimes appear and bear fruits on the same node after the first fruit becomes ripe. The frequency of this character is evaluated at the end of the growing season, and classified into 0: absent, 1: extremely scarce, 2: considerably scarce, 3: scarce, 4: rather scarce, 5: intermediate, 6: rather common, 7: common, 8: considerably common, 9: extremely common.

Parthenocarpy

Fruit setting ability of non-pollinated female flowers is classified into 0: absent, 1: extremely low, 2: considerably low, 3: low, 4: rather low, 5: intermediate, 6: rather high, 7: high, 8: considerably high, 9: extremely high.

Yielding ability

Yielding ability is evaluated based on the number of harvested fruits for table use or pickling under natural conditions (without artificial pollination), and classified into 1: extremely low,

2: considerably low, 3: low, 4: rather low, 5: intermediate, 6: rather high, 7: high, 8: considerably high, 9: extremely high.

Eating quality of fresh fruit

Eating quality of cucumber is evaluated based on the texture and flavor of flesh and classified into 1: extremely low, 2: considerably low, 3: low, 4: rather low, 5: intermediate, 6: rather high, 7: high, 8: considerably high, 9: extremely high.

Shelf life of fresh fruit for marketing and processing

Shelf life of fresh fruit kept at room temperature after harvest for fresh marketing and pickling is classified into 1: extremely short, 2: considerably short, 3: short, 4: rather short, 5: intermediate, 6: rather long, 7: long, 8: considerably long, 9: extremely long.

Hardness of fruit skin

Hardness of fruit skin is classified into 1: extremely low, 2: considerably low, 3: low, 4: rather low, 5: intermediate, 6: rather high, 7: high, 8: considerably high, 9: extremely high.

Hardness of fruit flesh

Hardness of fruit flesh is classified into 1: extremely low, 2: considerably low, 3: low, 4: rather low, 5: intermediate, 6: rather high, 7: high, 8: considerably high, 9: extremely high.

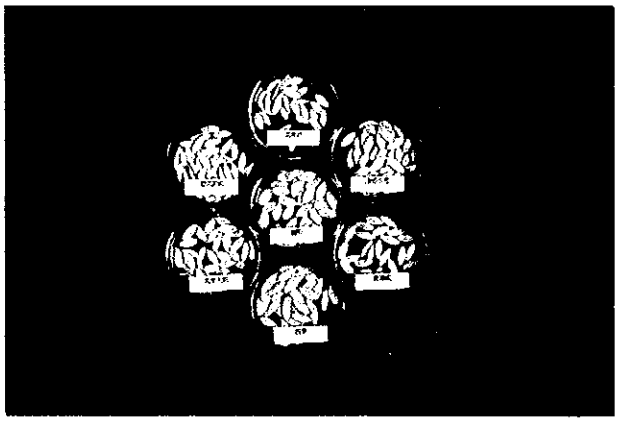


Photo. 1 Various seed shapes of cucumber.

Photo. 2 Various shapes and colors of cucumber fruit at table use maturity.

Photo. 3 Various shapes and colors of cucumber fruit at seed harvest maturity.

VI. Melon

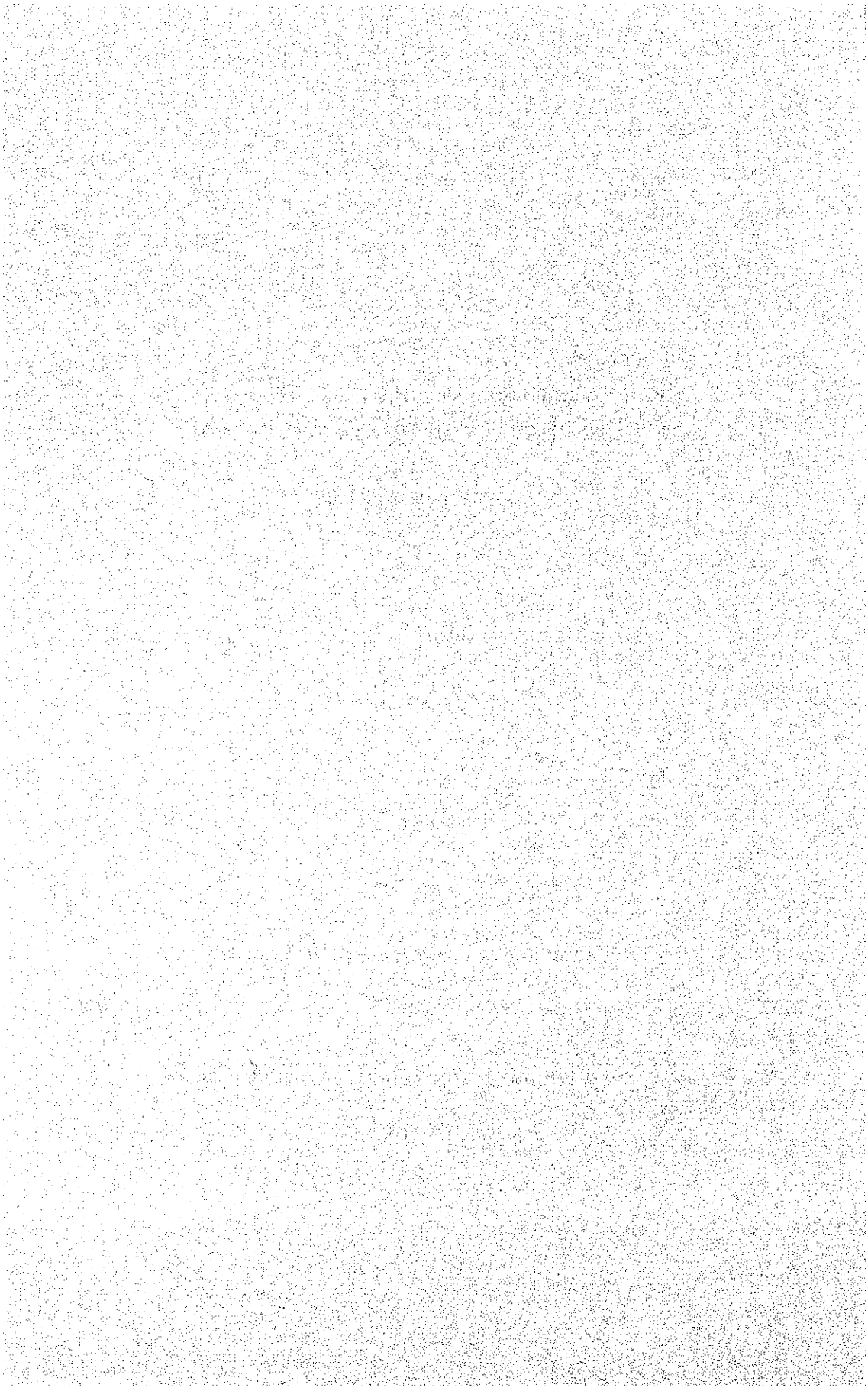
VI-1. Cultivation of melon PGR

VI-2. Evaluation of characteristics of melon PGR

by

Masami Morishita

Kurume Branch, National Research Institute of Vegetables, Ornamental Plants and Tea, MAFF,
Kurume 830 JAPAN



VI-1. Cultivation of melon PGR

Melon (*Cucumis melo*), which originates in areas extensively from the Middle East to the Mediterranean, grows better at high temperatures, under abundant sunshine and dry conditions. Therefore, melon is grown in glass houses, or under plastic cover in Japan, to avoid excessive humidity. Cropping seasons suitable for the evaluation of melon PGR in Japan are as follows:

(a) Warm south-western Japan

Sowing in the middle of February and harvest in the middle of June.

(b) Lowland area of Kanto region

Sowing in the middle of March and harvest in the middle of July.

(c) Highland Area and Northern Region

Sowing in the beginning of April and harvest in the beginning of August.

1. Seedling raising method

1) Preparation of pot soil

The use of clayey paddy soil mixed with mature fine compost in a ratio of 1:1 is most suitable for pot soil. The rate of fertilizer application of the soil mixture is as follows: magnesium lime: 1.5 kg and superphosphate: 1.0 kg per 1 m^3. In addition, soil mixture should be sterilized with chloropicrin before use in order to prevent the occurrence of soil-borne diseases and pests.

2) Disinfection of seed

To prevent the transmission of damping-off, seeds are disinfected with chemicals such as Captan powder. Seeds are mixed fully with the disinfectant in a ratio of 0.4% on a weight basis.

3) Seed sowing

Seeds are sown linearly at 6 cm intervals, on seed boxes 8 ~ 12 cm deep filled with sand and rice-husk charcoal or sieved fine compost. Seed bed should be kept under 30°C until germination to avoid excessive moisture. After germination, seed boxes are kept under 25°C to avoid excessive elongation of hypocotyls.

4) Transplanting to seedling pots

Seedlings are carefully transplanted in polyethylene pots 12 cm in diameter at the stage of full growth of cotyledons (before the first true leaf becomes visible). Deep setting should be avoided. It is essential to raise stout and solid seedlings with short internodes and without excessive elongation of stem, to avoid excessive humidity and dryness of seedling pots.

2. Cultivation method in growing beds

1) Land preparation with disinfection

One of the major problems in sweet melon cultivation is the control of soil-borne diseases such as damping-off (*Pythium debaryanum, P. cucurbitacearum, Rhizoctonia solaniosa*) which appears at the seedling stage, Fusarium wilt (*Fusarium oxysporum*) and gummy stem blight (*Mycosphaerella melonis*) and root knot nematode (*Meloidogyne* spp.) which appear throughout the growth period. In case of open fields, melon should be grown in non-infected virgin land to avoid successive cropping. However, successive cropping is unavoidable in Japan, because of the limited area of cultivation in plastic houses. Under these circumstances, disinfection becomes an essential procedure for sweet melon cultivation in Japan. Disinfection is usually carried out by the application of chloropicrin for the control of soil-borne diseases and 1,3-dichloropropene for the control of nematodes.

2) Setting in bed

① Setting conditions

Seedlings which are raised up to the 2.5 true leaf stage about 25 days after sowing, are set in beds in the morning. Setting of seedlings is carried out after confirmation that minimum daily air temperature in the house already rose above 12°C and that of soil above 15°C.

② Design of growing beds

The layout of the growing bed will vary to some extent with the area of the house as seen in Fig. 1. Standard distance between rows is approximately 130 cm and distance between plants is 40 cm. Density of plants per 3.3 m^2 will be eight plants.

③ Fertilizer application

The rate of fertilizer application is determined based on the soil fertility and residual effect of fertilizers applied to the preceding crop. In order to avoid nutrient deficiency, a combined application of organic fertilizers and slow-release chemical fertilizers is recommended. Basal application of all the fertilizers with broadcasting is recommended. Standard rate of fertilizer application per 10a is as follows: compost: 3000kg, magnesium lime: 100kg and chemical fertilizer of N:P:K at a rate of 8kg: 25kg: 15kg.

④ Irrigation before fruit setting

Required amount of irrigation water varies with the soil types. Watering should be kept minimum until pollination. Usually, ample supply of water is applied to planting holes before transplanting, and water is retained by film mulching. Water should not be supplied directly at the base of the plants because it may induce gummy stem blight. Watering should be applied to plants indirectly through passages or small irrigation ditches between rows, at a distance from the base of plants.

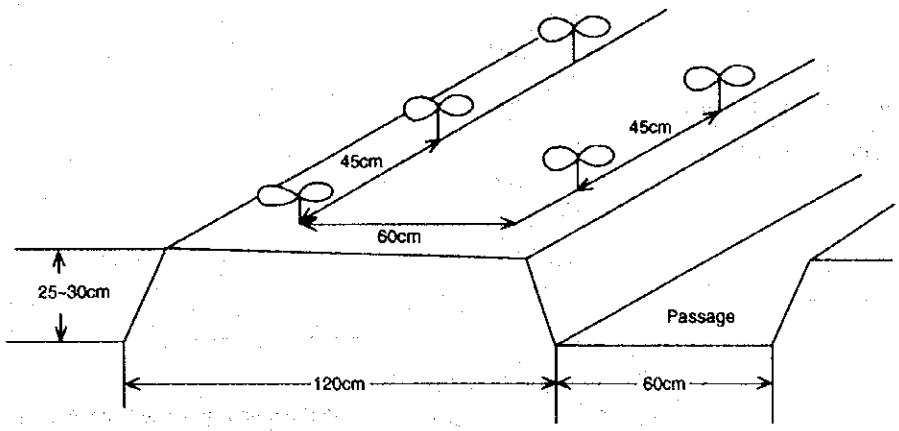


Fig. 1 Design of growing bed for melon.

3) Training of branches

At the 5 ~ 6 true leaf stage, supporting poles are set in order to train plants. Steel pipe, wire and Fulcon Tape are utilized as poles. The training methods are follows: (a) setting one stem style, (b) all the branches sprouting from lower than the 9th node are removed at the youngest stage, (c) pollination or fruit setting position starts from the 10th to 15th nodes (branches at those nodes are grown but tips are pinched out except for only two leaves per node), and (d) the main stem is pinched out at about the 25th node at the early stage as shown in Fig. 2.

4) Pollination and fruit setting

① Design of fruit setting

Artificial pollination is applied to four uniform healthy female flowers on the branches from the 10th to 15th nodes. In order to secure adequate fruit setting, it is necessary to pollinate four female flowers simultaneously. At the time of branch training, it is important to leave branches which show a similar growth rate and are expected to bear uniformly healthy female flowers.

② Time of pollination

Since the dehiscence of anther of melon takes place at above 30°C, and the optimum pollination time is about one hour after flower opening, it is necessary to complete pollination by 10 o'clock in the morning on a fine day.

5) Management after pollination

Although four flowers are pollinated per plant, final fruit setting is adjusted into only one fruit per plant, leaving the best one among the four fruits. When fruits grow up to the size of a chicken egg, the positions of fruits are fixed by vinyl tapes hanging at their peduncle.

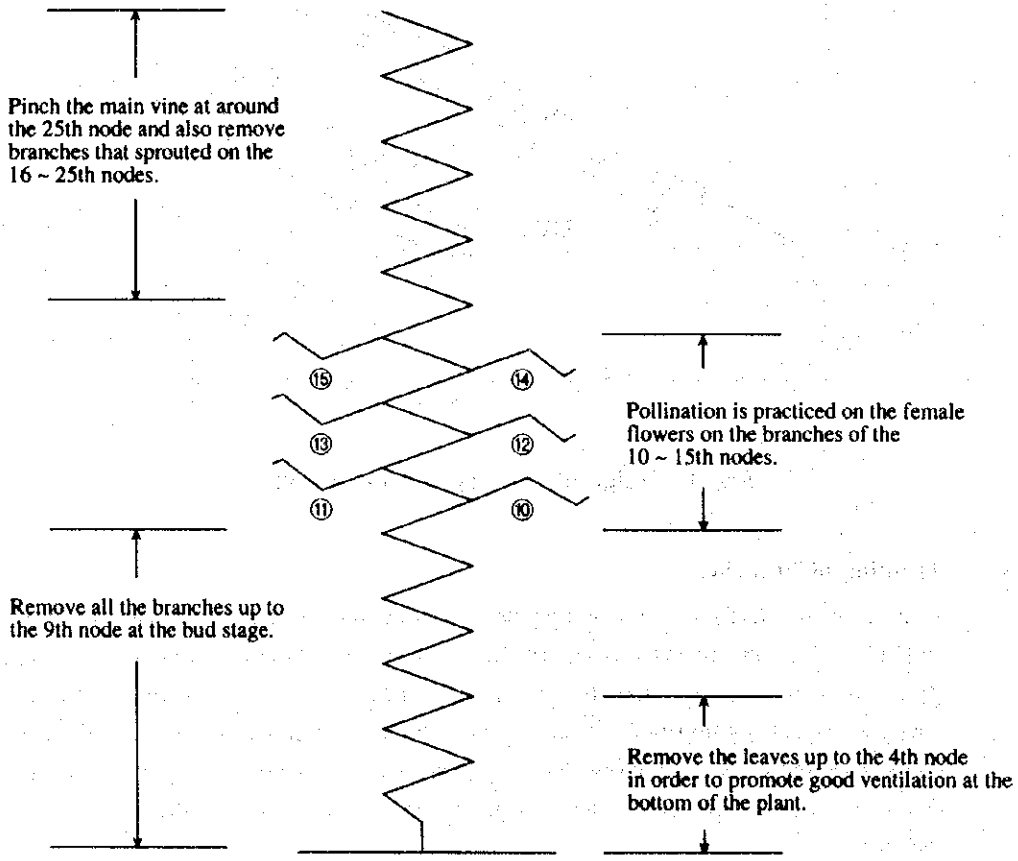


Fig. 2 Training method of melon.

After fruit setting, sufficient supply of water is necessary to promote fruit growth. After pollination, the fruit growing period lasts 35 days during which adequate watering is necessary for the supply of nutrients and water to promote the growth of fruits.

6) Fruit harvest

Fruits mature about 50 ~ 60 days after pollination, when they are harvested in keeping attached the peduncles over a certain distance.

VI-2. Evaluation of characteristics of melon PGR

1. Primary characters

<Essential items>

Leaf length

Average length of the 10 ~ 15th true leaves on the main vine is measured (in centimeters) at the mature-green fruit stage (n=5)*.

Number of leaves

Number of true leaves on the main vine is counted just before the pinching operation of the earliest entry (n=5).

Main vine length

Distance from the base to the tip of the main vine is measured (in centimeters) at the onset of the pinching operation of the earliest entry (n=5).

Internode length

Average internode length of the 10 ~ 15th nodes on the main vine is measured (in centimeters) at harvest time (n=5).

Sex of flower

Sex expression of flower is classified into 1: androecious, 2: monoecious, 3: trimonoecious, 4: andromonoecious, 5: gynomonoecious, 6: gynoecious, 7: hermaphrodite (n=5).

Female flower bearing ratio

Number of female (or hermaphrodite) flowers occurring on the first node of branch vine of the 10 ~ 15th nodes on the main vine is counted and expressed in percentage (n=5).

Fruit setting stability

Fruit setting stability is expressed as fruit setting percentage of female (or hermaphrodite) flowers pollinated on the first node of the branch vine of the 10 ~ 15th nodes on the main vine (n=5).

Fruit shape

Fruit shape is observed at harvest time and classified into 1: extremely flat round, 2: rather flat round, 3: flat round, 4: rather round, 5: round, 6: slightly long round, 7: long round, 8: considerably long round, 9: extremely long round (n=5).

---

*Minimum number of measurements

Fruit weight

Fruit weight is measured at harvest time and classified into 1: extremely light (below 100g), 2: considerably light (101 ~ 300g), 3: light (301 ~ 600g), 4: slightly light (601 ~ 1000g), 5: intermediate (1001 ~ 1400g), 6: rather heavy (1401 ~ 1800g), 7: heavy (1801 ~ 2200g), 8: considerably heavy (2201 ~ 3000g), 9: extremely heavy (over 3000g) (n=5).

Fruit skin color

Skin color of mature fruits is observed and classified into 0: white, 1: yellow, 2: orange, 3: red brown, 4: brown, 5: light green, 6: gray, 7: gray green, 8: green, 9: dark green (n=5).

Surface condition of fruits

Roughness of surface of mature fruits is observed and classified into 1: smooth, 2: slightly ribbed, 3: deeply ribbed, 4: slightly wrinkled, 5: deeply wrinkled, 6: rare warts, 7: numerous warts (n=5).

Net density

Net density of mature fruits is observed and classified into 0: no net, 1: extremely low, 2: considerably low, 3: low, 4: slightly low, 5: intermediate, 6: slightly high, 7: high, 8: considerably high, 9: extremely high (n=5).

<Optional items>

Seed length

Length of dried ripe seeds is measured (in millimeters) (n=50).

Seed width

Width of dried ripe seeds is measured (in millimeters) (n=50).

Seed shape

Shape of ripe seeds is classified into 1: round, 3: broad chicken egg type, 5: chicken egg type, 7: slender chicken egg type, 9: others (n=10).

Seed color

Color of ripe seeds is classified into 3: white, 4: rather yellow, 5: yellow, 6: rather brown, 7: brown (n=10).

Seed weight

One hundred ripe dry seeds are weighed (in milligrams).

Cotyledon length

Length of cotyledons is measured (in centimeters) at the time of first true leaf full expansion (n=20).

Cotyledon color

Color of cotyledons is observed at the time of first true leaf full expansion and classified into 3: light green, 4: slightly light green, 5: green, 6: slightly dark green, 7: dark green (n=10).

Hypocotyl length

Length of hypocotyls of seedlings which did not overgrow is measured (in centimeters) at the time of expansion of cotyledon (n=20).

Hypocotyl diameter

Diameter of hypocotyls is measured (in millimeters) at the time of first true leaf full expansion (n=20).

Plant type

Plant type is classified into the following four types; 1: self-topping type, 2: bush type, 3: intermediate type, 4: creeping type (n=5).

Diameter of main vines

Diameter of the main vines is measured (in centimeters) at the center between the 10th and 11th nodes at the mature-green stage (n=20).

Shape index of fruit

Shape index of fruits is expressed as ratio of height to width (n=5).

Shape of fruit shoulder

Shape of shoulder of ripe fruits is observed and classified into 3: obtuse, 4: slightly obtuse, 5: intermediate, 6: slightly acute, 7: acute (n=5).

Fruit tip shape

Tip shape of ripe fruits is observed and classified into 3: slender, 4: rather slender, 5: intermediate, 6: rather big, 7: big (n=5).

Blotch on fruit skin

Blotches on fruit skin are observed and classified into 0: absent, 9: present (n=5).

Color of blotch of fruit skin

Color of blotch is classified into 0: white, 1: yellow, 2: orange, 3: red brown, 4: brown, 5: light green, 6: gray, 7: gray green, 8: green, 9: dark green (n=5).

Height of net of fruit

Height of net on mature fruits is observed and classified into 0: no net, 1: extremely low, 2: considerably low, 3: low, 4: slightly low, 5: intermediate, 6: slightly high, 7: high, 8: considerably high, 9: extremely high (n=5).

Length of peduncle

Length of peduncle is observed at harvest and classified into 3: short, 4: rather short, 5: intermediate, 6: rather long, 7: long (n=5).

Diameter of peduncle

Diameter of peduncle is observed at harvest and classified into 3: small, 4: rather small, 5: intermediate, 6: rather large, 7: large (n=5).

Diameter of blossom-end

Diameter of abscission layer of flowers is observed at harvest and classified into 1: extremely small, 2: considerably small, 3: small, 4: slightly small, 5: intermediate, 6: slightly large, 7: large, 8: considerably large, 9: extremely large (n=5).

Shape of blossom-end

Shape of abscission layer of flowers is observed at harvest and classified into 3: concave, 4: rather concave, 5: flat, 6: rather convex, 7: convex (n=5).

Cracking habit of fruit in field

Frequency of cracking of fruits in field is observed and classified into 0: absent, 1: extremely low, 2: considerably low, 3: low, 4: slightly low, 5: intermediate, 6: slightly high, 7: high, 8: considerably high, 9: extremely high (n=5).

Degree of abscission layer development of fruit

Abscission layer development of mature fruits is observed and classified into 3: high, 4: rather high, 5: intermediate, 6: rather low, 7: low (n=5).

2. Secondary characters

<Essential items>

Resistance to powdery mildew *(Sphaerotheca fuliginea)* disease

Resistance to powdery mildew is evaluated based on the lesion density in the nursery or field test and classified into 1: extremely low, 2: considerably low, 3: low, 4: slightly low, 5: intermediate, 6: slightly high, 7: high, 8: considerably high, 9: extremely high (n=20).

Resistance to fusarium wilt *(Fusarium oxysporum)* disease

Resistance to fusarium wilt is evaluated based on symptoms in the nursery or field test and classified into 1: extremely low, 2: considerably low, 3: low, 4: slightly low, 5: intermediate, 6: slightly high, 7: high, 8: considerably high, 9: extremely high (n=20).

Resistance to gummy stem blight *(Mycosphaerella melonis)* disease

Resistance to gummy stem blight is evaluated based on symptoms in the nursery or field test and

classified into 1: extremely low, 2: considerably low, 3: low, 4: slightly low, 5: intermediate, 6: slightly high, 7: high, 8: considerably high, 9: extremely high (n=20).

Resistance to downy mildew *(Pseudoperonospora cubensis)* disease

Resistance to downy mildew is evaluated based on symptoms in the nursery or field test and classified into 1: extremely low, 2: considerably low, 3: low, 4: slightly low, 5: intermediate, 6: slightly high, 7: high, 8: considerably high, 9: extremely high (n=20).

Resistance to watermelon mosaic virus (WMV)

Resistance to watermelon mosaic virus is evaluated based on the appearance of WMV symptoms in the nursery or field test and classified into 1: extremely low, 2: considerably low, 3: low, 4: slightly low, 5: intermediate, 6: slightly high, 7: high, 8: considerably high, 9: extremely high (n=20).

Resistance to aphids

Resistance to aphids is evaluated based on the reproductive rate of aphids or the degree of damage of plants in the nursery or field test and classified into 1: extremely low, 2: considerably low, 3: low, 4: slightly low, 5: intermediate, 6: slightly high, 7: high, 8: considerably high, 9: extremely high (n=20).

Degree of physical leaf withering

Physical leaf withering is evaluated based on leaf withering symptoms caused physically after the fruiting time and classified into 1: extremely low, 2: considerably low, 3: low, 4: slightly low, 5: intermediate, 6: slightly high, 7: high, 8: considerably high, 9: extremely high (n=10).

Earliness of fruit bearing

Number of days from sowing to fruit bearing is counted and classified into 1: extremely early, 2: considerably early, 3: early, 4: slightly early, 5: intermediate, 6: slightly late, 7: late, 8: considerably late, 9: extremely late (n=10).

<Optional Items>

Resistance to cucumber mosaic virus(CMV)

Resistance to cucumber mosaic virus is evaluated based on CMV symptoms in field test and classified into 1: extremely low, 2: considerably low, 3: low, 4: slightly low, 5: intermediate, 6: slightly high, 7: high, 8: considerably high, 9: extremely high (n=10).

Resistance to *Thrips palmi*

Resistance to *Thrips palmi* is evaluated based on the reproductive rate of *Thrips palmi* or the degree of damage in field test and classified into 1: extremely low, 2: considerably low, 3: low, 4: slightly low, 5: intermediate, 6: slightly high, 7: high, 8: considerably high, 9: extremely high (n=20).

3. Tertiary characters

<Essential items>

Flesh color

Flesh color of fruits is observed at the time of consumption and classified into 1: green, 2: lightly green, 3: yellow green, 4: lightly yellow green, 5: white, 6: yellow, 7: orange, 8: orange to orange red, 9: orange red (n=5).

Flesh texture

Flesh texture of fruits is evaluated by sensory test and classified into 3: mealy, 5: fragile, 7: non-mealy, 9: melting (n=10).

Thickness of flesh

Thickness of fruit flesh and radius of fruits at equator are measured at the time of consumption and classified into 3: thin (ratio of flesh thickness to radius at equator is less than 45), 5: intermediate (from 46 to 60), 7: thick (more than 61) (n=10).

Brix value of fruit

Brix value of fruits is measured in the upper, equator and lower parts and expressed by an average value (n=10).

Eating quality

Eating quality of fruits is evaluated by sensory test and classified into 1: Makuwa type (oriental melon), 2: winter melon type, 3: net melon type, 4: cantaloupe type (n=10).

Flavor of fruit

Flavor of fruits is evaluated by sensory test in fruits preserved at 25°C after harvest and suitable for table consumption, and classified into 1: extremely weak, 2: considerably weak, 3: weak, 4: slightly weak, 5: intermediate, 6: slightly strong, 7: strong, 8: considerably strong, 9: extremely strong (n=10).

Days to ripening

Number of days to ripening (days from pollination to harvest) is classified into 1: extremely early (below 35 days), 3: early (36 ~ 40 days), 5: intermediate (41 ~ 50 days), 7: late (51 ~ 60 days), 9: extremely late (over 61 days) (n=10).

Days of after ripening

Number of days after ripening (days from harvest to time of consumption at 25°C) is classified into 0: 0 (0 day), 1: extremely short (1 ~ 2 days), 3: short (3 ~ 5 days), 5: intermediate (6 ~ 10 days), 7: long (11 ~ 20 days), 9: extremely long (over 21 days) (n=10).

Tendency to fermentation of fruit

Tendency to fermentation of fruits is evaluated at the time of consumption by sensory test and classified into 1: extremely high, 2: considerably high, 3: high, 4: slightly high, 5: intermediate, 6: slightly low, 7: low, 8: considerably low, 9: extremely low (n=10).

<Optional items>

Firmness of flesh

Firmness of flesh of fruits is evaluated at the time of consumption by sensory test and classified into 1: extremely soft, 2: considerably soft, 3: soft, 4: slightly soft, 5: intermediate, 6: slightly firm, 7: firm, 8: considerably firm, 9: extremely firm (n=10).

Quantity of fibers in flesh

Quantity of fibers in flesh is evaluated at the time of consumption by sensory test and classified into 0: 0, 3: small, 4: rather small, 5: intermediate, 6: rather large, 7: large (n=10).

Acidity of fruit

Acidity of fruits is evaluated at the time of consumption by sensory test and classified into 0: absent, 1: negligible, 2: minimal, 3: low, 4: rather low, 5: intermediate, 6: rather high, 7: high (n=5).

Bitterness of fruit

Bitterness of mature fruits is evaluated by sensory test and classified into 0: absent, 1: negligible, 2: minimal, 3: low, 4: rather low, 5: intermediate, 6: rather high, 7: high (n=5).

VII. Tomato

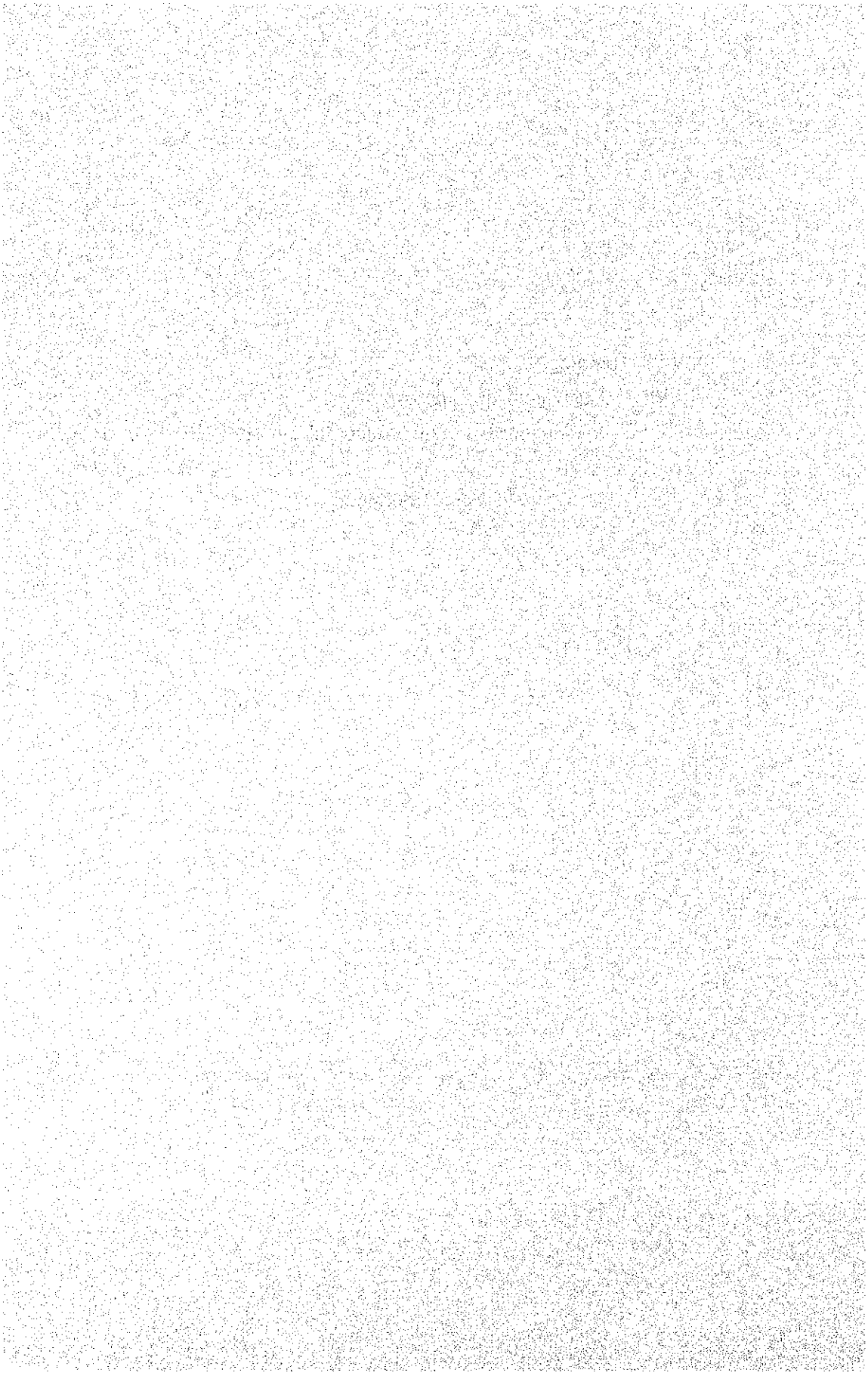
VII-1. Cultivation of tomato PGR

VII-2. Evaluation of characteristics of tomato PGR

by

Shinji Monnma

National Research Institute of Vegetables, Ornamental Plants and Tea, MAFF, Ano, Mie 514-23 JAPAN



VII-1. Cultivation of tomato PGR

In Japan, tomato is grown using several cultural systems, such as, staked or non-staked culture in open field, in greenhouse or with plastic covering. In this text, open field cultivation is presented as an example of cultivation methods.

1. Seed preparation

Seeds are treated with a 10% Trisodium Phosphate 12-H_2O solution or heat-sterilized at 72°C for 72 hours to avoid virus infection.

2. Preparation of nursery medium and seed flats

For seed germination, nursery media, such as mixtures of soil, perlite, organic matter, or commercially available mixtures are used. Nursery media should be sterilized to prevent damping-off of seedlings. Seed flats 50 × 35 × 7.5 cm are used.

3. Sowing and management of seedlings

Sowing on nursery beds should be performed at 25 ~ 28°C, in rows with an inter-row interval of about 6 cm. Moisture and temperature of seed flats should be kept at the optimum level until germination. Seedlings should be thinned to the optimum density about a week after germination.

4. Transplanting of seedlings to nursery pots

Seedlings are gently removed from nursery beds at the 2 ~ 3 true leaf stage and they are transplanted into nursery pots 12 cm in diameter packed with sterilized fertile soil. Seedlings are raised for 30 ~ 40 days in nursery pots. General management, such as watering, pest control, and temperature control should be carried out carefully.

5. Field Preparation

Fertilizer application varies depending on the soil fertility. Usually, 15 ~ 20 kg of nitrogen, 20 ~ 30 kg of phosphorus, 15 ~ 20 kg of potassium, 2,000 ~ 2,500 kg of manure and 150 ~ 200 kg of lime per 1,000 m^2 are applied.

Experimental fields are rotary-tilled and ridged at a height of 10 ~ 20 cm and a width of 80 ~ 90 cm. Then, ridges are covered with black or white mulching film.

Making holes for planting and setting poles for supporting plants are practiced with an intrarow spacing of 40 ~ 45 cm and interrow spacing of 70 cm.

6. Transplanting

Cloudy and moist weather is ideal, but wet soil is not adequate for transplanting. After the seedlings are transplanted to holes, they are fastened to supporting poles immediately. If soil is dry, watering is necessary.

7. Management of field

Pruning, pinching of lateral branches need to be performed. After pruning, plants are fastened to the supporting poles immediately. These pruning and pinching operations need to be practiced at least once a week.

Application of chemicals for preventing diseases and insect attacks as well as side-dressing are carried out if necessary.

VII-2. Evaluation of characteristics of tomato PGR

For the evaluation of traits of plant, 10 to 20 plants need to be tested and for the evaluation of traits of fruit, 20 to 30 fruits need to be tested.

1. Primary characters

<Essential items>

Growth habit

Growth habit is classified into 0: indeterminate, 9: determinate.

Number of leaves below the first inflorescence

In the counting of leaf number, cotyledon is not included.

Internode length

As internode length, the distance between the first and second inflorescences is usually measured. For the average value of internode length, stem length is divided by the number of internodes. Average internode length is expressed in centimeters (cm).

Leaf shape

Leaf shape is classified into four types, 1: type 1, 2: type 2, 3: type 3, 4: type 4 (Fig. 1).

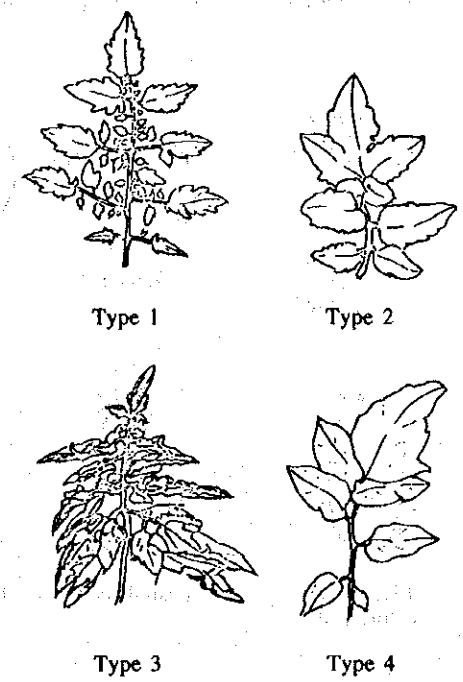


Fig. 1 Type of leaf.

Leaf length

Length of the largest leaf is measured at harvest time. Leaf length is expressed in centimeters.

Plant height

Distance from the base to the top of plants is measured at harvest time of the first cluster. Plant height is expressed in centimeters.

Type of inflorescence

Branching habit of inflorescence is classified into 1: simple, 2: complex, 3: mixed.

Number of flowers per inflorescence

Number of flowers on the second and third inflorescences is counted and classified into: 1: 1 ~ 2, 3: 3 ~ 5, 5: 6 ~ 10, 7: 11 ~ 20, 9: more than 21 flowers.

Fruit size

Average weight of fruit is calculated for 10 to 20 fruits and classified into 0: smaller than 1g, 1: 1 ~ 9g, 2: 10 ~ 29g, 3: 30 ~ 49g, 4: 50 ~ 99g, 5: 100 ~ 149g, 6: 150 ~ 199g, 7: 200 ~ 249g, 8: 250 ~ 299g, 9: larger than 300g.

Fruit shape

Fruit shape is classified into 1: flattened, 2: slightly flattened, 3: round, 4: high round, 5: heart-shaped, 6: elongated cylindrical, 7: pear-shaped, 8: plum-shaped (Fig. 2).

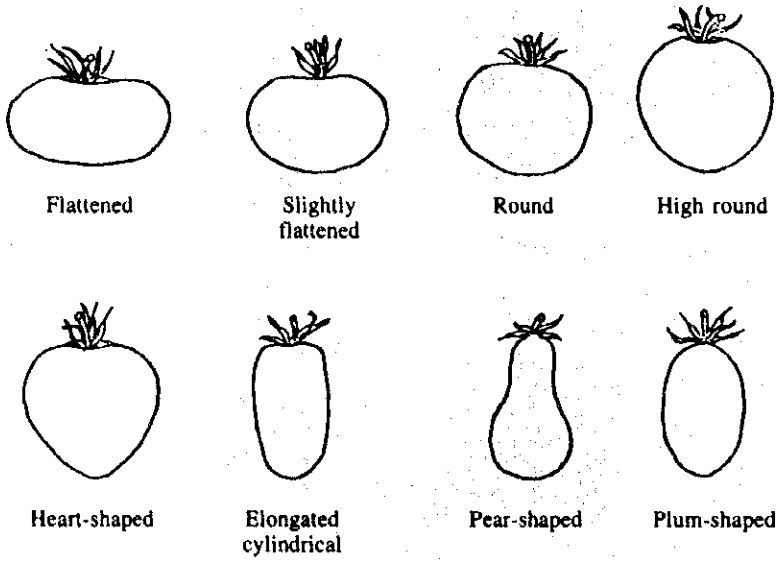


Fig. 2 Shape of fruit.

Number of locules

Fruits are cut transversely and the numbers of locules are counted. This character is classified into 1: 2, 2: 3 ~ 4, 3: 5 ~ 6, 4: 7 ~ 8, 5: more than 9.

Intensity of shoulder color at the immature stage

Intensity of green color of fruit shoulder is classified into 0: uniform (absent), 1: very light green, 3: light green, 5: green, 7: dark green, 9: very dark green.

Fruit color at maturity

External color of fruit is classified into 0: white, 1: green, 2: purple, 3: yellow, 4: orange, 5: pink, 6: red.

Fruit firmness at maturity

Fruit firmness is usually evaluated using the Push Pull Scale Unit 'firmness measuring apparatus' or Autograph 'firmness measuring machine'. If these instruments are not available, fruit firmness is evaluated by hand feeling. Fruit is classified into 1: very soft, 3: soft, 5: medium, 7: firm, 9: very firm.

Earliness of flowering

Number of days from sowing to anthesis of the first flower cluster.

<Optional items>

Color of cotyledon

Intensity of green color of cotyledons is classified into 1: very light green, 3: light green, 5: green, 7: dark green, 9: very dark green.

Color of hypocotyl

Absence or presence of purple color in hypocotyl and intensity of purple color is observed and classified into 0: absent (green color), 1: very light purple, 3: light purple, 5: purple, 7: deep purple, 9: very deep purple.

Number of leaves between inflorescences

The average number of leaves between first and third inflorescences.

Stem thickness

The average value of the maximum and minimum diameters in the thickest part of stem is expressed in centimeters as stem thickness.

Leaf width

Width of the largest leaf at harvest time is expressed in centimeters as leaf width.

Leaf color

Intensity of green color of leaves at harvest time of the first cluster is observed and classified into 1: very light green, 3: light green, 5: green, 7: dark green, 9: very dark green.

Density of hair of stem

Density of hair of stems is classified into 1: very low, 3: low, 5: intermediate, 7: high, 9: very high.

Fasciation of flower

The first flower of the first inflorescence is observed and the fasciation of flower is classified into 0: absent, 9: present.

Color of petal

This character is classified into 1: yellow, 2: orange.

Size of calyx

Size of calyx is classified by observation into 1: very small, 3: small, 5: intermediate, 7: large, 9: very large.

Length of pedicel

Length from the point of abscission of pedicel to the base of calyx is observed and classified into 1: very short, 3: short, 5: intermediate, 7: long, 9: very long (Fig. 3).

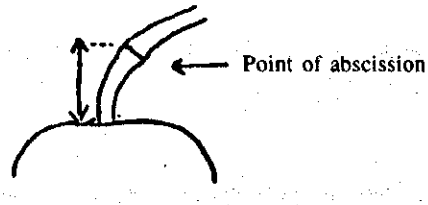


Fig. 3 Length of pedicel.

Presence of abscission layer on peduncle

This character is classified into 0: absent, 9: present.

Depression of pedicel area

Degree of depression at the pedicel end is observed and classified into 1: depressed, 3: intermediate, 5: shallow, 7: flat, 9: pointed (Fig. 4).

Size of pedicel scar

This character is classified by observation into 1: very small, 3: small, 5: intermediate, 7: large, 9: very large.

Size of corky area around pedicel scar

This character is classified by observation into 1: very small, 3: small, 5: intermediate, 7: large, 9: very large.

Fig. 4 Depression of pedicel area.

Shape of pistil scar

This character is classified by observation into 1: dot, 2: stellate, 3: linear, 4: irregular (Fig. 5).

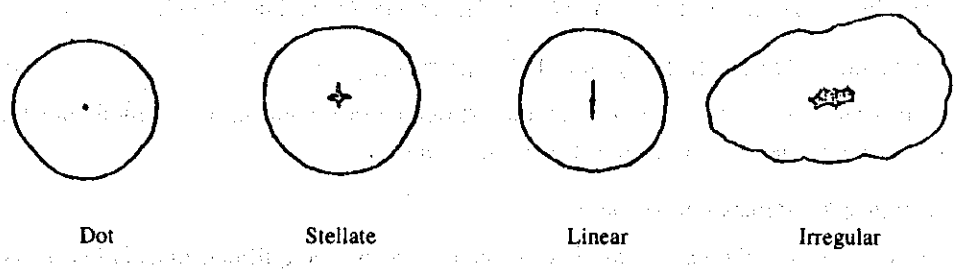


Fig. 5 Shape of pistil scar.

Shape of blossom-end

This character is classified by observation into 1: indented, 2: flat, 3: slightly pointed, 4: pointed.

Puffiness (hollow fruit)

This disorder is observed by cutting fruits transversely and classified into 0: absent, 1: very slight, 3: slight, 5: intermediate, 7: pronounced, 9: very pronounced.

Color of fruit flesh

This character is evaluated at maturity and classified into 1: yellow, 2: orange, 3: light red, 4: red, 5: deep red.

2. Secondary characters

<Essential items>

Date of maturity

Number of days from sowing to maturity of the first fruit on the first cluster.

Rate of fruit setting

Rate of fruit setting to the total number of flowers in a cluster is counted and classified into 1: very low, 3: low, 5: intermediate, 7: high, 9: very high.

Resistance to fruit cracking

Degree of fruit cracking is observed and classified into 1: very low, 3: low, 5: intermediate, 7: high, 9: very high.

Resistance to Tobacco Mosaic Virus

Resistance to Tobacco Mosaic Virus depends on the presence or absence of resistance genes. The resistance is classified into 0: absent, 1: unidentified virus, 2: Tm/+, 3: Tm/Tm, 4: Tm-2/+, 5: Tm-2/Tm-2, 6: Tm-2a/+, 7: Tm-2a/Tm-2a, 8: Tm-2/Tm-2a.

Resistance to *Fusarium oxysporum* f. *lycopersici* race 1

The resistance is evaluated based on the artificial inoculation or the natural infection in infected fields and classified into 0: absent, 9: present.

Resistance to *Verticillium dahliae*

Resistance to *Verticillium dahliae* is evaluated based on the artificial inoculation or natural infection in infested fields and classified into 0: absent, 9: present.

<Optional items>

Resistance to *Pseudomonas solanacearum*

Resistance to *Pseudomonas solanacearum* is evaluated based on artificial inoculation or natural infection in infested fields and classified into 0: absent, 1: very low, 3: low, 5: intermediate, 7: high, 9: very high.

Resistance to *Corynebacterium michiganense*

Resistance to *Corynebacterium michiganense* is evaluated based on artificial inoculation or natural infection in infested fields and classified into 0: absent, 1: very low, 3: low, 5: intermediate, 7: high, 9: very high.

Resistance to *Fusarium oxysporum* f. *lycopersici* race 2

The resistance is evaluated based on artificial inoculation or natural infection in infected fields and classified into 0: absent, 9: present.

Resistance to *Fusarium oxysporum* f. *lycopersici* race 3

The resistance is evaluated based on artificial inoculation or natural infection in infected fields and classified into 0: absent, 9: present.

Resistance to *Fusarium oxysporum* f. *radicis-lycopersici*

The resistance is evaluated based on artificial inoculation or natural infection in infected fields and classified into 0: absent, 9: present.

Resistance to *Meloidogyne* spp.

Resistance to *Meloidogyne* spp. is evaluated based on artificial inoculation or natural infection in infected fields and classified into 0: absent, 9: present.

3. Tertiary characters

<Essential items>

Soluble solids content

Refraction of filtrate of juice squeezed from mature fruits of the second and third clusters is measured with a refractometer and classified into 1: lower than 2%, 2: 3%, 3: 4%, 4: 5%, 5: 6%, 6: 7%, 7: 8%, 8: 9%, 9: higher than 10%.

Titratable acidity

Filtrate of juice squeezed from mature fruits of the second and third clusters is titrated with 0.1N NaOH to the end point of pH 8.1. Acidity is expressed in % of citric acid and classified into 1: lower than 0.2%, 2: 0.3%, 3: 0.4%, 4: 0.5%, 5: 0.6%, 6: 0.7%, 7: higher than 0.8%.

pH

PH of juice squeezed from fruits at the second and third clusters is measured with a pH meter, and classified into 1: lower than 3.9, 2: 4.0 ~ 4.1, 3: 4.2 ~ 4.3, 4: 4.4 ~ 4.5, 5: 4.6 ~ 4.7, 6: 4.8 ~ 4.9, 7: higher than 5.0.

Flavor

Taste and smell of fruits are evaluated by sensory test. Flavor is classified into 1: very poor, 3: poor, 5: intermediate, 7: good, 9: very good.

Use

Use of fruit is classified into 1: fresh market, 2: whole packing, 3: juice, 4: concentration, 5: other types of processing, 6: rootstock.

Yield

Fruit yield is measured for ten plants and classified into 1: very low, 3: low, 5: intermediate, 7: high, 9: very high.

<Optional items>

Firmness of flesh

Firmness of pericarp is measured using an Autograph or Push-Pull Scale Unit with a plunger 1mm in diameter and expressed in g force for the penetration of the plunger.

Toughness of skin

The toughness of skin is measured using an Autograph or Push-Pull Scale Unit with a plunger 1mm in diameter and expressed in g force for the penetration of the plunger.

Photo. 1 Tomato seedlings raised in seedling flats. The seedling flats are covered with plastic film to maintain the temperature.

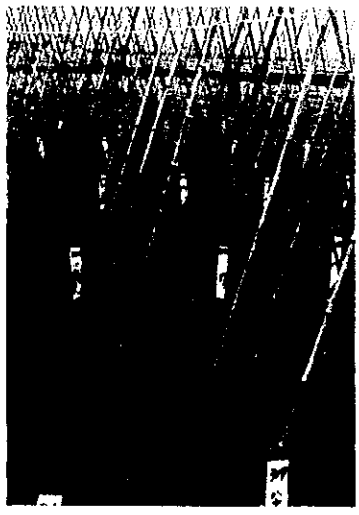


Photo. 2 Tomato plants for evaluation just after transplanting to field.

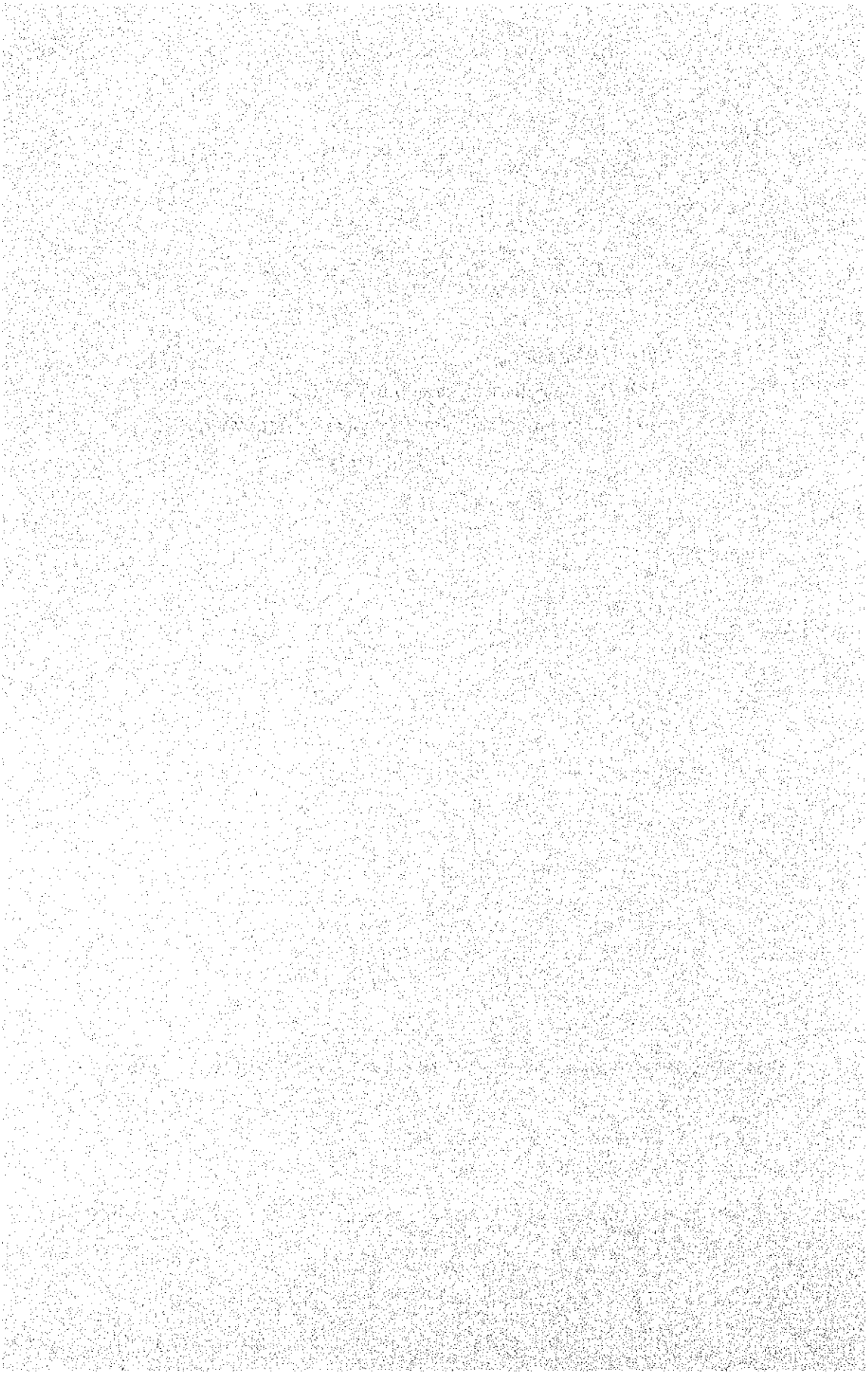
VIII. Strawberry

VIII-1. Cultivation of strawberry PGR

VIII-2. Evaluation of characteristics of strawberry PGR

Tatsuya Mochizuki

Kurume Branch, National Research Institute of Vegetables, Ornamental Plants and Tea, MAFF, Kurume 830 JAPAN



VIII-1. Cultivation of strawberry PGR

1. Cultivation systems

Strawberry is grown based on various cultivation methods, including open field, forcing or semi-forcing cultivation with plastic cover or greenhouse. However, for the evaluation of PGRs with a wide range of morphological and physiological traits, cultivation in open field is recommended. Traits related to forcing or semi-forcing cultivation should be evaluated separately.

2. Season for cultivation

The flower buds of strawberry are initiated under comparably low temperatures and short day conditions except for the everbearing varieties. Therefore, seedlings are transplanted in the field in autumn, to secure favorable outdoor conditions so as to induce flower bud initiation during autumn and winter. Usually, harvest starts from spring and continues until early summer. In case of everbearing cultivars, harvest continues until autumn.

3. Preparation of nursery plants

Strawberry is usually propagated by runner plants. Production of runner plants is induced by comparably high temperatures and long days, if dormancy has been fully broken by low temperatures. Therefore, mother plants are prepared before autumn and kept under low temperature conditions, in propagation fields or in nursery beds until transplantation in spring. Fungicides, mainly for the control of anthracnose or powdery mildew and pesticides for the control of weevils, *Tortrix* moths or aphids are applied during the propagation and nursery stages.

There are various systems for the preparation of seedlings from runner plants as follows.

① Waiting bed system: Runner plants are transplanted to nursery beds in early summer to secure uniform growth before transplanting to the experimental field.

② Potting system: Runner plants are raised in small pots (with a diameter of 9 ~ 12 cm) in early summer. The nutritional level (mainly nitrogen) can be regulated by the application of liquid or tablet type fertilizer to promote flower bud initiation before transplanting to the experimental field.

③ Direct transplantation system: Runner plants are kept in the propagation field until direct transplantation to the experimental field. Although the uniformity of runner plants is comparably low, this system enables to save labor.

4. Field preparation

Experimental fields are plowed and rotary-tilled at a depth of 20 ~ 30 cm, and beds (80 ~ 100 cm in width and 20 ~ 30 cm in height) are formed. Fertilizer (N, P, K, 1.0 ~ 1.5 kg/a) and organic manures (50 ~ 100 kg/a) are applied. Fumigation of soil with chemicals

or steam is recommended to avoid soilborne diseases, nematodes and beetles, in case experimental fields had been used for strawberry cultivation in the previous season.

5. Transplanting

Before transplanting, the number of leaves in each seedling is adjusted to secure uniform growth. Older leaves are removed, while only 4 ~ 5 fully expanded leaves remain. Ten to twenty plants of each cultivar are transplanted 40 ~ 50 cm apart in a single row in each bed with several replications. Watering is effective to secure good establishment after transplanting. Pesticides are applied to planting holes to control beetle larva.

6. Field management

Herbicides are applied to control weeds before germination of weeds in autumn. Mulching with plastic films or straw is applied in early spring to maintain the moisture and temperature of soil. Before mulching, top dressing of fertilizer (N, K, 0.5 ~ 1.0 kg/a) is applied to accelerate the growth after the breaking of dormancy. In autumn before the onset of dormancy and in spring before flowering, several fungicides and pesticides are applied to control pests and diseases. However, application after flowering should be avoided due to possible damage to natural pollinators.

7. Harvest and post-harvest handling

As strawberry fruits ripen quickly in spring, harvest should be carried out at least every two days. It is recommended to harvest in the morning when temperatures are comparably low, and store fruits in cool places as soon as possible to avoid direct exposure to sunshine. Shallow and soft trays are recommended for harvest because strawberry fruits are so soft that they are easily injured if they are piled up. Uniform and healthy fruits with adequate maturity should be collected carefully for the evaluation of traits of fruits.

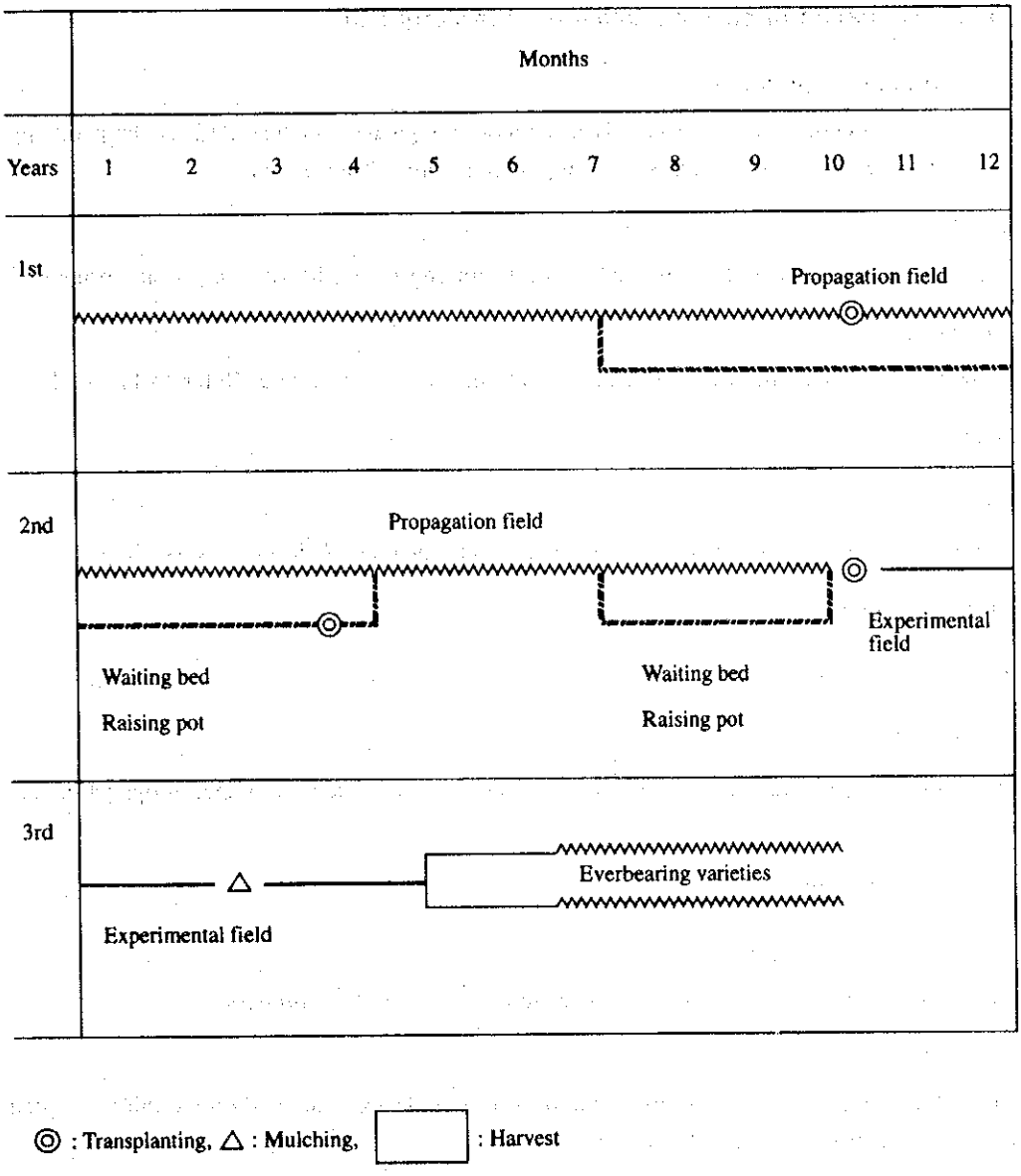


Fig. 1 Cultivation practices for open field culture of strawberry in Japan.

VIII-2. Evaluation of characteristics of strawberry PGR

1. Primary characters

This category consists of mainly basic morphological characters. At least ten plants per entry are necessary for evaluation, but replications are not necessary.

<PLANT>

Plant characters are mainly evaluated at the beginning of the harvest season in spring.

Growth habit*

Growth habit is classified into 3: erect, 5: intermediate, 7: prostrate. Refer to Photo. 1.

Height (cm)

Vigor

Vigor is classified into 1: very low, 3: low, 5: intermediate, 7: high, 9: very high.

Number of leaves*

Number of lateral shoots

<RUNNER>

In summer, from mid-July to early August, characters related to runner propagation are evaluated.

Number of runners

Diameter of runner (mm)

Diameter of runners is measured in the central part of the first runners.

<PETIOLE>

Just before transplanting in autumn, some traits of petiole are evaluated on the third (counted from the apical tips) fully unfolded leaves.

Petiole length* (mm)

Petiole coloration

Anthocyan pigmentation is classified into 0: absent 1: very weak, 3: weak, 5: intermediate, 7: strong, 9: very strong.

<LEAF>

At the beginning of the harvest season in spring, main traits of leaf are evaluated on the third

---

Note: Items with asterisks* indicate essential items and others are optional items.

(counted from the apical tips) fully unfolded leaves.

Petiole thickness (mm)

Leaflet length* (cm)

Leaflet width* (cm)

Bending

Bending of leaf is classified into 3: upward, 5: flat, 7: downward.

Leaf thickness (mm)

Leaf color

Color of leaf is classified into 1: yellow green, 3: green, 5: deep green, 7: dark green.

Depth of serration

Depth of serration is classified into 1: very shallow, 3: shallow, 5: intermediate, 7: deep, 9: very deep.

Number of leaflets

Number of leaflets is counted and classified into 1: three, 2: sometimes more than three.

<FLOWER>

At the beginning of the harvest season in spring, main traits of flower clusters and flowers are evaluated on the first flower clusters, and the second and third fruits of the cluster.

Length of flower cluster* (cm)

Number of flowers*

Diameter of flower (mm)

Diameter of calyx (mm)

Number of petals

Length of anther (mm)

Pollen fertility (%)

Microscopic observation of pollen is carried out by staining on three flowers per plant, and examining 300 pollen grains per flower for pollen fertility.

Pollen diameter (μm)

Microscopic observation of pollen is carried out for three flowers per plant, and examination

of 100 pollen grains per flower for measurement of pollen diameter.

<FRUIT>

Traits of fruits are mainly evaluated in the second and the third fruits of a cluster except for the thickness of peduncle and uniformity of fruits.

Thickness of peduncle (mm)

Thickness of peduncle is observed on the first fruit of the first clusters.

Detachment of peduncle

Detachment of peduncle is classified into 1: very easy, 3: easy, 5: intermediate, 7: difficult, 9: very difficult.

Detachment of calyx

Detachment of calyx is classified into 1: very easy, 3: easy, 5: intermediate, 7: difficult 9: very difficult.

Shape of fruit*

Shape of fruits is observed for normal fruits and classified into 1: oblate, 2: globose, 3: globose conic, 4: conic, 5: long conic, 6: wedge, 7: cylindrical, 8: oblong. Refer to Fig. 2.

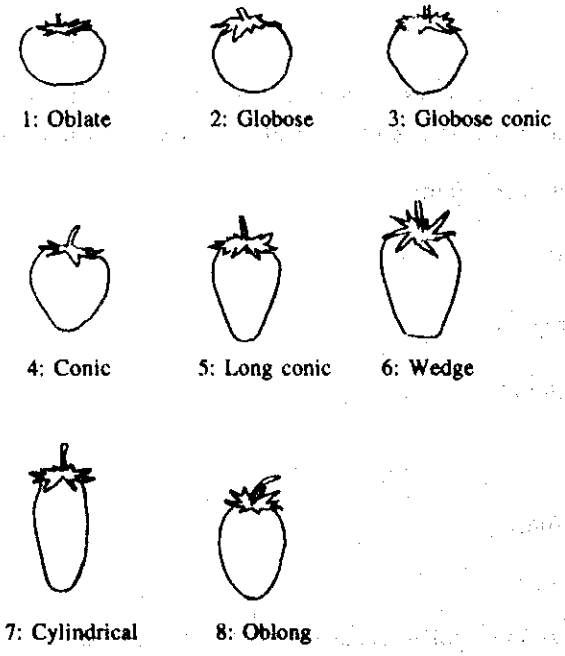


Fig. 2 Typical fruit shape of strawberry varieties.

Weight of fruit* (g)

Size of neck

Size of neck is classified into 1: very small, 3: small, 5: intermediate, 7: large, 9: very large.

Skin color of fruit*

Skin color of fruit is observed for mature fruits, and classified into 1: yellow white, 2: light orange, 3: orange red, 4: light red, 5: red, 6: dark red, 7: purple red.

Flesh color of fruit*

Flesh color of vertical section of mature fruit is classified into 1: white, 2: light yellow, 3: light orange, 4: light red, 5: red, 6: dark red.

Core color of fruit

Core color of vertical section of mature fruit is classified into 1: white, 2: light yellow, 3: light orange, 4: light red, 5: red, 6: dark red.

Hollow heart of fruit

Size of hollow heart is observed on the vertical section of mature fruits and classified into 0: no hollow heart, 1: very small, 3: small, 5: intermediate, 7: large, 9: very large.

Vertical furrow of fruit

Vertical furrow of fruit is observed on the surface of fruits and classified into 0: no furrows, 1: very small, 3: small, 5: intermediate, 7: large, 9: very large.

Gloss of fruit

Gloss of fruit is observed and classified into 1: very slight, 3: slight, 5: intermediate, 7: pronounced, 9: very pronounced.

Density of achene

Density of achene is expressed as number of achenes in a one cm diameter circle on the surface of fruits.

Depth of achene

Depth of achene is classified into 1: raised, 3: shallow, 5: intermediate, 7: deep.

Uniformity of fruit

Uniformity of fruit is observed in the second to tenth fruits of the first clusters and classified into 1: very low, 3: low, 5: intermediate, 7: high, 9: very high.

2. Secondary characters

This category consists of the traits mainly related to the adaptability such as eco-physiological responses, tolerance or resistance to environmental stresses, pests and diseases.

<GROWTH RESPONSE OF PLANT>

Growth response to environmental conditions needs to be evaluated under adequate conditions for each trait using at least 10 ~ 20 plants.

Date of first runner appearance*

Date of first runner appearance is observed from late spring to early summer in open field.

Fruiting habit*

Fruiting habit is evaluated based on the appearance of flowers all the year round and classified into 1: June bearing and 5: everbearing.

Date of first flowering*

Date of first flowering is observed in spring.

Date of first harvest*

Date of first harvest in spring is recorded as date of harvest.

Date of flower bud initiation

Date of flower bud initiation is assessed by the microscopic observation of apical buds dissected from plants grown under comparably short days and low temperatures (usually in autumn).

Degree of low temperature requirement for breaking dormancy

Degree of low temperature (below 5°C) requirement for breaking dormancy is evaluated by the gradual transfer from low temperature (usually outdoor in late autumn to winter) to high temperature (usually in green house or with plastic covering).

Dormancy

Dormancy is estimated from the dwarfness of plants while daily average temperatures remain around 10°C in late autumn or early spring and classified into 1: very shallow, 3: shallow, 5: intermediate, 7: deep, 9: very deep.

<ENVIRONMENTAL STRESS>

Tolerance to environmental stress is evaluated under natural conditions, in the field, in the greenhouse, or under plastic covering, using at least 20 plants.

Heat tolerance

Heat tolerance is estimated from the reduction of pollen fertility at 35°C compared to 17°C.

Cold tolerance

Cold tolerance is estimated from the reduction of pollen fertility at 5°C compared to 17°C.

Drought tolerance

Drought tolerance is evaluated in the propagation field in summer and classified into 1: very low, 3: low, 5: intermediate, 7: high, 9: very high.

<RESISTANCE TO PESTS AND DISEASES>

Resistance to pests and diseases is evaluated based on natural infection or artificial inoculation using at least 20 plants. Resistance is evaluated in relation to the percentage of infected plants and/or severity of symptoms, compared with check cultivars, and classified into 1: very low, 3: low, 5: intermediate, 7: high, 9: very high.

Powdery mildew

Natural infection using plastic tunnel or covering is evaluated from late spring to early summer.

Fusarium wilt

Transplantation to artificially or naturally infected soil and evaluation from late spring to summer.

Gray mold

Natural infection in the field, usually with plastic covering in late autumn.

Anthracnose

Artificial inoculation with spore suspension under warm and humid conditions.

Verticillium wilt

Transplantation to artificially or naturally infected soil from late summer to autumn.

Red stele

Artificial inoculation with spore suspension under warm and humid conditions.

Phytophthora rot

Artificial inoculation with spore suspension under warm and humid conditions.

Angular leaf spot

Natural infection in the field from late spring to summer.

Spider mite

Natural infection in the field.

Root knot nematode

Transplantation to infected soil or natural infection in the field.

Leaf and stem nematode

Transplantation to infected soil or natural infection in the field.

3. Tertiary characters

This category consists of traits related to fruit quality and productivity.

<FRUIT QUALITY>

At least ten of the second and third fruits from the first clusters are used for the evaluation of fruit quality. Fruits should be completely mature but not overripe. Appearance of fruits must be representative of each cultivar.

Sugar content*

Brix value of fruits is measured with a refractometer.

Titratable acidity

Titratable acidity is measured as percentage of citric acid by titration.

PH of juice*

PH of fruit juice is measured on raw extract of fruit using a pH meter. PH of juice is an alternative trait of titratable acidity which indicates sourness of fruit.

Flavor*

Flavor of fruit is examined by sensory test and classified into 1: very slight, 3: slight, 5: intermediate, 7: strong, 9: very strong.

Off-flavor

Off flavor of fruit is classified into 1: very slight, 3: slight, 5: intermediate, 7: strong, 9: very strong.

Firmness of fruit * (g)

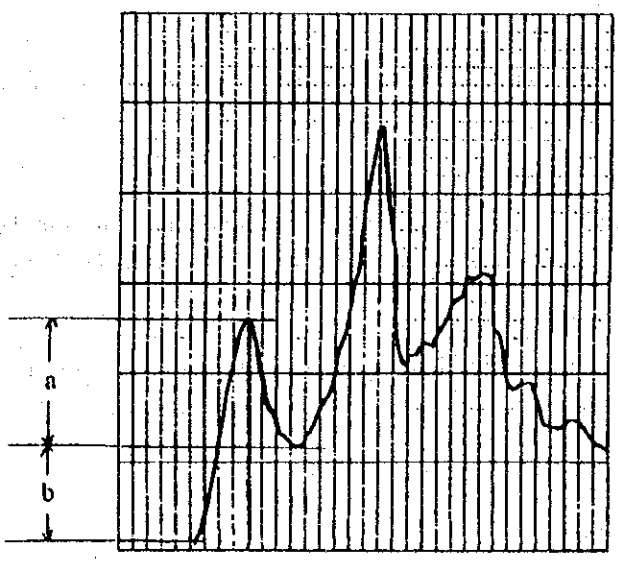
To evaluate firmness of fruit, maximum stress is applied to fruits by puncture force test using Force-gauge or Autograph with 3mmø depressing rod. Refer to Fig. 3.

Firmness of flesh (g)

Firmness of flesh is measured using an Autograph with 3mmø depressing rod. Refer to Fig. 2.

Toughness of skin (g)

Toughness of skin is measured using an Autograph with 3mmø depressing rod. Refer to. Fig. 2.



Fruit firmness: a+b, Flesh firmness: b, Skin toughness: a

Fig. 3 Typical force response curve in puncture force test of strawberry fruits using Autograph.
(Refer to Monma *et al.*, Bull. Veg. Ornam. Crops Res. Stn. B, 1:1-11, 1987)

Texture of fruit

Texture of fruit is classified into 1: extremely non-mealy, 3: non-mealy, 5: intermediate, 7: mealy, 9: very mealy.

Redness of juice

Redness of juice is measured by the absorbance of HCl-methanol extract (×10 ~ 20) with a spectrophotometer at 500 nm.

Pectin content (mg/100g)

Pectin content is measured by the determination of the total pectin and its components based on solubility in water, phosphoric acid and hydrochloric acid analyzed by Carbazole calorimetric method.

Drip ratio (%)

Drip ratio of fruit is estimated from the decrease of weight by defrosting compared to fresh weight.

Vitamin C content (mg/100g)

Vitamin C content is estimated by quantitative analysis, *e.g.*, hydrazine calorimetric method, fluorescence method or HPLC method.

Storability (%)

Storability of fruit is evaluated based on the changes in the skin color or fruit firmness after storage at 15°C for 3 ~ 5days.

Transportability

Transportability of fruit is evaluated based on the appearance of fruit before and after transportation and classified into 1: very low, 3: low, 5: intermediate, 7: high, 9: very high.

<YIELD COMPONENTS>

Ten plants with at least two replications are used for the estimation of yield components.

Total number of fruit

The average number of fruits for each replication.

Average fruit weight (g)

The average weight of all the fruits.

3: Erect

5: Intermediate

7: Prostrate

Photo. 1 Typical growth habit of strawberry varieties.