- 開発援助の現場における園芸の育苗技術 -

野菜の育苗技術

Raising Seedling Technique of Vegetables

20th September 2024

JICA 筑波

沼田光夫

NUMATA Mitsuo

Introduction

“ NAE-HANSAKU ”

苗半作

- The proverb that has been told in Japan for a long time
  - It means “If you could succeed in raising seedlings, you can almost accomplish more than 50% of whole cultivation.”
- Raising seedling is important
  - Especially in fruits vegetables, flower bud initiation start at the nursery stage, so it is important to raise well-balanced seedlings of both top and root by performing appropriate environmental control.

Seedling raising in the field of technical cooperation

The importance of raising seedlings is being recognized

Preparation of media for potting
(Ghana 2020)

Sowing on raised bed
(Ethiopia 2018)

(Photo provided by the "Market-Oriented Agriculture Promotion for Extension Officer" course)

※Refer : Technology that participants learned the most from the Knowledge Co-Creation Program in Japan

Reference

—Technical issues in the field of extension by trainees, individual issues implemented during training in Japan, and locally applicable technical items(2015～2019)—

Material provided by:
Market-Oriented Agriculture Promotion for Extension Officer Course

Technical issues in the field of extension and locally applicable technologies

Issue and challenge identified at the beginning of the training		Skill & knowledge to be applied after the training	No. of participants
Variety selection	Adaptability	Cultivation trial (sensory test)	1
Seed production	Non-certified seeds	Seed production (fermentation, washing and drying)	5
Nursery technique	Quality of seedlings	Raising seedlings (media and skills) Neridoko	38 2
Pest & disease management	Soil borne diseases Fungicide Knowledge	Grafting	26
		Solarization, soil burning	8
		Pest & disease identification and management	5
		Seed treatment	2
		Conservation of natural enemies	1
		Cost saving chemical sprayer	1
Fertilizer application	Amount & timing Organic manure	Compost making	22
		Utilization of carbonized rice husk	4
		Fertilizer application	4
		Soil analysis	1
Cultivation technique	General knowledge Plant density Training & pruning Mulching Ridge size Rain shelter Irrigation & water	Use of mulching for tomato production	17
		Pruning & training for Solanaceae and Cucurbitaceae	14
		Potato planting using cut tubers	2
		Carrot thinning according to market needs	1
		Planting in raised beds	1
		Potato ridging	1
Postharvest handling & marketing, Others (The rest is omitted)			

Seedling raising in the field of technical cooperation

Main theme of the technologies are;

- Growing media
- Container
- Raising seedling method
- Grafting technology

Growing Media

Nursery media preparation
(Sudan 2016)

Preparation of nursery media
(Lesotho 2020)

Compost making
(Zimbabwe 2020)

Making carbonized rice husk
(Kenya 2019)

Mixture of nursery media
(Tanzania 2020)

Preparation of nursery media
(Kenya 2013)

Sawdust for media mixture
(Uganda 2017)

Making carbonized maize stover
(Zambia 2014)

(Photo provided by the "Market-Oriented Agriculture Promotion for Extension Officer" course)

Container

Raising tray seedlings
(Tanzania 2010)

Utilization of seedling tray
(Zimbabwe 2011)

Utilization of sowing box
(Rwanda 2014)

Potting of seedlings
(Uganda 2014)

Utilization of egg tray
(Malawi 2018)

Paper pot nursery
(Zambia 2020)

Paper pot seedlings
(Nigeria 2020)

Improvising egg tray
(Ghana 2020)

(Photo provided by the "Market-Oriented Agriculture Promotion for Extension Officer" course)

Soil Block

Soil block nursery demo (Malawi 2019)

Soil block nursery (Tanzania 2019)

Grafting

Grafting of tomato (Kenya 2012)

(Photo provided by the "Market-Oriented Agriculture Promotion for Extension Officer" course)

Contents

1. The objectives of raising seedlings and methods
2. Raising Ordinary seedlings
3. Raising Plug seedling
4. Grafting
5. Dividing labor of raising seedlings

1 The objectives of raising seedlings and methods

1.1 The objectives of raising seedlings

1.2 Types of seedlings and raising seedling methods

1.3 History of raising seedling technique

1.1 The objectives of raising seedlings

1. Ensure germination and initial growth, enhance its uniformity.
2. Protect young seedlings from damage caused weather or pest and disease.
3. Possible to start early sowing and raising seedling when the natural environment such as temperature is still unfavorable.
4. Increase utilization efficiency of field and cultivation facilities.
5. To do several treatment, such as grafting or promotion of flower bud differentiation etc., efficiently.
6. Save labor in cultivation management and materials, by concentrating on a limited space.

1.2 Type of seedlings and raising seedling methods

1. Type of seedlings

- **Molded seedling** : Plug seedling, Pot seedling, Soil block, etc.
- **Non-molded seedling** : Outdoor raising seedling, Bare seedling, etc.

Plug seedlings

Pot seedlings

Soil block seedling

(Source: httpecovillagehokkaido.blogspot.com2009050506.html)

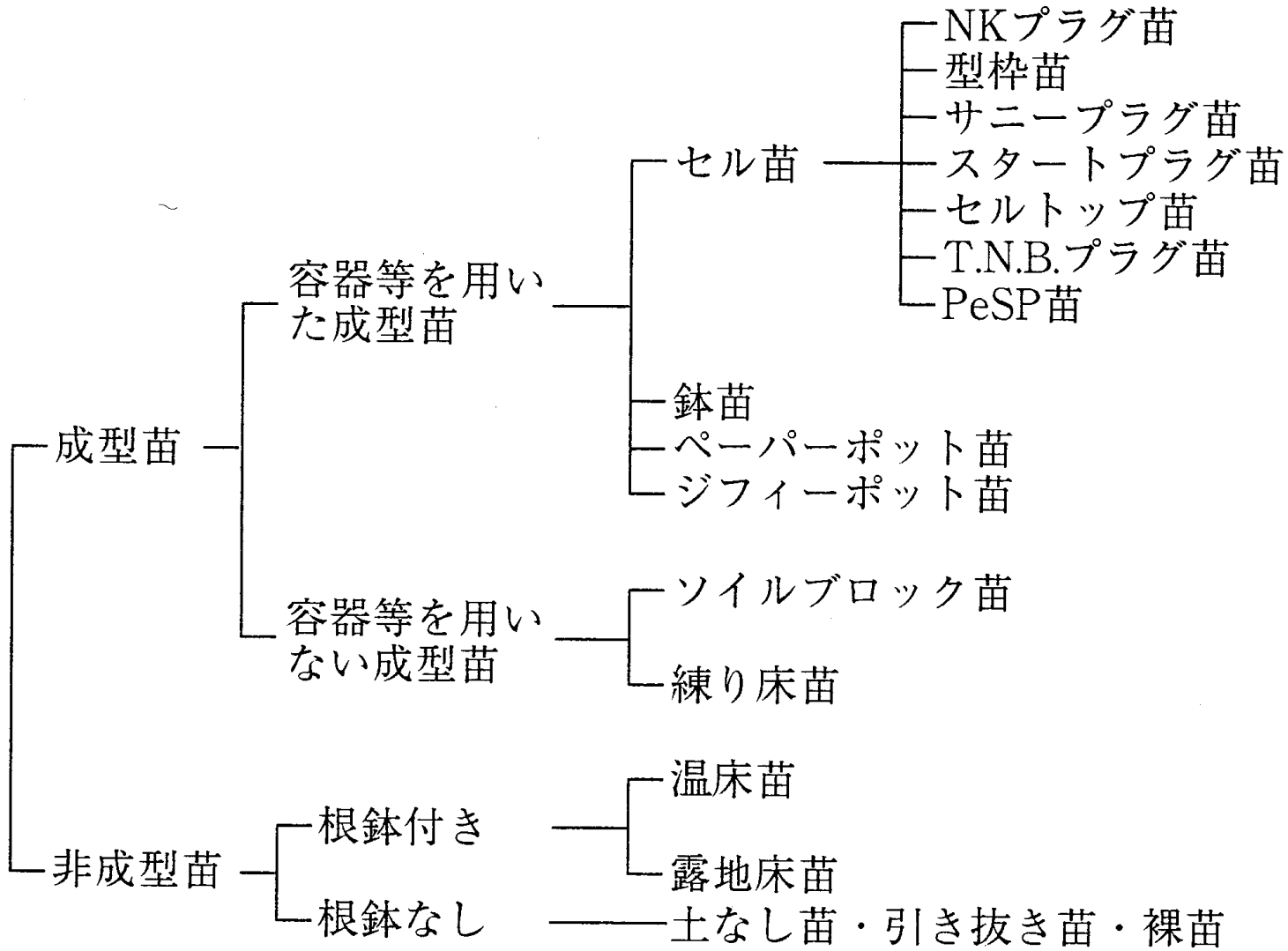

成型苗
容器等を用いた成型苗
セル苗
NKプラグ苗
型枠苗
サニープラグ苗
スタートプラグ苗
セルトップ苗
T.N.B.プラグ苗
PeSP苗
鉢苗
ペーパーポット苗
ジフィーポット苗
容器等を用いない成型苗
ソイルブロック苗
練り床苗
非成型苗
根鉢付き
温床苗
露地床苗
根鉢なし
土なし苗・引き抜き苗・裸苗

図　　苗の分類（崎山，西）

1.2 Type of seedlings and raising seedling methods

2. Raising seedling methods

- **Place of raising seedlings** : Green house, Open field
- **Temperature control** : Heating /Heat insulation, Unheated raising seedling
- **Container** : Raising seedling in Plastic pot, Paper pot, Cell tray, Soil block etc.

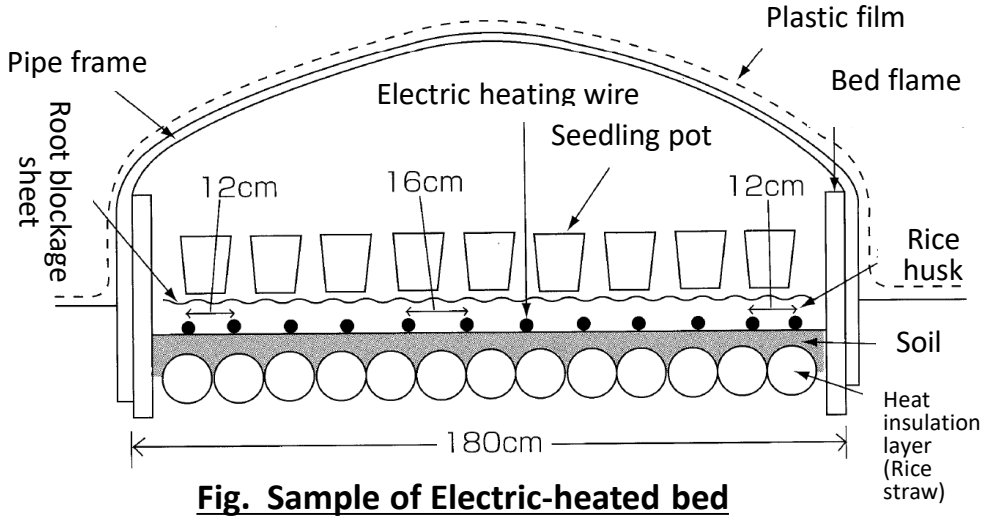
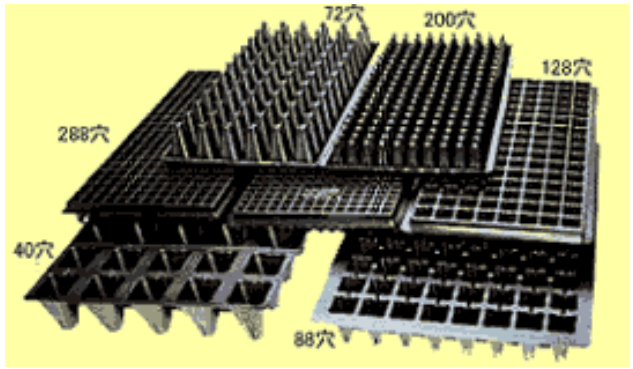


Fig. Sample of Electric-heated bed



. Raising seedling container

Electric- heated bed

1.2 Type of seedlings and raising seedling methods

2. Raising seedling methods (Cont.)

- **Cultivation management**: Night cooling treatment, Grafting seedling , Soilless culture, etc.

Soilless culture

Night cooling

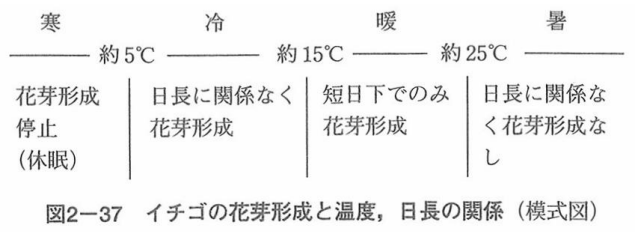
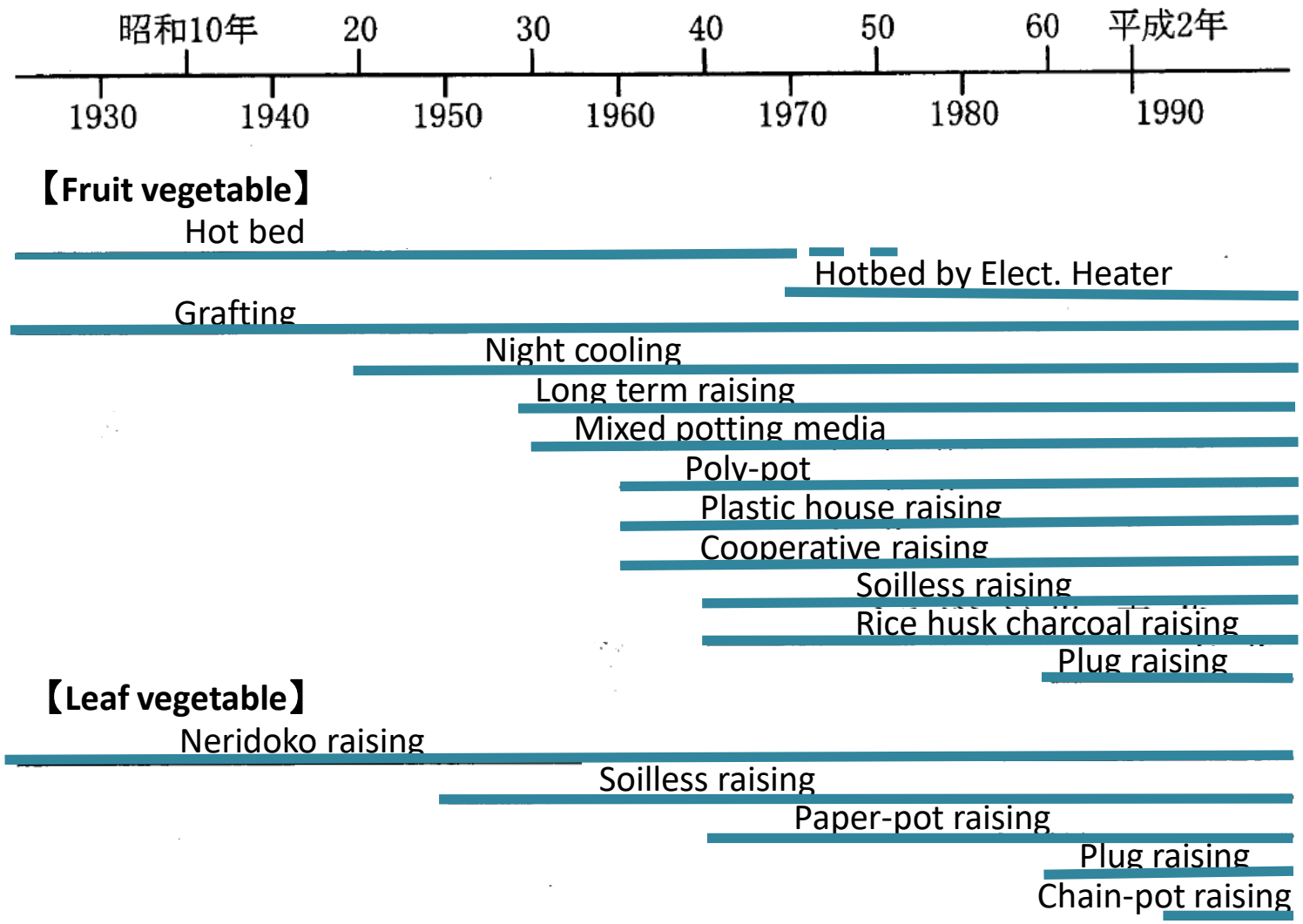


図2−37　イチゴの花芽形成と温度，日長の関係（模式図）

Grafting

1.3 History of raising seedling technique

Fig. History of raising seedling technique in Japan



（Source：施設園芸・植物工場ハンドブック）

＜Practice case＞

Making hot-bed

Making Electric- heated bed

2 Raising Ordinary seedlings

2.1 Glowing media

2.2 Container

2.3 Raising seedling management

2.4 Transplanting

2.1 Glowing media

Requirement of growing media

1. Both drainage and water holding capacity are good.
2. Retain sufficient amount of fertilizer component and its component are well balanced.
3. Free from pathogenic organisms, pests, weed seeds, harmful substances.
4. Easy to handle.

2.1 Glowing media

Types of media

- Piled bed soil
- Instant bed soil
- Artificial soil mix
- Soil block
- Rice husk charcoal
- Rock wool

Piled bed soil for sale

(Source:httpsukagawaten.blog33.fc2.comblog-entry-129.html)

Instant bed soil

(Source:httpsblogs.yahoo.co.jpmetalwoodmanGALLERYshow_image.htmlid=35704739&no=0)

Artificial soil mix product

Soil block

Rice husk charcoal

Rock wool

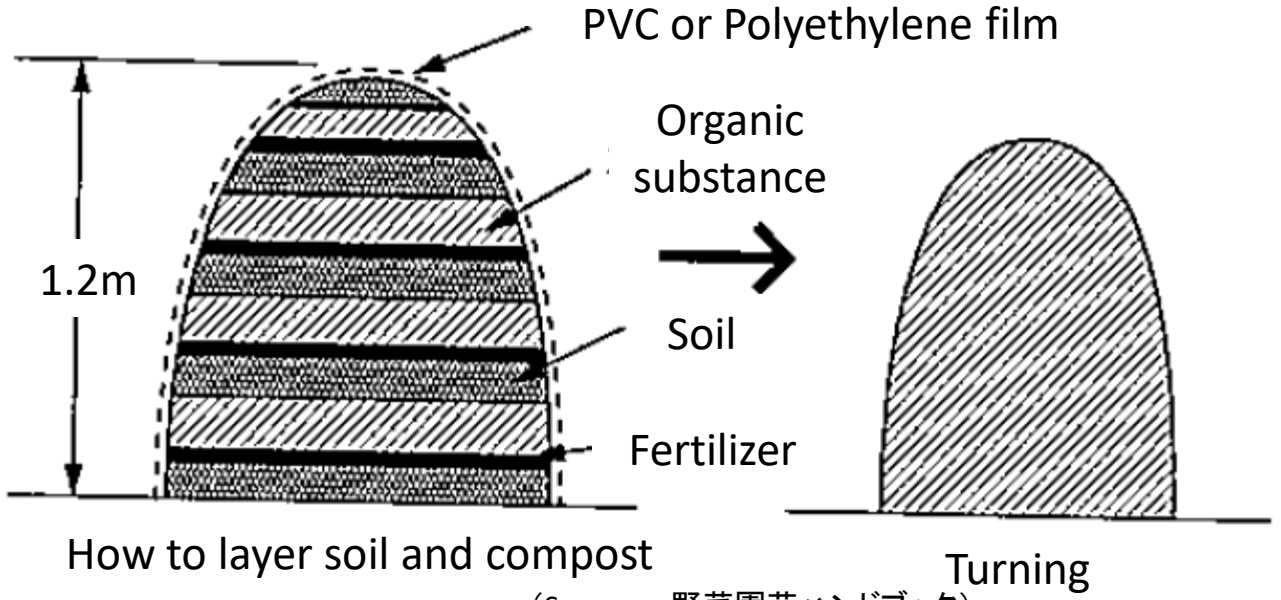
Peat moss

2.1 Glowing media

■ Piled bed soil

- Pile several layers of soil, immature organic matter, fertilizer, and mature well by turning and mixing the soil 2 or 3 times.
- Use soil from sub-soil or mountain which is uncontaminated from disease.
- For organic matter, rice straw, wheat straw, fallen leaves etc. are used.
- Add appropriate amount of fertilizer and water.

Fig.　Piling and turning of bed soil



（Source：　野菜園芸ハンドブック）

2.1 Glowing media

Instant bed soil

- Mix organic matter(well matured compost, leaf mold, matured organic matter etc.) and fertilizer to the soil and make it.
- It takes less time and labor by making just before to use.

Table: Instant growing media mixture

crops	Mixture ratio Soil: Compost	Fertilizer(g/m3)			Remarks
		N	P2O5	K2O	
Cucumber	1:3	100	1,000	100	Watermelon, Pumpkin
Tomato	2:2	100	1,000	100	Tobacco
Egg plant	3:1	200	1,000	200	Pepper, Sweet pepper

(Takahashi)

2.1 Glowing media

Soil Block

- Add water and soil to peat moss, well fermented compost etc., and knead it.
- Make block with a size of 3～ 15cm square.

Soil block

Rice husk charcoal

- Used alone with as rice husk charcoal, or mixed with other medium.
- Alkalinity is strong, so adjust acidity and use it.

Rice husk charcoal

2.2 Raising seedling container

■ Type of container

1. Sowing box

- Used as sowing bed, and after cotyledon spreading, potted in plastic pot.

2. Plastic pot

- Made of plastic, individual or connected.

3. Paper pot

- Made of paper, light weigh and compact collapsible connection pot.
- Connection pot, connected in a chain form at the end of raising seedling.

（日本甜菜製糖）

2.3 Raising seedling management

Light condition management

- The intensity of light directly affects photosynthesis.
- It also affects flower bud formation and succulent growth of seedling.
- Raising seedlings in winter when light to be weak, take proper space between seedlings.
- Raising seedlings in hot season, may need to shade with cheesecloth or nonwoven fabric.

2.3 Raising seedling management

■ Temperature control

- Generally, the optimum growth temperature of crops is high during seedling season and decreases as growth progresses.
- If it is higher than optimum temperature during raising seedling, it cause low quality of seedlings, such as succulent growth or effect on flower bud differentiation.
- The seedlings grow compact and firm by temperature management of 7 to 10 ℃ difference of day and night.
- Good seedling with well developed root can be raised by temperature management of 5 to 7℃difference of day and night.
- The growth will be of reproductive type, if the temperature controlled lower.

Table: Optimum temperature for raising fruits vegetable seedling

Vegetable	Temperature (℃)		Soil (℃)
	Day	Night	
Tomato	24～27	15～17	18～20
Eggplant	25～30	18～20	23～25
Sweet pepper	25～30	18～20	25～26
Cucumber	25～28	17～20	20～23
Watermelon	25～30	18～20	23～25
Melon	25～30	18～22	23～25

(Itagi)

2.3 Raising seedling management

Water management

- Basic watering method is to irrigate the amount of water that required for the day, in the morning.
- Watering on cloudy weather or in evening time are one of the cause of succulent growth.
- Volume of watering amount is closely related to amount of fertilizer absorption of the seedlings.

2.4 Transplanting

Duration of raising seedlings

1. Cucurbitaceae vegetables:

- Rooting ability of seedling is weak and easy to be over aged, so transplant in young seedling stage.

2. Solanaceae vegetables:

- It has strong rooting ability.
- Young seedling is vigorous in fertilizer and water absorption, then suitable for transplanting when environmental condition after planting is bad.
- Large seedlings are capable of early harvesting or shortening of field occupying period, however rooting ability is weak, then suitable for transplanting when environmental condition after transplanting is good .

2.4 Transplanting

Acclimatization

- In order to adapt to the environment after transplanting, refrain from watering, lower the night temperature, and increase ventilation, in the late stage of raising seedlings.

Transplanting method

- Plant in a depth that the root bowl is slightly hidden.
- In dry season, to be planted somewhat deep, and in cold season, planted after soil temperature rise by plastic mulch etc.

表　　各種野菜の育苗日数と定植時の苗の大きさ

野菜の種類	作型	播種期	定植期	育苗方式	育苗日数	定植苗の状態
		月・旬　月・旬	月・旬　月・旬			
トマト	露地	3・中～3・下	6・上	ポリ鉢	70	本葉7～8枚，第1花房開花始
	ハウス促成	7・下～8・上	8・上	ポリ鉢	25～30	本葉8枚前後，第1花房開花直前
	ハウス半促	9・下～10・上	11・中～11・下	ポリ鉢	55～60	本葉8～9枚，第1花房開花始
	ハウス抑制	6・上～6・下	7・中～7・下	ポリ鉢	30～33	本葉8枚前後，第1花房開花直前
ナス	露地	1・上～1・中	4・上～4・中	ポリ鉢	80～90	本葉12～13枚，1番花開花前後
	ハウス促成	6・下	8・下	ポリ鉢	56～57	本葉12～13枚，1番花開花前後
	ハウス半促	10・下～11・上	1・下～2・上	ポリ鉢	80～90	本葉12～13枚，1番花開花前後
ピーマン	露地	2・中～2・下	4・下	ポリ鉢	60～70	本葉10～12枚，1番花開花直前
	ハウス促成	8・上	9・下	ポリ鉢	40前後	本葉10～12枚，1番花開花直前
	ハウス半促	1・中	3・下	ポリ鉢	60～70	本葉10～12枚，1番花開花直前
キュウリ	ハウス促成	9・中～9・下	10・中	ポリ鉢	25	本葉2.5枚
	ハウス半促	12・上～12・下	1・上	ポリ鉢	30前後	本葉3枚
	ハウス抑制	7・下～8・上	8・中～8・下	ポリ鉢	20前後	本葉3～3.5枚
スイカ	トンネル	1・下～2・上	2・下～4・中	ポリ鉢	40～45	本葉5.5枚
メロン	露地	3・下～4・中	4・下～5・中	ポリ鉢	30～35	本葉4～5枚で摘心
温室メロン	冬どり	10・上～10・中	11・上	ポリ鉢	30	本葉3枚
カボチャ	露地	3・下	4・下～5・上	ポリ鉢	30～35	本葉4～5枚
ハクサイ	秋冬どり	8・中～8・下	9・上～9・中	練床	15～18	本葉5枚
キャベツ	夏まき	7・上～8・上	8・上～9・中	苗床	25～30	本葉6～7枚
ブロッコリー	秋冬どり	7・下～8・下	8・下～10・上	苗床	30～35	本葉5～6枚
ネギ	秋冬どり	4・上～5・上	5・中～7・中	ペーパーポット	40～50	本葉2～2.5枚，20cm程度で切断
タマネギ	普通	9・下	11・上	苗床	50～55	本葉3枚程度，苗重4～5g
レタス	秋どり	8・中～8・下	9・中～9・下	連結ポット	30	本葉4.5～5枚
セルリー	露地秋どり	5・下～6・中	8・中～9・上	苗床	55～60	本葉7～9枚

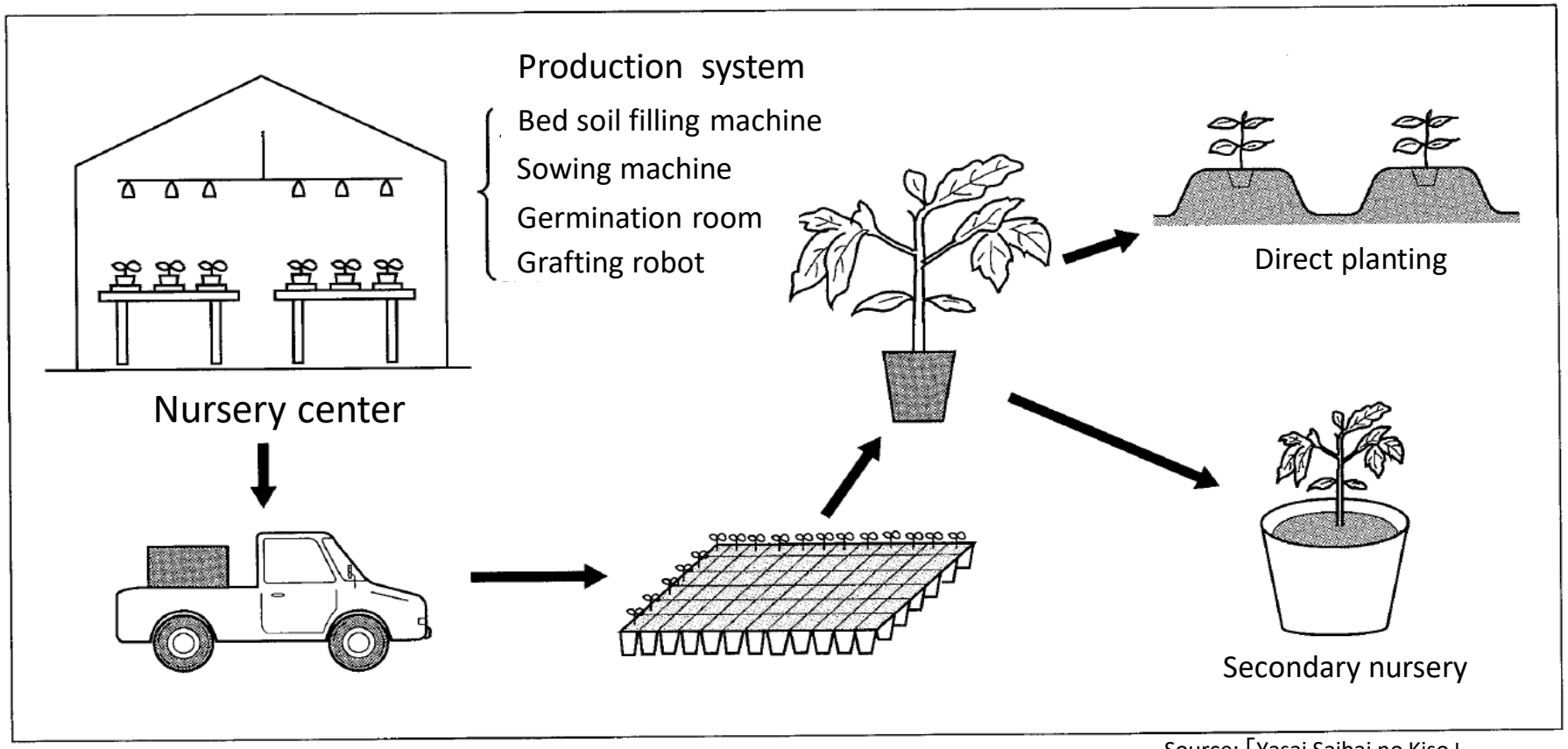
資料：千葉県農業改良協会編　最新野菜ハンドブック，1997

3 Raising plug seedling

3.1 Characteristics of plug seedlings

3.2 Plug seedlings production system

Fig. Usage sample of plug seedling



Source:「Yasai Saibai no Kiso」

Shipping style

http://www.bergearth.co.jp/manufacturer/product/seedling05.html

3.1 Characteristics of plug seedlings

- The production efficiency is high, because of seedling size is small and large number of seedlings can be grown in a small area.
- Weigh of seedling is light, easy to handle, and exceed for carrying or transportation.
- The formation of root bowl is good and easy to transplant, and little damage at the transplanting.
- Suitable for mechanization of sowing or planting.
- Easy to systematize and automate seedling production.

3.2 Plug seedlings production system

Seedling production process

1. Sowing
2. Germination
3. Raising seedling
4. Distribution

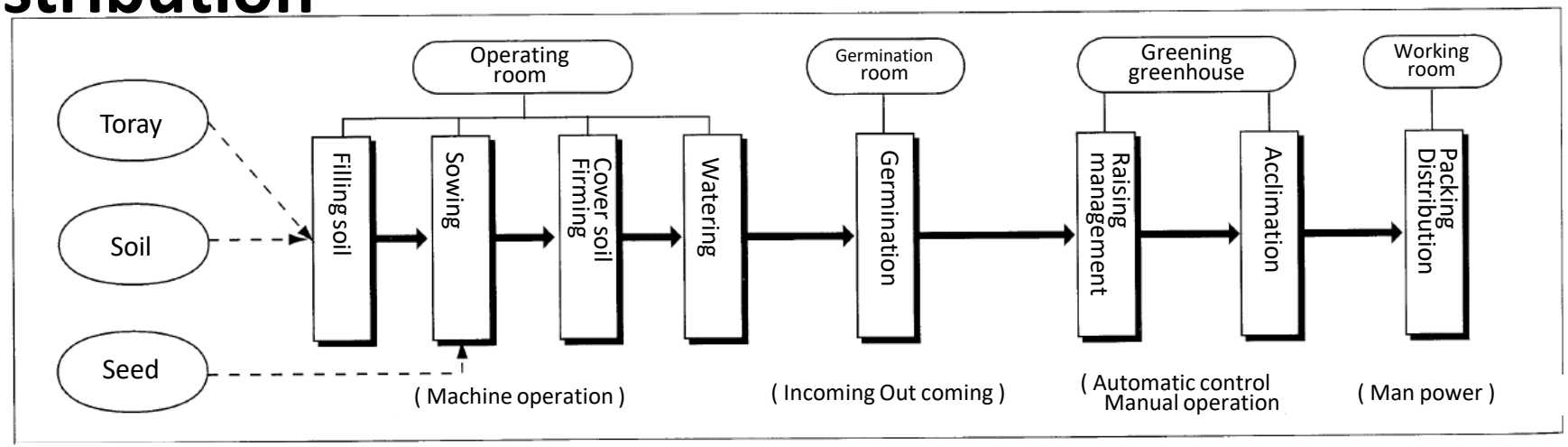


Fig. Operational procedure of plug seedling production

3.2 Plug seedlings production system

Characteristics of materials and equipment

1. Seed

- High germination rate is required.

2. Nursery medium

- Since the capacity per cell is small, appropriate water holding and well drainage are required.

3. Cell tray

- Plug is trapezoid shape for easy removal.
- Volume per cell for fruit vegetables: 30～50ml, leaf vegetables: 20～30ml .

4. Nursery bench

- Put seedlings on the bench so that roots do not come out.

5. Sowing machine

6. Watering equipment

- Equipment for uniform watering.

表　‘園芸用育苗培土’の具備すべき条件と検査方法（JA 全農）

検査項目		単位	検査基準	検査方法
物理性	気相率	%	15％以上	培土 100 m*l* 有穴円筒管に充てんし（軽く 3 回たたく），下方より 1 時間飽水させた後，24 時間有がい（蓋）にして排水させ，実容積測定装置を用いて実容積（$V = V_s + V_L$）を測定する 気相率（V_A）＝ 100 − V（V_s ＝固定容積，V_L ＝水分容積）
	正常生育有効水分	%	20％以上	上記試料から遠心法により pF 1.8～2.7 の水分を採取し，その容積を求める
	全孔げき	%	75％以上	水分採取後の試料を 105℃・1 昼夜放置し，その水分減少量に上記正常生育有効水分を加え液相率（V_L）を求める．全孔げき率＝ $V_A + V_L$
	透水速度	min／100 m*l*	10 分以下	培土を 100 m*l* 円筒管に充てんし（軽く 3 回たたく），下方より 1 時間飽水させた後，水を注入して定水位とする．5 分後いつ（溢）流量 100 m*l* に要する時間を測定する（透水係数測定の際の定水位測定法に準ずる）
	水分	%	粒状：15～22％ 粉粒状：40％以下	培土を一定量採取し，105℃・1 昼夜乾燥後の減量率を水分とする
	最大容水量	g／100 g	60 g／100 g 以上	培土を 100 m*l* 円筒管に粗充てんし，下方より 1 時間飽水させた後の重量を測定し，乾土当たりの水分量を求める
化学性	pH		5.8～7.0	培土 100 m*l* に水 250 m*l* を加え，1 時間振とう後，pH メーターで測定する
	EC	mS／cm	1.2 以下	培土 100 m*l* に水 500 m*l* 加え，1 時間振とう後，EC メーターで測定する
	水溶性 P_2O_5	mg／100 m*l*	1～40	培土 5 m*l* に水 200 m*l* を加え，1 時間振とう後ろ過し，ろ過液中のリン酸を定量する

表　‘園芸用育苗培土’の具備すべき条件と検査方法（JA 全農）（続き）

検査項目		単位	検査基準	検査方法
栽培試験	育苗試験		著しい生育差が認められないこと	土壌：腐葉＝1：1，N-P_2O_5-K_2O mg/l ＝200-1000-200（NH_4-N：NO_3-N ＝ 75：25）の基準培土を対照としてキュウリを育苗し，基準培土との生育の違い（草丈・葉数・地上部生体重）を観察する 検査法・育苗培土：現物のまま使用する 育苗資材：沖積土壌・洪積土壌・火山灰土壌などの数種類の土壌を混合原土壌として，規定に従いおのおの育苗資材と混合して使用する
	ブロック崩壊性		崩壊率25％以内	育苗終了後，培土をプラスチックポットから取り出し，10 cm の高さから投下してブロックの崩壊状況を観察する 評価は4段階とする 1. ブロック崩壊率 0～10％ 2. ブロック崩壊率 10～25％ 3. ブロック崩壊率 25～50％ 4. ブロック崩壊率 50％以上（根が露出する）

表　　セル成型苗育苗培地（培養土）の好適な条件（JA 全農）

項　　目	条　　件	
全孔げき率	85％以上	実容積法（100 m*l* 容円柱）
はっ（撥）水性	認められない	播種前後かん水時の肉眼観察
pH	5.8～7.0	土液比 1：5（容積），1 時間振とう
EC	1.0 dS/m 以下	土液比 1：5（容積），1 時間振とう
無機態窒素	200 mg/*l* 以下[1)]	土液比 1：5（容積），1 MKC 11 時間振とう
水溶性リン酸	10～300 mg/*l*	土液比 1：40（容積），室温 1 時間振とう
発芽率	種子発芽保証率以上	標準的な仕様に基づき対照品と比較する
生育状況	対照培養土と同等の生育を示し，障害がないこと[2)]	標準的な仕様に基づき対照品と比較し，生育状況および障害の有無を観察する
抜取り株率	80％以上[3)]	移植適正時にトレイ当たり 30 株以上を人手により抜き取り，根鉢が良好に抜けた割合

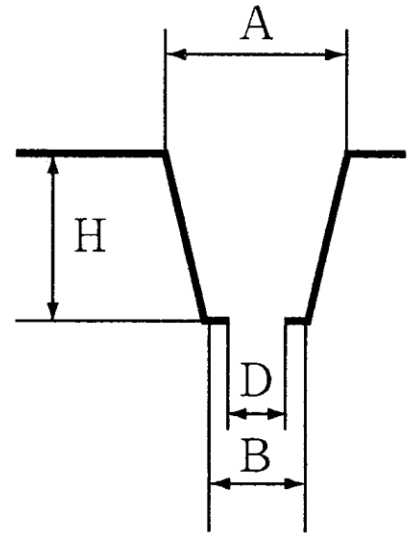
（注）1. 無機態窒素は生育に大きく影響するため，製造設計どおり含有していることが望ましい．ただし，好適量は作物の種類・育苗時期・場所により異なる

2. 対照培養土：ピートモス（ファイン）・焼成バーミキュライト（パラボラ2号，細粒品）を容積比1：1で配合したもの

3. 全自動移植機での適応性は，移植機による抜き取り株割合が95％以上とする

表　　セル成型苗の育苗トレイ標準規格

（単位：mm）

セルタイプ / 項目		128タイプ	200タイプ	288タイプ	備考
外枠	長辺 短辺	590 300	590 300	586 300	
	四角のR	10	10	10	
セルの配列		8×16	10×20	12×24	
セル	ピッチ縦 ピッチ横	36.6 36.0	29.2 28.7	24.35 23.70	
	高さ(H)	44＊	44＊	38.5＊	
	上部寸法(A) 上部R	31＊ 10	26＊ 7	21.5＊ 6	
	下部寸法(B) 下部R	18＊ 7	12＊ 5	9＊ 3	
	底穴径(D)	12	9	7	
板厚 シート素材板厚 0.8mm(参考値)		0.6以上 (側・底部面 0.1以上)	0.6以上 (側・底部面 0.1以上)	0.6以上 (側・底部面 0.1以上)	
質量(g)		150(参考値)	150(参考値)	150(参考値)	

(注) 1. ＊印は、板厚の寸法を加えた値となっている
2. 重なり防止装置を設ける.ただし,トレイの周辺および中央のセル列2条には設けない

表　　NKプラグ育苗システムにおける育苗日数と出荷苗の大きさ（馬場）

培地	品質	トレイの種類	培地量 (g/トレイ)	育苗日数（日）	苗生育の目安 (枚・cm)
改良培地	レタス	苗作くん253号	900	20～25	葉数3.5
	ハクサイ	136-4	1,300	30～35	葉数4.0
	キャベツ	136-4	1,300	30	葉数3.5
	アスパラガス	136-4	1,300	70～80	茎数2.5～3.0
	ブロッコリー	136-5	1,700	40	葉数3.5～4.0
	チンゲンサイ	253	900	20～25	葉数2.5～3.0
	タアサイ	253	900	20～25	葉数2.5～3.0
	トマト稚苗	253	900	20～25	草丈10, 葉数2
	ピーマン稚苗	253	900	25～30	草丈10, 葉数2
	ナス稚苗	171	1,100	35	草丈10～12, 葉数2.5
	ナス台木（トルバムビガー）	448	770	40～45	草丈7～8, 葉数3～4
	ハクサイ	全自動 128	1,200	30～35	葉数4.0
	キャベツ	移植機 128	1,200	30～35	葉数3.5
	レタス	対　応 200	1,100	20～25	葉数3.5
	レタス	288	930	20～25	葉数3.5

4 Grafting

4.1 Purpose of grafting

4.2 Dissemination of grafting

4.3 Kind of rootstock

4.4 Method of grafting

4.5 Seedling management after grafting

4.1 Purpose of grafting

1. **To prevent from soil-born disease**
   - Fusarium wilt of Watermelon, Bacterial wilt of Tomato etc.

2. **Expansion of cultivation duration and improvement of yield**
   - Expansion of root zone, improvement of fertilizer absorption, growth promotion in cold season, keeping plant's vigor.

3. **Improvement(Modification) of fruit quality**
   - Reduce bloom appearance of cucumber etc.

Tomato Bacterial wilt

（出所：タキイ種苗）

Bloom of Cucumber

（出所：タキイ種苗）

Table: The purpose of grafting for fruit vegetables (2009)

Vegetable	Number of prefecture	The purpose of grafting (Number of prefecture)					
		Tolerance to disease	Plant vigor promotion	Yield increases	Effect on fruit quality	Tolerance to cold temperature	Others
Watermelon	35	32	6	1	0	15	2
Cucumber	45	39	16	2	41	27	3
Melon	33	14	2	0	2	6	2
Bitter gourd	17	9	2	1	0	4	1
Tomato	46	42	13	1	1	2	6
Egg plant	44	41	16	1	2	9	5
Pepper	32	17	1	2	0	1	0
Paprika (パプリカ)	11	5	0	1	0	0	2

※温室メロンを除く

（Source：Vegetable research institute）

4.2 Dissemination of grafting

- Disseminated as the technology of high-quality, high yielding, soil born disease prevention, and extension of cropping duration, for fruit vegetable production.
- The grafting rate of the main fruit vegetables are; watermelon cucumber 90% more, eggplant 80% , tomato 60 %. Melon that focuses on fruit quality is lower ratio.

Table. Grafting rate of main fruit vegetables (2009)

Crop	Rate of grafting
Water melon	93.9
Cucumber	92.6
Melon	32.0
Tomato	57.7
Egg plant	79.0

（Source：Vegetable research institute）

Table: Rate of grafting and movement (2009)

Vegetable	Cropping type	Rate of Grafting(%)				Movement
		1980	1990	1998	2009	(2009/1998)
Watermelon	Open field/Tunnel	95.3	91.7	88.3	91.8	+3.5
	Plastic house	90.0	98.3	97.2	97.9	+0.7
	Total	95.7	92.8	91.1	93.9	+2.8
Cucumber	Open field/Tunnel	31.0	55.0	64.2	88.8	+24.6
	Plastic house	85.3	96.0	95.8	97.4	+1.6
	Glass house	—	95.5	97.2	99.8	+2.6
	Total	48.5	71.7	78.7	92.6	+13.9
Melon※	Open field/Tunnel	64.7	38.8	17.5	21.3	+3.8
	Plastic house	60.3	22.4	17.7	37.9	+20.2
	Glass house	—	—	—	6.1	—
	Total	63.0	30.3	17.6	32.0	+14.4
Tomato	Open field/Tunnel	5.2	8.1	19.0	26.4	+7.4
	Plastic house	16.1	39.7	48.9	63.0	+14.1
	Glass house	15.4	66.6	53.8	64.5	+10.7
	Total	9.8	31.5	40.8	57.7	+16.9
Eggplant	Open field/Tunnel	20.0	42.9	49.4	74.9	+25.5
	Plastic house	96.4	94.4	95.9	97.7	+1.8
	Glass house	—	—	—	100.0	—
	Total	28.6	49.9	57.1	79.0	+21.9

※温室メロンを除く

（Source：Vegetable research institute）

4.3 Kind of rootstock

Rootstocks are selected according to graft affinity, disease resistance, ecological characteristics, and affects in fruit quality.

Cucumber

- Prevention of soil born disease : Pumpkin rootstock.
  C.maxima × *C.moschata* (Shin-tosa)
- Encourage vigor in low temperature: Pumpkin rootstock
  C.ficifolia (Kurodane: Black seed)
- Quality modification: Pumpkin rootstock(Super Unryu, Kitora, etc.)

Watermelon

- Prevention of soil born disease: Bottle gourd *C.moschata*

Tomato

- Prevention of soil born disease: Tomato rootstock

Eggplant

- Prevention of soil born disease: Torvum vigor, etc.

表　　トマトの台木用品種の病害虫抵抗性

品　種	青枯病	萎ちょう病・J_1	萎ちょう病・J_2	根腐萎ちょう病	半身萎ちょう病	褐色根腐病	ネコブセンチュウ	TMV	TMV抵抗性遺伝子
バルカン		○		○	○	○	○	○	*Tm*-2 / *Tm*-2^a
KCFTN2号		○		○	○	○	○	○	*Tm*
ドクターK		○	○	○	○	○	○	○	*Tm*-2^a
KNVF		○	○	○	○	○	○	○	*Tm*-2
BF興津101号	○	○	○						
LS-89	○	○	○						
BFNT-R	○	○					○	○	*Tm*-2^a
アキレスM	○	○			○		○	○	*Tm*
ヘルパーM	○	○	○		○		○	○	*Tm*
アンカーT	○	○	○		○		○	○	*Tm*-2^a
ツエーゼ	○	○		○				○	*Tm*
メイト	○	○	○	○			○	○	*Tm*-2 / *Tm*-2^a
キャディ1号	○	○	○	○		○	○	○	*Tm*-2^a
カップルO	○	○	○	○	○		○	○	*Tm*
がんばる根3号	○	○	○	○	○		○	○	*Tm*-2
影武者	○	○	○	○	○		○	○	*Tm*-2^a
デュエットO	○	○	○	○	○		○	○	*Tm*
スーパー良縁	○	○	○	○	○		○	○	*Tm*-2 / *Tm*-2^a
ジョイント	○	○		○	○	○	○	○	*Tm*-2 / *Tm*-2^a
助人	○	○	○	○	○	○	○	○	*Tm*-2 / *Tm*-2^a
マグネット	○	○	○	○	○	○	○	○	*Tm*-2 / *Tm*-2^a

（注）1.○は抵抗性を示す　2.KCFTN２号は黒点根腐病にも抵抗性

表　　台木と穂木品種の TMV 抵抗性による接ぎ木の可否

台木の種類	穂木品種		
	り病性または *Tm* 型抵抗性	*Tm*-$_2$ 型抵抗性	*Tm*-$_2^a$ 型抵抗性
り病性または *Tm* 型抵抗性	○	△	×
Tm-$_2$ 型	△	○	○
Tm-$_2^a$ 型	×	○	○

（注）*Tm* 型は増殖抑制型の抵抗性で感染しても症状は軽い．*Tm*-$_2^a$ 型は免疫型の抵抗性，*Tm*-$_2$ 型は免疫型の抵抗性であるが，増殖抑制型と中間的な抵抗性も示す．上表で×印の組み合わせでは，り病性品種や *Tm* 型抵抗性品種で増殖した TMV が接ぎ木部を通って *Tm*-$_2$，*Tm*-$_2^a$ 型抵抗性の台木や穂木に移動し，被害が発生する

○：可，×：不可，△：時として発病する場合がある

表　　ナスの台木品種の病害虫抵抗性

台木の種類	品　種	青枯病	半身萎ちょう病	半枯病	ネコブセンチュウ
野生種台	ヒラナス（アカナス）	×	×	○	×
	アオナス	×	×	○	×
	トルバム・ビガー	△	○	○	○
	ツノナス	△	×	○	×
	トレロ	○	○	×	×
種間雑種台	アシスト	○	×	○	×
	サポート1号	×	○	○	×
	耐病 VF	×	○	○	×
	くろがね1号	×	×	○	×
共台	興津1号	○	×	×	×
	台太郎	○	×	○	×

（注）○：高度抵抗性　△：中度抵抗性　×：り病性　トレロはナス青枯病菌Ⅰ，Ⅱ，Ⅲ，Ⅴ群病に抵抗性

Table 3
Rootstocks for cucurbitaceous crops and some related characteristics.

Rootstock	Cultivar[a]	Major characteristics[b]	Possible disadvantage
Watermelon			
Bottle gourd (*Lagenaria siceraria* L.)	Dongjanggoon, Bulrojangsaeng, Sinhwachangjo (Korea), FR Dantos, Renshi, Friend, Super FR Power (Japan),	VRS, FT, LTT	New *fusarium* race, susceptible to anthracnose
Squash (*Cucurbita moschata* Duch.)	Chinkyo, No. 8, Keumkang (Korea)	VRS, FT, LTT	Inferior fruit shape and quality
Interspecific hybrid squash (*Cucurbita maxima* Duch. × *C. moschata* Duch.)	Shintozwa, Shintozwa #1, Shintozwa #2, Chulgap, (Japan, China, Taiwan, Korea)	VRS, FT, LTT, HTT, SV	Reduced fertilizers required. Some quality reduction may result.
Pumpkins (*Cucurbita pepo* L.)	Keumsakwa, Unyong, Super Unyong	VRS, FT, LTT	Mostly for cucumbers
Wintermelon (*Benincasa hispida* Thunb.)	Lion, Best, Donga	GDR	Incompatibility
Watermelon [*Citrullus lanatus* (Thunb.) Matsum. et Nakai]	Kanggang, Res. #1, Tuffnes (Japan), Ojakkyo(Syngenta)	FT	Not enough vigor and disease resistance
African horned (AH) cucumber (*Cucumis metuliferus* E. Mey. ex Naud)	NHRI-1	FT, NMT	Medium to poor graft Compatibility
Cucumber			
Figleaf gourd (*Cucurbita ficifolia* Bouché)	Heukjong (black seeded figleaf gourd)	LTT, GDT	Narrow graft compatibility
Squash (*Cucurbita moschata* Duch.)	Butternut, Unyong #1, Super Unyong	FT, FQ	Affected by Phytophthora
Interspecific hybrid squash (*Cucurbita maxima* Duch. × *C. moschata* Duch.)	Shintozwa, Keumtozwa, Ferro RZ, 64-05 RZ, Gangryuk Shinwha	FT, LTT	Slight quality reduction expected
Bur cucumber (*Sicyos angulatus* L.)	Andong	FT, LTT, SMT, NMT	Reduced yield
AH cucumber (*Cucumis metuliferus* E. Mey. ex Naud)	NHRI-1	FT, NMT	Weak temperature tolerance
Melon			
Squash (*Cucurbita moschata* Duch.)	Baekkukzwa, No. 8, Keumkang, Hongtozwa	FT, LTT	Phytophthora infection
Interspecific hybrid squash (*Cucurbita maxima* Duch. × *C. moschata* Duch.)	Shintozwa, Shintozwa #1, Shintozwa #2	FT, LTT, HTT, SMT	Phytophthora infection, poor fruit quality
Pumpkin (*Cucurbita pepo* L.)	Keumsakwa, Unyong, Super Unyong	FT, LTT and HTT, SMT	Phytophthora infection
Melon (*Cucumis melo* L.)	Rootstock #1, Kangyoung, Keonkak, Keumgang	FT, FQ	Phytophthora problem
AH cucumber(E. Mey. ex Naud)	NHRI-1	FT, LTT, SMT, NMT	Weak temperature tolerance

[a] Cultivars vary greatly depending upon countries, growing types, years, and grafting methods.
[b] VRS: vigorous root systems; FT: *Fusarium* tolerance; LTT: low temperature tolerance; ST: strong vigor; HTT: high temperature tolerance; GDT: good disease tolerance; GDR: good disease resistance; NMT: nematode tolerance; SMT: high soil moisture tolerance; FQ: fruit quality modification.

(Source: Scientia Horticulturae 127 (2010) 93–105)

Table
Rootstocks for solanaceous crops (*Solanum*, *Capsicum*, and *Datura*) and their performances.

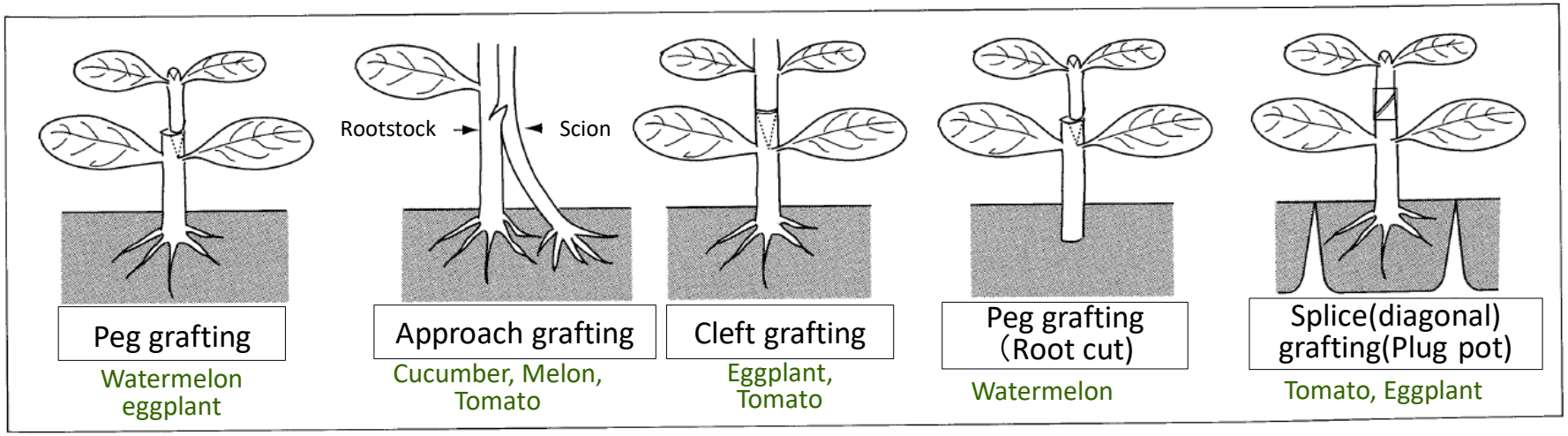
Rootstock	Scion	Performance	Practical uses or popularity
S. lycopersicum L.	Tomato	Vigor and virus tolerances	Extensive
S. lycopersicum L.	Tobacco	Nicotine & alkaloid absorption affected	Experimental
S. lycopersicum L.	Tomato	High temperature tolerance	Extensive
S. habrochaites S. Knapp & D.M Spooner	Tomato	Resistant to corky root disease	Very limited
Solanum spp.	Tomato	Resistant to bacterial wilt & nematode Yield increase	Interspecific hybrids
S. sodomaeum L.	Tomato	Growth & yield reduction	Experimental
S. auricularum Ait.	Tomato	Growth & yield reduction	Experimental
S. laciniatum Ait.	Tomato	Resistant to water-logging	Local
S. melongena L.	Tomato	Growth & yield reduction	Moderate
S. integrifolium Poir.	Tomato	Sugar content increase	Local
S. sisymbrifolium Lam.	Tomato	Disease resistance, no effect on sugar content	Local
S. torvum Sw.	Tomato Eggplants	Disease resistance, no effect on sugar content	Nematode tolerant, poor seed germination, good vigor Extensive
S. toxicarium Lam.	Tomato	Disease resistance, no effect on sugar content	
S. melongena L.	Tomato	Multiple disease resistance	Local
S. nigrum L.	Tomato	Fruit size and quality control	Selective
S. lycopersicum L. × *S. habrochaites* S. Knapp & D.M Spooner	Tomato	Low *Fusarium* infection	Experimental
S. lycopersicum L. × *S. habrochaites* S. Knapp & D.M Spooner	Tomato	Multiple disease resistance	Extensive
S. lycopersicum L.	Tomato	Resistant to corky root (K), Root knot nematode (N), Verticillium wilt (V), and *Fusarium* wilt (F) Yield increase	Extensive
S. melongena L.	Tomato	Low & high temperature tolerance	Selective
S. lycopersicum L.	Tomato	Resistance to tomato brown root rot	Selective
Solanum torvum Sw.	Eggplant	Resistant to nematodes	Extensive
S. torvum Sw. × *S. sanitwongsei* Craib.	Eggplant	Resistance to bacterial wilt	Local
S. integrifolium Poir. × *S. melongena* L.	Eggplant	High temperature tolerance	Experimental
Capsicum spp.	Sweet pepper (green)	Compatible with Capsicum only	Extensive
C. annuum L. × *C. chinensis* Jacq.	Green pepper	Superior growth & yield	Extensive
Datura tatula	Tomato	Low yield	Experimental

(Source: Scientia Horticulturae 127 (2010) 93–105)

4.4 Method of Grafting

Types of grafting

- Hole insertion(Peg) grafting
- Cleft(split) grafting
- Approach grafting
- Splice (Diagonal Sp., Flat Sp.)grafting



（Source：野菜栽培の基礎）

Fig. Major grafting method and vegetables to use

Table: Cultivated Area of Grafting Method (2009)

1. Grafted seedlings produced own

Vegetable	Answered Area(ha)	Grafting method (%)						
		Peg grafting	Peg grafting (Root cut)	Diagonal splice grafting	Diagonal splice grafting(Root cut)	Cleft grafting	Approach grafting	Others
Watermelon	4,265	23.0	69.0	0.1	—	1.7	6.3	—
Cucumber	2,284	4.2	3.7	0.1	0.9	0.9	89.2	1.0
Melon	1,329	61.3	—	—	3.0	4.2	30.6	0.9
Bitter gourd	38	—	13.0	—	—	—	87.0	—
Tomato	1,703	0.9	54.8	27.3	1.2	2.6	8.8	4.3
Egg plant	595	3.2	19.5	16.6	0.9	59.0	—	0.8
Pepper	34	—	—	—	94.1	5.9	—	—
Paprika (パプリカ)	—	—	—	—	—	—	—	—

※温室メロンを除く

2. Grafted seedlings purchased

Vegetable	Answered Area(ha)	Grafting method (%)						
		Peg grafting	Peg grafting (Root cut)	Diagonal splice grafting	Diagonal splice grafting(Root cut)	Cleft grafting	Approach grafting	Others
Watermelon	2,886	22.6	74.0	0.5	1.1	0.8	0.7	0.3
Cucumber	4,213	8.7	45.0	1.7	18.0	0.1	24.8	1.8
Melon	865	72.8	18.1	0.3	1.8	0.1	5.4	1.6
Bitter gourd	302	—	41.4	0.3	54.7	0.2	3.5	—
Tomato	2,591	13.1	9.9	56.4	10.6	2.8	5.6	1.7
Egg plant	3,031	12.5	8.2	43.8	5.5	28.4	0.1	1.4
Pepper	155	4.4	5.2	86.4	0.2	1.8	2.0	—
Paprika (パプリカ)	12	6.3	—	53.1	24.6	15.9	—	—

※温室メロンを除く

（Source：Vegetable research institute）

4.4 Method of Grafting

Insert(peg) grafting

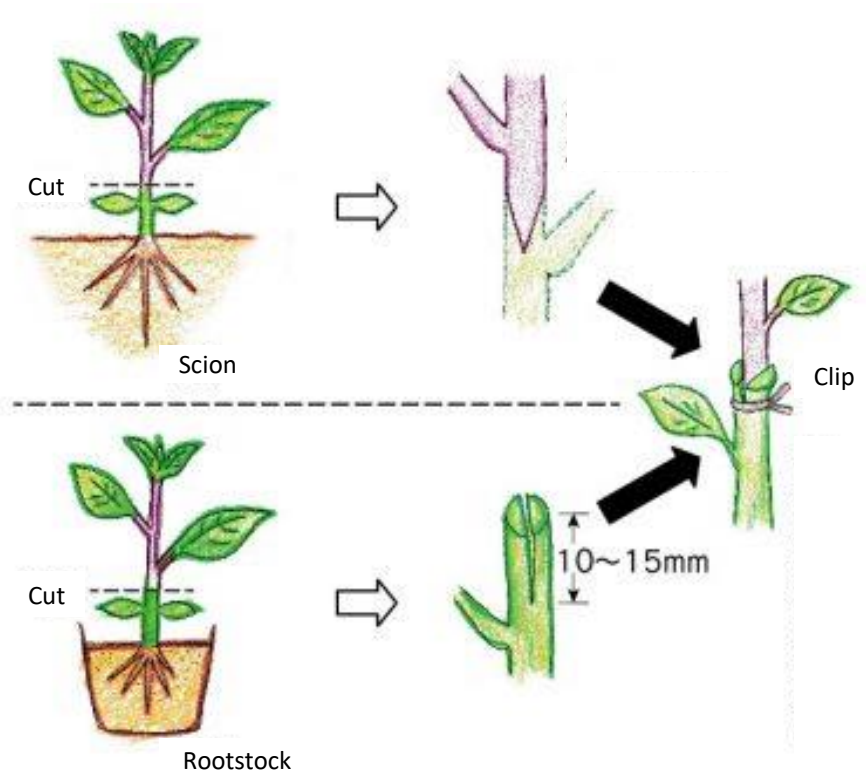
- Method of inserting the scion into the hole which was made on the cut surface or side of the rootstock stem.
- It need not be used extra materials, so the grafting work could be done efficient.
- Insert grafting method, in which the hypocotyl of the rootstock is also cut, has good working efficiency and improve the seedlings uniformity.
- The method is commonly used for watermelon and cucumber.

Souece:httpwww.seibutsushi.netblog200908867.html

4.4 Method of Grafting

■ Cleft grafting

- The most basic method, with a wide range of adaptation.
- The stem of the rootstock is cut horizontally, a cut is made longitudinally, a wedge-shaped scion is inserted into it, and hold with a clip.
- Used for tomato and eggplant.



（Source：httpswww.ja-osakahokubu.or.jpkateisaie）

4.4 Method of Grafting

Approach grafting

- The method is to put a cut downward on the rootstock and an upward cut on the scion, and fix them together with a clip.
- Both rootstock and scion leave roots, so there is less wilting after grafting and management is easy, and graft-taking ratio is high.
- The root of the scion is cut off after the graft has taken.

（出所：httpsblog.goo.ne.jpyashima-farmebcd50617387d2294ef12f77dcde3d96f）

4.4 Method of Grafting

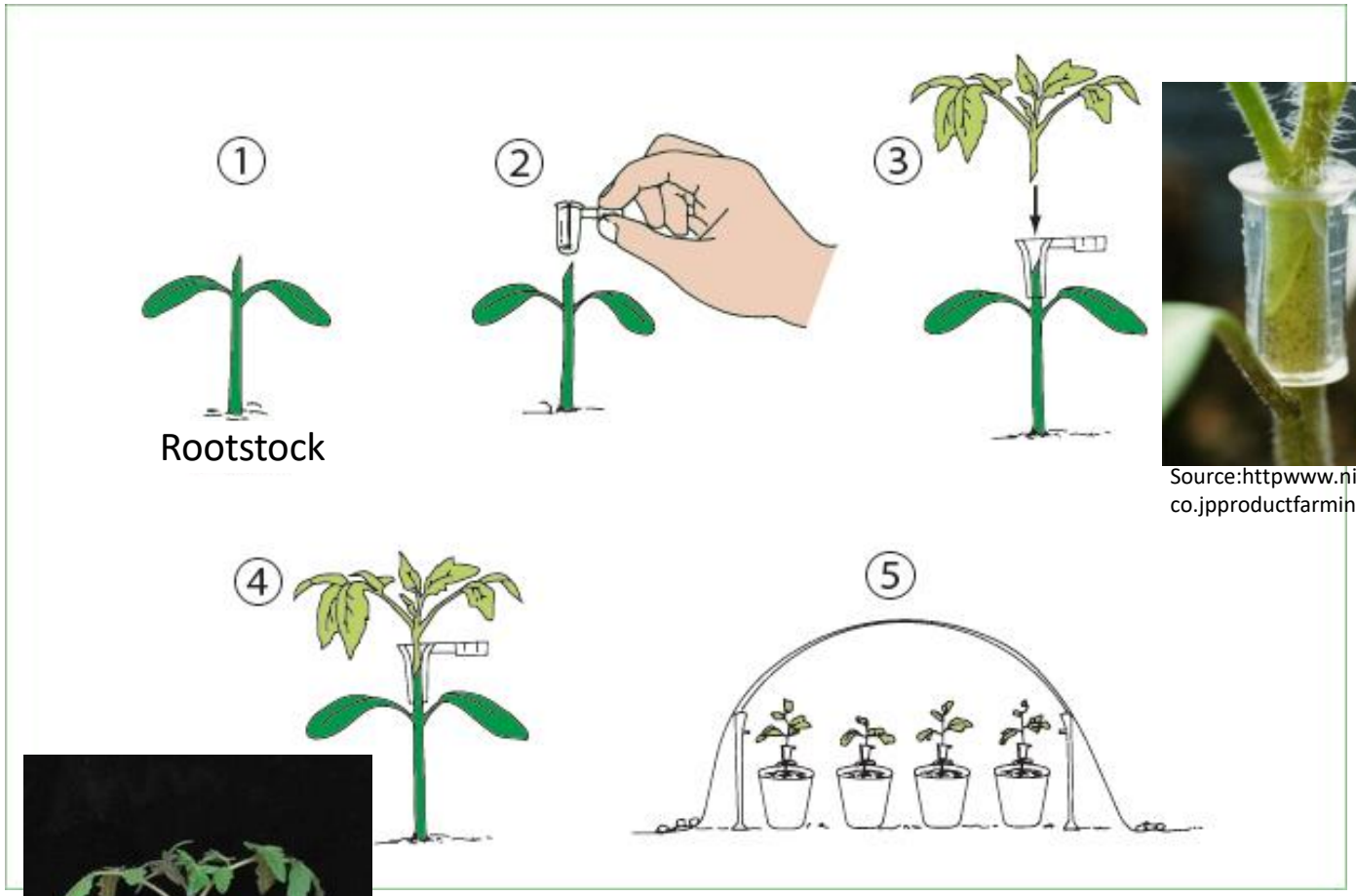
Splice (Diagonal) grafting

- The method of cutting stem of rootstock and scion diagonally, joining the cut surface and fixing them with clip or tube.
- It is easy to operate and is applied to mechanical grafting

Splice(Flat) grafting

- The method of cutting the stem horizontally in both rootstock and scion, joining the cut surface together and fixing them with adhesive or other materials.
- It is applied to mechanical grafting.

Fig. Splice grafting



Source:httpwww.nishikawazen.co.jpproductfarmingpost-9.php

（出所：httpswww.sakataseed.co.jpproductsearchcode069330.html）

Source:httpwww.nishikawazen.co.jpproductfarmingpost-9.php

Table: Rootstock, Scion cutting angle and taking

切断角度	断面積比[1]	接ぎ木本数	活着状態[2] +++	++	+	−	活着率
		本					%
30°	372	51	49	1	0	1	98.8
45°	218	51	47	0	1	2	92.2
60°	172	51	38	5	1	6	84.2
90°	100	51	32	7	7	5	76.4

注：1)；実測値　2)；+++ 完全活着　++ やや不完全　+ 不完全　− 枯死

Table: Compression strength of the joint and taking ratio

圧着程度	加圧重	活着状態[1] +++	++	+	−	活着率
	g					%
弱	100～150	5	2	2	1	70
中	300～350	7	2	1	0	90
やや強	600～650	10	0	0	0	100
強	800～850	6	1	2	1	70

注：1)；表 2 に同じ

出所：野菜の成型苗利用と生産システム　東京近郊蔬菜技術研究会

4.4 Method of Grafting

Recent research result

■Double Grafting

- A method of enhancing the disease-suppressing effect by grafting an intermediate rootstock with different disease resistance between the rootstock and the scion.

■High Grafting

- A method that is expected to have an effect of suppressing disease onset by grafting at a higher position than conventional grafting.

https://www.pref.niigata.lg.jp/sec/nosoken/kiban-top.html

Source: Nakaho

4.5 Seedling management after grafting

Acclimatization of seedlings

- After grafting, avoid strong sunlight and dryness, reduce transpiration and control appropriate temperature environment.
- Keep temperature 30℃ and humidity 100%.

Source : httpsakagefarm.coms-re-nae4.html

Source : httpsakagefarm.coms-re-nae4.html

Source : httpsencrypted-tbn0.gstatic.comimages

5 Dividing labor of raising seedlings

5.1 Specialization of raising seedlings and distribution

5.1 Specialization of raising seedlings and distribution

The reason of seedling industry grew

- Labor saving of cultivation
- Diffusion of grafting vegetables
- Popularized of plug seedlings

Table: Purchasing rate of fruit vegetables seedling and movement (2009)

Crop	Cultivated area(ha)	Seedling purchased rate(%)	Grafted seedlings(%)
Watermelon	8,336	36.7 (5)	96.2 (-0.3)
Cucumber	7,060	62.2 (30.6)	96.4 (8.2)
Melon	6,905	18.6 (2.7)	67.9 (50.9)
(Net type)	848	14.2 —	3.3 —
(Others)	6,057	19.2 —	74.6 —
Bitter gourd	1,242	43.3 —	56.2 —
Tomato	7,467	48.5 (15.6)	70.9 (12.5)
Eggplant	4,644	69.2 (20.8)	95.6 (17.1)
Sweet pepper	1,777	59.8 —	16.4 —
Paprika	55	71.4 —	34.5 —

注）括弧内は1998年に対する増減を示す。
※温室メロンを除く

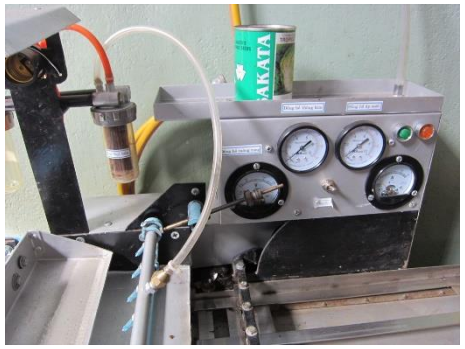
（Source：Vegetable research institute）

Case of JA nursery center

— JA Yumemirai —

Case of overseas nursery center

— Vietnam, DaLat area —



Thank you very much

- End -

-主な参考資料・引用文献 -

- 野菜園芸ハンドブック　西貞夫監修　養賢堂
- 野菜栽培の基礎　農文協
- 施設園芸ハンドブック　施設園芸協会
- 野菜の接ぎ木栽培の現状と課題　野菜茶業研究所
- 農業技術体系（トマト、キュウリ、スイカ・メロン、共通技術、各編）　農文協

- 参考リンク -

- **Introduction to NERIDOKO ~Evolution of vegetable seedling raising & Environmental friendly seedling~ :** https://www.youtube.com/watch?v=aZYsFYS2NUI
- **Compost and BOKASHI:** https://www.youtube.com/watch?v=OvSsnt-JKMc
- **Newspaper pot:** https://www.youtube.com/watch?v=PmD8ZJNEN8c
- **Vegetable Grafting Technique :** https://www.youtube.com/watch?v=wlI65cSRx7o
- **葉菜類全自動機械移植システム育苗・移植マニュアル（JA全農）:** https://www.zennoh.or.jp/eigi/research/pdf/manual_01.pdf
- **革新的接ぎ木法によるナス科野菜の複合土壌病害総合技術の開発:** https://www.affrc.maff.go.jp/docs/public_offering/agri_food/2016/25062c.html