Modern approaches in tea breeding

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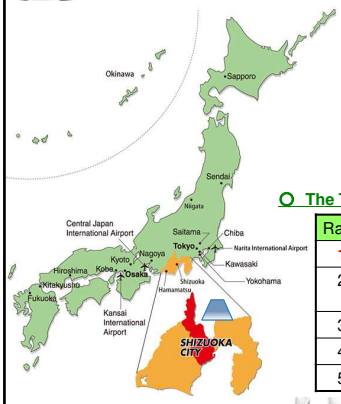
General information of Shizuoka



○ Geographical Information

Population	3,583,194 (2022)
Area	7,780.42 km²
Ave. Temp.	16.5℃
Prefectural Capital	Shizuoka city

○ The Top 5 Main Agricultural Products(2021)

Rank	Products	Amount (mil JPY)
1	Tea	26,800
2	Tangerine (Mandarin Orange)	23,000
3	Rice	16,200
4	Strawbery	10,900
5	Raw milk	9,700

Source: Ministry of Agriculture, Forestry and Fisheries

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Shizuoka's proudg global standards

● Izu Peninsula Geopark to join the Global Geoparks Network

● The Southern Alps as a UNESCO Eco Park

● Chagusaba as a Globally Important Agricultural Heritage System (GIAHS)

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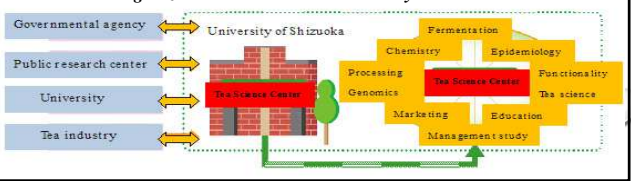
University of Shizuoka

The University of Shizuoka, by absorbing various prefectural universities established in Shizuoka, came into being in 1987. It combined the Shizuoka College of Pharmacology, originally founded in 1916 as Shizuoka Women's Pharmacology School, along with Shizuoka Women's University and Shizuoka Women's Junior College.
Currently, there are about 3000 students in 5 faculties.

Tea Science Center

At the Tea Science Center, we teach about the health benefits of tea and pass on our knowledge about the best methods of cultivation, processing and marketing the various types of teas. The Center also collaborates extensively with other laboratories and organizations related to the tea industry

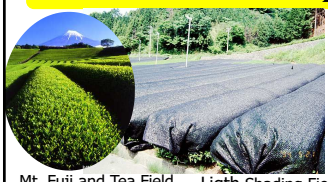


Japanese green tea production

Area and production of tea (2021)

Prefecture	Area (ha)	Production (1000t)
Shizuoka	14,500	29,700
Kagoshima	8,300	26,500
Mie	2,640	5,360
Kumamoto	1,130	1,084
Kyoto	1,550	1,280
Fukuoka	1,520	1,650
Miyazaki	1,270	3,050
Saitama	783	728
Saga	705	1,140
Others	5,602	7,608
Total	38,000	78,100

Scene of tea fields in Japan


Mt. Fuji and Tea Field

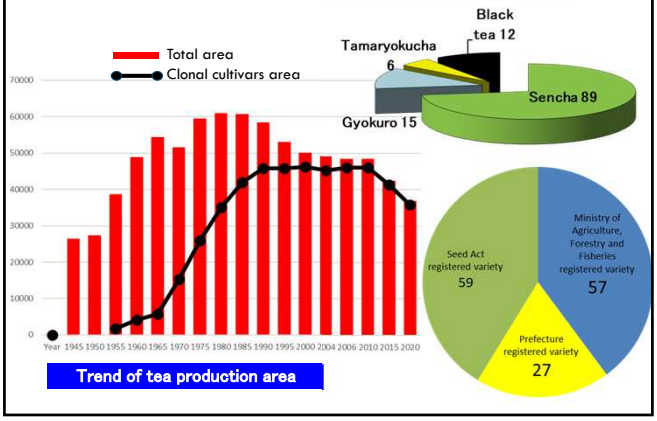

Ligth Shading Field

Field for Riding-type Machine


Tea Field in Mountain Area


Field in Snow

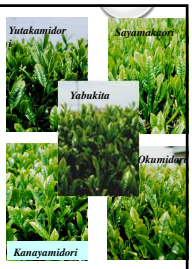
Spread of superior cultivars by cutting



Changes in tea fields due to introduction of cultivated tea


Traditional tea field


Cultivation and popularization of high-quality cultivars




Improvement of productivity due to cutting and growing tea fields

Improvement of crop yields and quality was achieved by making vegetative propagation tea fields through cultivation and cutting of high-quality cultivars instead of the traditional tea fields that used seedlings.

Breeding has also been a major contributor to innovations in mechanization

Along with the spread of the cultivar, technological innovations from hand-picking to riding machines for picking and from manual rubbing to automation for production have established Japan's unique production and processing technology, contributing to a high level of yield and quality per unit area.

Plucking methods of new shoots


Hand plucking

Plucking efficiency

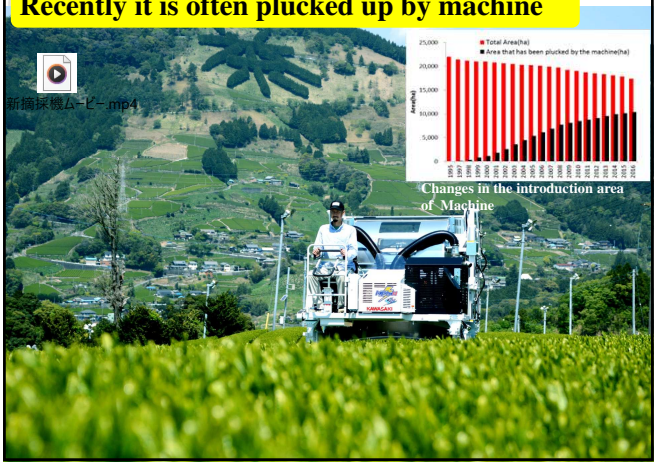
Methods	The amount of new shoots per day per person
Hand plucking	10 ～ 15 kg
Hand-shear plucking	100 ～ 200
Mechanical plucking	
Portable machine for two persons	700 ～ 1,000
Riding machine	4,000 ～ 5,000
Self-rail-tracking machine	2,000 ～ 3,000


Hand-shear plucking

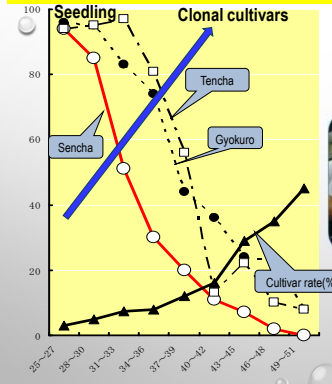

Portable machine for two persons


Riding-type plucking machine

Recently it is often plucked up by machine



The cultivars have greatly contributed to quality improvement !



Judging Scene

Quality

Seedling

Clone

As tea caltivars became clonal, quality improved.

Changes in tea exhibited by tea type at the National Tea Fair (4th to 30th)

Changes in breeding methods in Japan

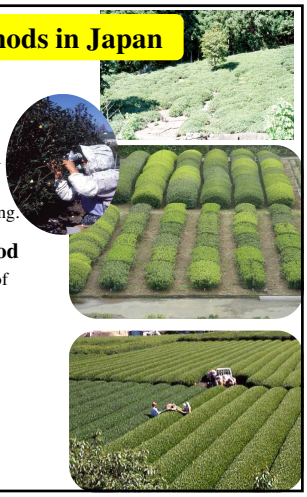
Period 1: Individual selection era
Selection focused on early and late plucking

Period 2: Isolation breeding period
Selection of superior cultivars from native seedling on the premise of nutritional breeding.

Period 3: Early crossbreeding period
The budding of crossbreeding. Breeding of black tea cultivars

Period 4: Crossbreeding period
Breeding high quality, high yield, stress tolerant cultivars

The Future: Genomic Breeding
Early selection of targeted phenotypes



The cultivars have been breeded according to the demands of the times

Period	Historical context	Purpose of selection	Selected cultivars
1930S	Expansion and strengthening of exports	Higher yield and higher quality by breeding vegetative cultivars	Yabukita, Koyanishi, Rokutrou etc.
1950s	Shift to domestic demand due to economic improvement	Proliferation of black tea products, adoption of cultivars suitable for Western food	Benihomare, Karabeni, Tadanishiki, Fujimidori etc.
1960s	Rapid increase in domestic demand, upsizing of tea making machines	High yield, early and late cultivars, high quality	Kurasawa, Kanayamidori, Ooiwase etc.
1970s	Frequent weather disasters	Adoption of cold-resistant cultivars	Sayamakaori, Okuhikari etc.
1990s～	Bubble burst and diversification	Adoption of cultivars with distinctive aroma and taste	kousyun, Tuyuhikari etc.

Overview of current general breeding methods

	Number of years used
Selection of the mother plant	
↓	
Crossing	1
↓	
Harvesting of crossing seeds	1
↓	
Growth of individual plants and selection	3～6
↓	
Cutting and nursery selection	2
↓	
Clonal test	4～7
↓	
Regional Adaptability Testing Test for specific character	5～7
↓	
Registration of cultivars	
Total	16～24

Tea Breeding Procedures in Japan


Crossing


owing seeds


Clonal test


Quality test

Breeding objectives of tea in Japan

Breeding objectives of tea in Japan	Importance
Items of basic importance	
High-yield property	◎
High-quality property	◎
Environmental Stress Tolerance	
Cold resistance	○
Freezing resistance	△
Drought resistance	△
Insect resistance	○
Disease resistance	◎
Time of harvest	
Early, Medium, Late budding cultivar	○
Others	
Rooting from cuttings	○
Wide area adaptability	○
Mechanization adaptability	◎
Important Characteristics	
Highly Functional Chemical Containi	○
Low input responsive clone	○

Crossing by hand

Early quality testing by small tea machine

Primary selection by 25g machine
Secondary selection by 50g machine

Crude tea in a small-volume tea making machine (25g , 50g), then dried and used for quality evaluation.

25g machine for 12 sets

50g machine for 6 sets

Quality assessment and quality control of Japanese green tea

Very speedy and efficient machine for analysis of chemical composition

Ingredients Analyzer using near-infrared technology

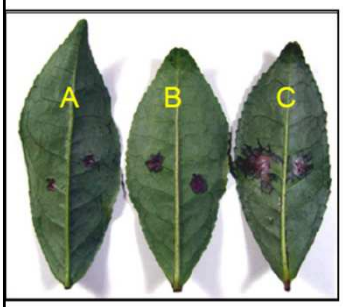
Ingredient analyzer is operated quickly, simply and safely with high accuracy, without the use of any reagents and solvents, carried out in seconds and easily used by anyone

The analysis components

- Moisture Content
- Total Nitrogen
- Fiber
- Caffeine
- Tannin
- Total Free Amino Acid
- Theanine
- Vitamin C
- Catechin

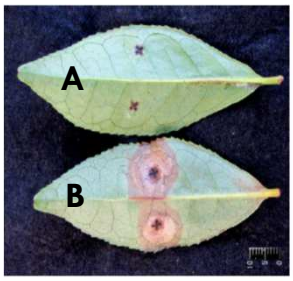
Disease resistance tests

Inoculate cut leaves with pathogens and determine



Anthracnose resistance test

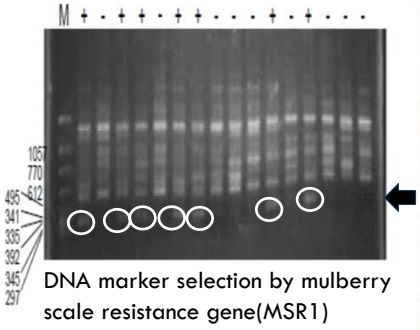
A:Resistance, B:Medium, C:Weak



Gray blight resistance test

A:Resistance, B:Weak

Genomic breeding for mulberry scale resistance

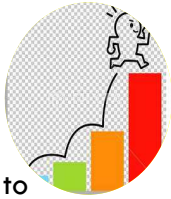


DNA marker selection by mulberry scale resistance gene(MSR1)

○ marks bands linked to resistance genes

Genomic breeding will be important in the future

Genomic breeding has been used successfully in Japan to breed for resistance to the mulberry scale resistance



In near future, the use of genome breeding for specific ingredients such as caffeine and for resistance to environmental stresses such as disease resistance is expected to increase.

Cold resistance tests (Lab. test)

Freezing damage test (-10～-11℃)

Bark split frost injury test (-8～-9℃)

Cold drought damage test (-15℃) れ検定

Importance of cloning and propagation techniques

Difference between seedling and clonal propagation


Seedling field


Clonal field

High yields and high quality come from clonal cultivars

	Seedling	Clonal
Nursery bed	Not necessary	Necessary
Cost of nursery	Low	High
Root system	Tap	Lateral
Early growth	Good	Bad
Tea field	Not uniform	Uniform

Difference between the hand plucking and the mechanical plucking tea fields


Hand plucking

★ A new shoot is chosen and it plucking
★ The amount of plucked shoot is 10 -15kg/day
★ Plucking method for high grade tea

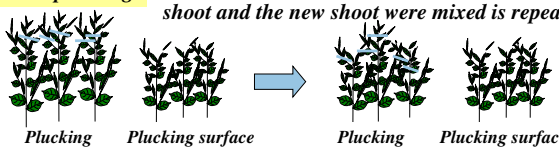

Mechanical plucking

★ All the new shoots are plucked in fixed height
★ The amount of plucked shoot is 700 – 1000kg/day using portable machine for two person
★ Plucking method for midle grade tea

Difference between the hand plucking and the mechanical plucking

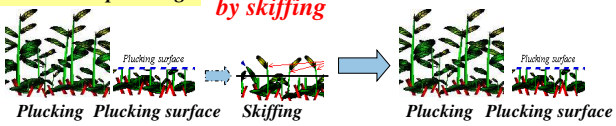
Hand plucking

The plucking of the shoot in which the delayed shoot and the new shoot were mixed is repeated

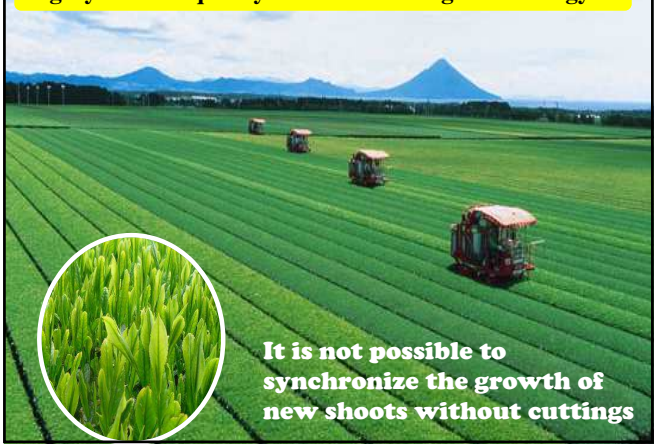


Mechanical plucking

The plucking of the only new shoot by skiffing



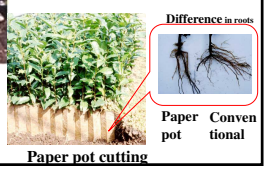
High-yield and quality tea field with high technology



Trend of Japanese green tea production area with superior cultivars


Cutting in nursery bed

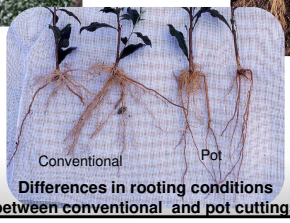

Planting of cuttng



Differences in root systems between conventional cuttings and cutting in paper pot


Rooting status of paper-pot seedlings in the second year of planting


Cutting in paper pot



Differences in rooting conditions between conventional and pot cuttings

Mass propagation by tissue culture method
Propagation system by in vitro cuttings

1/2M&S + IBA(0.1mg/L)+BA(1.0mg/L)+GA_3(5.0mg/L)
or IBA(0.1mg/L)+BA(0.1mg/L)+2iP(5.0mg/L)+GA_3(5.0mg/L)

In vitro cutting

Mass propagation

47,000本/年 (6^6)
6本/1回＊6回(1年間/2ヶ月)

Propagated shoot
(after 2 months of culture)

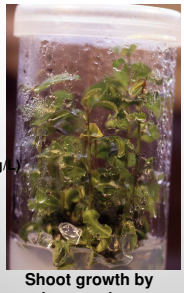
Mass propagation method by tissue culture

Apex culture

BA(0.1~1.0mg/L)+GA_3(5.0mg/L)

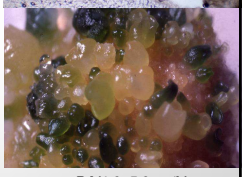
Axillary bud culture

BA(1.0, 5.0mg/L)+GA_3(1.0mg/L)
or BA(5.0mg/L)+GA_3(5.0mg/L)

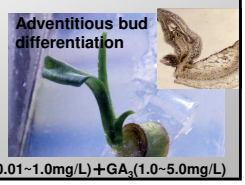


Shoot growth by primary culture system

Adventitious embryonic differentiation



BA(1.0~5.0mg/L)

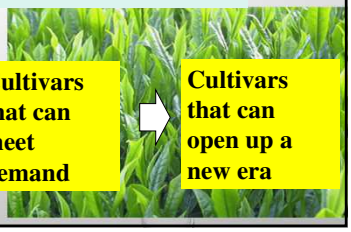


Adventitious bud differentiation

IAA(0.01~1.0mg/L)+GA_3(1.0~5.0mg/L)

Factors that change cultivars

① Changes in socio-economic needs
② Changes in demand needs
③ Introducing new cultivars
④ Changes in production style
⑤ Changes in the production environment



Cultivars that contribute to production promotion → Cultivars that can meet demand → Cultivars that can open up a new era

Important factors in considering the future development of the tea industry in Japan

Coming society

Changes in social structure

Keyword; Globalization, advanced information, Communication society, declining birthrate and aging population, services Industrial socialization, population decline → Decrease in consumers, stress society, information society

Changes in demand / supply structure

Keyword; Natural health consciousness, values, Diversification of lifestyles, women's society, Advancement, → Diversified society, small household society, prepared food society, health desire society

Strengthening environmental protection

Keyword; global warming, low-carbon society, SDGs, natural circulation function-oriented type → Energy saving, nature maintenance society

Future development of variety utilization

What are the traits required for future varieties ?

Keyword ;

- ◎ Globalization,
- ◎ Declining birthrate and aging population,
- ◎ Socialization of service industry,
- ◎ Natural health oriented,
- ◎ Diversification of values and lifestyles,
- ◎ Social advancement of women,
- ◎ Global warming,
- ◎ Low-carbon society,
- ◎ Emphasis on natural circulation function

Cultivars that can meet demand needs

- ☆ Cultivars with world-class flavor
- ☆ Low caffeine variety with less irritation
- ☆ Cultivars with enhanced functionality
- ☆ Low cost type ultra-high yield variety
- ☆ Cultivars with unique flavor
- ☆ Various demand type (food and drink)(Material, etc.) cultivars
- ☆ Stable production cultivars
- ☆ Stress resistant cultivars
- ☆ Low fertilizer adaptive cultivars
- ☆ Others

About Breeding drought-tolerant cultivars

What is a drought tolerant cultivars ?

Water collection mechanism

Mechanism that absorbs water from the soil and delivers it to the leaves
- ☆Development of root system
- ☆Development of conducting tissue, etc.

Water retention mechanism

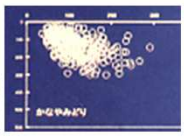
Mechanisms that attempt to reduce transpiration in response to atmospheric transpiration demand
- ☆Opening and closing of stomata
- ☆Cuticle layer
- ☆Membrane structure, etc.

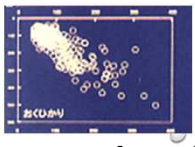
Water collection mechanism

Mechanism that absorbs water from the soil and delivers it to the leaves

☆Development of root system

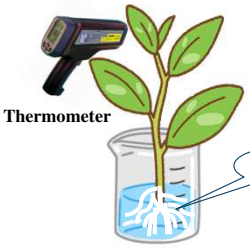
☆Development of conducting tissue, etc.

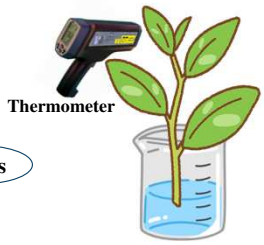




Varietal differences in tea root development are observed. Deep root penetration and many roots are important for drought tolerance

Simple test for water supply from root or conduit tissue





When the water supply capacity of the roots is high, transpiration is more active and leaf temperature is less elevated.

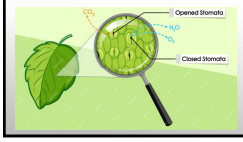
When the capacity of conducting tissues is high, transpiration is more active and leaf temperature is less elevated.

Water retention mechanism etc.

Many genes for drought tolerance have recently been analyzed. It would be interesting to conduct genome analysis and promote genomic selection if there are drought tolerant individuals in Turkey as well, as drought tolerant cultivars have been bred in Iran.

⇨ **Genome breeding becomes important.**

It is well known that flavonoids, lignin and long-chain fatty acids play important roles in drought resistance.



Abscisic acid imparts resistance to a number of stresses, including stomatal closure and desiccation tolerance.