Establishment of Database on Fruit Trees under the Genebank Project, Japan

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Abstract

The Genebank Project of the Ministry of Agriculture, Forestry and Fisheries, Japan established in 1985, has developed an extensive network for collection, classification, preservation, evaluation, utilization and documentation of genetic resources preserved in Japan. Among these activities, evaluation and documentation are of particular importance for breeding programs. A database system has been established with the purpose for promoting efficient utilization of the genetic resources contained in the Genebank. This paper presents an outline of the database on fruit trees. The characters of fruit trees are divided into three categories: primary or morphological: secondary or physiological and ecology: and third or agronomic and qualitative characters. The number of primary characters ranges between 11 to 53, depending on kinds of fruits. The evaluation data on various characters are coded into 0-9; those coded data, or measured values in some cases, are recorded on data sheets with fixed forms. Eleven items, including cultivar name, evaluation year and others are registered every year in a computer system of the Central Bank together with other items directly related to the characters under evaluation. Under this system, various types of comprehensive information on fruit trees could be easily obtained through the database: in particular, any variety or group of varieties which might have suitable characters for breeding programs could be identified within a short time from among a number of varieties preserved in the Genebank.

Discipline: Horticulture
Additional key words: characterization, citrus, documentation, evaluation, genetic, resources

Introduction

The Genebank Project of the Ministry of Agriculture, Forestry and Fisheries (MAFF), Japan has been undertaken since 1985 with a long-term objective of providing access to genetic resources in various fields, including plants, microorganisms, animals, forest trees and aquatic organisms widely collected from both Japan and overseas. It aims at classification, identification, evaluation, multiplication and preservation of genetic resources and supply of the relevant information for the use by public research institutions and universities as well as by private

sectors. The Project is also expected to contribute to promoting agricultural research activities in other countries as well.

The National Institute of Agrobiological Resources (NIAR), with which an executing section, i.e. the Central Bank for Plant Genetic Resources is affiliated, is responsible for establishing a database that contains passports and evaluation data relating to the genetic resources of economically useful crops such as rice, wheat, barley, vegetables, fruit trees, tea and mulberries. The plant materials stored at the Genebank have to be properly processed so that data on those genetic resources could be easily available for users.

The authors have been engaged in the Project specifically for the evaluation and characterization of fruit trees.

The present paper gives an outline of the database on fruit trees with special emphasis placed on evaluation and documentation methods adopted by the Plant Genetic Resources Division (PGRD) of the Project.

Evaluation of fruit trees

Regarding the major characters and preliminary evaluations of the plant genetic resources, a manual containing these items was published in 1987 by the joint efforts of the Agriculture, Forestry and Fisheries Research Council Secretariat (AFFRCS) of MAFF and NIAR under the Genebank Project[1]. The manual provides brief information on the characters of plant resources maintained by various institutions participating in the Project. Twenty-one kinds of fruit trees such as apples and European pears are included in the manual. In documenting

the characteristics of the materials in the manual, there are some differences from the itemization and the criteria that the IBPGR has employed in its documentation and evaluation[3,4].

Evaluations on characters in each fruit tree are given by the designated research institutions as shown in Table 1 on the basis of a fixed criterion for each trait. The results are annually reported to the Genebank Center for processing and documentation.

Table 1 presents the following status of the Project.

(1) The Project includes 18 species of fruit trees for evaluation.

(2) In evaluating those fruit trees, 15 laboratories /sections are assigned to deal with one species each such as myrica, persimmon and fig, two sections for grape and apple each, and four sections under the Fruit Tree Research Station of MAFF for citrus.

(3) The fruit tree group of the Project consists of a number of stations and sections under the MAFF and the prefectural governments directly associated with the research programs on those crops.

Table 1. Kinds of fruit trees, experiment stations, no. of varieties, items of definition

No.	Kinds of fruit trees	Experiment station	No. of varieties	Items of definition		
				Characters	Others	Total
1	Citrus	Fruit Tree Res. Sta., Okitsu Br., Br. 1 Lab.	75	29	11	40
		Fruit Tree Res. Sta., Okitsu Br., Br. 2 Lab.	59			
		Fruit Tree Res. Sta., Akitsu Br., Br. Tech. Lab.	73			
		Fruit Tree Res. Sta., Kuchinotsu Br., Br. Lab.	78			
2	Myrica	Fruit Tree Res. Sta., Okitsu Br., Br. 2 Lab.	13	28	11	39
3	Grape	Fruit Tree Res. Sta., Akitsu Br., Br. Lab.	170	16	11	27
		Yamanashi Pref. Fruit Tree Exp. Sta.	106			
4	Persimmon	Fruit Tree Res. Sta., Akitsu Br., Br. Lab.	276	19	11	30
5	Fig	Fruit Tree Res. Sta., Kuchinotsu Br., Br. Lab.	25	53	11	64
6	Loquot	Nagasaki Pref. Fruit Tree Exp. Sta.	88	16	11	27
7	Apple	Fruit Tree Res. Sta., Morioka Br., Br. Lab.	232	14	11	25
		NCSS*, Kamikita Sta.	222			
8	Int. Apple	Fruit Tree Res. Sta., Br. Di., 4 Lab.	224	27	11	38
9	E. Pear	Fruit Tree Res. Sta., Morioka Br., Br. Lab.	44	11	11	22
10	Cherry	Fruit Tree Res. Sta., Morioka Br., Br. Lab.	44	16	11	27
11	Currant	Hokkaido Agr. Exp. Sta., Fruit Tree Lab.	16	14	11	25
12	Gooseberry	Hokkaido Agr. Exp. Sta., Fruit Tree Lab.	10	15	11	26
13	Pear	Fruit Tree Res. Sta., Br. Di., 2 Lab.	200	16	11	27
14	Chestnut	Fruit Tree Res. Sta., Br. Di., 2 Lab.	145	14	11	25
15	Mume	Fruit Tree Res. Sta., Br. Di., 3 Lab.	64	11	11	22
16	Peach	Fruit Tree Res. Sta., Br. Di., 3 Lab.	25	12	11	23
17	Bramble	Hokkaido Agr. Exp. Sta., Fruit Tree Lab.	19	16	11	27
18	Quince	Fruit Tree Res. Sta., Morioka Br., Br. Lab.	12	13	11	24
Total			2,220			

*NCSS: National Center for Seeds and Seedlings.

It includes various sections of the Fruit Tree Research Station located in Tsukuba, the Morioka Branch in northern Honshu, the Okitsu Branch in middle Honshu, the Akitsu Branch in southern Honshu, the Kuchinotsu Branch in Kyushu, and the Hokkaido National Agricultural Experiment Station in Hokkaido, Japan. In addition to these national institutions, some prefectural research stations also participate in the Project with a special assignment for variety evaluation on grape and loquot.

(4) Among the 18 species in the Project, the minimum number of evaluated varieties is 10 for gooseberry and the maximum is 454 (an aggregate total 678) for apple, and the total number of varieties evaluated is 2,220 as of 1989.

(5) Characteristic items are classified into three categories: the primary (morphological), the secondary (physiological and ecological) and the third (environmental) characters. The primary characteristic items (called descriptor in the database construction) range from 11 in Japanese apricot (mume) to 53 in fig. A majority of the varieties are subjected to evaluation on their primary characters, the number of which is 20 at most.

Additional eleven items which are not directly related to the characteristic items above are also contained in the descriptors, which indicate names of the cultivars, records on their background, evaluation year and the relevant station/section and the registration number at the Central Bank.

Since the varying environmental conditions at the experimental stations might affect differently from year to year on plant growth, outbreak of pests and diseases and yields, additional records are supplied to the descriptors, as required.

The registration number at the Central Bank is given to each entity when passport information of the variety to be stored and managed is put in at the Central Bank. The Bank manages all the entities by using those numbers attaching to passport management information. These numbers for registrations are also attached to the records on characterization information. This arrangement would make it easy for users to search for targeted materials through the linked system for those two types of information, which will be established in the near future.

If the number of varieties and the items of characters are rather small, as in the cases of quince and myrica, where they are 12 and 13, respectively, it might not be extremely difficult to search for a desired variety without a database. However, it may not be easy to identify appropriate varieties fit for the purpose of breeding or other research programs from among the varieties planted in a wide range of distant places as in the case of apple and citrus. The database established would be useful for easy access to needed information in such cases.

Establishment of database on fruit trees

The results of evaluation at each station/section are recorded on data sheets with some fixed forms as described later. The evaluation data are compiled by the Central Bank. Newly coming data are added to the existing database by the Central Bank each year.

It is strictly requested to follow the rules and the criteria defined by the manual in recording the evaluation data.

A database management program is now available at the Computer Center for Agriculture, Forestry and Fisheries Research (CCAFFR)[2]. The program is named Genetic Resources Information Management System for Center of Genetic Stocks (GRIMS/CGS)[2].

The first step to be taken is to define the format for inputting primary data into the data file. For convenience, an example on citrus trees is used hereafter for explanation. The format of citrus database is shown in Table 2.

The descriptors from no. 1 to no. 11 in Table 2 relate to registrations, while those from no. 12 to no. 40 are associated with the primary characters under evaluation.

The figure of 1/2–7 in the fifth column from the left indicates that the relevant data are written or put in the columns 2–7 in the first line.

In the case where a letter type is "N", only numeric can be used, while in the case of "AN", numeric and alphabet are both available in addition to special letters applicable to computer usage.

The second step is to store data on the first variety, putting the related items no. 1 (no. of laboratory/section) through no. 4 (variety name) in the first line, no. 5 (consecutive no. of laboratory/section) through no. 10 (no. of central bank) in the second line, no. 11 (past life) in the third line and no. 12 (color of young

Table 2. Items of definition in citrus

No.	Items (Descriptors for explanation)	Items (Descriptors in database)	No. of letters	Written space	Letter type	No. of descriptors	Data type
1	No. of laboratory	SEIRI NO.	6	1/2–7	N	1	TEXT
2	Kinds of plant	SHOKUBUTSU SHURUI	2	1/9–10	N	1	CODEZ
3	Name of plant	SAKUMOTSU MEI	13	1/12–24	A	1	NAME
4	Variety name	HINSHU MEI	55	1/26–80	AN	1	TEXT
5	Consecutive no. of lab.	KENKYUUSHITSU TOSHI NO.	8	2/9–16	N	1	ORDER
6	Registration no. in MAFF, year	NOURIN NO. TO TOUROKU NENDO	12	2/18–29	N	1	TEXT
7	Reg. seeds no., year	SHUBYOU NO. TO TOUROKU NENDO	14	2/31–44	N	1	TEXT
8	Evaluation sta., lab.	CHOUSA KIKAN	12	2/46–57	AN	1	NAME
9	Evaluation year	CHOUSA NENDO	4	2/59–62	N	1	ORDER
10	No. of central bank	CENTER BANK NO.	8	2/64–71	N	1	TEXT
11	Past life	RAIREKI	72	3/9–80	AN	1	TEXT
12	Color of young leaves	YOUYOU NO IRO	1	4/9	N	5	CODEZ
13	Spine	TOGE NO UMU	1	4/11	N	4	CODEZ
14	Wave of leaf blade	YOUSHIN NO NAMIJOU	1	4/13	N	4	CODEZ
15	Shape of leaf blade	YOUSHIN NO KATACHI	1	4/15	N	9	CODEZ
16	Leaf blade index	YOUSHIN SHISUU	4	4/17–20	N	1	ORDER
17	Wing shape	YOKUYOU NO KATACHI	1	4/22	N	4	CODEZ
18	Wing index	YOKUYOU SHISUU	4	4/24–27	N	1	ORDER
19	Color of flower bud	KARAI NO IRO	1	4/29	N	6	CODEZ
20	Petal size	KABEN NO OOKISA	2	4/31–32	N	1	ORDER
21	Fruit shape	KAKEI	1	4/34	N	9	CODEZ
22	Base shape	KAKOUBU NO KATACHI	1	4/36	N	9	CODEZ
23	Apex shape	KACHOU NO KATACHI	1	4/38	N	5	CODEZ
24	Peel color	KAHISHOKU	1	4/40	N	9	CODEZ
25	Collar	OUKAN NO KEISEI	1	4/42	N	3	CODEZ
26	Navel	HESO NO UMU	1	4/44	N	2	CODEZ
27	Rind adherence	HAKUHISEI	1	4/46	N	4	CODEZ
28	Pulp color	KANIKUSHOKU	1	4/48	N	9	CODEZ
29	Thickness of septa	JOUNOU NO ATSUSA	1	4/50	N	3	CODEZ
30	Bitterness of septa	JOUNOU NO NIGAMI	1	4/52	N	4	CODEZ
31	Bitterness of vesicle	SAJOU NO NIGAMI	1	4/54	N	4	CODEZ
32	Color of mesocarp	ARUBEDO NO IRO	1	4/56	N	5	CODEZ
33	Uniformity of pulp color	KANIKU NO KIN'ITSUTEIDO	1	4/58	N	3	CODEZ
34	Juice amount	KAJUUBUN NO TASHOU	1	4/60	N	3	CODEZ
35	Pulp texture	KANIKU NO KATACHI	1	4/62	N	3	CODEZ
36	Seed size	SHUSHI NO OOKISA	1	4/64	N	3	CODEZ
37	Seed surface	SHUSHI HYOUMEN	1	4/66	N	2	CODEZ
38	Seed color	GAISHUHISHOKU	1	4/68	N	6	CODEZ
39	Color of inner seed coat	NAISHUHISHOKU	1	4/70	N	6	CODEZ
40	Embryo color	HAISHOKU	1	4/72	N	5	CODEZ

Table 3. Contents of CODEZ

No.	Items	Descriptor states
2	Kind of plant	KAJURUI (07)
12	Color of young leaves	PALE YELLOW (1), LIGHT GREEN (3), GREEN (5), PURPLE (7), DARK PURPLE (9)
13	Spine	SPINELESS (1), SHORT (3), MEDIUM (5), LONG (7)
14	Wave of leaf blade	FLAT (1), SLIGHT (3), MEDIUM (5), STRONG (7)
15	Shape of leaf blade	FUSIFORM (1), LANCEOLATE (2), OBLANCEOLATE (3), ELLIPTIC (4), OVATE (5), OBOVATE (6), ORBICULAR (7), OBDELTOID (8), OTHERS (9)
17	Wing shape	TRACE (1), NARROW (3), OBDELTOID (5), CORDATE (7)
19	Color of flower bud	WHITE (1), WHITISH YELLOW (2), YELLOWISH GREEN (3), LIGHT PURPLE (4), PURPLE (5), REDDISH PURPLE (6)
21	Fruit shape	OBLATE (1), GLOBOSE (2), OVOID (3), OBLONG (4), OBLIQUE (5), OBVOID (6), PYRIFORM (7), FUSIFORM (8), OTHERS (9)
22	Base shape	LONG NECKED (1), SHORT NECKED (2), EVENLY ROUNDED (3), FLAT OR TRUNCATE (4), MODERATELY DEPRESSED (5), DEEPLY DEPRESSED (6), LOW COLLARED AND DEPRESSED (7), HIGH COLLARED AND DEPRESSED (8), LOW COLLARED AND SHORT NECKED (9)
23	Apex shape	NIPPLED (1), OBTUSE (2), ROUNDED (3), TRUNCATED (4), DEPRESSED (5)
24	Peel color	CREAM (1), LIGHT GREEN (2), YELLOW (3), YELLOWISH ORANGE (4), ORANGE (5), DARK ORANGE (6), PINK (7), RED (8), PURPLE (9)
25	Collar	SHOULDERED (1), LOW-COLLARED (3), HIGH-COLLARED (5)
26	Navel	ABSENT (1), PRESENT (2)
27	Rind adherence	SLIGHT (1), MEDIUM (3), STRONG (5), DIFFICULT (7)
28	Pulp color	CREAM (1), LIGHT GREEN (2), YELLOW (3), LIGHT ORANGE (4), ORANGE (5), SCARLET (6), PINK (7), RED (8), PURPLE (9)
29	Thickness of septa	THIN (3), MEDIUM (5), THICK (7)
30	Bitterness of septa	ABSENT (1), WEAK (3), MEDIUM (5), STRONG (7)
31	Bitterness of vesicle	MILD (1), WEAK (3), MEDIUM (5), STRONG (7)
32	Color of mesocarp	WHITE (1), LIGHT YELLOW (3), GREENISH WHITE (5), LIGHT ORANGE (7), RED (9)
33	Uniformity of pulp color	SCATTERED (3), MEDIUM (5), SOLID (7)
34	Juice amount	DRY (3), JUICY (5), VERY JUICY (7)
35	Pulp texture	TENDER (3), FIRM (5), TOUGH (7)
36	Seed size	SMALL (3), MEDIUM (5), LARGE (7)
37	Seed surface	SMOOTH (1), ROUGH (9)
38	Seed color	WHITE (1), CREAM (3), YELLOW (4), LIGHT BROWN (5), BROWN (7), OTHERS (9)
39	Color of inner seed coat	WHITE (1), YELLOWISH BROWN (2), LIGHT BROWN (3), BROWN (5), RED (7), OTHERS (9)
40	Embryo color	WHITE (1), CREAM (3), LIGHT GREEN (5), GREEN (7), DARK GREEN (9)

leaves) through no. 40 (embryo color) in the fourth line by using defined letters in the designated columns. Descriptions of all the registration-related

data on the second variety and beyond successively follow the format for the first variety, consisting of four lines each, as mentioned above. As far as the

data on characters of all varieties are concerned, they are stored in the file with an appropriately defined name. Since the data on characters are stored independently for each fruit tree in different files, adequate formats for data input have to be set up for the respective trees.

There are two types of stored data on characters: one is coded and the other is actual. In the former case, it would be recommendable to convert actual measurements into simple codes: e.g., PALE YELLOW; 1, LIGHT GREEN; 3 for colors of young leaves. The items of characters under evaluation and the coded status in each item or descriptor states (codes: CODEZ of the Data type in Table 2) are shown in Table 3.

In the latter case, numerals of the measurements, which are dealt with by ORDER of the Data type in Table 2, are registered within the relevant columns of each descriptor. The contents of order in case of using ORDER of the Data type in Table 2 are shown in Table 4.

In constructing a database, the first step of defining items and descriptors as shown in Table 2 is followed by the second step consisting of: (a) defin-

ing a file name for storing data; and (b) registering such a database at CCAFFR to further process the stored data.

An access to those database files could be made through each terminal connected to the Computer Center, as required.

Now, an example is presented hereafter to obtain information on thickness and bitterness of septa and fruit shape of citrus from the above-mentioned database. Tables 5, 6 and 7 indicate interrelations among those characters; i.e. thickness and bitterness of septa, thickness of septa and fruit shape, and thickness, bitterness of septa and fruit shape, respectively.

Table 5 shows that as far as thickness and bitterness of septa are concerned, 121 out of 285, or 42%, of citrus varieties registered are thin and bitterness-free and the remaining portion has great variations, especially in thickness of septa.

It is recognized from Table 6 that over 60% of the citrus varieties evaluated have a fruit shape of OBLATE or GLOBOSE with THIN or MEDIUM thickness of septa, with limited variations.

Table 7 indicates that 75 varieties have combined characters of thin and bitterness-free septa with OBLATE in fruit shape, with significant variations in interrelations of those three characters.

In such a way as described above, comprehensive information can be easily obtained through the established database. In addition, one can easily identify any variety or group of varieties which has suitable characters needed for breeding and other research programs from among a number of varieties preserved in the Genebank.

Table 4. Contents of ORDER

No.	Items	Min.	Max.	Pitch
5	Consecutive no. of lab.	1	99,999,999	1
9	Evaluation year	1	9,999	1
16	Leaf blade index	1.00	4.50	0.01
18	Wing index	1.00	13.00	0.01
20	Petal size	8	35	1

Table 5. Relations between thickness and bitterness of septa in citrus

Items			Bitterness of septa					Total	Percentage (%)
			1	3	5	7	Unknown		
			ABSENT	WEAK	MEDIUM	STRONG			
Thickness of septa	3	THIN	121	3	2	5	1	132	46
	5	MEDIUM	50	19	11	8	0	88	31
	7	THICK	28	16	7	6	3	60	21
	Unknown		0	0	0	0	5	5	2
Total			199	38	20	19	9	285	
Percentage			70	13	7	7	3		100

Table 6. Relations between thickness of septa and fruit shape in citrus

Items			Thickness of septa				Total	Percentage (%)
			3	5	7	Unknown		
			THIN	MEDIUM	THICK			
Fruit	1	OBLATE	82	31	13	0	126	44
shape	2	GLOBOSE	34	36	23	1	94	33
	3	OVOID	7	4	8	0	19	7
	4	OBLONG	5	5	6	0	16	6
	5	OBLIQUE	1	1	0	0	2	1
	6	OBVOID	0	2	6	0	8	3
	7	PYRIFORM	1	2	1	0	4	1
	8	FUSIFORM	0	0	0	0	0	0
	9	OTHERS	2	7	3	1	13	5
	Unknown		0	0	0	3	3	1
Total			132	88	60	5	285	
Percentage			46	31	21	2		100

Table 7. Relations among fruit shape, thickness and bitterness of septa in citrus

Thickness			3 (THIN)					5 (MEDIUM)					7 (THICK)					UK*	Total
Bitterness			1	3	5	7	UK*	1	3	5	7	UK*	1	3	5	7	UK*		
Fruit	1	OBLATE	75	0	2	5	0	11	8	6	6	0	6	4	2	1	0	0	126
shape	2	GLOBOSE	32	2	0	0	0	24	9	2	1	0	13	4	4	2	0	1	94
	3	OVOID	6	2	0	0	1	2	1	0	1	0	4	1	0	2	1	0	19
	4	OBLONG	4	1	0	0	0	4	0	1	0	0	1	1	1	1	2	0	16
	5	OBLIQUE	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2
	6	OBVOID	0	0	0	0	0	1	0	1	0	0	1	5	0	0	0	0	8
	7	PYRIFORM	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	4
	8	FUSIFORM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	OTHERS	2	0	0	0	0	6	1	0	0	0	3	0	0	0	0	1	13
	Unknown		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
Total			121	3	2	5	1	50	19	11	8	0	28	16	7	6	3	5	285

*UK: Unknown

References

1) AFFRCS/NIAR (1987): Characterization manual in plant genetic resources (primary characters) [In Japanese].
2) CCAFFR (1982): Genetic resources information management system for center of genetic stocks (GRIMS/CGS). CCAFFR' manual No. 14 [In Japanese].
3) IBPGR (1982): Descriptor list for apple. 16–39.
4) IBPGR (1984): Revised descriptor list for apricot. 20–31.