LUNDERGAN and JANICK (1979) without particular effect on survival rates. WESTCOTT (1981) stated that high survival rates were achieved for potatoes without sealing. In the same way, PREIL and HOFFMAN (1985) made a comparison in the preservation of chrysanthemum shoots between two methods; a) caps of the containers were completely sealed with parafilm, and b) ventilation rings were inserted between the caps and the containers. There was a clear difference between the two methods. In the containers with the tightly sealed caps, chrysanthemum shoots became vitrified, and the bases of the stems turned brown. In contrast, all the shoots in the ventilated containers were healthy. From these results, it is evident that the prevention of drying and the provision of aeration are needed for each of the materials preserved.

(4) Growth and variation of plants after regeneration

No matter which preservation method has been used, preservation is of no value, if the characteristics of the regenerated plants differ from the original ones. It has been stated that there is relatively few genetic mutations in meristem culture. But it is extremely difficult to prove that any genetic mutation has not occurred during preservation. CHEYNE and DALE (1980) reproduced up to 500 plants of clover after preservation, but they did not observe any phenotipically abnormal variants. On the other hand, MIEDEMA (1982) reported that sugar beet plantlets reproduced after 6 months preservation were normal, while those reproduced after 13 months preservation showed decline in rooting ability and the appearance of abnormal leaf shapes. MONETTE (1986) stated that regenerants of kiwi fruit tree sometimes had swollen leaves and/or abnormal leaf color also. For the vegetatively propagated plants, it is difficult to determine whether these variations are simply phenotypic abnormalities appearing only in a particular plant, or they are genetic mutations. For the present, therefore,genetic stability should be determined in no other way than by evaluation from a practical viewpoint, mainly on the basis of observations of the appearance of the form of each plant.

4. Freeze Preservation

Preservation method by growth retardation is simple and applicable to many genetic resources, but it is impossible to apply this methods for extremely long periods (several decades or longer). Drying and degeneration of the culture

medium and the decline in vigor of the material itself cannot be completely avoided. In addition, the possibility of occurrence of genetic mutations cannot be fully denied by subculturing during preservation. The freeze preservation (cryopreservation) method is expected to solve these problems. In this method, the organs, tissues and cells of plants are kept at ultra low temperatures where biological reactions are stopped completely and no mutation occurs except those which occur naturally due to ordinary background radiation. In most cases, liquid nitrogen (-196°C) is now used to achieve ultra low temperatures, so that when "freeze preservation" is referred to, it generally means preservation with the use of liquid nitrogen.

1) *Method of freeze preservation*

The relationship between the freeze preservation method and the growth retardation methods for woody plants is shown in Fig. 2. Generally, shoot apex for "system A" and callus for "system B" are the materials used for the freeze preservation, for both herbaceous and woody plants. The shoot apex, in this case, must be cut from the terminal or axillary bud, and must be handled in a aseptic culture system. The winter buds of some woody plants acquire freezing resistance under natural conditions from autumn to winter. "System C", which utilize the freeze resistance of the winter buds, can be applicable to the preservation of this kind of plants. In "system C", the intact winter bud itself is the material to be frozen and is transferred into the culture system after freezing period.

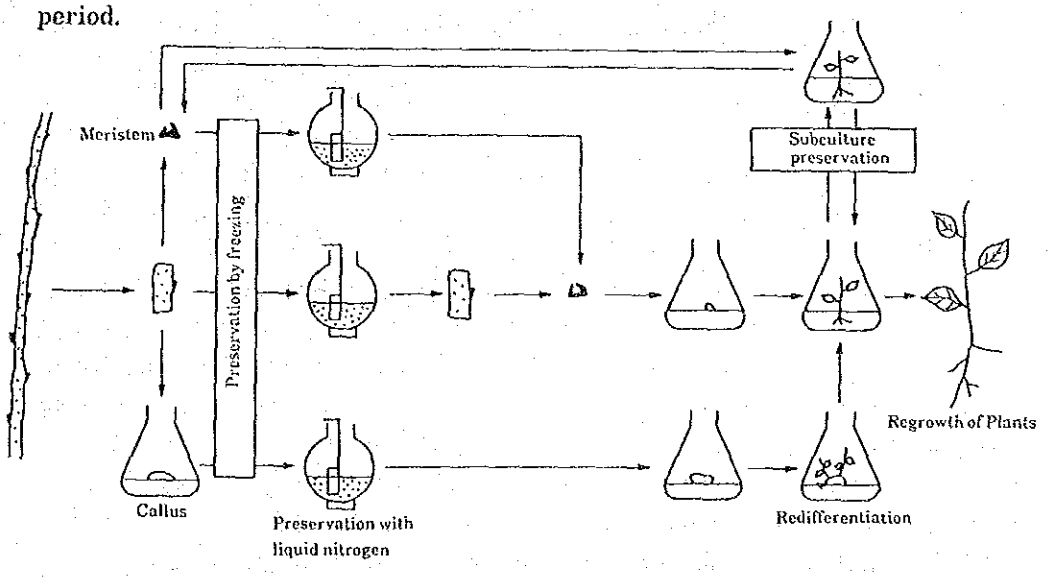

Fig. 2 Materials and methods for tissure culture preservation

No matter which material or system is used, the basic procedures before and after freezing are common. Freeze preservation is practiced in the following order. (1) Pretreatment of materials, (2) Preliminary freezing, (3) Freezing with liquid nitrogen, (4) Thawing and (5) Regeneration of plants.

Procedure (1) is done to increase freezing resistance of materials prior to freezing. In this operation, the material is cultured in a medium which contains special chemical substances, or the material is treated with cryoprotectants.

Procedure (2) is the operation in which the material is cooled at a temperature of around -30°C with a fixed speed, in order to induce an extracellular freezing, which reduces the water content of the cells sufficiently enough to avoid damage when the cells are later exposed to the ultra low temperature of liquid nitrogen.

Procedure (3) is the freezing with liquid nitrogen. The ordinary freezing method with preliminary freezing procedure is referred to as "slow freezing method", and the other one is the "rapid freezing method", in which the meristems are plunged directly into liquid nitrogen without any preliminary freezing.

Procedure (4) includes two methods. One is "slow thawing" at normal temperature in air, and the other is "rapid thawing" in water of 35 to 40°C.

Procedure (5) is the same as ordinary tissue culture conditions. When callus is used as the material for the freeze preservation the process of differentiation of plantlets is needed.

2) Freeze preservation of callus and cultured cells

SAKAI and SUGAWARA (1973) acclimatized poplar callus to low temperature by exposing it to a temperature of 0°C for 20 days, and then plunged it in liquid nitrogen. After thawing, they succeeded in the regrowth of the treated callus. In the same year, NAG and STREET (1973) reported that carrot cells preserved in liquid nitrogen maintained the viability and possessed the ability of producing somatic embryos. These researches have first proven that the preservation at ultra low temperature, in the form of callus or cultured cells has practical significance in plant reproduction. These studies also clarified the fact that DMSO is highly effective as a cryoprotectant, and there is an optimum cooling rate for a high survival rate.

Since that time, freeze preservation of callus and cultured cells has been utilized for various materials. The main purpose in this research area, however, lies in the fundamental study to elucidate effective freezing and thawing conditions, or the pursuit of physiological and morphological changes of cells and tissues during the processes of freezing and thawing. Therefore, there are not many successful examples leading finally to plant regeneration, toward the preservation of genetic resources. Among these studies, TISSERAT *et al.* (1985) succeeded in forming somatic embryos from the callus of date palm which had been preserved for 3 months in liquid nitrogen. The date palm is a tropical fruit tree, and the preservation of its genetic resources is particularly difficult at low temperature. Therefore, if this method can be utilized effectively for tropical plant species, it will prove most useful.

3) Freeze preservation of shoot apex

Shoot apex is used as the material to be preserved. The most efficient shortcut to the use of freeze preservation of genetic resources is considered to be the preservation of shoot apex. The first trial to afford survival of shoot apex in liquid nitrogen was made by SUN (1958). He demonstrated that pea seedlings survived in liquid nitrogen, when they were dried in oven until their water content decreased to between 27 and 40%. This type of preliminary treatment is considered very rough today, but SUN's finding of preventing freezing damage by removing part of water in the plants, was truly brilliant. The freeze preservation of shoot apex with the use of cryoprotectant, was first done with carnations by SEIBERT and WETHERBEE (1977). Following this, GROUT and HENSHAW (1978) preserved meristems excised from the axillary buds of potato for 3 weeks in liquid nitrogen, and then thawed the frozen meristems at 35°C. They reported that 38 out of 188 plants survived and also stated that their experiment was the first successful case of liquid nitrogen freeze preservation of materials which originally had no freezing resistance. In both of these cases, the "rapid freezing method" was used. This involves the direct exposure of the shoot apex to liquid nitrogen. Most researchers have later used the preliminary freezing method, which allows relatively stable results. Today, the "rapid freezing method" is used only to specific materials. The "rapid freezing method" requires the placing of the materials directly into the liquid nitrogen, and it is difficult to prevent microbial contamination at this time, and to determine the stable cooling rate.

4) Freeze preservation of shoot apex of vegetatively propagated crops

Studies of the freeze preservation of vegetatively propagated crops other

than potatoes, began at the end of the 1960s. Table 3 shows major examples of these studies. KARTHA *et al.* (1980) cryopreserved shoot apex (runner-tip) of strawberry, and achieved a survival rate of over 50%. A distinctive feature of this study was the combination of the freeze preservation of shoot apex with *in vitro* mass propagation. Strawberry shoot apices which were initially cultured in MS medium +1μM BA +1μM IBA + 0.1μM GA_3 could be propagated in MS medium + 10μM BA at a proliferation rate of more than 100 times in 2 to 3 months in the next generation. Large number of shoots obtained in this way were used as experimental materials. From the shoot apices preserved for 8 weeks in liquid nitrogen, 58 plants were regenerated. When these regenerated plants were transferred into propagation medium, they propagated at the same rate as untreated materials. Prior to this experiment, SAKAI *et al.* (1978) succeeded in regenerating plants from strawberry runner-tips isolated in summer, which were rapidly frozen in liquid nitrogen, though cryopreservation was not attempt for long periods. KARTHA *et al.* (1982) also carried out freeze preservation of shoot apex of cassava. They obtained good results using the method in which shoot apices were placed in aluminum foil containers with a few drops of DMSO solution. They called this technique the "droplet-freezing method", and have stated that the conventional method using ampoules was not successful.

Table 3 Preservation of meristems of vegetatively propagated plants by freeze preservation

Material	Freezing rate	Cryoprotectant	Duration of freezing period	Survival rate (%)	References
Potato	Rapid	10% DMSO	3 weeks	63	GROUT, HENSHAW (1978)
Strawberry	Slow	10-16% DMSO	10 minutes	60	SAKAI *et al.* (1978)
Strawberry	Slow	5% DMSO	5 minutes	100	KARTHA *et al.* (1980)
Cassava	Slow	15% DMSO	1 hour	16-18	KARTHA *et al.* (1982)
Apple	Slow	None	15 minutes	80-90	KATANO *et al.* (1983)
Japanese pear	Slow	None	20 minutes	95-100	MORIGUCHI *et al.* (1985)
Brambleberry	Slow	DMSO+Glu+PEG	1 hour		REED, LAGERSTEDT (1987)

A certain number of reports have been published on the freeze preservation of shoot apex of fruit trees. KATANO *et al.* (1983) succeeded in maintaining the viability of shoot apices collected from dormant buds of apple cultivar "Fuji" which were prefrozen at temperatures below -10°C prior to plunge in liquid nitrogen. A distinctive feature of this experiment was that the shoot apex did not require the addition of any cryoprotectants. This means that the freezing resistance of winter buds of apples is quite strong. Similar results were obtained by MORIGUCHI *et al.* (1985) with shoot apices of Japanese pear, which were able to survive in liquid nitrogen without the use of any cryoprotectant. However, the elongation of shoots from the shoot apices of Japanese pear after thawing was not satisfactory. It was assumed that even if the leaf tissues of Japanese pear survived, the apical meristems suffered certain amount of freezing injury. UEMATSU and AKIHAMA (1986) confirmed that the shoot apices of stone fruits preserved in liquid nitrogen survived regardless of whether cryoprotectant was used or not, but they did not check the regrowth of shoots.

In some experiments, apple meristems from *in vitro* propagated shoots were used as the materials to be frozen. KUO and LINEBERGER (1985) pre-treated *in vitro* cultured meristems of Jonathan apples, in darkness for 6 weeks at 4°C, and placed them in glycerol solution before freezing in liquid nitrogen. The effect of this pre-treatment was quite remarkable, but, unfortunately, the meristems when thawed, grew only into callus, and never formed shoots. They stated that the freezing damage had occurred, interfering with the normal growth of the meristem tissue. Similarly, ISHIHARA *et al.* (1987) reported the possibility of increasing the survival rate of cryopreserved shoots of apple by hardening *in vitro* cultured shoots. This was done either by the method of gradual temperature decrease, or by the pre-culturing the shoots in medium to which abscisic acid was added. Recently, successful result of normal growth from cryopreserved *in vitro* cultured meristems of *Rubus* was reported by REED and LAGERSTEDT (1987). As mentioned above, it is sometimes difficult to induce regrowth of shoots, when *in vitro* cultured meristems are used as the materials for freeze preservation. With this method, however, an abundance of germ-free materials can be assured. This is an attractive advantage. Since freeze preservation experiments are likely to involve quite wide fluctuations of results, reproducible preservation conditions can not be established unless a sufficient number of samples are prepared. Therefore, further development of studies relative to methods minimizing freezing injury is expected in future.

5) Hardening and cryoprotectants

As previously stated, the shoot apices from winter buds of apple and Japanese pear survive after freezing treatment with liquid nitrogen, without the addition of cryoprotectants. These materials, however, are exceptional examples. Most materials cannot tolerate even the preliminary freezing temperatures of –30° to –40°C, so that hardening is indispensable for these materials to increase freezing resistance to a certain degree. The method of hardening is to expose the materials to low temperature conditions for a fixed term. If hardening is not done, then cryoprotectant treatment is essential.

In vitro cultured meristem without hardening is considered to have no freezing resistance. Sometimes, however, these materials are affected by day-length conditions during *in vitro* culture. KATANO *et al.* (1984) increased freezing resistance of *in vitro* cultured apple meristems, by culturing under the condition of 10 hour day-length at 10°C. Similarly, CASWELL *et al.* (1986) reported that freezing resistance of *in vitro* cultured meristems of apple increased by a combination of low temperature and short day conditions. CASWELL *et al.* (1986) reported that callus and cultured cells also increased freezing resistance by low temperature treatment. SAKAI and SUGAWARA (1973) indicated that callus derived from cambium of poplar reached its maximum freezing resistance, when it was kept for 25 days at day and night temperatures of 12°C and 0°C, respectively. BANNIER and STEPONKUS (1972) reported that when chrysanthemum callus was treated on agar medium for a fixed term at 4.5°C, and the temperature later decreased to –16°C, its freezing resistance improved. The maximum level of freezing resistance of untreated callus was –6.6°C, while that of the callus pretreated for 6 weeks was at –16.1°C. In addition to the above, CHEN and GUSTA (1982) reported that freezing resistance was increased by raising the concentration of sugars. The effect of ABA has also been noted recently. RIKIN *et al.* (1979) reported that ABA related to the resistance of plants to various environmental stresses including low temperature. CHEN and GUSTA (1983) reported that the cell lines of wheat, whose freezing resistant level was –8°C in the standard medium, improved their level of resistance to between –30°C and –33°C, when they were cultured in a medium containing ABA, and that the effect of ABA was higher than that of low temperature treatment at 2°C. CHEN and GUSTA (1983) investigated the effect of ABA for various crops, and noted an interesting result that the crops for which freezing resistance was increased by low temperature treatment, also reacted to ABA. CHEN's group (1985) later succeeded in regeneration of plants from cryopreserved cultured

cells of wheat, freezing resistance of which was improved with low temperature and ABA treatments.

DMSO, glycerol, sugars (glucose, trehalose etc.), and proline or combinations of these substances, are used as cryoprotectants. Of them, DMSO is most commonly used. For freeze preservation of callus of alfalfa and date palm, FINKLE *et al.* (1985) reported PGD (Polyethylene glycol + glucose + DMSO) or PTD which included trehalose instead of glucose in PGD, gave better results with the meristem culture of *Rubus* than DMSO only. The use of combined cryoprotectants seems to provide improvement in the overall effect, by complementary interactions of the advantages and disadvantages of each cryoprotectant. This type of cryoprotectant mixture will be used wider in future.

6) Preservation of intact buds followed by meristem culture

SAKAI and NISHIYAMA (1977) processed the branches of apple cultivar "Asahi" in liquid nitrogen after preliminary freezing to –40°C. After thawing these branches in air at 0°C, their buds were grafted, and an 80% rooting rate was obtained. They (1978) also froze winter branches of deciduous fruit trees, such as apple, Japanese pear, currant, gooseberry and raspberry, in liquid nitrogen. After thawing these branches, they observed sprouting by inserting the branches in water. Their method was as follows; as a preliminary freezing process, branches sampled in January were kept at –5°C for 14 days, and at –10°C for 3 days, and then the temperature was decreased with the rate of –5°C per day down to –30°C. The temperature was then decreased with the rate of –10°C per day until a temperature reached to –50°C. The branches were next placed in liquid nitrogen for 2 hours, then taken out and thawed in air at 0°C.

The results of the above experiments were that the winter buds of these deciduous fruit trees all survived and resumed growth after the liquid nitrogen treatment. They (1978) also confirmed that the apple leaf buds survived after the preservation in liquid nitrogen for 23 months. Prior to this experiment, SAKAI (1963) proved that the branches of willow, poplar and white birch trees survived in liquid nitrogen, if the preliminary freezing method was applied. In these experiments, small branches about 20 cm in length were used as the materials to be frozen. After the branches were frozen, they were gradually thawed in air at 0°C, and then survival of buds was confirmed either by grafting or placing in water. SAKAI and NISHIYAMA (1978) recommended that when large materials such as branches are frozen, slow thawing should be used, since they are injured when thawed rapidly.

YOKOYAMA and OKA (1983) sampled mulberry shoots of 25 cm in length in February, and applied preliminary freezing for a total of 8 days (one day at −10°C, 3 days at −20°C, and 4 days at −30°C), then placed them in liquid nitrogen for 15 days. After thawing, these mulberry shoots did not sprout by either grafting or cutting, but when winter buds were isolated from the treated shoots and were cultured *in vitro*, they developed shoots, thus the meristem was confirmed to be surviving. YAKUWA and OKA (1987) developed this method further, and demonstrated that the shoot segments as short as 1.5 to 2cm in length could be freeze-preserved. They also demonstrated that when the material had sufficient freezing resistance, it could be preserved in liquid nitrogen with the application of preliminary freezing for a minimum period of 28 to 48 hours at a minimum temperature of −10°C (Photo. 1). In case of mulberry shoot cuttings, these results show that buds on relatively large materials did not suffer from any noticeable damage as a result of rapid thawing. The method for freezing the whole shoot segment (system C in Fig. 2) involves a very simple preliminary freezing operation, and provides much higher survival rate than the conventional freezing methods in which the isolation of meristem precedes the freezing procedure. In any cases in which the regenerating plants are obtained by grafting, cutting or meristem culture, the freeze preservation of the whole branch is considered to be effective for woody plants such as mulberry and other deciduous fruit trees which have winter buds with strong freezing resistance.

5. Conclusion

Two methods, growth retardation preservation (slow growth preservation) and freeze preservation (cryopreservation) have been discussed here, from the viewpoint of the utilization of tissue culture for preserving genetic resources of vegetatively propagated crops. For both methods, a considerable number of records and studies have accumulated. The growth retardation preservation method is already in practical use for some crops. The freeze preservation method, however, requires further study before it becomes of practical use. The U.S. National Seed Storage Laboratory has already begun the freeze preservation of seeds on a practical scale. They are now planning a future research project involving the use of liquid nitrogen for the preservation of callus, pollen, shoot apex and cultured cells. Inspired by this, other countries are also gradually developing research activities in these areas. The preservation of genetic resources is often considered to have the same meaning as the preservation of varieties. the preservation of genetic resources, however, includes various subjects and various materials for experiments, as well as

breeding materials. Callus and cell lines, which have the capacity for redifferentiation, are considered to be of greater importance than ever before, with the development of biotechnological research. These cell lines, however, are assumed to undergo the gradual loss of their capacities for differentiation in repeated ordinary subculturing, and sometimes the optimum timing for subculturing might be missed. Such a loss of materials is a major problem. Thus, if these cell lines can be preserved in the form of frozen cells, retaining their capacities for differentiation, it will save us worrying about unexpected accidents. In the U.S.A, new business such as cell stock banks for the preservation of experimental materials, have been established.

As I conclude this paper, I wish to introduce one more idea for the utilization of tissue culture preservation. The breeding of forest trees requires many years. This is related to the long period for growth from seed to flowering, and many years are required for mating and seed production. The main problem, however, is the difficulty in selecting plants with excellent characteristics and propagating their clones in a short period. However, many experimental trials of the utilization of tissue culture for rapid propagation of woody plants have been carried out recently. Then the idea here is the use of tissue culture for propagation of superior plants which have been selected in ordinary breeding. The problem is that the meristem culture does not always work well when the mature tree is too aged. SMITH *et al.* (1982) proposed to culture the meristems from all seedlings before selection. These are transferred once into low temperature conditions for growth retardation preservation. In parallel with the preservation, evaluation can be practiced for the characteristics of the plants in the field. Once excellent plants have been selected in the field, then they are clonally propagated from the meristems in storage. The materials in this case are being preserved in the juvenile stage, so that their propagation can be smoothly continued even several years later. SMITH's group actually applied this method to the breeding of radiata pine since 1983. At present, 200 clones have been stored at 4°C, while evaluation in the field is simultaneously in progress, and will continue for 5 to 8 years.

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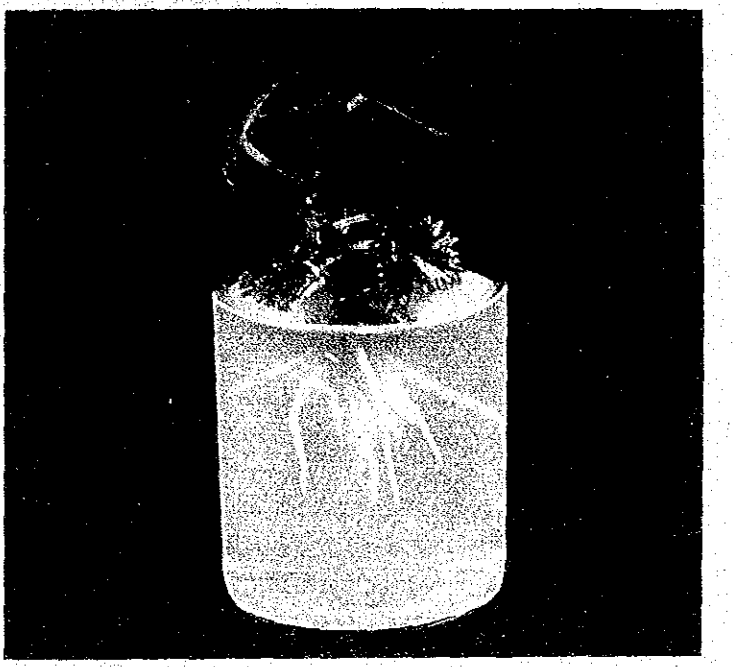

Photo 1 A shoot regenerated by tissue culture from a mulberry shoot segment preserved in liquid nitrogen

VI Management and Utilization of Information for Genetic Resources

by

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CONTENTS

1. Introduction

The rapid development of electronics and computer science in recent years has given a great impact for our society. The amazing reduction in the price of hardware and the great progress in the diversity and user-friedliness of software, have allowed us to utilize these facilities with ease in research, as well as in daily life. Introduction of these techniques into our research activities, such as collection, storage and retrieval of various kinds of information, and also the mathematical or statistical handling of accumulated data by sophisticated analytical methods, can accelerate further advancement in the efficiency of genetic resource utilization.

Genetic resources are the reservoir of genetic information accumulated for generations and have survived through acute or chronic changes in evolutionary pressures at various localities. They are indeed the precious heritage of the history of life on earth, and are of immeasurable value for the future of mankind.

Progress in farming practices, especially in the rapid diffusion of newly bred high-yielding varieties, can easily cause genetic erosion or the loss of the diversity of genetic resources that are scattered and adapted each to its restricted niche. Unless special care is taken, this may result in a serious loss which can never be recovered again.

In line with the international trend of computer use in genetic resource management, we have been engaged in the establishment of our genetic resource information management system in the Ministry of Agriculture, Forestry and Fisheries in recent years. The outline of present activities utilizing computers for information processing of genetic resources and related fields will be introduced here.

2. Progress in Computer Science

Starting from the first realization of the electronic computer "ENIAC" in 1947, several important subsequent steps have been accomplished. Vacuum tubes, used for computers at the earliest stage, now a historical monument, were soon replaced by the transistor, and then, again, by integrated circuits. Large-scale integration, or LSI, generally accepted as the background for the so-called 4th generation computer, is very important in contemporary main-frame and micro computer development because of its speed of switching, high degree of

integration in size and function, reduced power requirements, and resulting in a quite significant reduction in the price of computers. The price of computer memory or micro-prosessors has declined to one hundredth of its original cost in ten years. As a result, we now see extensively wide use of computers in large and small scales.

Great progress has been achieved in the development and improvement of computer software. Presently, a major portion of computer price is comprised of the cost of software in contrast to earlier stages of computer history. Operating systems and programs are now evaluated not only for their efficiency in processing, but also by the ease of operation for general users of varied disciplines. Accelerated by the rapid progress in communication control techniques, on-line use of large scale computers from simple terminals in laboratories has become commonplace, and user-friendly softwares are used extensively. The use of computers is no longer confined to special fields of science and industry. Communication network has quickly been introduced into our daily life all over the world. They not only deliver information through voice, visual or graphic images as found in the display of home computer terminals, but also directly accept our decisions through the network. An experimental system "CAPTAIN", (standing for Character and Pattern Telephone Access Information Network) has now been in general use in Tokyo district. This was the first step in the use of VAN (Value Added Network) in this country. Rapid extension of systems utilizing the optical fibre or laser beam network, are expected to give great impact as "informatic revolution" to our society through its immense capacity of information transfer.

As for micro-computers, highly reduced price has made it possible to be used widely for various kinds of industrial research as well as for use in daily life. Physical and chemical analysers, for instance, usually install several micros in the reaction regulating systems, resulting in the improved efficiency in operation. Automobiles, new cooking devices, and various other home equipments utilize many invisible micros to assure ease of operation and realize economy of energy consumption. We are unconsciously using many micros in every home according to statistics.

Keeping abreast with this trend, our research field of genetic resources, has also been using many micro-computers to attain high efficiency.

```
COMMAND? SEA
INQUIRY? KEY_WORD=RUBP
 #01        2  RECORDS
INQUIRY? KEY_WORD=AOH
 #02        2  RECORDS
INQUIRY? AUTORAUTHOR=TAKAIWA
 #03        2  RECORDS
INQUIRY?
COMMAND? SEA
INQUIRY?
COMMAND? DIS
INQUIRY NUMBER? 1
DISPLAY STARTING POINT?
DISPLAY COUNT? 1
DISPLAY FORM?
LINE LENGTH?
DISPLAY ITEM NAME?
CONDITION?

  #01          2 RECORDS

         1/2
ID          CHSORC
ENTRY_DATE  19320116
DOR         DNA
BASE_NUM        1303
GC_CONTENT    41.0
ACCESS_NUM V00168;
KEY_WORD      CHLORO.SPINACIA.OLERACEA.RUBPASESpinach chloroplast gene for the
            large subunit of RUBP(ribulose 1,5-bisphophate carboxylase)ribulose
             bisphosphate carboxylase.Chloroplast Spinacia oleracea (spinach, e
            pinard, Spinat)Chloroplastida; Spermatophyta; Magnoliopsida; Caryop
            hyllidae;Caryophyllales; Chenopodiaceae.Spinacia oleracea (spinach,
             epinard, Spinat)Caryophyllales; Chenopodiaceae. "The structure of
            the gene for the large subunit of ribulose 1,5-bisphosphate carboxy
            lase from spinach chloroplast DNA";
REFERENCE   Nucl. Acids Res.
AUTHOR      Zurawski G., Perrot B., Bottomley W., Whitfeld P.R.;
HEADER      CHSORC    CHLORO.SPINACIA.OLERACEA.RUBPASE;  DNA;  1303 BP.
DATE        16-JAN-1982  (first entry)16-JAN-1982  (first entry)07-APR-1983  (m
            inor modifications)
DESCRIPT    Spinach chloroplast gene for the large subunit of RUBP(ribulose 1,5
            -bisphophate carboxylase)
TERMINOL    Chloroplast Spinacia oleracea (spinach, epinard, Spinat)
EACH_BASE   Sequence   1303 BP;  523 A;  331 C;  540 T;  409 G.
HOST_SPEC   Spinacia oleracea (spinach, epinard, Spinat)
HOST_CLASS  Caryophyllales; Chenopodiaceae.
 SEQUENCE              1          2          3          4          5          6
 SEQUENCE    AACGGTTACGGTTGGGTTGCGCCATATATATGAAAGAGTATACAATAATGATGTATTTGG
 SEQUENCE    CGAATCAAATACATGGTCTATTAACGAACCATTTTGATTAGTTGATAATATTAATTGAGA
 SEQUENCE    ATTTGATGAAAGATTGCTATAAAAGGTTTCATTAAGGCCTAATTTATGTCGAGTAGACCT
 SEQUENCE    TGTTGCTTTGTTGTAAAAATTAAAATTTGAAGTTGTAGGGAGGGACTTATGTCACCACAA
 SEQUENCE    ACAGAGACTAAAGCAAGTGTTGAATTTAAAGCTGGTGTTAAAGATTACAAATTGACTTAT
 SEQUENCE    TATACTCCTGAGTATGAAACCCTAGATACTGATATCTTGGCAGCATTCCGAGTAAGTCCT
 SEQUENCE    CAACCTGGAGTTCCACCCGAAGAAGCAGGGGCTGCAGTAGCTGCTGAATCTTCTACTGGT
 SEQUENCE    ACATGGACAACTGTATGGACCGACGGACTTACCAACCTTGATCGTTACAAAGGACGATGC
 SEQUENCE    TACCACATCGAGCCCGTTGCTGGAGAAGAAAATCAATATATTTGTTATGTAGCGTATCCT
 SEQUENCE    TTAGACCTTTTTGAACAAGGTTCTGTTACTAACATGTTTACTTCCATTGTGGGTAACGTA
```

Fig. 1 Example of retrieved output from DNA database

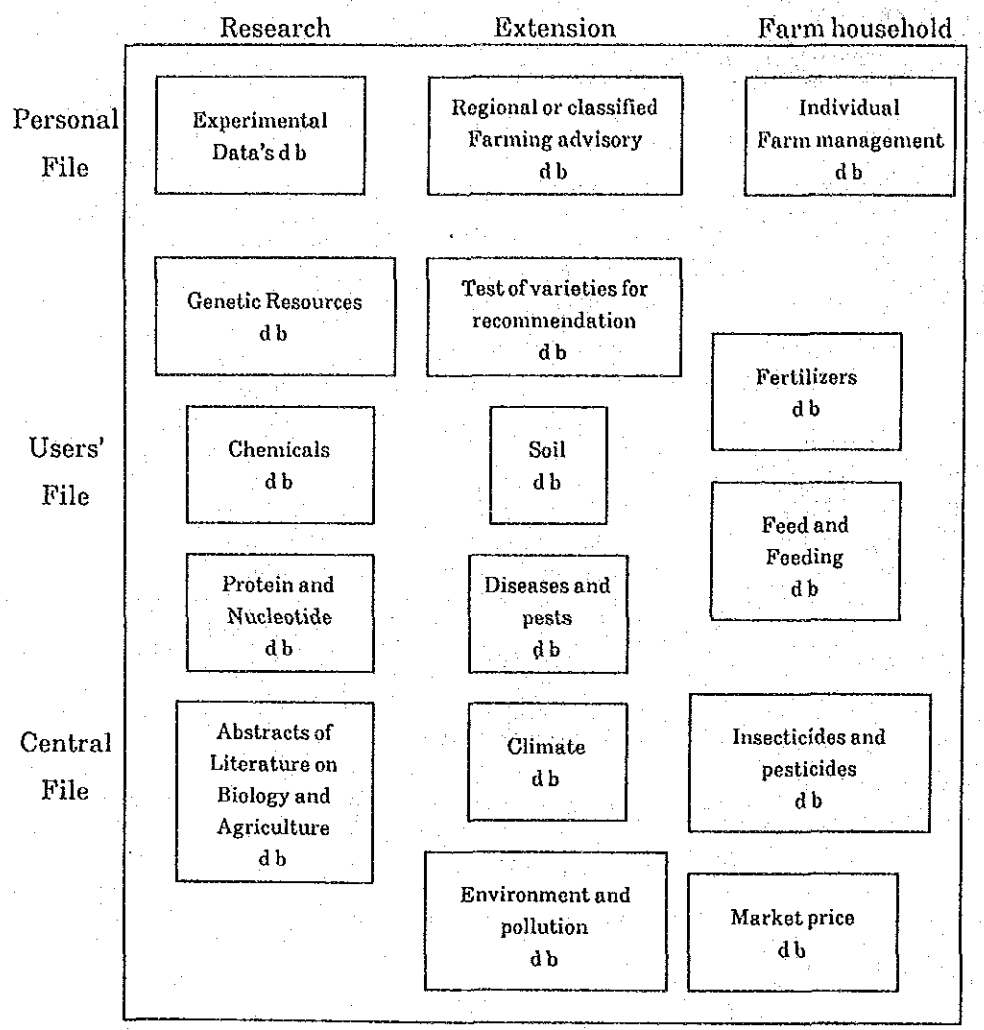


Fig. 2 Kinds and purposes of databases

```
RS> SHOW DB

LISTING OF AVAILABLE DATABASE(S)
AHCI      ANIME     BA        BCODE     BHEAD     BI        CAB       CANCER
CANCERLT  CANCERO   CANLTMST  CANPROJ   CCODE     CDI       CHEAD     CIJE
CLINPROT  COMPENDX  DBDB      EAC       EDNARS    EN        ENCLAS    ENNEW
ENP       ENERGY    ENV       ERICT     GAKUYO    IEEEAC    IEEEACTH  INSPEC
INSPECT   IPA       ISEKI     JEDI      JMARC     KAIZUKA   KANKYOG   KANKYOR
LCMARC    LISA      PA        PAALERT   PASCAL    POLL      RIE       SCI
SCIO      SHOEN     SSCI      UKMARC    YAMAKEI   YAMANAKA

RS> SHOW DB(DBDB)

LISTING OF SPECIFIED DATABASE
DATABASE        COUNT
DBDB             3134
          SUMMARY : DATABASE OF DATABASE
(CURRENT )       3134
          SUMMARY : 1988 VOL.09 NO.01    :   3134 RECORDS

RS> SEL DBDB

RS> SHOW ELEMENT

LISTING OF 25 ELEMENT(S)

ANO  NAM  NAS  TYP  SUB  PRO  PBS  PCT  SYC  SYS  SCT  GAT  GAS  GCT  CND
CON  LAN  COV  TSP  UPD  ISS  VOL  QTR  STA  ADD

RS> BRO PCT EN

BROWSING OF ELEMENT 'PCT'
     W-NO.     RECORDS VALUE
    #00084          87 AUSTRALIA
    #00085          10 AUSTRIA
    #00086          30 BELGIUM
    #00087         206 CANADA
    #00088           7 DENMARK
(*)#00089         239 ENGLAND
    #00090         135 FEDERAL REPUBLIC OF GERMANY
    #00091           6 FINLAND
    #00092         191 FRANCE
    #00093           2 HONG KONG
    #00094           1 INDONESIA

RS> BRO PCT J

BROWSING OF ELEMENT 'PCT'
     W-NO.     RECORDS VALUE
    #00095           2 HONG KONG
    #00096           1 INDONESIA
    #00097           4 IRELAND
    #00098           3 ISRAEL
    #00099          94 ITALY
(*)#00100          41 JAPAN
    #00101           7 LUXEMBOURG
    #00102           1 MALAYSIA
    #00103           1 MEXICO
    #00104           2 NEW ZEALAND
    #00105          15 NORWAY
RS> BRO SUB BIO

BROWSING OF ELEMENT 'SUB'
     W-NO.     RECORDS VALUE
    #00117          18 AUTOMOBILES & AUTOMOTIVE INDUSTRY
    #00118          31 AVIATION INDUSTRY
    #00119           8 AVIATION INDUSTRY-FLIGHT SCHEDULES
    #00120           7 BARTERING & BROKERING
    #00121           1 BIBLIOGRAPHIES
(*)#00122          45 BIOGRAPHIES
    #00123          79 BIOMEDICINE
    #00124          24 BIOTECHNOLOGY
    #00125          68 BUSINESS & INDUSTRY
    #00126           2 BUSINESS & INDUSTRY DIRECTORIES-AUSTRALIA
    #00127           1 BUSINESS & INDUSTRY DIRECTORIES-AUSTRIA

RS> BRO SUB LIF

BROWSING OF ELEMENT 'SUB'
     W-NO.     RECORDS VALUE
    #00128          58 LEGAL & REGULATORY-U.S. STATE
    #00129           4 LEGAL FORMS & PROCEDURES
    #00130           7 LEISURE & RECREATION
    #00131          17 LIBRARY & INFORMATION SCIENCE
    #00132          77 LIBRARY HOLDINGS-CATALOGS
(*)#00133          22 LIFE SCIENCES
    #00134           3 LITERATURE
    #00135           1 MAPS
    #00136          27 MARKETING
    #00137          46 MARKETING-AUDIENCE MEASUREMENTS
    #00138          38 MARKETING-CONSUMER SURVEYS
```

Fig. 3a Examples of retrieval output from the database DBDB (Utopia system of University of Tsukuba Information Center)

```
RS> SEA SUB LIFE@
22  FOUND
RS> OUT ELE(NAM SUB PCT COV UPD VOL)

#1
 NAM            BIOSIS PREVIEWS <REGISTERED>
 SUB            LIFE SCIENCES
 PCT            U.S.
 COV            INTERNATIONAL
 UPD            MOST SERVICES, ABOUT 20,000 RECORDS FROM BA A MONTH; ABOUT
                20,000 RECORDS FROM BA/RRM A MONTH; CISTI, EVERY 2 WEEKS.
 VOL            FALL 1979

#2
 NAM            LIFE SCIENCES COLLECTION
 SUB            LIFE SCIENCES
 PCT            U.S.
 COV            INTERNATIONAL
 UPD            ABOUT 8200 RECORDS A MONTH
 VOL            SPRING 1980

#3
 NAM            MICROBIAL CULTURE INFORMATION SERVICE <SERVICEMARK> (MICIS)
 SUB            LIFE SCIENCES
 PCT            ENGLAND
 COV            U.K.
 UPD            PERIODICALLY, AS NEW DATA BECOME AVAILABLE
 VOL            OCTOBER 1987

#4
 NAM            GENBANK <REGISTERED> (GENETIC SEQUENCES DATABANK)
 SUB            BIOTECHNOLOGY
                LIFE SCIENCES
 PCT            U.S.
 COV            PRIMARILY U.S. AND EUROPE
 UPD            ABOUT 100 RECORDS A MONTH
 VOL            WINTER 1983

#5
 NAM            BIOLOGICAL & AGRICULTURAL INDEX <SERVICEMARK>
 SUB            AGRICULTURE
                LIFE SCIENCES
 PCT            U.S.
 COV            INTERNATIONAL
 UPD            TWICE A WEEK; ABOUT 4500 ARTICLES A MONTH.
 VOL            SUMMER 1984

#6
 NAM            ZOOLOGICAL RECORD ONLINE <TRADEMARK>
 SUB            LIFE SCIENCES
 PCT            U.S.
 COV            INTERNATIONAL
 UPD            MONTHLY
 VOL            WINTER 1983

#7
 NAM            CURRENT AWARENESS IN BIOLOGICAL SCIENCES
 SUB            LIFE SCIENCES
 PCT            ENGLAND
 COV            INTERNATIONAL
 UPD            MONTHLY
 VOL            SPRING 1984

#8
 NAM            PHYTOMED
 SUB            BIOMEDICINE
                LIFE SCIENCES
 PCT            FEDERAL REPUBLIC OF GERMANY
 COV            INTERNATIONAL
 UPD            ABOUT 4000 RECORDS A QUARTER
 VOL            WINTER 1985

#9
 NAM            THE GENBANK <REGISTERED> SOFTWARE CLEARINGHOUSE
 SUB            BIOTECHNOLOGY
                COMPUTER HARDWARE & SOFTWARE-CATALOGS
                LIFE SCIENCES
 PCT            U.S.
 COV            INTERNATIONAL
 UPD            PERIODICALLY, AS NEW DATA BECOME AVAILABLE
 VOL            APRIL 1987
```

Fig. 3b Continued: search of databases with subject on life science

```
#10
 NAM            VECTORBANK (TRADEMARK)
 SUB            BIOTECHNOLOGY
                LIFE SCIENCES
 PCT            U.S.
 COV            INTERNATIONAL
 UPD            TWICE A YEAR
 VOL            SPRING 1985

#11
 NAM            BIOBUSINESS (REGISTERED)
 SUB            BIOTECHNOLOGY
                BUSINESS & INDUSTRY
                LIFE SCIENCES
 PCT            U.S.
 COV            INTERNATIONAL
 UPD            ABOUT 3000 RECORDS A MONTH
 VOL            SPRING 1985

#12
 NAM            PASCAL: ZOOLINE
 SUB            AGRICULTURE
                LIFE SCIENCES
 PCT            FRANCE
 COV            INTERNATIONAL
 UPD            ABOUT 1300 RECORDS A MONTH
 VOL            JANUARY 1986


RS> SEL BA
RS> SEA ST GENETI@ AND ST RESOURC@
45 DOCUMENT(S) FOUND
RS> AND YR 1987
6 DOCUMENT(S) FOUND
RS> OUT ELE(A T J B)

#1
 A              ELLIS R H;HONG T D;ROBERTS E H;
 T              THE DEVELOPMENT OF DESICCATION-TOLERANCE AND MAXIMUM SEED
                QUALITY DURING SEED MATURATION IN SIX GRAIN LEGUMES
 J              ANN BOT (LOND)
 B              59 (1). 23-30.

#2
 A              CHRISTIANSEN F B;LOESCHCKE V;
 T              EVOLUTION AND INTRASPECIFIC COMPETITION III. ONE-LOCUS THEORY
                FOR SMALL ADDITIVE GENE EFFECTS AND MULTIDIMENSIONAL RESOURCE
                QUALITIES
 J              THEOR POPUL BIOL
 B              31 (1). 33-46.

#3
 A              HALL A V;
 T              THREATENED PLANTS IN THE FYNBOS AND KAROO BIOMES SOUTH AFRICA
 J              BIOL CONSERV
 B              40 (1). 29-52.

#4
 A              WOOD I M;LARKENS A G;
 T              AGRONOMIC AND PHENOLOGICAL DATA FOR A COLLECTION OF SESBANIA-SP
                GROWN IN SOUTH-EAST QUEENSLAND AUSTRALIA
 J              GRC (GENET RESOUR COMMUN)
 B              0 (11). 1-13.

#5
 A              REEKIE E G;BAZZAZ F A;
 T              REPRODUCTIVE EFFORT IN PLANTS 3. EFFECT OF REPRODUCTION OF
                VEGETATIVE ACTIVITY
 J              AM MIDL NAT
 B              129 (6). 907-919.

#6
 A              GREGORIUS H-R;ROSS M D;
 T              SELECTION WITH GENE-CYTOPLASM INTERACTIONS III. EVOLUTION OF
                DIOECY
 J              EVOL THEORY
 B              8 (2). 87-99.
```

Fig. 3c Continued: search of articles on genetic resources from BIOSIS

3. Information Retrieval and Database

Recently, search of literature by an appropriate combination of several keywords from laboratory terminals has become a common practice. Only a few minutes are needed to find research affiliations and important papers of a sudden guest, by keying his/her name into a desk terminal.

The word database has long been familiar to scientists for the purpose of finding information. Rapid progress in the biological sciences produced difficulties in finding necessary articles from among frequent issues of great many journals. Secondary reference materials, like BIOSIS, are almost indispensable in making a new survey on literatures. In reply to this need, BIOSIS, for instance, has been supplied as a database in magnetic-tape since 1969. Search for an appropriate article out of over 3 million ones of BIOSIS through the time span of 15 years is almost impossible without help of the computer. Structure, molecular formula, chemically standardized formal name, common name etc. of over 5 million chemical substances appearing in Chemical Abstracts can not be managed without computers.

Explosive development in genetic engineering technique has determined the nucleic acid base sequences of more than 5,000 genes during the past several years.[1] Nucleotide Sequence Data Library has been compiled by the European Molecular Biology Laboratory in Heidelberg from published papers in leading journals. In the United States, GenBank and NBRF databases have been compiled by NIH and National Biomedical Research Foundation, respectively. In principle these databases are open to research purposes worldwide. In Japan a new move of establishing the Japanese DNA database by the National Institute of Genetics is announced. Registry number, ID name, keywords, organism species, organism classification, date of registration, bibliography, author, base number and base alignment in capitals of 4 kinds of nucleotides A, G, C and T or U, are edited in a file. An example is shown in Fig. 1 as the output from our test database.[2]

There are many kinds of databases with different purposes or contents concerning research and extention of agriculture as shown in Fig. 2, They are also classified as personal, user group, or central level, according to vertical axis. Most of them are already established, while some are in preparation. Many databases are on the market, and 3,134 of which are stored in the database of databases named DBDB (Fig. 3). For instance, the University of Tsukuba

Information Center provides as many as 55 data bases. Some of them are original development for research purposes, and accept on-line queries from terminals through the database management system (DBMS) named UTOPIA.

Data are presented, usually in one of three forms: 1) two-way table (or flat-file), 2) tree-like structure or 3) network, according to the semantic make-up or inner relationship of information specific to the field. The structure of database and the appropriate form for its managing system largely depend on these properties of data.

Genetic Resource information appears basically as a flat-file consisting of many items with mutually independent descriptors, often including missing cells. Importance of numerical expression or value of most descriptors, and needs

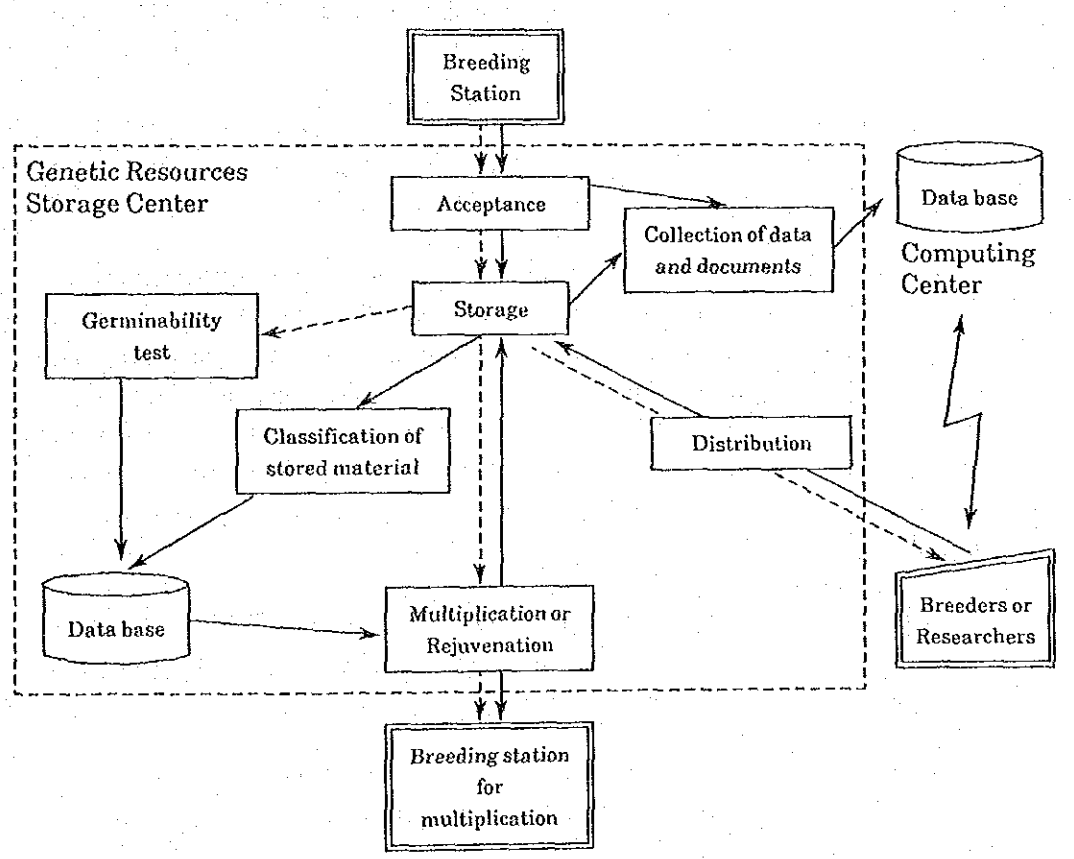


Fig. 4 Flow chart of genetic resources in GRSC, NIAR

for statistical analysis of the retrieved results are main features of Genetic Resource databases.[3] In the advanced use of these data for breeding purposes, there are cases where the search of information among these separate files, using common tags, prove to be more appropriate.

Information of genetic resources may be classified into three categories: 1) inventory or management data, 2) passport or ID data and 3) information on characteristic values. These will be briefly followed in subsequent sections.

4. Inventory Information

Management of genetic resources of main seed crops for agriculture is officially taken over by the Genetic Resources Storage Center (GRSC) in the National Institute of Agrobiological Resources (NIAR), as far as research activities in the Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF) are concerned.

Routine passage of crop seeds for conservation as genetic resources, introduced or collected by breeders or researchers as well as those of new varieties or strains harvested at breeding stations, is outlined in Fig. 4.[4]

At the time of reception, accessions are dried and tested of germinability and then registered and inscribed in the inventory file. If the initial germinability is poor, better seed samples are requested. The species name, variety or strain name, ID number, amount of seed, germination percentage, date of reception, storage address will be recorded as inventory data of each accession. Germinability is later monitored periodically, every five years by stratified sampling usually, and then those with lower germinability than some standard, say 50%, will be rejuvenated.

At the time of receiving seed orders, a fixed amount for each species is taken out for available accessions, and then delivered. Amount of available seeds will be updated and delivering list will be prepared.

Accessions with amount less than a standard fixed for each species, say equivalent to five dispatches, will be suspended before rejuvenated for future delivery.

These inventory management processes are covered by a minicomputer system.

植物遺伝資源パスポート・保存管理情報記入表

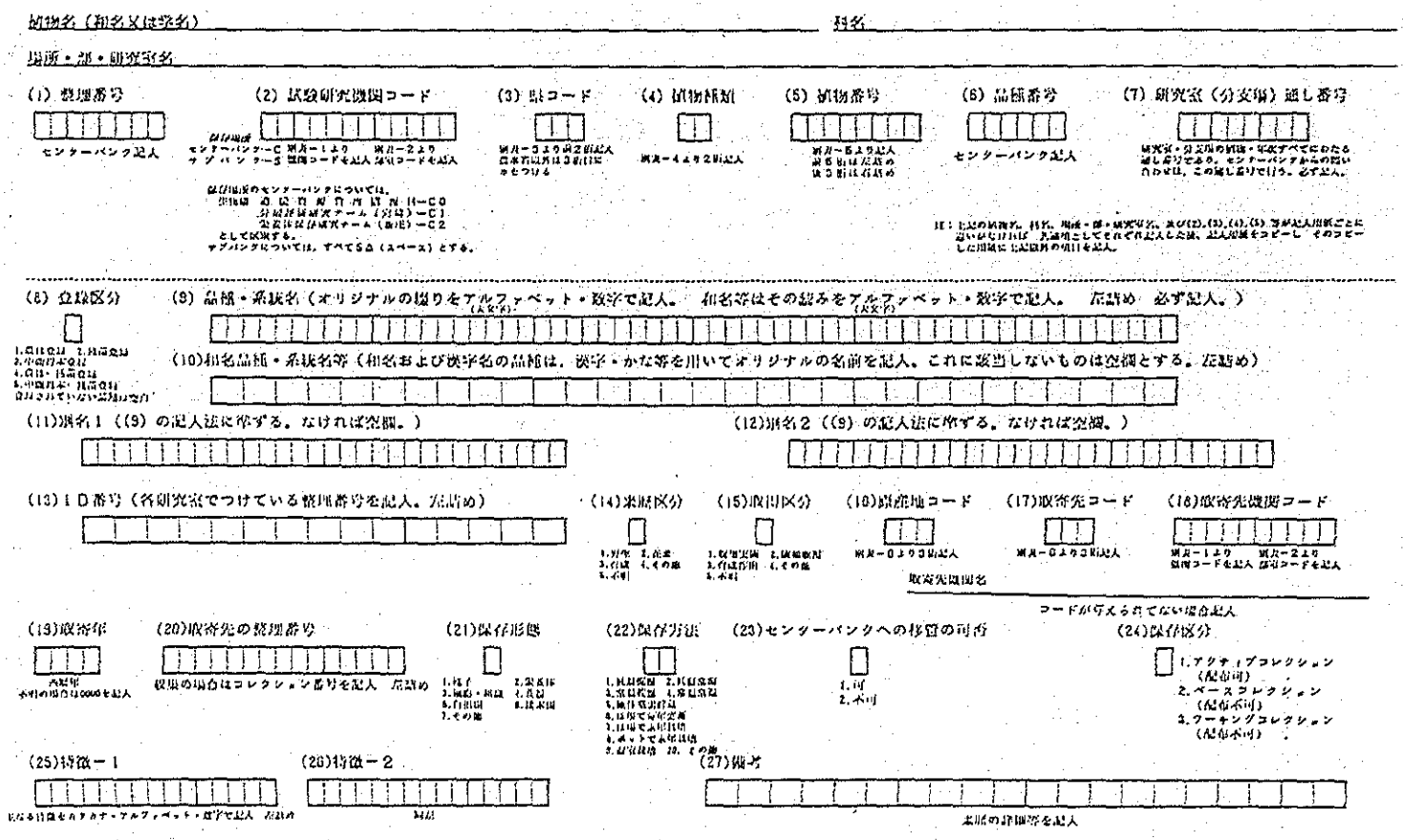


Fig. 5 The form used for passport data registration in GRSC

113905 ORYZA SATIVA L. (PADDY RICE) ** SUITOU **

610163 B 581 A6-545
180123 B 1265 C KN 13-2-3-1
140111 B 5416
140062 B 5580AL 15
200019 B 76-116
200161 B M 3
200764 B-23-12
200036 B.J.I.
170004 B.M. 5
150066 BA XE
200626 BACHAIKALMA
040371 BACK CHAMPA
250002 BACK CHAMPA
200155 BADACHAMPA
201014 BADKALAMATI
201000 BADKALAMKATI 65
201001 BADKALAMKATI 7
200793 BADRAS
200378 BADRASH
100168 BAEGYANGBYEO

100099 BAEK JO(HAKUSO)
200200 BAGMURI
110646 BAIMANGDAO
200811 BAKOLI IMPROVED
200812 BAKOLI POPULATION
200813 BAKOLI POPULATION
200814 BAKOLI POPULATION
200201 BAKTHANA
200202 BAKTULSI
200349 BAKU
130049 BAKUSHIRYUU
100076 BAKUTOU
230146 BALAMURUNGA
420116 BALDO
180145 BALI KUNING
180146 BALI PENGANTEN
180107 BALI PRIA
420010 BALILLA
420074 BALILLA
420083 BALILLA

420127 BALILLA
920622 BALILLA
390001 BALILLA 28
920372 BALILLA 28
390012 BALILLA/SOLLANA
420013 BALILLONE R253
390013 BALISIA C
390014 BALISIA Z
200702 BALLA MINJI
420047 BALLILA/R77.ST 264
200910 BALUCHATA
040507 BAN 3
040476 BAN 17
040321 BAN 33
050168 BAN AIKOKU
110141 BAN KYOUSO
060362 BAN SHINRIKI 25
050147 BAN SHIROZASA
040293 BAN YUUKEI SHINRIKI
200203 BANCHI

110042 BANCHOUKOU
050049 BANDAI NISHIKI
090143 BANDOU
200583 BANGALI BHOG
180013 BANGENDER
110376 BANHAKUSEN 3
020533 BANHENTOU
200751 BANKAT
200375 BANKCHUR
110320 BANKOKU NANSHOU MEIROUZANSAN
020704 BANKOKUZOU
110306 BANKOU
060357 BANSEI ASAHI
042409 BANSEI ASAHI RT14
042410 BANSEI ASAHI RT15
042411 BANSEI ASAHI RT16
042412 BANSEI ASAHI RT17
042413 BANSEI ASAHI RT18
042414 BANSEI ASAHI RT19
042415 BANSEI ASAHI RT20

042416 BANSEI ASAHI RT21
042417 BANSEI ASAHI RT22
042418 BANSEI ASAHI RT23
042419 BANSEI ASAHI RT24
042420 BANSEI ASAHI RT25
042421 BANSEI ASAHI RT26
042422 BANSEI ASAHI RT27
042423 BANSEI ASAHI RT28
042431 BANSEI ASAHI RT36
042432 BANSEI ASAHI RT37
042433 BANSEI ASAHI RT38
042434 BANSEI ASAHI RT39
042435 BANSEI ASAHI RT40
042436 BANSEI ASAHI RT41
042437 BANSEI ASAHI RT42
042445 BANSEI ASAHI RT50
042391 BANSEI ASAHIMOCHI
010029 BANSEI EIKOU
110024 BANSEN 26
110178 BANSEN(KOU)

110235 BANSEN(SEN)KUYOUSAN
130012 BANSHOU HAKUTOU
200839 BANSHPHPATA
060303 BANSHUU
200204 BANSMUGAR
180066 BANTEN
040457 BANTOU KOUHAI 33
110228 BANTOU(SEN)TANYOUSAN
040311 BANZAI
050029 BANZAI
201048 BAR KAT
200735 BARABADRASH
200439 BARABHADEU
201051 BARADHADEU
200843 BARADHAMENE 1
200569 BARAGALI 1
200570 BARAGALI 2
200754 BARANGI
200208 BARASANI
200656 BARDHAMAN PANLAI

Fig. 6 Sample page from the "List of Available Accessions" of GRSC

5. Passport Information

Incoming accessions are eventually registered with their passport or ID information. Besides the basic identifiers like GRSC ID Number, species name or accession's name, data such as provenance country or region, previous name or anonym, sender's organization and laboratory name, its location code, year and place of harvest, etc. are also inscribed. These are marked in a printed sheet or written in FD with a format like shown in Fig. 5. These are created in a passport database and used very efficiently to describe and analyse the collection.[5]

Index seminum or list of available accessions is compiled using a part of these passport data. Because of printing cost and ease of handling, only a small portion of the passport data is usually included in the list (Fig. 6). For closer observation, these data in detail will be disseminated after created into an easy-handling database, in the form of CD ROM. Passport data may also be prepared for on-line access from general users. Thus genetic resources are made available for extensive use from wide range of potential users.

In order to assure better understanding and cooperation with national as well as international organizations, descriptors and descriptor states of genetic resource information should be standardized as far as possible. In this sense consultation with specialist's groups of several crop species is important. IBPGR has been publishing minimum descriptor lists of many important crops after repeated discussion of international advisory committee of each crop. Of course discussion is more important and sometimes difficult to reach an unanimous consent on the way of representing characteristics data than of passport data in these committees. But usually there are some difference in historical background or in custom among research personnel or organizations, so discussion and standardization are recommended. An example of passport data in the descriptor list published by IBPGR is shown in Tables 1 - 3. Some difference, although not serious, are noticed among crops in these examples.[6,7,8]

Situation is a little different for multi-crop storage center like our GRSC, because standardization of passport data description through all plant species is needed.[4] This has been done by the discussion among curators of each crop group (12 in our case). In this case description of organizations, places, plant species, etc. becomes very important. Secretariat of GRSC has prepared code tables of these descriptors for the simple and unified handling of the data.

Table 1 Minimum list of descriptors and descriptor-states for characterizing the cultivars of rice (*Oryza sativa* L.)

Descriptor[1]	Code	Guide	Growth stage
1. Accession number			
2. Name			
3. Former designation			
4. Seed source			
5. Country of origin			
6. Variety group	1	indica	
	2	sinica (japonica)	
	3	javanica	
	4	intermediates (hybrids)	
7. Seedling height	[2]		5-leaf stage
LEAF (below the flag leaf)			
8. Length	[2]		late vegetative stage
9. Width	[2]		late vegetative stage
10. Blade pubescence[3]	1	glabrous	late vegetative stage
	2	intermediate	
	3	pubescent	
11. Blade color[3]	1	pale green	late vegetative stage
	2	green	
	3	dark green	
	4	purple tips	
	5	purple margins	
	6	purple blotch	
12. Basal leaf sheath color[3]	1	green	early to late vegetative stage
	2	purple lines	
	3	light purple	
	4	purple	
13. Angle[3]	1	erect	prior to heading
	5	horizontal	
14. Flag leaf angle[3]	1	errect	after heading
(see Fig. 1)	3	intermediate	
	5	horizontal	
	7	descending	

Table 1 Continued: 2/2

Descriptor[1]	Code	Guide	Growth stage
LIGULE			
15.Length	[2]		*late vegetative stage*
16.Color[3]	1	white	late vegetative stage
	2	purple lines	
	3	purple	
17.Shape[3] *(see Fig. 2)*	1	*acute to acuminate*	*late vegetative stage*
	2	2-cleft	
	3	truncate	

1) The capitalized words will serve as the main heading for the various descriptors flollowing it, when arranged in a tabular form.
2) Enter actual measurements (in metric units) or counts.
3) Use X for a mixture of different types.

Passport data: 1 to 7 (from IRRI, 1980)

Table 2 Revised descriptor list for wheat

The IBPGR now uses the following definitions in genetic resources documentation.

(i) *passport data* (accession identifiers and information recorded by collectors);

(ii) *characterization* (consists of recording those characters which are highly heritable, can be easily seen by the eye and are expressed in all environments);

(iii) *preliminary evaluation* (consists of recording a limited number of additional traits thought to be desirable by a consensus of users of the particular crop).

Characterization and preliminary evaluation will be the responsibility of the curators, while data from *further evaluation* should be fed back to the curator who will maintain a data file.

Many descriptors which are continuously variable are recorded on a 1-9 scale. The authors of this list have sometimes described only a selection of the states, e.g. 3, 5 and 7 for such descriptors. Where this has been done the full range of codes is available for use by extension of the codes given or by using values between them e.g. SEED SIZE (3.7) could also be recorded as:

1 Very small

or

6 Intermediate-to-large

Table 2 Continued: 2/4

PASSPORT DATA

1. *ACCESSION DATA*

1.1 ACCESSION NUMBER

This number serves as an identifier for accessions in a genebank and is assigned by the curator when an accession is entered into his collection. Once assigned this number should never be re-assigned to another accession in the collection. Even if an accession is lost, its accession number is not available for re-use. Letters should occur before the number to give an abbreviation identifying the genebank.

1.2 SCIENTIFIC NAME

1.2.1 *Genus*

1.2.2 *Species*

1.2.3 *Subspecies*

1.2.4 *Botanical variety (convariety)*

1.3 DONOR NAME

The institution or person responsible for donating the germplasm to the collection

1.4 DONOR NUMBER

Accession number or accession name assigned by the donor

1.5 PEDIGREE/CULTIVAR NAME

Names and numbers assigned to breeder's material, or registered variety name (see remarks under 2.2). Additional data includes the breeding institute and country where bred.

1.6 SYNONYMS

Any other names or numbers associated with the accession not the collector's number (2.2), cultivar name (1.5) or vernacular name (2.10). synonyms will usually be accession numbers assigned by other institutes, e.g. PI number, MG number, BGRC number, etc.

Table 2 Continued: 3/4

2. *COLLECTION DATA*

2.1 COLLECTING INSTITUTE

Abbreviation for the institute or person collecting the original sample

2.2 COLLECTOR'S NUMBER

Original number assigned by the collector of the sample. Normally composed of the initials of the collector, team or expedition followed by a number. This item is essential for identifying duplicates held in different collections and should always accompany sub-samples wherever they are sent. [In many genebanks this item is combined with pedigree/cultivar name (1.5) to form a single descriptor the "accession name".]

2.3 DATE OF COLLECTION OF ORIGINAL SAMPLE

Expressed as day/month/year, e.g. 20 October 1981 is recorded as 201081

2.4 COUNTRY OF COLLECTION

Use of the three letter abbreviations supported by the statistical office of the United Nations. Copies of these abbreviations are available from the IBPGR Secretariat.

2.5 LATITUDE OF COLLECTION SITE

Degrees and minutes followed by N (north) or S (south), e.g. 32°30'N

2.6 LONGITUDE OF COLLECTION SITE

Degrees and minutes followed by E (east) or W (west) e.g. 41°25'E

2.7 PROVINCE/STATE

Name of the administrative subdivision of the country in which the sample was collected

2.8 LOCATION OF COLLECTION SITE

Number of kilometres and direction from nearest town or village; or map grid reference

Table 2 Continued: 4/4

2.9 ALTITUDE OF COLLECTION SITE

Height above sea level in metres

2.10 VERNACULAR NAME

Farmer's name for landrace material

2.11 SAMPLE TYPE

1 Wild
2 Weed
3 Primitive cultivar/landrace
4 Breeder's line
5 Advanced cultivar

2.12 SAMPLE SOURCE

1 Natural habitat
2 Ruderal [1)]
3 Farm field
4 Farm store/threshing place
5 Market
6 Agricultural institute

---

1) Occurring in a habitat disturbed by man but not growing wild or as a crop weed.

(from IBPGR, 1981)

Table 3 Descriptor list for barley

The IBPGR now uses the following definitions in genetic resources documentation.

(i) *passport data* (accession identifiers and information recorded by collectors);

(ii) *characterization* (consists of recording those characters which are highly heritable, can be easily seen by the eye and are expressed in all environments);

(iii) *preliminary evaluation* (consists of recording a limited number of additional traits thought desirable by a consensus of users of the particular crop).

Characterization and preliminary evaluation will be the responsibility of the curators, while further characterization and evaluation should be carried out by the plant breeder. The data from further evaluation should be fed back to the curator who will maintain a data file.

The following internationally accepted norms for the scoring or coding of descriptor states should be followed as indicated below;

a) measurements are made in metric units;

b) many descriptors which are continuously variable are recorded on a 1-9 scale. The authors of this list have sometimes described only a selection of the states, e.g. 3, 5 and 7 for such descriptors. Where this has occurred the full range of codes is available for use by extension of the codes given or by interpolation between them – e.g. in 8. (Pest and disease susceptibility) 1 = extremely low susceptibility and 8 = high to extremely high susceptibility;

c) presence/absence characters are scored as + (present) / 0 (absent);

d) for descriptors which are not generally uniform throughout the accession (e.g. mixed collection, genetic segregation) mean and standard deviation could be reported where the descriptor is continuous or mean and 'x' where the descriptor is discontinuous;

e) when the information does not exist (descriptor is inapplicable), '0' is used;

f) blanks are used for information not yet available;

g) standard colour charts e.g. Royal Horticultural Society Colour Chart, Methuen Handbook of Colour, Munsell Color Charts for Plant Tissues are strongly recommended for all ungraded colour characters (the precise chart used should be specified).

PASSPORT

1. *ACCESSION DATA*

1.1 ACCESSION NUMBER

This number serves as a unique identifier for accessions and is assigned by the curator when an accession is entered into his collection. Once assigned this number should never be reassigned to another accession in the collection. Even if an accession is lost, its assigned number is still not available for re-use. Letters should occur before the number to identify the genebank or national system (e.g. MG indicates an accession comes from the genebank at Bari, Italy, PI indicates an accession within the USA system).

1.2 DONOR NAME

Name of institution or individual responsible for donating the germplasm

1.3 DONOR IDENTIFICATION NUMBER

Number assigned to accession by the donor

1.4 OTHER NUMBERS ASSOCIATED WITH THE ACCESSION (other numbers can be added as 1.4.3. etc.)

Any other identification number known to exist in other collections for this accession, e.g. USDA Plant Inventory number (*not* collection

Table 3 Continued: 3/5

number, see 2.1)

1.4.1 *Other number 1*

1.4.2 *Other number 2*

1.5 SCIENTIFIC NAME

1.5.1 *Genus*

1.5.2 *Species*

1.5.3 *Subspecies*

1.5.4 *Botanical variety (convariety)*

1.6 PEDIGREE/CULTIVAR NAME

Nomenclature and designations assigned to breeder's material

1.7 ACQUISITION DATE

The month and year in which the accession entered the collection, expressed numerically, e.g. June = 06, 1981 = 81

1.7.1 *Month*

1.7.2 *Year*

1.8 DATE OF LAST REGENERATION OR MULTIPLICATION

The month and year expressed numerically, e.g. October = 10, 1978 = 78

1.8.1 *Month*

1.8.2 *Year*

1.9 ACCESSION SIZE

Approximate number of seeds of accession in collection

1.10 NUMBER OF TIMES ACCESSION REGENERATED

Number of regenerations or multiplications since original collection

2. *COLLECTION DATA*

2.1 COLLECTOR'S NUMBER

Table 3 Continued: 4/5

Original number assigned by collector of the sample normally composed of the name or initials of the collector(s) followed by a number. This item is essential for identifying duplicates held in different collections and should always accompany sub-samples wherever they are sent

2.2 COLLECTING INSTITUTE

Institute or person collecting/sponsoring the original sample

2.3 DATE OF COLLECTION OF ORIGINAL SAMPLE

Expressed numerically, e.g. March = 03, 1980-80

2.3.1 *Month*

2.3.2 *Year*

2.4 COUNTRY OF COLLECTION OR COUNTRY WHERE CULTIVAR/VARIETY WAS BRED

Use the three letter abbreviations supported by the Statistical Office of the United Nations. Copies of these abbreviations are available from the IBPGR Secretariat and have been published in the FAO/IBPGR Plant Genetic Resources Newsletter number 49

2.5 PROVINCE/STATE

Name of the administrative subdivision of the country in which the sample was collected

2.6 LOCATION OF COLLECTION SITE

Number of kilometres and direction from nearest town, village or map grid reference (e.g. TIMBUKTU7S means 7km South of Timbuktu)

2.7 LATITUDE OF COLLECTION SITE

Degrees and minutes followed by N (north) or S (south), e.g. 1030S

2.8 LONGITUDE OF COLLECTION SITE

Degrees and minutes followed by E (east) or W (west), e.g. 7625W

2.9 ALTITUDE OF COLLECTION SITE

Table 3 Continued: 5/5

Elevation above sea level in metres

2.10 COLLECTION SOURCE

1 Wild
2 Farm land
3 Farm store
4 Backyard
5 Village market
6 Commercial market
7 Institute
8 Other (specify)

2.11 STATUS OF SAMPLE

1 Wild
2 Weedy
3 Breeders line
4 Primitive cultivar/landrace
5 Advanced cultivar (bred)
6 Other (specify)

2.12 LOCAL/VERNACULAR NAME

Name given by farmer to cultivar/landrace/weed

2.13 NUMBER OF PLANTS SAMPLED

Approximate number of plants collected in the field to produce this accession

2.14 PHOTOGRAPH

Was a photograph taken of the accession or environment at collection?

0 = No
+ = Yes

2.15 OTHER NOTES FROM COLLECTOR

Collectors will record ecological information. For cultivated crops, cultivation practices such as irrigation, season of sowing, etc. will be recorded

(from IBPGR, 1982)

6. Information on Characteristics

The importance of genetic resources in plant breeding is well accepted, and national as well as international plans for the collection, preservation and utilization of these resources are going on at the present time. For the efficient use of genetic resources, proper management of information on characteristics of these resources is almost indispensable. In searching for breeding materials, breeders are inevitably concerned about the characteristics they want to incorporate into the new variety. Efficient retrieval of stored accessions, according to given character values, is very important for their efficient utilization. Simple storage of genetic resources without associated information of characteristics is, in fact, not sufficient for the future use of the resources. Easy retrieval and rapid addition or updating of their information, guarantee the practical value of resources conservation.

Management of information is important primarily in the finding of appropriate material in the index seminum. Retrieval of strain names that satisfy various conditions of characteristics is the basic requirement, and even statistical analysis of related character values and their mode of association in the retrieved strain groups corresponding to differences in some key character is also of interest.[3)]

Information on genetic resources has been utilized in plant breeding for many years. In olden times, it was compiled, perhaps in a note-book of the breeder, only for his personal use. Recently, systematic collection and introduction of genetic resources that is concentrated on special crop species are often done by research stations or universities, and the nomenclature and other information, with or without the result of primary evaluation, have been compiled in books. They contain very important information for plant breeding and therefore have been used quite extensively by the breeders concerned.

This is an efficient method when the number of strains and evaluated characteristics is limited. However, when the number of strains increases and the motive for the search becomes more specific, manual or visual retrieval from the printed list will become almost impossible. Thus, the worldwide trend of increase in the use of computerised databases has also been followed in the field of genetic resources.

As mentioned earlier, IBPGR has been standardizing genetic resource information through discussion of cropwise advisory committees. Examples of

descriptors and descriptor states of characteristic information on some important crop species are shown in Tables 4 - 6. These may be the international standard, but actually there are still some difference in the importance and accustomed way of describing characteristics among countries.

In MAFF, a special committee to study the information management system for genetic resources was organized in 1979, and a project aiming at the efficient processing of genetic resource information by computers was initiated.[4)]

The effort of standardization on characteristic data has been continuing within each of cropwise breeding community, and the manual of evaluating primary characteristics of genetic resources incorporating 90 important crop species or species groups was published in 1985 (cf. Table 7).[9)] Here, primary characteristics refer mainly morphological traits, relatively stable for years and locations, and rather easily evaluated without expensive instruments or devices. For other characteristics such as physiological traits, tolerance or resistance to various kinds of stresses, biochemical traits, yielding ability or environmental adaptability, situation is different among crop groups. Standardization has been reached in some crops, while discussion has been continuing in others.

Table 4 Minimum list of descriptors and descriptor-states for characterizing the cultivars of rice (*Oryza sativa* L.)

Descriptor[1]	Code	Guide	Growth stage
1. Accession number			
2. Name			
3. Former designation			
4. Seed source			
5. Country of origin			
6. Variety group	1	indica	
	2	sinica (japonica)	
	3	javanica	
	4	intermediates (hybrids)	
7. Seedling height	2)		5-leaf stage
LEAF (below the flag leaf)			
8. Length	2)		late vegetative stage
9. Width	2)		late vegetative stage
10. Blade pubescence[3]	1	glabrous	late vegetative stage
	2	intermediate	
	3	pubescent	
11. Blade color[3]	1	pale green	late vegetative stage
	2	green	
	3	dark green	
	4	purple tips	
	5	purple margins	
	6	purple blotch	
	7	purple	
12. Basal leaf sheath color[3]	1	green	early to late vegetative stage
	2	purple lines	
	3	light purple	
	4	purple	
13. Angle[3]	1	erect	prior to heading
	5	horizontal	
	9	drooping	
14. Flag leaf angle[3] (see Fig. 1)	1	erect	after heading
	3	intermediate	
	5	horizontal	
	7	descending	

Table 4 Continued: 2/6

Descriptor[1]	Code	Guide	Growth stage
LIGULE			
15. Length	2)		late vegetative stage
16. Color[3]	1	white	late vegetative stage
	2	purple lines	
	3	purple	
17. Shape[3] (see Fig. 2)	1	acute to acuminate	late vegetative stage
	2	2-cleft	
	3	truncate	
18. Collar color[3]	1	pale green	late vegetative stage
	2	green	
	3	purple	
19. Auricle color[3]	1	pale green	late vegetative stage
	2	purple	
DAYS TO HEADING			
20. Number of days from effective seeding date to 50% heading.			
CULM			
21. Length	2)		after flowering
22. Number	2)		after flowering
23. Angle[3] (see Fig. 3)	1	erect	after flowering
	3	intermediate	
	5	open	
	7	spreading	
	9	procumbent	
24. Culm diameter	2)		after flowering
25. Internode color[3]	1	green	after flowering
	2	light gold	
	3	purple lines	
	4	purple	
26. Strength (lodging resistance)	1	strong (no lodging)	after flowering up to maturity
	3	moderately strong (most plants leaning)	
	5	intermediate (most plants moderately lodged)	
	7	weak (most plants nearly flat)	

Table 4 Continued: 3/6

Descriptor[1]	Code	Guide	Growth stage
26.Strength (lodging resistance)	9	very weak (all plants flat)	
PANICLE			
27.Length	2)		near maturity
28.Type[3] (see Fig. 4)	1	compact	near maturity
	5	intermediate	
	9	open	
29.Secondary branching[3] (see Fig. 5)	0	absent	near maturity
	1	light	
	2	heavy	
	3	clustering	
30.Exsertion[3] (see Fig. 6)	1	well exserted	near maturity
	3	moderately well exserted	
	5	just exserted	
	7	partly exserted	
	9	enclosed	
31.Axis[3]	1	straight	at maturity
	2	droopy	
32.Shattering	1	very low (less than 1%) at maturity	
	3	low (1-5%)	
	5	moderate (6-25%)	
	7	moderately high(26-50%)	
	9	high (more than 50%)	
33.Threshability	1	difficult	at maturity
	5	intermediate	
	9	easy	

Table 4 Continued: 4/6

Descriptor[1]	Code	Guide	Growth stage
GRAIN (Spikelet)			
34. Awning[3]	0	absent	flowering to maturity
	1	short and partly awned	
	5	short and fully awned	
	7	long and partly awned	
	9	long and fully awned	
35. Awn color[3]	1	straw	at maturity
	2	gold	
	3	brown (tawny)	
	4	red	
	5	purple	
	6	black	
36. Apiculus color[3]	1	white	at maturity
	2	straw	
	3	brown (tawny)	
	4	red	
	5	red apex	
	6	purple	
	7	purple apex	
37. Stigma color[3]	1	white	at flowering
	2	light green	
	3	yellow	
	4	light purple	
	5	purple	
38. Lemma and palea color[3]	0	straw	at maturity
	1	gold and/or gold furrows on straw background	
	2	brown spots on straw	
	3	brown furrows on straw	
	4	brown (tawny)	
	5	reddish to light purple	

Table 4 Continued: 5/6

Descriptor[1]	Code	Guide	Growth stage
38. Lemma and palea color[3]	6	purple spots on straw	at maturity
	7	purple furrows on straw	
	8	purple	
	9	black	
	W	white	
39. Lemma and palea pubescence[3]	1	glabrous	flowering to maturity
	2	hairs on lemma keel	
	3	hairs on upper portion	
	4	short hairs	
	5	long hairs (velvety)	
40. Sterile lemma color[3]	1	straw (yellow)	at maturity
	2	gold	
	3	red	
	4	purple	
41. Sterile lemma length[3]	1	short (not longer than 1.5 mm)	at maturity
	3	medium (1.6-2.5 mm)	
	5	long (longer than 2.5mm but shorter than the lemma)	
	7	extra long (equal to or longer than the lemma)	
	9	asymmetrical	
42. Spikelet sterility[3]	1	highly fertile (>90%)	at maturity
	3	fertile (75-90%)	
	5	partly sterile (50-74%)	
	7	high sterile (<50% to trace)	
	9	completely sterile (0%)	
43. 100-grain weight	2)		at maturity
44. Length	2)		at maturity
45. Width	2)		at maturity

Table 4 Continued: 6/6

Descriptor[1]	Code	Guide	Growth stage
46. Seed coat (bran) color[3]	1	white	at maturity
	2	light brown	
	3	speckled brown	
	4	brown	
	5	red	
	6	variable purple	
	7	purple	
47. Endosperm type[3]	1	nonglutinous (nonwaxy)	at maturity
	2	glutinous (waxy)	
	3	indeterminate	
48. Scent (aroma)	0	nonscented	at flowering or at maturity
	1	lightly scented	
	2	scented	
49. Leaf senescence	1	late and slow	at maturity
	5	intermediate	
	9	early and fast	
MATURITY			
50. Days from seeding (when 80% of grains on panicle are mature)	2)		at maturity

1) The capitalized words will serve as the main heading for the various descriptors flollowing it, when arranged in a tabular form.
2) Enter actual measurements (in metric units) or counts.
3) Use X for a mixture of different types.

Characteristics data: after 8 (from IRRI, 1980)

Table 5 Revised descriptor list for wheat

CHARACTERIZATION AND PRELIMINARY EVALUATION

3. CHARACTERIZATION

If an accession is variable for any characteristic then the most frequent form is recorded, followed by the letter V to indicate that it is Variable

3.1 GROWTH CLASS (SEASONALITY)

1 Winter
2 Facultative (neither a winter nor spring wheat)
3 Spring

3.2 SPIKE DENSITY

A visual measure of density of a spike measured on a 1-9 scale. (*NB*. Spike density is not the same as spike shape.) See Figure

1 Very lax
2 Lax
5 Intermediate
7 Dense
9 Very dense

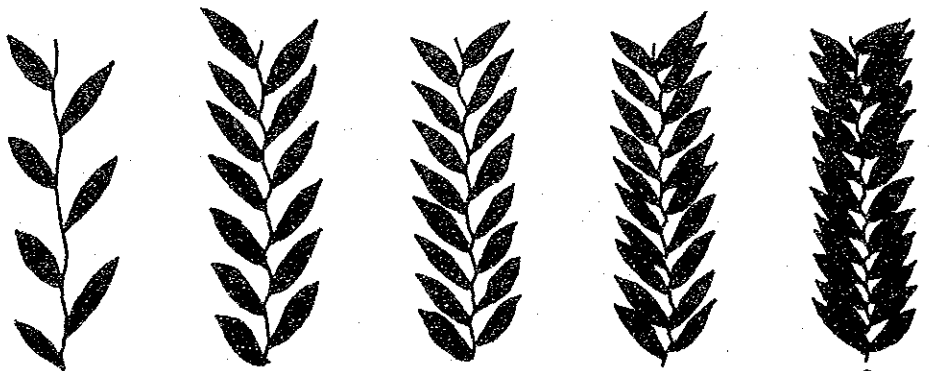


Table 5 **Continued:** 2/2

3.3 AWNEDNESS

0	Awnless
3	Awnletted (short awns)
7	Awned (conspicuous awns)

3.4 SEED COLOUR

1	White
2	Red
3	Purple

(If this is difficult to decide then the sodium hydroxide test can be used. Place grains in a petri-dish and add 25 millimetres of a 5 percent solution of sodium hydroxide for 60-90 minutes. Original red grains will be dark brownish orange, and white grains will be straw yellow.)

3.5 GLUME COLOUR

Observed on the outer glume

1	White
2	Red to brown
3	Purple to black

3.6 GLUME HAIRINESS

Measured on outer side of sterile glume

0	Absent
3	Low
7	High

– Continuing –

(from IBPGR, 1981)

Table 6 Descriptor list for barley

CHARACTERIZATION AND PRELIMINARY EVALUATION DATA

SITE DATA

3.1 COUNTRY OF CHARACTERIZATION AND PRELIMINARY EVALUATION

3.2 SITE (RESEARCH INSTITUTE)

3.3 NAME OF PERSON IN CHARGE OF CHARACTERIZATION

3.4 SOWING DATE

3.4.1 *Day*

3.4.2 *Month*

3.4.3 *Year*

3.5 HARVEST DATE

3.5.1 *Day*

3.5.2 *Month*

3.5.3 *Year*

PLANT DATA

4.1 VEGETATIVE

4.1.1 *Growth class (seasonality)*

1 Winter
2 Facultative (intermediate)
3 Spring

4.1.2 Plant height

Height of plant at maturity, measured in cm from the ground to top of spike excluding awns

Table 6 Continued: 2/3

4.2 INFLORESCENCE AND FRUIT

4.2.1 *Days to flower*

Counted as days from sowing to 50% of plants in flower. However, in dryland areas when planting in dry soils, it is counted from the first day of rainfall or irrigation, which is sufficient for germination

4.2.2 *Row number/lateral florets*

1 Six rowed
2 Two rowed, large or small sterile lateral florets
3 Two rowed, rudimentary sterile lateral florets

4.2.3 *Spike density*

A visual measure of spike density

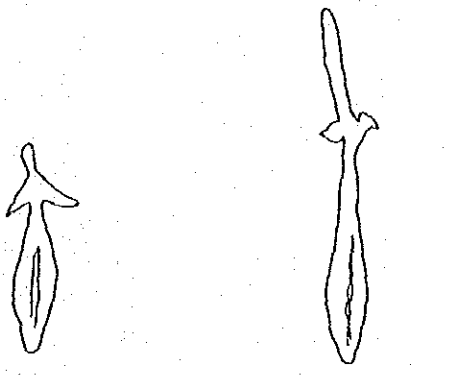
1 Lax (rachis internode length ≧ 4mm)
2 Intermediate
3 Dense (rachis internode length ≦ 2mm)

4.2.4 *Number of spikelet groups per spike*

Number of spikelet groups (triplets) per spike.
An average from five typical spikes selected from a growing accession

4.2.5 *Hoodedness/awnedness* (See Figure 1)

1 Sessile hoods
2 Elevated hoods
3 Awnless, or awnleted (≦ 2cm), on all rows
4 Awned (on central rows only for two-rowed forms, on all six rows for six-rowed forms)
5 Awned on central rows only, lateral rows awnless or awnleted (for six-rowed forms only)



Sessile hoods
1

Elevated hoods
2

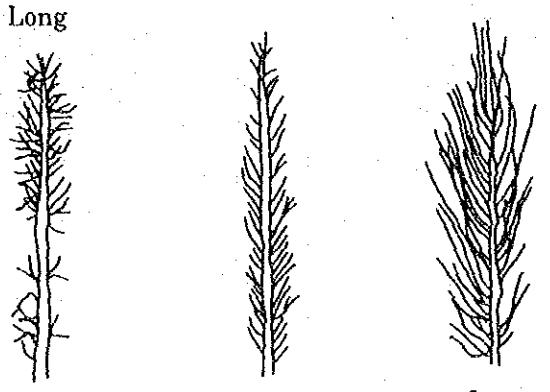
(Figure 1. Hoodedness/awnedness)

4.2.6 *Awn roughness*

1 Smooth
2 Rough

4.2.7 *Length of rachilla hairs* (See Figure 2)

1 Short
2 Long



Short
1

Short
1

Long
2

(Figure 2. Lengtht of rachilla hairs)

– Continuing –

Characteristics data: after 3.1 (from IBPGR, 1982)

Table 7　Minimum descriptor list for primary evaluation of peanuts

作物の種類	(3)　らっかせい

番号	特性調査項目	調査数	観察又は測定	分級内容，測定単位 0	1	2	3	4	5	6	7	8	9	調査方法
1	草型	区	観察			立性 I	立性 II	立性 III	中間型 I	中間型 II	伏性 I	伏性 II		開花期後40日頃の草型
2	分枝長	生育中庸20個体	測定	cm（小数第1位を四捨五入）										一次分枝のうち最も長い分枝の長さ
3	葉色	区	観察			黄緑	濃黄緑	暗黄緑	淡緑	緑	濃緑	暗緑		開花期後40日頃の主茎最上位展開葉から5葉目前後の完全葉の色
4	着花習性	区	観察		無								有	主茎着花の有無
5	粒重	100粒	測定	g／100粒（小数第2位四捨五入）										上実約100粒をとり重量を測定
6	実の粒間のくびれ		観察		浅		やや浅		中		やや深		深	上実の粒間のくびれの深浅
7	粒形				短形		やや短形		中形		やや長形		長形	子実の形状
8	粒色				白	淡橙白	淡黄白	淡橙黄	淡橙褐	淡橙赤	暗赤	赤紫	濃紫	収穫後約50日の種皮の色
9	開花期	区	観察	月　日										全個体の40～50%が開花を始めた日
10														
11														
12														

（注）
番号：稍縦径
a：主　茎
b：最長分枝

7. Database Management System

MAFF has the Computing Center for Research in Agriculture, Forestry and Fisheries (CCRAFF) at Tsukuba with ACOS 850 as the host machine. It acts as the center of an on-line network system (Fig. 7), having 5 A-class translating stations. This station has a set of standard I/O devices, which enable local control of remote batch use, and has several terminals for time-sharing use at the station. It is also equipped with a communication control unit which accepts and transfers local telephone calls to the center, from time-sharing terminals at nearby research institutions. The B- or D-class translating stations have all of these capabilities except communication control facility and are now established at more than ten reseach stations mainly in the Kanto District, and will be established in several more research stations in turn.

A database management system (DBMS) EXIS, especially designed for information retrieval and analysis of genetic resources at the University of Colorado was introduced into Japan and adapted to the current operating system, ACOS-6 of the CCRAFF.[10] Numerical data, coded data and word data such as names can be processed by selecting descriptor options appropriate for the particular data structure. It has its own macro commands in natural English expression, such as "READ DATA BANK, HOW MANY ITEMS WITH ....., or PRINT ..... FOR WITH .....", that assure easy conversation with the system. EXIS includes 1) EXIR, a retrieval system, 2) RPG, a report paper generator, 3) MINITAB, an elementary statistical package and 4) NTSYS, a multivariate classificatory package (Fig. 8).

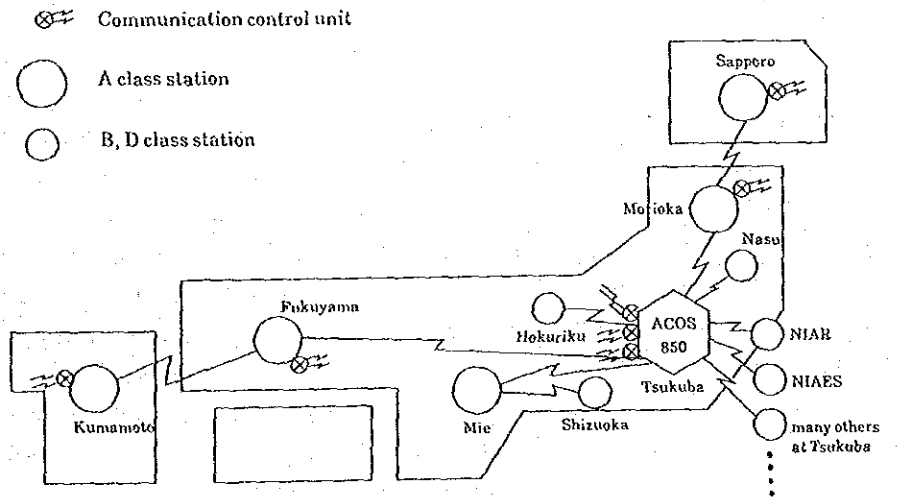


Fig. 7 On-line network of CCRAFF

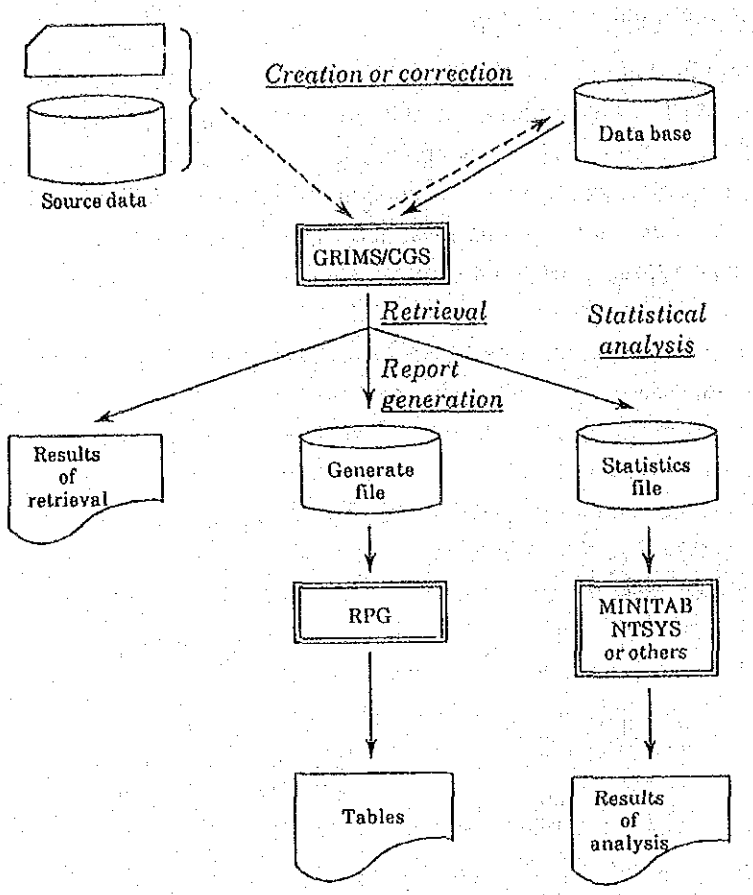


Fig. 8 System flow diagram of GRIMS/CGS

First, the database is created by defining the necessary descriptors in literal, code or numerical options, and using descriptor state expressions prepared in the card image following the defined format as source data. Retrieved items satisfying the conditions which the user indicated by a query, or a combination of logical expressions, are counted, and the states of given descriptors of these responded items are shown according to the commands. If necessary, these retrieved data can be transferred by the interface program through a work file facility for further analyses. Various statistical packages are available to analyze retrieved data by using an interface program. If the user is interested in handling the retrieved data in his own way, he can store them in his user's file by the appropriate Job Control Language. EXIR was later revised and

several new functions that are especially useful for the information management of plant breeding were added, and was renamed as GRIMS/CGS, after Genetic Resource Information Management System for the Center of Germplasm Seed Storage.[11]

In this report I will mainly discuss the use of GRIMS, although several other DBMS are available now in CCRAFF. For example, Saito established a DBMS SERIS, for the silkworm breeding project. Annual performance reports are processed by this system, and past breeding records are also available for retrieval and analysis by breeders. OOTSUKA developed a DBMS BIRS-T, named after Breeders' Information Retrieval System for family Tree reference. It is based on the TAXIR accessioner theory with special facilities for breeders such as the drawing of a family pedigree tree and the printing of agronomic character values paired with those of the standard variety.

As mentioned before, dynamic reference to many kinds of information prepared in different tables are very important in the management or analysis of genetic resources information. In this sense, recent trends in the use of relational type DBMS are also interested in this field. A new idea of DBMS developed by a group headed by Prof. SAIO of the University of Tokyo, aiming at the establishment of more efficient and user-friendly DBMS for plant breeding or genetic resource community. It is announced to include some convenient data types, retrieving functions and table manipulating facilities.[12] It has just been installed after functional tests into CCRAFF as a library program, whose users' manual is under printing. This is expected to serve as a powerful and friendly tool for users.

Development and diffusion of personal computers have been strikingly rapid recently. In our researh environment most of us are using them virtually in personal basis. User-oriented software and inexpensive memories allow us to use them for various purposes relating to research. Many of our scientists have been efficiently using personal computers for the management of genetic resources by themselves. Several DBMS for personal computers are on market and are also used for these purposes in various ways.

Development of mini-computers or work-stations is also remarkable and rapidly accepted by the users concerned with high efficiency processing of larger amount of information and with local network formation. The GRSC has started to use a kind, NEWS system, for the inventory and passport data manipulation of

the resources. For other problems, characteristic information for example, we may use the nationwide network of CCRAFF.

8. Use of Database for Genetic Resources

About 70,000 accessions of seeds and plants in the MAFF Genebank available for users are created into a database of descriptors mainly of passport data. Species name, common name, accession number, submitted institution, date of registration, place of origin are among the useful information available for the management.

For the time being, not many of them are evaluated on agronomic characters. Databases of agronomic characters of those collections have been created using the published data books of former evaluation projects. Under the MAFF Genebank Project, evaluation of GRSC accessions as well as newly introduced exotic germplasm has been started in the cooperating research institutions and the standardized data for these genetic resources are being created into databases for extensive use in the future. Present status is shown in Table 8.

Evaluation data of the accessions in the storage is very important for the effective use of these resources as already mentioned. However, collection and inscription of standardized characteristic data of several thousand accessions are really difficult by nature. So, we may use separate small databases as shown in the Table while continuing the ever-lasting effort for the strandardized and unified database.

Some examples of the utilization of these databases will be shown here. The old and newly developed two-rowed barley strains preserved at the Kyushu National Agricultural Experiment Station were defined using 34 descriptors including variety name, origin, mother name, culm length, panicle length, grain size, spring habit, etc. (see Table 9). Breeding materials were extracted by queries formulating the necessary conditions concerning agronomic characters, and were examined closely.[13] Correlations among these characters were determined for the two groups that were different in heading dates (Table 10).

Table 8 Evaluation and documentation of collected genetic resources

Crop name	No. of accessions in databases (until 1984)	Databases created in 1985, 86		Total No. of Evaluated accessions
		No. of accessions	No. of Databases	
Rice	9,178	3,035	1	12,213
Wheat & Barley	9,623	3,449	3	13,072
Beans	437	482	1	919
Potato	368	845	1	1,213
Forages	3,876	654	9	4,530
Fruit tree	797	492	11	1,289
Vegetable	1,090	167	3	1,257
Flowers	184	50	1	234
Tea	1,730	0	0	1,730
Mulberry	91	195	1	286
Misc.	429	0	0	429
Total	27,803	9,369	31	37,192

Table 9 Barley data base

Descriptors		Option	
1	NUMBER	ORDER	FROM 1 TO 2000
2	VARIETY NAME	TEXT	< 32 letters
3	ORIGIN COUNTRY	NAME	< 100 cases
4	ORIGIN PREFECTURE	CODEZ	HOKKAIDO (01), AOMORI (02) ····· KAGOSHIMA (46), OKINAWA (47)
⋮			
8	MOTHER NAME	TEXT	< 24 letters
⋮			
20	CULM LENGTH	ORDER	FROM 0 TO 1000 BY 1 IN CM
⋮			
21	PANICLE LENGTH	ORDER	FROM 0 TO 50.0 BY 0.1 IN CM
⋮			
25	GRAIN SIZE	ORDER	FROM 1 TO 10 BY 1
⋮			
34	SPRING HABIT	ORDER	FROM 1 TO 99 BY 1

34 descriptors and 849 items.
Investigated and published at Kyushu National Agricultural Experiment Station.

Table 10 Retrieved results: difference of character values and their association between early and late varieties

Late varieties	mean	s.d.	Early varieties					
			C_1 plant type	C_2 days to heading	C_4 culm length	C_5 panicle length	C_8 grain size	C_{12} 1000 grain weight
mean			2.29	18.6	84.3	8.30	2.23	49.0
s.d.			1.20	3.25	11.3	1.34	0.805	5.51
C_1	3.39	1.12		0.39**	−0.10	−0.06	0.02	−0.03
C_2	39.4	1.88	0.13		0.14	0.25*	0.08	0.08
C_4	87.2	8.01	0.24	−0.14		0.24*	−0.04	−0.21
C_5	10.3	1.99	0.02	−0.06	0.17		−0.04	−0.12
C_8	2.23	0.762	0.05	0.03	−0.33*	0.13		−0.30*
C_{12}	47.7	4.40	0.21	−0.04	0.35*	−0.21	−0.75**	

C_1 plant type: prostrate 1, erect 5
C_2 days to heading: number of days from April 1 to heading
C_4 culm length: cm
C_5 panicle length: cm
C_8 grain size: large 1, small 5
C_{12} 1000 grain weight: g
*: significant at 5% level
**: significant at 1% level

Character associations, including culm length or panicle length were sharply contrasted between the two groups, indicating their relative configuration in the multi-dimentional space of these groups that are different in the maturity date. This is important in selecting breeding materials and their crossing combinations appropriate for the breeding purposes. Correlations among agronomic characters are also determined for several groups that varied in their site of origin, and were compared with each other to examine the regional effects on the character combinations in the collection and to evaluate their relative importance for breeding use.

Making subdivisions of the data that correspond to the difference in any combination of characters is not always simple by the usual methods of data handling. By using database techniques it is simplified, and by using GRIMS, the retrieved data groups are easily transferred for the subsequent analyses of the various statistical methods available.

Another example of the usefulness of database techniques is on the repeated retrieval of the parent-offspring relationship of rice varieties. Over 600

recommended rice varieties are defined with their old strain names before registration, mother name, father name, and other breeding records. Parents of any variety can be retrieved and varieties having the same parent or parental combination can be listed conversationally.

Database technique is also used very efficiently in analysing and comparing the regional adaptability of newly established genetic resources. An example of evaluating new strains of grass species follows.

Tall fescue strains, improved at the Hokkaido National Agricultural Experiment Station, were tested at 18 locations through Japan for 1 to 3 years. Their forage production was measured by clipping 1 to 11 times per year, depending on the strains and the locations.[14] Climatic variables such as temperature, and day length were also recorded. These data were created in a database with 35 descriptors, comprising test location, strain name, year of stand, clipping number, clipping date, dry matter weight, mean temperature, amount of precipitation, etc. Total number of data items amounted to 2,065. For the analysis of adaptability, many subsets of the data, i.e., subgroups of environments and/or strains,are often subjected to the same type of analyses. Also several different types of multivariate statistical methods are applied to the same data set. Not only yield, but also several other characteristics sometimes even climatic variables are subjected to the analysis. For this type of data handling, the use of DBMS is quite efficient. The wide adaptability of the

Table 11 Regression analysis of dry matter yield on site mean for three regions

Strain	Hokkaido		North central Japan		Southern Japan	
	D.m. yield kg/a	Regr. coef.	D.m. yield kg/a	Regr. coef.	D.m. yield kg/a	Regr. coef.
Hokuryo	31.0	1.24	26.7	1.28	17.6	1.09
Yamanami	27.5	.881	27.6	.761	18.3	.749
Hokkai-No.3	28.7	.947	27.5	1.02	16.6	1.10
Hokkai-No.4	28.2	.915	28.1	1.07	19.4	1.09
Hokkai-No.5	29.3	1.15	23.8	1.07	15.2	1.17
Kentucky-31	25.0	.736	25.4	.808	16.0	.806

Table 12 Regression analysis of dry matter yield on climatic conditions

Strain	D.m. yield kg/a	Partial regr. coef.			Mult corr. coef.	% of reg. ss.		
		Gr. days	Acc. temp.	Day length		Gr. days	Acc. temp.	Day length
Hokuryo	23.50	.518**	-.0148**	4.07**	.626**	69.0	9.5	21.5
Yamanami	23.05	.360**	-.0108**	1.88**	.508**	70.3	17.1	12.7
Hokkai-No.3	23.92	.420**	-.0099**	2.15**	.558**	81.7	7.8	10.4
Hokkai-No.4	23.79	.424**	-.0100**	2.46**	.559**	80.8	6.7	12.5
Kentucky-31	20.84	.326**	-.0098**	1.69*	.490**	71.3	16.3	12.5

reg. ss.: regr. sum of squares, Acc. temp.: accumulated temperature
Gr. days: No. of growing days
*: significant at 5% level
**: significant at 1% level

variety, Yamanami, through the Mainland of Japan, and the specific adaptability of another variety, Hokuryo, in Hokkaido Island was indicated in the Table 11.

Difference in the climatic response among the strains, especially to accumulated temperature and day length, were revealed by regression analysis (Table 12). Stepwise regression analysis of dry matter yield on 8 environmental variables for the test period in three regions of Japan indicated similarities and differences among the strains within and between various regions. The relative incorporation of dry matter yield into a few large principal components that were extracted from climatic records and performance data, clearly indicated that the physiological response of these strains to climatic conditions was different. Hokuryo and Yamanami were registered by MAFF as being new, high-yielding varieties adaptable to Hokkaido and the south-western Mainland, respectively, for the use of grazing beef cattle. The result of these analyses were useful and important for further breeding, in accumulating basic information as well as for the evaluation of the candidate strains.

9. Future Scope

The international exchange of genetic resources information has become of more and more importance recently. Exchange of printed characteristic tables has been a common practice for many years. More efficient forms of information exchange using magnetic-tape or floppy disk may become practical when the unanimous standardization of data is attained, and easier access to computers is assured in all related countries. On-line search for appropriate breeding materials through the international information network system might not be a dream. This may become more time-saving and economical after mutual understanding and the common genetic resource information system is established. A study group headed by Professor SAIO has been constructing a prototype of the local network for the image as well as characteristics DBMS especially designed for the more efficient use of information to help the progress of genetic resources and plant breeding projects. For other stages of plant breeding, such as the planning of the selection procedure over several generations, appropriate use of the database in the conversational mode through terminals may be helpful in examining the available data, in considering the possible choice, and in deciding the way to take. Wide use of database techniques in plant breeding that makes the best use of genetic resource information will become more important in the future.

As for the future development of computers, the use of VLSI or Very Large Scale Integration, will begin a new era of so-called 5th generation computers. The development of the Ga-As device and the Josephson element could assure ultra-high speed processing, and promote natural language processing with logical inference as the result of artificial intelligence. Promising picture is announced in the field of expert system application in biology and agriculture, which deliver substantial hope for the future of our specialities. We can communicate with computers using the normal Japanese language (or any other language you like), and use any rule or knowledge already stored with much ease, and add new ones into the library of rules, if necessary.

Processing of image data may also become practical by the use of ultra-high speed computers. For genetic resources, the image as a whole from the outside, the precise image in detail, or even in microscopic level in cases, may become very important. Retrieval and analysis of these image data, as well as accompanying verbal or numerical descriptions, may help efficient management of genetic resources considerably.

We may start handling DNA as the most basic form of genetic resources in our genebanks in near future. New field of discipline is thus required in the troop. In USDA a new project, in house of Beltsville Agricultural Research Center, has started in 1986 on the possibility of making a link between nucleotide sequence databases and phenotypic descriptor databases in the GRIN system of USDA. A standard format will also be sought in the project to display linkage status of identified genes in various genetic stocks of important crop species they have been holding.

The development of electronics, in hard- and software of computers, and the steady accumulation of new attainments in the field of genetic resource sciences, will assure the most efficient use of genetic resources for the betterment of mankind in the future.

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