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An Image-based Germplasm Database for *Vitis* Spp.

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In this paper a hardware-software computer aided grape germplasm (*Vitis* spp.) monitoring and classification system is described. Typical plant organ data (young shoot, lower surface of mature leaf and bunch) were acquired into the system through a digital still camera and memory card processor. Simultaneous display of these organs on the RGB monitor could be accomplished due to the digital processing of images. The resulting digital images were stored into an image-based database running at an Apple Macintosh computer system equipped with graphical operating environment and a magneto optical disk. The image database structure was based on a series of commands associated with pop-up menus and icons. This gives an operator the possibility to choose an image which correctly matches the actual accession phenotype among a number of pre-stored image data.

INTRODUCTION

An availability of genetic resources is a primary need for breeders because of their fundamental role for the genetic improvement of cultivated crops. Starting from the early 60s, a number of collecting and storing institutions has been created to preserve plant germplasm and to protect it from genetic erosion (Ford-Lloyd and Jackson, 1986). In 1986, 225 gene banks were active throughout the world, operated by national and international institutions in 99 countries. Recently, it is estimated that the total amount held by those gene banks reaches 2.5 millions accessions (Fitzgerald, 1989).

Along with the need for storage and evaluation of germplasm, the increasing number of accessions driven to the implementation of retrieval systems, also known as germplasm data banks for the classification of accession data. The role of such an information system was not only for classifying data for archival purposes, but mainly for extracting useful information on valuable characters (descriptors) related to breeder's specific needs (Shands, 1990). During the last years, information systems conceived for storing descriptor data were exclusively morphological descriptor-based computer applications. However, it is very difficult, if not impossible, for non-specialists to examine and classify morphological plant data using these applications.

Meanwhile, in germplasm management system, the use of image-based data is relatively new (Grosky and Mehrotra, 1989; Shiraishi et al., 1994), but software and hardware costs prevented an extensive use of image acquisition and processing tools. For biological sciences, a number of applications involving digital images has been developed in physiology (Estep and MacIntire, 1989; Smith et al., 1989), cytogenetics (Fukui and Iijima, 1991), agronomy (Petry and Kuhbauch, 1989; Zoon and Vantienderen, 1990), and

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plant breeding fields (Blaich and Blaich, 1990). Image-based database is thus the new frontier in germplasm management system because the visual data is more suitable for direct characterization and further electronic image analysis. The study reported here presents an image-based database system to facilitate monitor and classify morphological traits of grapevine (*Vitis* spp.) by the use of digital processing of typical plant organs.

MATERIALS AND METHODS

Plant material

A total of 130 grape (*Vitis* spp.) germplasm accessions was provided by the Fruit Science Laboratory, Faculty of Agriculture, Kyushu University, Japan. With respect to each accession, accession number was assigned to identify, classify and preserve of grape germplasm.

Hardware

Block diagram of the image-based database system was illustrated in Fig. 1. For image database system, an Apple Macintosh IIsi personal computer working on a system software version 7.0.1 was used together with a 17 Megabytes of RAM memory storage and a mouse pointing device. In the system plant image was digital processed by an image memory card (IM-8S, 1Mbits SRAM x 8), and converted as RGB data by a FUJIX memoy card processor DP-100. For mass memory storage, digitalized image data were recorded in a 300 Megabytes magneto optical disk (FUJIFILM MR-5012, 512 bytes/sector), running at a FUJIX multi data disk drive AF55. A 13" Apple colour RGB monitor was used, equipped with a Macintosh video card 8 • 24 capable of displaying 16777216 colours (24-bit) simultaneously which were placed into an expansion slot of the computer. To print out the image data, a Canon ink jet colour printer FP-510 SPA was used.

Image acquisition and processing

The equipment used for the image acquisition consisted of a FUJIX DS-100 1/2" CCD digital still camera with a macro zoom lens ($f=8\text{--}24\text{mm}$), as shown in Fig. 1. The photographic stand was placed on a firm surface, and the camera-stand complex was kept apart from the computer system to avoid surrounding vibrations. Methods for image acquisition and processing were as follows:

- (i) to reduce colour interpretation mistakes on the digitalized image, a black, velvet background was used. Plant samples were left on the middle of the background at a distance of 10 to 30 cm from the camera lens. Focusing, shutter speed and white balance of the digital still camera was set at the auto mode. Images of plant samples were captured in the IM-8S card.
- (ii) after image acquisition, the IM-8S card was inserted into the card processor DP-100. From here on, a FUJIX image handling software, a SD-MA version 1.0.2 was started on the computer, and each image was stored as a PICT file format together with a file number.
- (iii) Adobe Photoshop version 1.0.7 (Adobe Systems Inc.) was started to perform

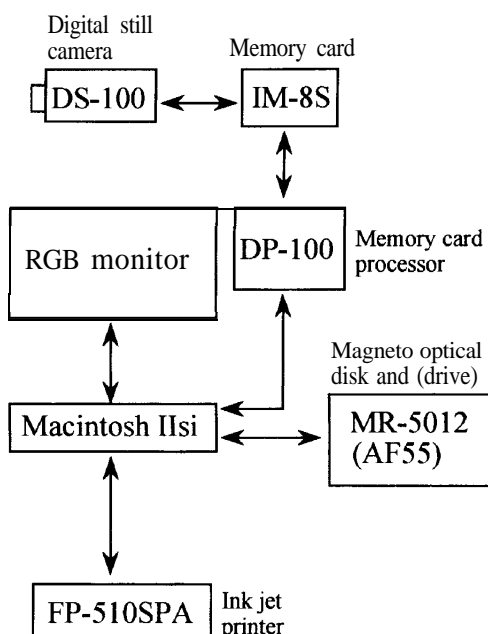


Fig. 1. Block diagram of the image-based database system of grape germplasm used in this study.

processing of the images that captured by digital still camera: colour/contrast adjustment, rescaling and integration.

Image database

The GRAND MUSÉE version 1.0 (Kohshin Graphic Systems Inc.) was used as the image database application. By this software, fast retrieval and display of grape accession can be performed easily using pop-up menus and icons.

RESULTS AND DISCUSSION

Image acquisition

Descriptors are used to identify germplasm by keeping track of their morphological, biochemical and physiological traits (Hilu, 1989). In this study, young shoot, lower surface of mature leaf and bunch were selected as typical images because these traits are, in general, important for identification and classification of grape germplasm (IBPGR, 1983). For an adequate acquisition of images, a standard capture procedure was done without flood-light lamps because the DS-100 still camera could be captured images of plant organ at room light condition. If image acquisition is done under high illumination, image captured is obtained with halation.

After image acquisition by the camera, as shown in Fig. 1, images which were

Table 1. FUJIFILM image handling software SD-MA for the image conversion

Command	Content
1) Open	shows a current flame (e.g. No.1 ~No.5*) recorded in the memory card IM-8S
2) Get Picture	loads a file number (=an image) from the IM-8S card, and displays the image
3) Save	saves an image at the PICT format, and tentatively stores the image in the Macintosh hard disk
4) Quit	closes the SD-MA

*: Picture mode of the DS-100 camera is fixed as fine.

digitalized in the memory card IM-8S appeared on the RGB monitor through DP-100 memory card processor and its interface (FUJIFILM image handling software SD-MA). Table 1 shows that primary commands of the SD-MA for the image file conversion. The SD-MA program desktop appeared on the screen, and the images were displayed together with file number (e.g. No. 1-No. 5: picture mode of the camera is fixed as fine). An image was selected and displayed through the SD-MA command "Get Picture", loading a file number (=image) from IM-8S card. Thereafter, the image selected was tentatively stored into the Macintosh hard disk using the command "Save". Using a mouse pointing device ("single-" or "double-" click), these steps were conducted based on pop-up menus and icons operation system common to the Apple Macintosh computer. Also, image processing and database follows the same system described above.

Image processing

When a PICT file was obtained by the SD-MA software, the digitizing process was completed but the image had to be converted into a suitable form for a correct handling and display on the database structure. Three different modifications have to take place (Fig. 2); the first involves changing the colour/contrast of the digitalized image, the second requires rescaling of the images for plant organs to economise the magneto optical disk space, and the third performs integrating of the images rescaled in order to display a number of information simultaneously.

To obtain as real images as possible, using an Adobe Photoshop software, colour/contrast adjustment on images that captured by the camera was important operation, thereby fairly recovering loss such as colour changing and halation of the images. The image rescaling was performed through the Photoshop command "Resizing", where size of image could be changed in the degree of percent (10~90%) to the original image. In this step, resizing value of young shoot and mature leaf (lower surface) is defined as 40%, while that of bunch is defined as 60 %. Once the image rescaling was completed, three images (young shoot, mature leaf and bunch) were integrated to create a new file (640 X 488 pixel) by the Photoshop command "Cut & Paste". After image processing by Photoshop, the new image file on PICT format was saved in the magneto optical disk together with the corresponding accession number (e.g. E0001, UO034). As a result, the accession number is used as the clew (= keyword) to retrieval of the image file.

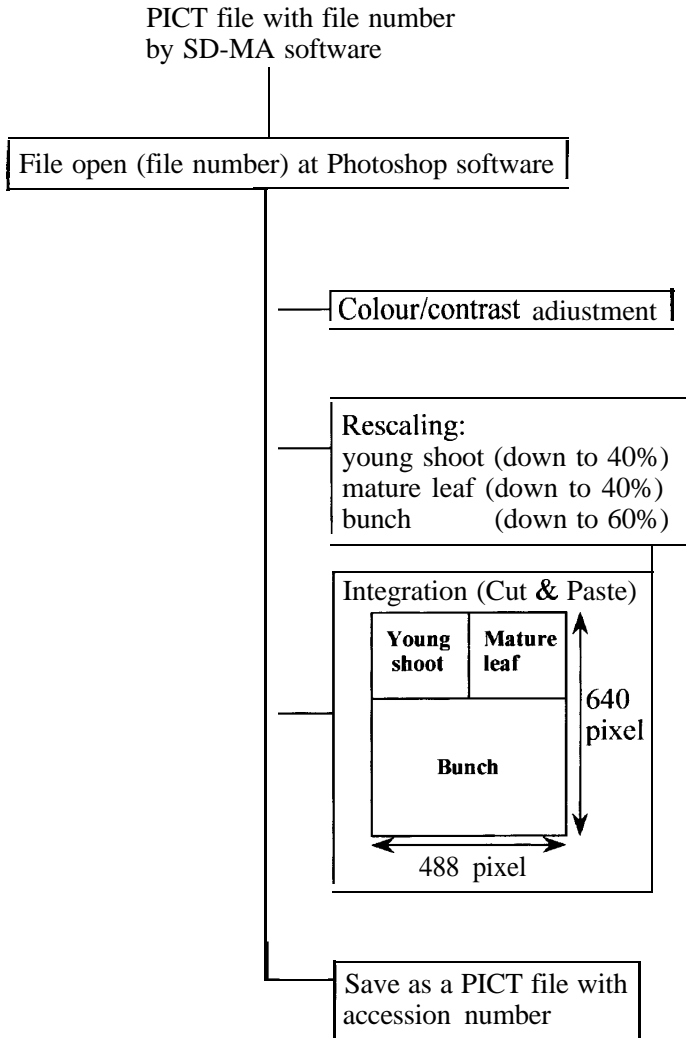


Fig. 2. Image processing procedure flow-chart by Adobe Photoshop software.

Image-based database

As a main program for setting up the image-based database, we preferred to use a commercial software “GRAND MUSÉE Ver. 1.0” (GM) to a custom made routine. By doing so, attention was focused on the database structure construction rather than on programming; there was no need to upgrade the software since in a commercial package this task is done directly by the software producer.

Based on their origin, the accessions used in this study were classified as follows: European (e.g. ‘Alicante Bouschet’: E0001), North American (i.e. ‘Golden Muscat’: U0034), Japanese (‘Kyoho’: J0009). As shown in Fig. 3, each accession of grape

germplasm is composed by three linked images together with its accession number (screen output, of a 'Niagara', N0060). With respect to an outline of the image database, application features flow-chart is shown in Fig. 4. As the first step, image data files that stored in the magneto optical disk were required to register into the GM folder by the GM command "Folder Registration". With respect to cultivated variety, a total of three GM



Fig. 3. Screen output of a 'Niagara' (North American, N0060).

folder was established: European collection ($n=40$), North American collection ($n=36$), Japanese collection ($n=54$). At present, other collections such as 'Chinese variety', 'rootstock' and 'wild species' are being constructed. If the images once registered in the GM, an operator is enabled to make reference to the correct grape accession by looking at GM folder appearing on the screen. To simplify the data retrieval, two different strategies have been implemented: pop-up menus and icons. Input only a "accession number" in the accession number field of the icon which is defined previously by user. After making appropriate image registration and retrieval, image can be displayed on high-resolution RGB monitor and printed out by a Canon ink jet printer FP-510SPA.

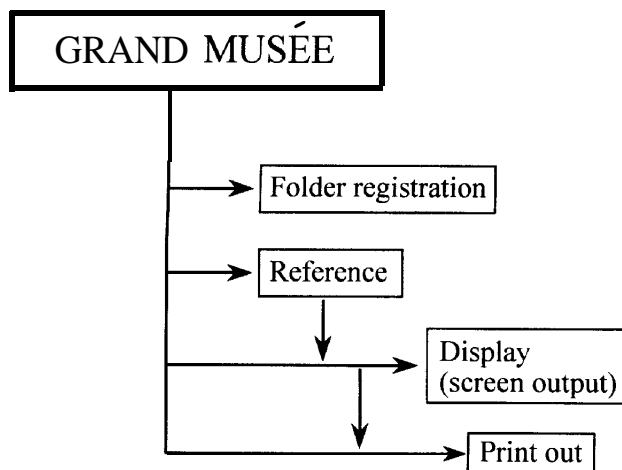


Fig. 4. Database application features flow-chart

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