A Computerized Soil Information System for Arable Land in Japan (JAPSIS)

— Present structure and some applications —

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Introduction

The human activities which affect the natural environment are being increased in Japan. The maintenance of a good environment for high levels of food production and human habitation is a very important consideration for the Japanese agriculture. The soil which is one of the basic factors of food production is deeply related to the natural environment. From this point of view, it is important to determine the present nature and to predict future changes of national soil resources. A soil information system is a composite system which enables us not only to process and store many kinds of soil data and soil maps, but also to manipulate and provide many kinds of retrievals[1]. In general, information systems can be divided into two groups. The first is the simplest system involving only manual coding on punch cards, and manual sorting and data manipulations. This system is easy to establish and its operation cost is low.

The second system is a computerized system in which cartographic data, for example, polygon data, site data, grid data, etc. can be inserted and stored in the computer by using digitizers or scanners, making these data available for automatic interpretation. The shortcoming of this method is the high cost and high level of technology involved in data input, output and other data handling procedures. Once that information system is completed, however, and clean data are stored on magnetic tapes or disks, many kinds of interpretative maps and numerical data handling and classification procedure can be performed very quickly and often economically. The computerized soil information system is preferable to punch cards one for the modern soil information system. Some countries have started to construct or investigate the computerized soil information systems[2,3,7-10].

A large amount of raw soil survey data of arable land have been accumulated by various researchers and soil surveyors. Although some of these data have been published, the major part has been stored in individual filing systems after having been used for drawing soil maps. Because these data are not in standardized forms they cannot be easily manipulated without hand coding and standardization and must be analyzed using sophisticated numerical techniques. Furthermore since they are stored in individual filing cabinets in the agricultural research institute of each prefecture, they are not easily accessible. On the other hand, a large number of soil maps have been printed and published. But it takes a long time to manually prepare interpretative maps or update the mapping data from these printed maps. If these data are not collected and organized, they will not be used in the future. In view of these many factors, the Soil Information Systems for Arable Land in Japan (JAPSIS) has been constructed by Ministry of Agriculture, Forestry and Fisheries from 1982. This paper summarizes the present structure and some examples of the application of JAPSIS.

The objective of JAPSIS

There are many ways in the utilization of JAPSIS. Three major objectives of the system are as follows:

1) To understand the soil resources at present

The distribution patterns of soil resources in Japan at present are provided if JAPSIS is completed and managed very well. If the very near location of old soil survey data could be obtained, it would become possible to investigate how soils have been modified over the time.

2) To make many kinds of interpretation maps automatically

The soil maps constituting the greater part of soil maps in Japan are genetic soil classification maps. It is difficult to use these soil maps for practical problems without interpretation by specialists. Interpretative soil maps can be made automatically from fundamental soil maps by using JAPSIS.

3) To contribute to soil science, especially pedology

The statistical manipulation of a large amount of soil survey data can contribute to the development of a taxonomic classification of soil genetic theory and better understanding of soil geography. Multifactorial analysis of survey data is one of the promising avenues for pedological research because of strong interrelationships between soil variables.

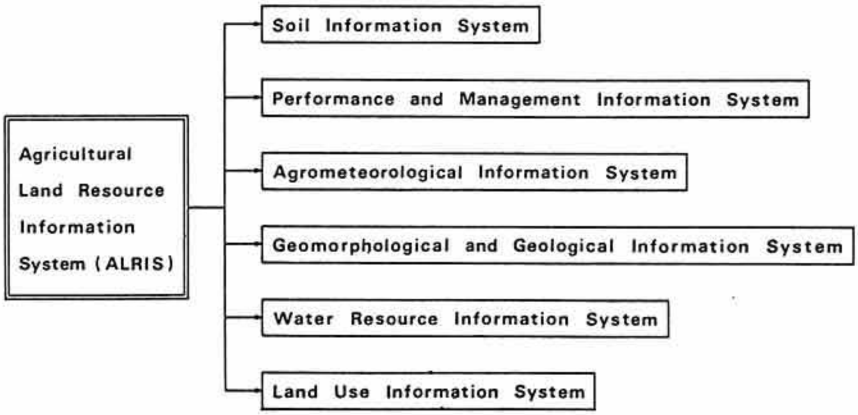

Fig. 1. Representative structure of ALRIS

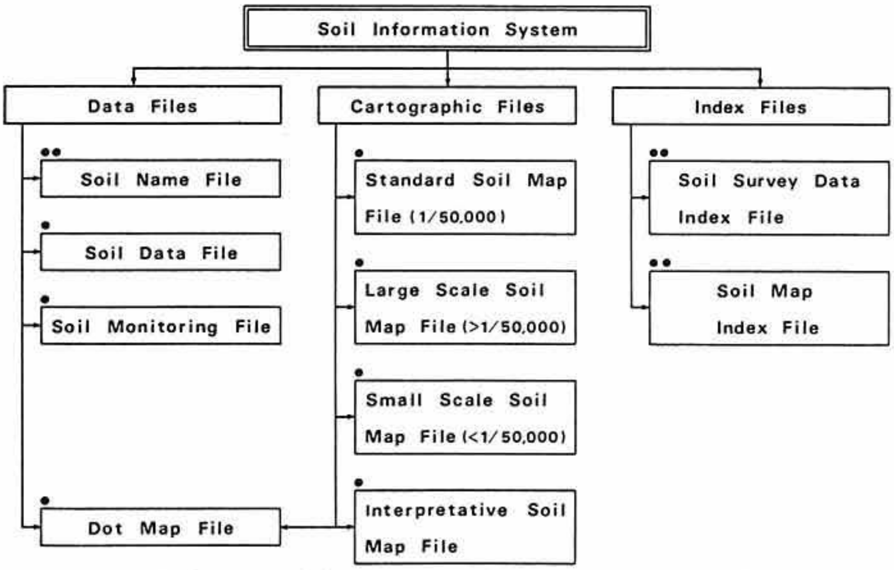

Fig. 2. Structure of Soil Information System for arable land in Japan
• Batch processing, •• Conversational processing

Structure of JAPSIS

JAPSIS is one of the representative subsystems of the Agricultural Land Resource Information System (ALRIS) which has a broader data base system than JAPSIS[4]. A representative structure of ALRIS is shown in Fig. 1. The ALRIS is constructed with six subsystems and can contribute to land policy, calculation of the crop production potential, decision making in land use planning, crop management, environmental assessment and so forth. The data from these six subsystems can be interfaced with each other smoothly in ALRIS, because all data have the same type of location and time code in the header parts of each record. The present structure of JAPSIS is shown in Fig. 2. JAPSIS contains many files, but these are divided into three groups of characteristic files. The first group consists of data files which contain qualitative and quantitative soil data whereas the second group includes cartographic files containing many kinds of map information. In the cartographic file, once the boundaries and symbols of map data are put into the computer by digitizer or scanner and processed, any categorical area can be calculated very rapidly and many kinds of interpretative maps can be obtained by autodrafter, X-Y plotter or inkjet-plotter. The third group consists of index files in which all of the surveyed data and mapping information in the files of JAPSIS are retrieved by topographical map unit or administrative district. On the basis of computer processing of data, these files of JAPSIS can be divided into two groups. Soil Name File, Soil Survey Data Index File and Soil Map Index File are suited to conversational time sharing system using many kinds of display devices. The other files of JAPSIS are more suitable for batch processing. The most parts of programs in JAPSIS are written in Fortran language.

Source data of JAPSIS

Soil survey data from administrative projects are suitable for inclusion in JAPSIS because these data were standardized owing to the use of standard soil profile descriptions and analytical methods. The data of Fertilizer Application Improvement Program (FAI Program 1953–1961) and Soil Survey Program for the Maintenance of Farm Land Fertility (SMFF Program 1959–1978) are useful to basic data of JAPSIS, because these two programs were done using similar methods and were historically continuous. In addition, the amount of data is very large (about 1,000 sheets of soil maps and 200,000 soil profile data) and covers all arable land in Japan. The data from new soil inventory projects e.g. the Monitoring Survey Program for Soil Conditions

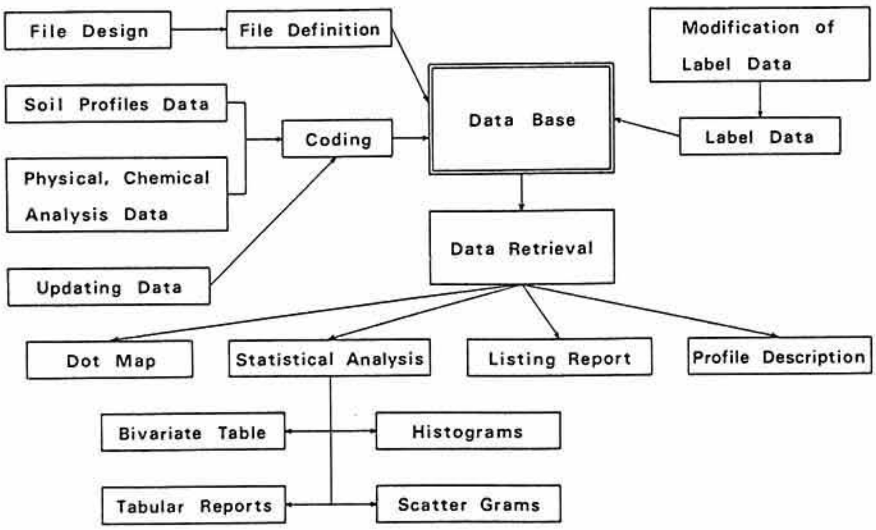

Fig. 3. Representative diagrams of soil data file

(1979–present) could be used for updating these basic data.

Soil data file subsystem

In SMFF and FAI programs, precise soil survey data including chemical and physical analysis were recorded in representative soil profiles of each soil series and phase. All of these sites and morphological descriptions, as well as data of chemical and physical analysis can be stored in the soil data file. The ordinary soil survey data containing only site and morphological descriptions can also be stored in this file. The structure and functions of the soil data file subsystem are illustrated in Fig. 3. The main purpose of this subsystem is to analyze statistically

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JSD  1979 PROFILE NO. 3

IDENTIFICATION:  SURVEYED BY HK, FOR THE PURPOSE OF DETAILED SURVEY; SOIL RESOURCES, OTTAWA, OTTAWA, ONT.
                 STATUS; MODEL.
LOCATION:  LAT:  35 DEG 19 MIN 23 SEC, LONG; 139 DEG 9 MIN 13 SEC.
CLIMATE:  30 METERS ABOVE MEAN SEA LEVEL.
SOIL SITE:  PARENT MATERIAL 1; WEAK CHEMICAL WEATHERINC,FINE LOAMY AND FINE SILTY (18 TO 35% CLAY),
            UNDIFFERENTIATED, FLUVIAL, MIXED; ORGANIC DEPOSIT IS 19 M;·LANDFORM CLASSIFICATION; FLUVIAL, LOAMY
            LEVEL; SLOPE; LEVEL MICROTOPOGRAPHY,; SLIGHTLY STONY; PRESENT LAND USE; CROPLAND.
SPECIAL NOTES:  OGINO-TO, KKASHIOKUTEICHI-DOJO ZENSSOO-OOKASHIOKUDOSSOO JOOSHITSU-MANGANKKEKAKUNASHI.
                DAIHYOCHITEN ASHIGARAKAMIGUN OOI-MACHI KANEKO 1412 (SAKAWAGAWA 44).  BUNPU, TSURUMIGAWARYUIKI
                CHIIKI (HATAKE YOKOHAMA-SHI), SAGAMIGAWARYUIKICHIIKI (SUIDEN HATAKE KOOZA-GUN EBINA-CHO,
                SAMUKAWA-MACHI, CHIGASAKI-SHI, ATSUGI-SHI, ISEHARA-SHI, HIRATSUKA-SHI), SAKAWAGAWARYUIKICHIKI
                (SUIDEN HATAKE,  ASHIGARAKAMIGUN OOI-MACHI, ODAWARA-SHI, ASHIGARAKAMIGUN MINAMIASHIGARA-MACHI),
                SANKANCHIIKI (ASHIGARASHIMO-GUN YUGAWARA-MACHI).
1APG:  0 TO 19 CM; HORIZON MOIST; MATRIX MOIST 2.6Y 4.8/4.6, MATRIX MOIST 8.9YR 5.4/3.9; MATERIAL COMPOSITION
       HIGH DECOMPOSITION; CLAY LOAM; COMMON, 7.5YR 5/5 MOTTLES; SLIGHTLY STICKY, VERY PLASTIC CONSISTENCE;
       MICRO PORES; 10% COARSE FRAGMENTS; SMOOTH,CLEAR HORIZOM BOUNDARY.
1C1G:  19 TO 24 CM; HORIZON MOIST; MATRIX MOIST 1.5Y 6.4/2.8, MATRIX MOIST 8.8Y  6.6/3.1; SANDY LOAM; MANY, 5YR
       6/7 MOTTLES; SLIGHTLY STICKY, VERY PLASTIC CONSISTENCE; FEW, MICRO PORES; 10% COARSE FRAGMENTS; SMOOTH,
       CLEAR HORIZOM BOUNDARY.
1C2G:  24 TO 41 CM; HORIZON MOIST; MATRIX MOIST 9.8YR 4.8/2.5; SILTY CLAY LOAM; COMMON, 7.5YR 5/5 MOTTLES;
       SLIGHTLY STICKY, VERY PLASTIC CONSISTENCE; COMMON, MICRO PORES; 10% COARSE FRAGMENTS; SMOOTH, CLEAR
       HORIZON BOUNDARY.
2C3:  41 TO 54 CM; HORIZON MOIST; MATRIX MOIST N 4.1; SAND; NONSTICKY, NONPLASTIC CONSISTENCE; MICRO PORES; 30%
      COARSE FRAGMENTS; SMOOTH, CLEAR HORIZON BOUNDARY.
4C4:  54 TO 100 CM; HORIZON MOIST; MATRIX MOIST 8.9YR 5.4/3.9; SILTY CLAY LOAM; FEW, 10YR 6/6 MOTTLES; STICKY,
      VERY PLASTIC CONSISTENCE; COMMON PORES; 20% COARSE FRAGMENTS.
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CHEMICAL DATA

HORIZON	ORG C (%)	TOTAL N (%)	C. E. C. (ME/100G) BUFF.	PERM. CHARG	EXCHANGEABLE CATIONS BUFFERED (ME/100G) CA	MG	NA	K
1APG	3.48	0.34	21.1		11.5	0.2		
1C1G	1.22	0.14	18.4		12.4	0.2		
1C2G					11.2	0.1		
2C3								
4C4								

PHYSICAL DATA

	PARTICLE SIZE ANALYSIS													
	% PASSING										% OF SAMPLE			
HORIZON	3" SIEVE	75" SIEVE	NO.4 SIEVE	NO.10 SIEVE	V.C. SAND	C. SAND	MED. SAND	F. SAND	V.F. SAND	TOT. SAND	70-2U SILT	50-2U SILT	2U CLAY	0.2U CLAY
1APG						20		30		50		29	21	
1C1G						28		39		67		23	10	
1C2G														
2C3														
4C4														

Fig. 4. Example of soil profile description in standard prose

a large number of soil profile data, to make interpretation maps combined with the cartographic file subsystem and so forth. Data input, storage, retrieval and output are the main functions of this subsystem. The software program of this subsystem comprises data file making programs, data retrieval programs,

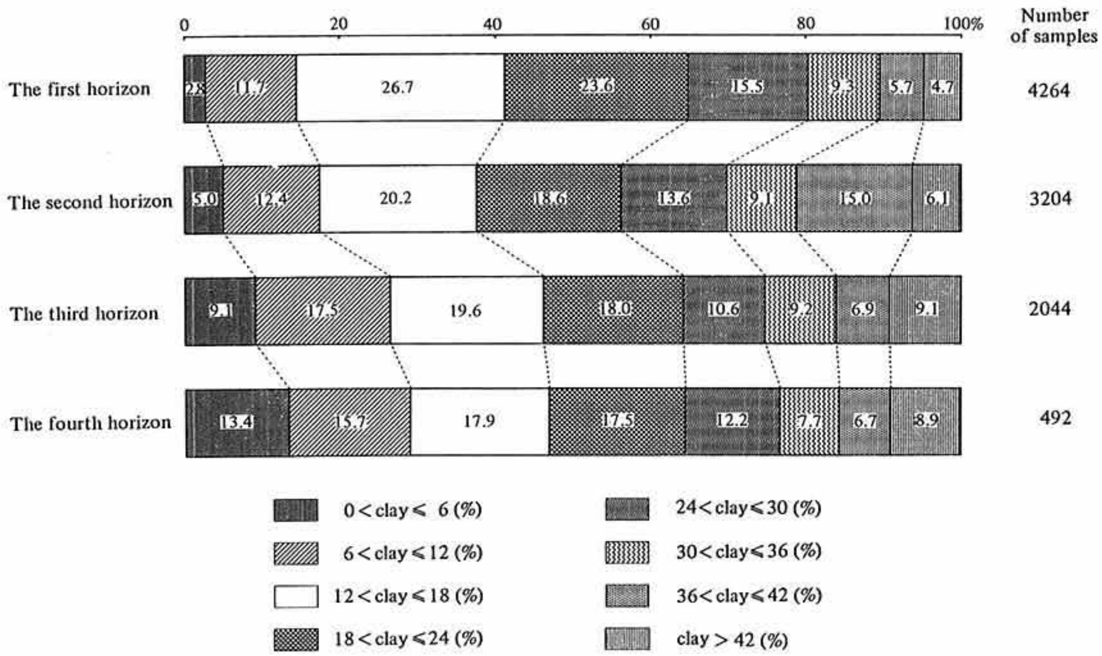

Fig. 5. Clay content of each horizon in Japanese paddy fields

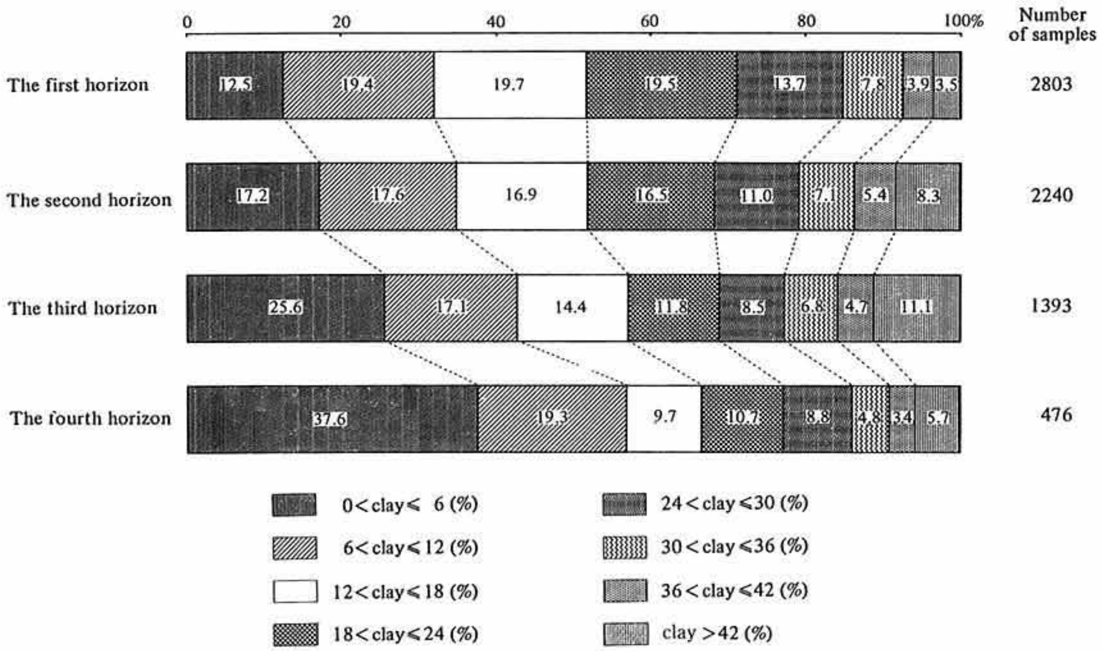

Fig. 6. Clay content of each horizon in Japanese upland fields

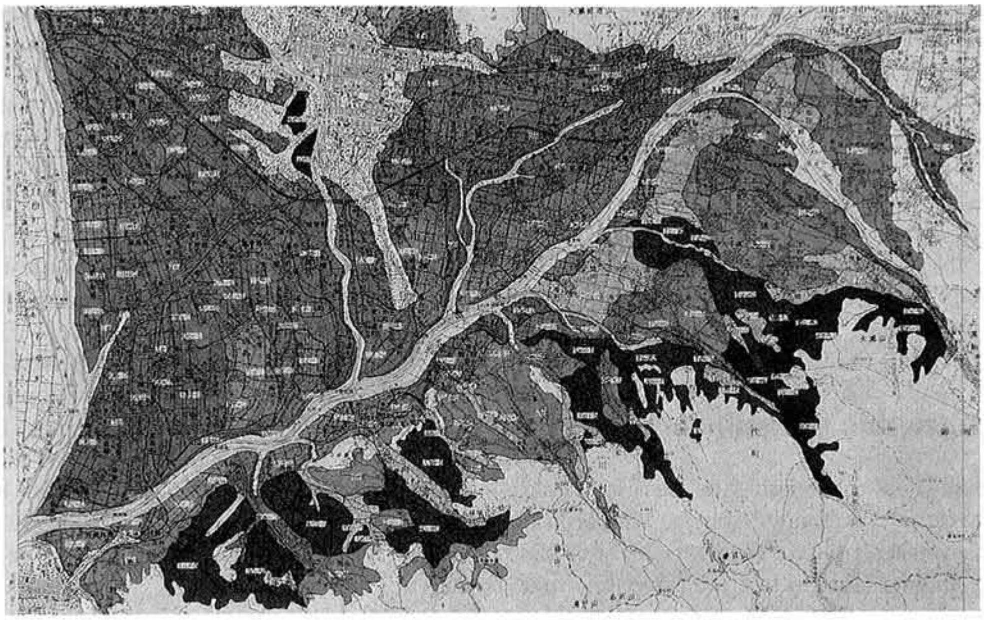

Plate 1. The standard soil map which is derived from the cartographic file subsystem and drafted by an inkjet-plotter (Southern part of Kofu City)
Colors show soil groups and symbols show soil series.

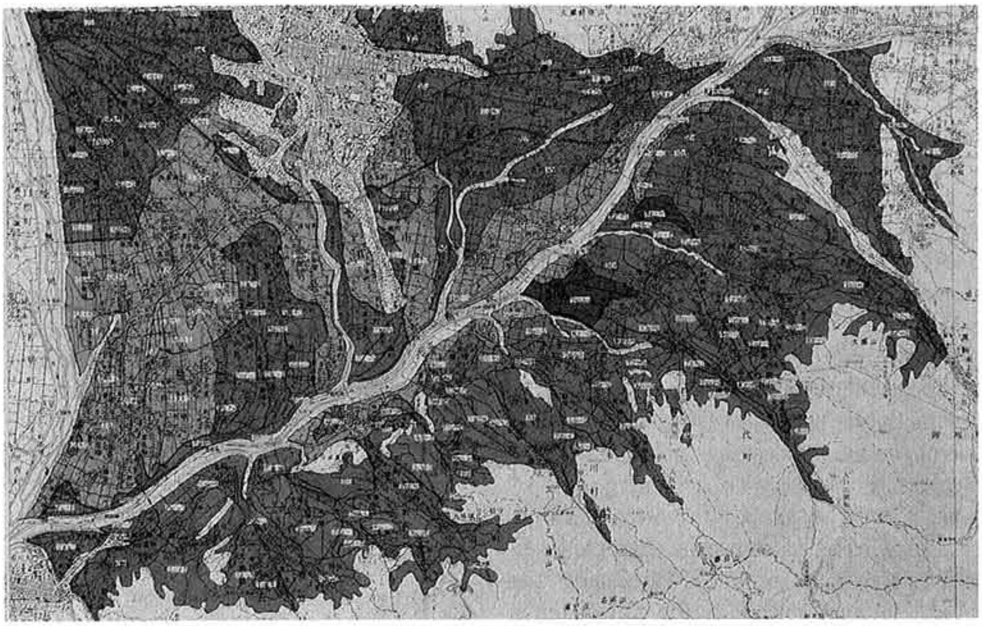

Plate 2. The suitability map for grape cultivation (Southern part of Kofu City)
Purple color: very suitable area, Brown color: suitable area.
Green color: moderately suitable area, Blue color: not suitable area.

dot map programs, file description programs and statistical programs. An example of soil profile description in standard prose (English type) which was printed out by the profile description program is shown in Fig. 4[5]. The histograms of clay contents of Japanese soils in paddy and upland fields were calculated using more than 5,000 horizon data, and expressed graphically (Figs. 5 and 6). In general, the clay contents of paddy soils are higher than those of upland soils. The deeper the soil horizon, the lower the content of fine clay in the upland field. In the paddy field area the fine clay content of the second horizon is higher than that of surface horizon.

Cartographic file subsystem

All mapping data concerning the soil resources are stored and retrieved in this subsystem. The hardware of this subsystem consists of a computer, color display, digitizer, scanner, autodrafter and inkjet color plotter. The software of the subsystems is divided into four major groups. The first is the program which coordinates the mapping data into latitude and longitude data using a digitizer or scanner. By the second, the vector data of polygons are converted into raster data and vice versa. The third is the program which can produce hatching data. The fourth group of programs is used for drafting maps by means of an autodrafter. JAPSIS has succeeded in developing the following eight functions:

1) To digitize and edit the soil map data.
2) To interchange the vector data and raster data.
3) To draft many kinds of soil maps (color) automatically.
4) To overlay many kinds of mapping data.
5) To clip the map data by any polygon area.
6) To change the polygon data into grid data.
7) To smooth the shapes of polygons when the scale of the maps is reduced to a small one.
8) To calculate the areas of each category.

The suitability maps for grape cultivation in Yamanashi Prefecture were taken as an example of an interpretative soil map produced by using the cartographic file and soil data file subsystems. Suitability rank data for grape cultivation and soil survey data (profile description data, chemical and physical analysis data) in the model area were collected. The statistical analysis (multi-dimensional quantification-II analysis) of these data was executed using a computer. As the result of the analysis, it was clarified that the suitable soil conditions are very fine soil texture and less than 700 of phosphate absorption coefficient of the surface soil. Unsuitable conditions are high altitude (higher than 700 m), steep slope, and high ground water table (higher than 30 cm). In addition, weather conditions are also an important factor for grape quality. A slight lack of precipitation (annual precipitation 1000–1200 mm) and a large diurnal temperature range (more than 9–10°C) during summer season result in good grape production. According to these results, soil map data (Plate 1) and weather condition data were overlaid by the cartographic file subsystem. Suitability maps for grape cultivation (scale 1 : 50,000) were directly plotted on the topographic maps using a color inkjet-plotter. The accuracy of suitability maps was checked by aerial color photographs. Namely the grape planted areas of each category were measured by means of photo-interpretation and the result verified the maps (Plate 2) as appropriate.

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