Arable Soil Survey in Niigata Prefecture and Development of Potable Soil Information System

Toshimitsu HONMA[1,2] and Takuji OHYAMA[2,3]*

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Summary

Many soil survey projects had launched in the 1950s in Japan. As a result, assessment of arable soils revealed the status and problems of soils and the consequent measure for amendment succeeded in soil productivity improvement. Recently, however, the number of soil monitoring sites has decreased conspicuously for several reasons. Continuous soil monitoring is necessary to assess the present soil conditions and to predict a change of soil conditions by different soil management practices.

We introduce the outlines of the soil survey and monitoring activity in Niigata prefecture and its outcomes. Furthermore, the authors show a new soil survey style with Personal Digital Assistant (PDA).

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Key words : digital soil map, geographic information system, soil information system, soil survey

1. Introduction

In Japan, the national soil information database was developed with the obtained data from Fundamental Soil Survey for Soil Fertility Conservation, and Basic Soil-Environment Monitoring Project (Stationary Monitoring) conducted by the Ministry of Agriculture, Forestry and Fisheries (MAFF). Using this information, detailed soil maps were produced in every prefecture and some of the progressive applications were reported.

In the case of Chiba prefecture, an integrated GIS composed of digital soil map and soil attribution was developed, and it provided web based several thematic maps, i.e. CEC map (Yamaki, 2001). While Mie prefecture developed Mie Agriculture Soil Information System (MASIS), which was comprised of Mie prefecture Geographic Information System (M-GIS) and the digital soil map. Using this system, it could display the soil map and soil properties and also to search soil survey data. Even so this system was only accessible to the people who live in Mie prefecture (Murakami et. al., 2001). In Niigata prefecture, the soil map for potential decomposability classification of organic matter had been produced by spatial analysis technique, using soil properties, precipitation data, and land use classification and so forth.

However, the soil surveys for these digital soil maps were conducted about 20-30 years ago. Due to land use change the shape of soil region had been changed. It is necessary to update the polygon data and soil information. Nakai (2005) had developed the Soil Resource Inventory (SRI), which could update the soil information through web. Initially, it was open to the public, but it is not available due to security issues at present.

2. Use of Soil Data for Farming Management in Niigata Prefecture

2.1 Present Status of Soil Survey

a. Fundamental Soil Survey for Soil Fertility Conservation

To identify limiting factors of production efficiency and soil amendment, a soil survey had been carried out at each twenty-five ha of arable land for seventeen years (1959-1976) in Niigata prefecture. This survey showed that arable land in Niigata prefecture was classified into 13 soil groups, 40 soil series groups, and 108 soil series. The main limiting factor for production efficiency in paddy was shown to be the difficulty of plowing and the potential ability of oxidation-reduction. These were mainly due to the fine textured heavy soil. The application of silicic acid amendments and subsurface drainage were used as countermeasures for these limiting factors as noted in 'Report on Fundamental Soil Survey for Soil Fertility Conservation'. Finally, the map for Soil Productivity Capability Classification and the map for Countermeasure of Maintenance of Farmland Fertility were

[1] Niigata Agricultural Research Institute
[2] Graduate School of Science and Technology, Niigata University
[3] Faculty of Agriculture, Niigata University
* Corresponding author: ohyama@agr.niigata-u.ac.jp

produced (Niigata pref., 1978).

b. Basic Soil - Environment Monitoring Project (Stationary Monitoring)

Soil profile description was carried out in every 5 years for 20 years (1979-1998) in Niigata prefecture. The effects of soil management, such as the application of fertilizer, soil amendments and organic matter in several soil types, on changes of soil psycho-chemical properties (mainly in top soil) were examined with interviewing farmers. From 1979 to 1998, there were about 500 stationary survey sites in Niigata prefecture. After 1998, there were about 100 sites, due to more detailed soil survey for selected major soils (Table 1).

c. Recent Outcomes

ｉ) Digital soil map

Basically, the digital soil map was composed of the Arable Soil Map in Niigata Prefecture (1983) combined with the soil properties found in the Fundamental Soil Survey for Soil Fertility Conservation which averaged every soil series in Niigata prefecture. Soil classification data (soil group, soil series group, soil series) and soil properties (area, depth of plow layer, texture, bulk density, solid ratio, CEC, phosphate absorption coefficient, total carbon, total nitrogen, exchangeable cations, calcium saturation ration, pH, exchangeable acidity) were included in the digital soil map. Today, in Niigata prefecture, the digital soil map has been distributed to several Agricultural Development Centers with viewer software (Arc Explore, Esri. Corp.) and has been used for technical advice (Fig.1) .

ⅱ) Map for Ability of Decomposition of Organic Matter

Recently, organic wastes like animal manure and sewage sludge compost have been applied to arable land to maintain the soil fertility. In Niigata prefecture, the amount of organic waste was estimated at 3,358,200 t per the year (Niigata pref., 2004), and the effective use for farmland become important due to rapid raise of fertilizer price. The ability of decomposition of organic matter in arable land was assessed based upon five factors. A map for the ability of decomposition of organic matter was produced using this assessment. The five factors included air temperature, precipitation, soil texture, land slope and land use. The factors, except air temperature, were quantified by

Table 1. Number of soil survey sites in Niigata pref *

soil group	1st (1979～1982)	2nd (1984～1987)	3rd (1989～1992)	4th (1994～1997)	5th (1999～2002)	6th (2004～2007)	Total
			Paddy				
Gley Lowland soils	279	278	279	279	57	57	1229
Gray Lowland soils	64	64	64	64	10	10	276
Wet Andosols	30	29	30	30	2	2	123
Gley Upland soils	25	25	25	25	5	5	110
Gleyed Andosols	14	14	15	15	8	8	74
Brown Lowland soils	5	5	5	5	2	2	24
Gray Upland soils	5	5	5	5	−	−	20
			Upland				
Andosols	40	40	40	40	5	5	170
Brown Lowland soils	25	25	25	25	5	5	110
Sand-dune Regosols	10	10	10	10	6	6	52
Brown Forest soils	9	9	9	9	−	−	36
Gray Lowland soils	2	2	2	2	−	−	8
Gleyed Andosols	1	1	−	−	−	−	2
			Orchard				
Brown Lowland soils	10	10	10	10	−	−	40
Sand-dune Regosols	5	5	5	5	−	−	20
Andosols	5	5	5	5	−	−	20
Yellow soils	5	5	5	5	−	−	20
Gray Lowland soils	3	3	3	3	−	−	12
Brown Forest soils	−	−	−	−	3	3	6
Total	537	535	537	537	103	103	2352

* Basic Soil-Environment Monitoring Project

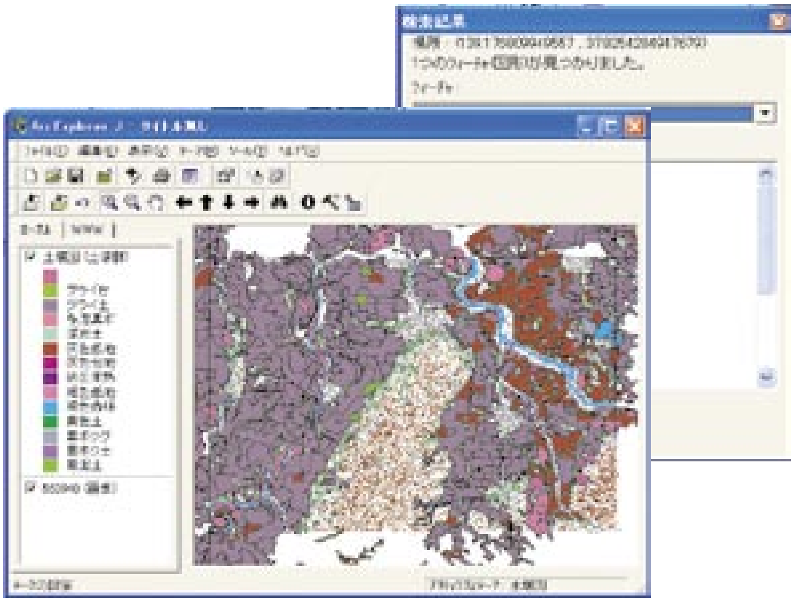

Fig.1 Digital soil map

categorization. Furthermore, these points were substituted for following formulas for evaluation (Table. 2, 3). Fig.2 showed a part of map classified into 'Nothing' to 'Strong'. Additionally, these methods for evaluation were quoted from 'Evaluation for ability of decomposition of organic waste' (Sugahara and Inoko, 1987).

2.2 Problems

Some problems have been pointed out regarding the soil survey system and the utilization of the data. On the soil survey system, it has been difficult to evaluate the actual state of every soil type of the cultivated land areas in Niigata prefecture due to the decrease in the numbers of the soil survey sites provided by farmers. More than one hundred soil survey sites were investigated for each year ten years ago, while today there are only thirty soil survey sites. This has been an issue not only in Niigata prefecture but also throughout the country. The main reasons for the decrease in the monitoring sites are the decreases in the number of the surveyors and the budget constraint. Due to this, it has been challenging to maintain the accuracy of the soil survey.

Practically speaking, the data utilization has been limited. Unfortunately there has been inadequate follow up by the researchers to see if the recommendations are utilized and whether they have any impact.

Changes in the application of organic matter and soil amendments, depth of the plow layer and lowering groundwater level due to farmland development has caused changes in the soil environment. If we failed to understand the actual soil condition, it's difficult to, not only lower the soil fertility, but also disseminate the environmentally sound agriculture practices. Moreover, climate changes in recent years are considered to have affected the soil moisture,

Table.2 Point of several category

Factor	Category	Point
Rainfall (R)	<1000mm	1
	1000-2000mm	2
	2000mm <	3
Soil Texture (ST)	HC	0
	LiC, SiC, SC	1
	CL, SiCL, SCL	2
	L, SiL, SL	3
	S	4
Slope (S)	8-15°	1
	3-8°	2
	0-3°	4
Land use (Lu)	Poorly drained paddy	0
	Well drained paddy	2
	Upland,Orchard	4

Table.3 Evaluation for ability of decomposition of organic matter*

Grade	Avility	D-value
I	Strong	240<
II	Slightly strong	160-240
III	Normal	80-160
IV	Weak	20-80
V	Nothing	<20

D** = (T*** + R + ST) *S*Lu

* Quotation from "Evaluation for ability of decomposition of organic waste (Sugahara and Inoko,1987)"

** Ability of decomposition of organic matter

*** Averaged air temperature

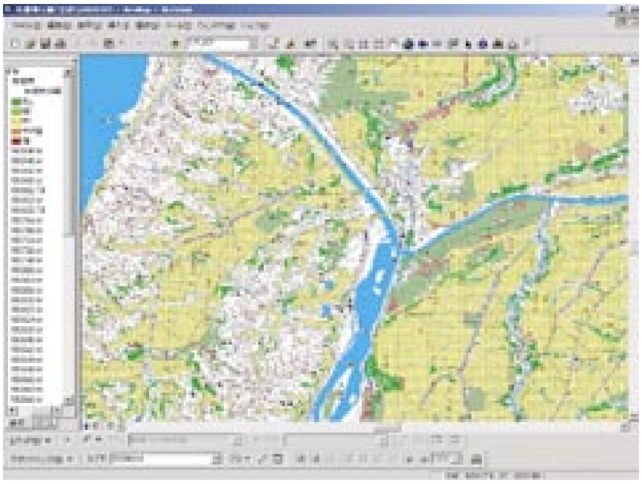

Fig. 2　Map for ability of decomposition of organic matter

mineralization of nitrogen and carbon stock. Therefore, it is of the utmost importance to recruit and train new soil surveyors and maintain the Stationary Monitoring Survey to better understand the actual soil condition.

3. Development of Portable Soil Information System

Today, it has become possible to analyze soil data, which has the spatial information by the development of the Geographic Information System (GIS). Simulated information from the data of the GIS has been used to combine the soil survey data. Including Niigata prefecture, many other prefectures have been updating old soil maps using the GIS. Using these new systems, land application potential for organic matter can be mapped out by analyzing the simulated information data of soil texture, precipitation,

Fig. 3 Picture of inputting the information

Table.4 Input information of Portable Soil Information System

Input information		Detail
Horizon		1, 2, 3, 4, 5, 6
Layer depth		input directly
Horizon boundary		Abrupt, Clear, Gradual, Diffuse
Texture		HC, SC, LiC, SiC, SCL, CL, SiCL, SL, L, SiL, LS, S, Gravel
Gravel	Abundance	None, Few, Common, Many, Abundant, Dominant
	Shape	Rounded, Subrounded, Angular
	State of weathering	Fresh, Slightly weathered, Weathered, Strongly weathered
	Size	Fine gravel, Gravel, Stone, Large stone
Soil color	Hue-1	2.5, 5, 7.5, 10
	Hue-2	YR, Y, GY, G, BG
	Value	2, 3, 4, 5, 6, 7, 8
	Chroma	1, 2, 3, 4, 5, 6, 7, 8, 0
Organic matter	Content	Low, Medium, High, Very high, Organic layer
Structure	Type	Platy, Prismlike, Subangular blocky, Angular blocky, Granular, Single grain Massive
	Grade	Weak, Moderate, Strong
	Size	Very fine, Fine, Medium, Coarse, Very coarse
Compactness		input directly
Moisture condition	Wetness	Dry, Moderately dry, Moist, Wet
Mottling-1	Abundance	None, Few, Common, Many, Abundant
	Nature	Iron, Mangan, Other
	Shape	Threadlike, Root-like, Filmy, Tubular, Speckled, Cloudy, Irregular
	Contrast	Faint, Distinct, Prominent
Mottling-2	Abundance	None, Few, Common, Many, Abundant
	Nature	Iron, Mangan, Other
	Shape	Threadlike, Root-like, Filmy, Tubular, Speckled, Cloudy, Irregular
	Contrast	Faint, Distinct, Prominent
Gleyzation	Dipyridyl reaction	−, +−, +, ++, +++
Peat・Muck	Grade of decomposition	Weak, Moderate, Strong, Muck
	Nature	Low-moor peat, Transitional-moor peat, High-moor peat
Porosity	Abundance	None, Few, Common, Many
	Size	Very fine, Fine, Medium, Coarse

inclination, and so forth.

However, it has been problematic to update with the recent soil conditions due to the decrease in the number of the soil monitoring sites. In addition to that, due to the difficulty of obtaining support from the Agricultural Development Center, there has been a need to increase the efficiency of the soil survey system and to maximize the use of the data of the soil survey.

To solve the problems discussed above, the Portable Soil Information System (PSIS) has been developed in Niigata prefecture. PSIS was developed for improving the efficiency and the analysis of the soil survey by combining the simulated data to the survey data. To specify the system, a customized Arc Pad6.0 with PDA with Windows Mobile with OS for a soil survey was installed. In addition to that, Global Positioning System (GPS) is installed. Since the digital soil map of Niigata prefecture was stored in PSIS, it was able to update polygon, update the properties on the soil map using the soil survey data, and make assumptions of the soil data of the survey sites beforehand.

First, at the soil monitoring sites, information such as site numbers, farmer's name, address, land category and the cultivated crop were input using select dialogs. Then, the soil horizon was decided and soil properties such as soil texture, color, gravel, mottle and gley reaction were selected. Spatial information would be taken automatically by GPS. Then, information of soil management practices such as plowing, crop rotation, application of organic matter were input into notes. After the soil survey, acquired data using PSIS would be synchronized to the soil data in the desktop PC automatically by cradle.

Table 4 showed input information to the PDA. Basic information of the survey point was as follows: profile number, land use, latitude, and longitude, day of description, cultivator and crop name. Soil information was as follows: horizons, horizon boundary, texture, gravel (abundance, shape, stake of weathering, size), soil color (hue, value, chroma), organic matter content, structure (type, grade, size), compactness, moisture condition, mottling (abundance, nature, shape, contrast), gleyzation, peat (grade of decomposition, nature) and porosity (abundance, size). Much of the information could be selected from the 'List Box' for saving input work. (Fig. 3)

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新潟県における農耕地土壌調査と携帯型土壌情報システムの開発

本間利光[1,2]・大山卓爾[2,3]*

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要　約

日本では1950年代に多くの土壌調査事業が行われ、その結果、農耕地土壌の状況や問題点が明らかにされ、関連法令により土壌生産性が向上した。しかし、近年、様々な理由で土壌調査地点数が顕著に減少してきている。継続的な土壌調査は土壌の現況を明らかにし、異なる土壌管理の実践による土壌の変化を予測する上で必須である。ここでは、新潟県における土壌調査の概要と成果について記載し、更に携帯情報端末（PDA）を用いた新たな土壌調査法を紹介した。

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[1] 新潟県農業総合研究所

[2] 新潟大学大学院自然科学研究科

[3] 新潟大学農学部

*代表著者：ohyama@agr.niigata-u.ac.jp