Korean J. Soil Sci. Fert. **42**(1), 21-28(2009)

Article

An Introduction of Korean Soil Information System

S. Young Hong,* Yong-Seon Zhang, Byung-Keun Hyun, Yeon-Kyu Sonn, Yi-Hyun Kim, Sug-Jae Jung, Chan-Won Park, Kwan-Cheol Song, Byoung-Choon Jang, Eun-Young Choe, Ye-Jin Lee, Sang-Keun Ha, Myung-Suk Kim, Jong-Sik Lee[1], Goo-Bok Jung[2], Byong-Gu Ko, and Gun-Yeob Kim

Department of Agricultural Environment, National Academy of Agricultural Science(NAAS),
[1]Research Policy Bureau
[2]Extension Service Bureau, RDA, Suwon 441-707, Korea

Detailed information on soil characteristics is of great importance for the use and conservation of soil resources that are essential for human welfare and ecosystem sustainability. This paper introduces soil inventory of Korea focusing on national soil database establishment, information systems, use, and future direction for natural resources management. Different scales of soil maps surveyed and soil test data collected by RDA (Rural Development Administration) were computerized to construct digital soil maps and database. Soil chemical properties and heavy metal concentrations in agricultural soils including vulnerable agricultural soils were investigated regularly at fixed sampling points. Internet-based information systems for soil and agro-environmental resources were developed based on 'National Soil Survey Projects' for managing soil resources and for providing soil information to the public, and 'Agro-environmental Change Monitoring Project' to monitor spatial and temporal changes of agricultural environment will be opened soon. Soils data has a great potential of further application in estimation of soil carbon storage, water capacity, and soil loss. Digital mapping of soil and environment using state-of-the-art and emerging technologies with a pedometrics concept will lead to future direction.

Key words : Soil database, soil map, GIS, information system, inventory

Introduction

Soil information is important for land management, food production and environment and ecosystem management. The purpose of a soil map is to delineate the boundaries of various soils whose characteristics are markedly different due to the various factors affecting soil formation. These factors include climate, parent material, topography, vegetation and length of time for the formation of the soil. Detailed knowledge on soil characteristics is of great importance for the use and conservation of soil resources that are essential for human welfare and ecosystem sustainability.

The first modern soil survey in Korea was initiated in 1964, when the Korean Government and UNDP/FAO jointly established Korea Soil Survey Organization, Plant Environment Research Institute (recently National Academy of Agricultural Science, NAAS) which belong to the Office of Rural Development (recently Rural Development Administration, RDA) in Suwon. Since then substantial progress of soil survey has been made to understand spatial soil distribution, to recommend fertilizer prescription and land suitability for crop cultivation, as well as to manage agricultural soils (RDA, 2005).

All the soil maps surveyed and made in RDA were computerized to make digital soil maps (NIAST, RDA, 2001). An internet-based soil information system was developed based on the results of all the Soil Survey Projects led by RDA for approximately 40 years for managing soil resources rationally and for providing soil information to the public (NIAST, RDA, 2008).

Many countries established their own soil information system including European Union (http://eusoils.jrc.ec.europa.eu/), Canada (http://sis.agr.gc.ca/cansis/), The United States (http://soils.usda.gov/technical/nasis/), Australia (http://www.asris.csiro.au/) by user needs for soil resource information.

This paper introduces and explains soil inventory focusing on soils database and soil information system (http://asis.rda.go.kr), and suggests its use and future direction for natural resources management.

Received : June 12. 2008 Accepted : August 6. 2008
*Corresponding author: Phone : +8231290044,
E-mail : syhong@rda.go.kr

Soils Database

The soil survey initiated with a reconnaissance survey, making use of aerial photographs purchased from USA funded by Korea Soil Survey Organization between 1964 and 1967. As a result, 1:250,000 and 1:50,000 scales of soil maps of Korea were published. Thereafter, the detailed soil survey was followed by adoption of the Soil Taxonomy of United States Department of Agriculture (USDA) between 1968 and 1990. Now detailed soil maps (1:25,000) are available for entire country in both hard copies and digital soil map files. Furthermore, highly detailed digital soil maps (1:5,000) for entire country are available through on-line for the public and will be published by March of 2009 (Fig. 1).

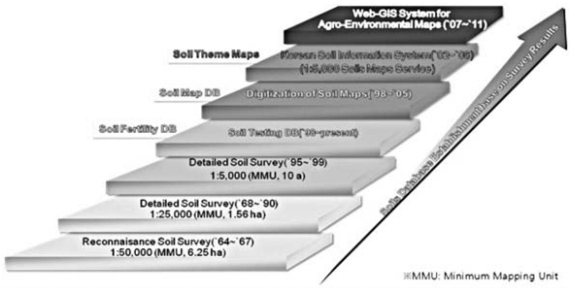

Fig. 1. History of soil survey and database established in Korea (NIAST, RDA, 2001).

In a soil survey, morphological and physical characteristics of a soil such as parent material, soil texture, topography, soil drainage classes, gravel content, slope, effective soil depth, and the rate of soil erosion are often used to determine the series, order, and age of soil. Topography, soil drainage classes, soil texture, effective soil depth, and gravel content play important roles not only in determining soil series, but also along with vegetation and climate are considered and fundamental factors for both understanding the formation of soils and analyzing the characteristics of farmland.

Based on the National Soil Survey Projects, two different kinds of soil databases were constructed that are the concrete basis of the soil information system of Korea. One is spatial database of soil map at a variety of scales (1:250,000, 1:50,000, 1:25,000, and 1:5,000) established between 1998 and 2005. Table 1 summarizes soil survey methods at each scale and its application. All the soil maps were digitized and made in a GIS file format.

The other is parcel-based soil fertility (chemical properties) database established using an oracle relational database management system through soil testing. Soil testing determines both the amount of soil essential nutrients for plant growth and the existence of any harmful ingredients in the soil. It can be contributed to make a recommendation for optimum plant growth via amount and type of fertilizer, the timing and exact location of fertilizer application. Furthermore, it can support proper and effective nutrient management for crops. Improper application of fertilizer would be a problematic because of the uniqueness of soils and crops. Understanding soil chemistry is the first step towards maintaining and managing environmentally sound soil by

Table 1. Soil survey methods at each scale and its application (NIAST, RDA, 2001).

Division	Reconnaissance Soil Survey	Detailed Soil Survey	Highly Detailed Soil Survey
Scale of base map	1:40,000	1:10,000-18,750	1:1,200-5,000
Scale of soil map	1:50,000	1:25,000	1:5,000
Minimum mapping unit	6.25 ha	1.56 ha	10 a
Accuracy and soil classification	Aerial Photogrammetry	Field investigation	Analysis of individual plots
	Soil group and subgroup	Soil series and mapping units	Soil series and other mapping units, landuse
Distance between sampling points	500-1,000 m	Less than 100 m	Less than 50 m
Application	Soil genesis and distribution of soil group	Agricultural advice at regional and local level	Individual household farm management
	Central and regional land use planning	Regional landuse planning	Soil management for individual plots
		Identification of major crop zone	Choice of crop for individual plots
		Soil fertility management	Identification of suitable crops
		Basic information for soil management	Selection of specific land management

Table 2. Characteristics of soil map and soil fertility databases.

	Soil Map Database	Soil Fertility Database
Characteristics	Morphological, physical, and chemical characteristics from topsoil to subsoil	Chemical properties of top soil
Sampling Unit	Soil boundary	Each field with parcel information
Purpose	Soil survey	Soil testing
Utilization	Landuse recommendation, crop suitability, land suitability	Fertilizer recommendation
DB	Spatial database	Non-spatial database
Data form	A variety scale of soil map - 1:250,000, 1:50,000, 1:25,000, 1:5,000	Greater than 5 million samples (since 1995)

measuring the exact chemicals content in soil. The purpose of the data collection and utilization, check items, the form of data sampled and built, of two databases are significantly different as shown in Table 2.

RDA is in charge of National Soil Survey Project and update of soils information. Regarding soil testing project, RDA makes a plan which Agricultural Technical Center (ATC) of each city or county puts into operation. RDA provides the standard of fertilization for 99 crops, checks samples for lab. analysis, and web-based operating program to print out fertilizer recommendation. Each local Agricultural Technical Center collects and analyzes soil samples for the areas. There is a need to upload the soil fertility data analyzed to RDA database. Web-based fertilizer recommendation program developed in 2007 for uploads soil testing data from local ATCs automatically to the RDA soil fertility database while they input the soil test data for printing a fertilizer prescription out.

RDA is also carring out the 'Agro-environmental Change Monitoring Project', which collects soil chemical properties and heavy metal concentraions in agricultural soils including vulnerable agricultural soils in a regular basis at fixed sampling sites. Soils data from top soil and/or sub soil are collected in paddy, upland, plastic film houses, and orchards to analyze chemical properties including pH, organic matter, available phosphate, and exchangeable cations. Soil samples for each cropland type are designed to collect every four years in turn in paddy, upland, plastic film houses, and orchards from 1999. The number of sampling points are about 2,000 for paddy, 1,600 for upland, 1,200 for plastic film houses, and 1,300 for orchards. Soil microbes and their biomass C of 450 samples are examined every year in turn from paddy, upland, plastic film houses, and orchards using the same soil samples for soil properties. Concentration of heavy metals including arsenic, cadmium, chrome, copper, nickel, lead and zinc and chemical properties of 600 soil samples are examined each year in vulnerable agricultural fields near adjacent to metal mines, near industry complex areas, near highway, and municipal wastewater in turn from 1999 (NIAST/YARI/HARI, RDA, 2004).

Information System Development

Information systems are software and hardware systems that support data-intensive applications. A geographic information system (GIS) is used to integrate, store, edit, analyze, share, and display georeferenced information. GIS plays essential roles in integrating a variety of data layers to simulate a real world. The usefulness of an information system depends on its ability to provide the decision maker with the correct data at the right time in the proper manner.

Internet-based soil information system of Korea was developed to provide soil information for the public in 2006 to anybody, anywhere, and anytime since the highly detailed soil map (1:5,000) and soil testing data which started to be computerized from 1998. Now we just started to develop National Agro-environmental Resources Information System (NARIS).

Soil Information System A digital soil database based on paper soil maps at different scales 1:250,000, 1:50,000, 1:25,000, and 1:5,000 made in Korea over a period of more than 40-year period to provide valuable soil information encompassing whole the country. RDA made a soil information system (http://asis.rda.go.kr) of Korea based on highly detailed soil map (1:5,000) and opened 'all about soils' information to the public through the web as shown in Fig. 2. It is an internet-based system to show soil theme maps for suitable crops and recommend the amount of fertilizer.

Korean soils web-site consists of five main parts; 1)

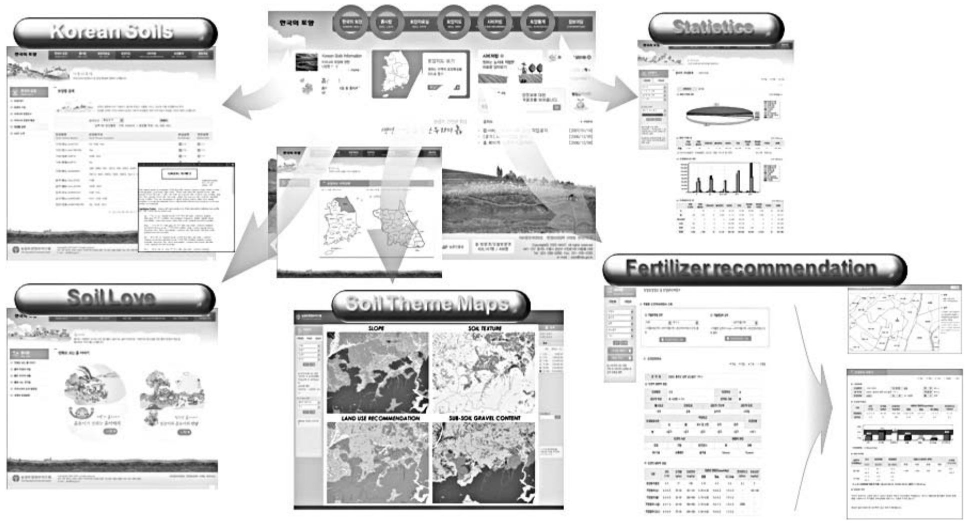

Fig. 2. An overview of Korean Soil Information System (http://asis.rda.go.kr).

digital soil map service such as soil theme maps and crop suitability maps, 2) fertilizer recommendation, 3) soil statistics for selected soil themes, 4) 'Korean soils', and 'soil love' for kids. Soil attributes showed graphically in the digital maps are 89 items which are soil texture (family), gravel content, drainage class, available soil depth, slope, topography, parent material, land use at the time of soil survey, soil suitability group for paddy, upland, and orchard, as well as soil classification regimes, etc. as shown in Table 3. Each soil property can be provided in a form of map, showing its spatial distribution with statistics such as sum and average of the attributes.

Soil map-based attributes provided at the web-site are morphological, physical, landuse, soil classification, crop and soil suitability (Fig. 3). Parcel information as a spatial database provided by Ministry of Land, Transport and Marine Affairs was used to link the soil testing database to express the parcel-based soil fertility map using the parcel information as a relational key in the web site (Fig. 4).

Improper application of fertilizer would be problematic because of the uniqueness of soils and crops. Understanding soil chemistry by measuring the exact content of chemicals in soil is the first step towards maintaining and managing environmentally sound soil. Soil testing reveals soil chemical properties including pH, soil organic matter, available phosphate acid, available silicate, and exchangeable cations. Soil information system of Korea (http://asis.rda.go.kr) provides web-based fertilizer prescription program to recommend the amount, type, and the timing of fertilizer application for optimum plant growth by diagnosis of soil nutrition in the crop land as shown in Fig. 5. A person in charge of soil testing and diagnosis at ATC has his or her own ID and password to access the system to use the data and program functions in the system. Program provides fertilization standards of 99 crops to issue the fertilizer and management prescription. Soil test data are

Table 3. Soil digital maps and number of attributes shown through the soil information system.

Soil Themes Maps	No. of Attributes	Soil Attributes
Morphological and physical maps	9	Soil texture, drainage class, available depth, slope, gravel content, soil color, soil erosion grade, etc.
Landuse maps	6	Landuse, landuse recommendation(paddy, upland, orchard), soil type(paddy, upland, forest), etc.
Soil classification maps	5	Soil order, suborder, topography, parent materials, deposition
Crop suitability maps	39	Apple, pear, mandarin orange, water melon, grapes, strawberry, tomato, cucumber, cabbage, etc.
Soil suitability maps	5	Paddy, upland, orchard, grass, forest soils
Soil chemical maps	25	pH, organic matter, available phosphate, potassium, calcium, available silicate, etc. for each cropland unit

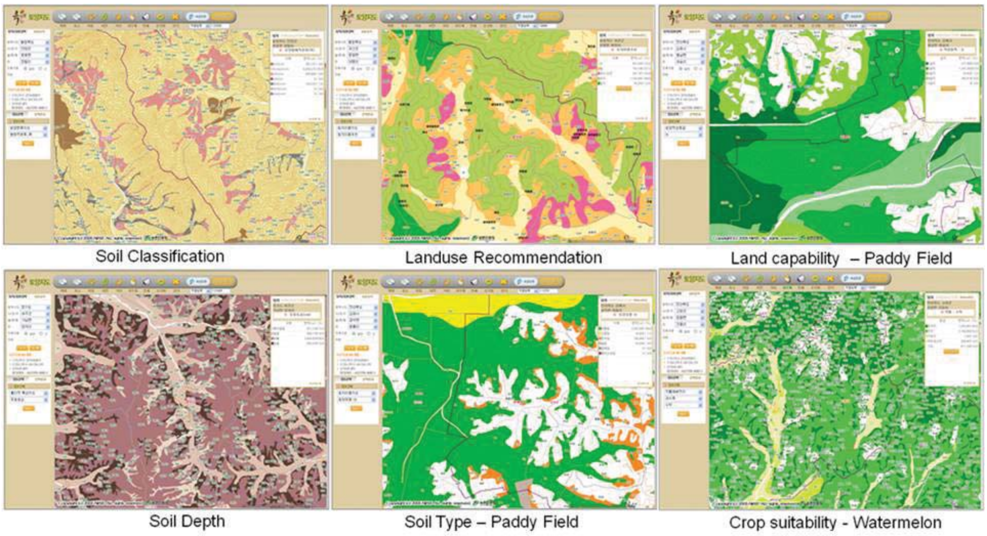

Fig. 3. Morphological and physical properties of korean soils provided through soil information system.

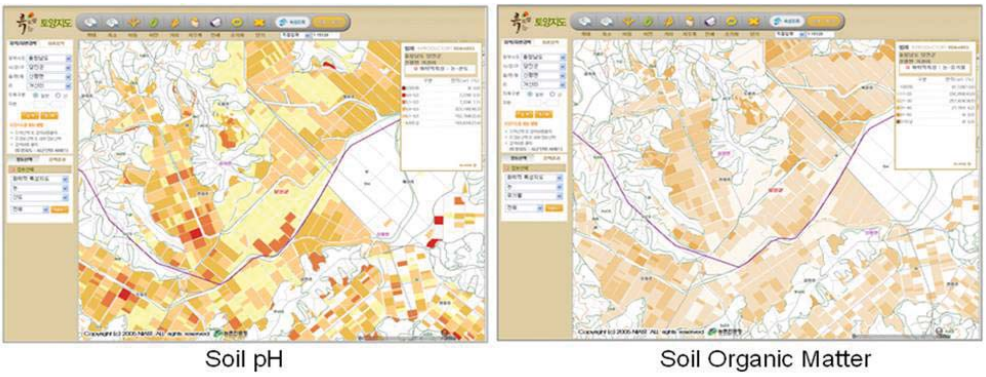

Fig. 4. Parcel-based soil chemical properties provided through soil information system.

automatically uploaded to the oracle database located at NAAS when one inputs the soils data and saves them for the program operation.

For the web-based fertilizer prescription program, Korea Land Information was provided by Ministry of Land, Transportation and Marine Affairs and farm land data were provided by Ministry for Food, Agriculture, Forestry and Fisheries to offer parcel-based soil fertility map and fertilizer prescription for farming.

The statistics of soil attributes queried on the web can be calculated for representative areas in the form of pie charts, bar charts, and tables (Fig. 6). Soil information

Fig. 5. Web-based fertilizer prescription program from data input to fertilizer recommendation.

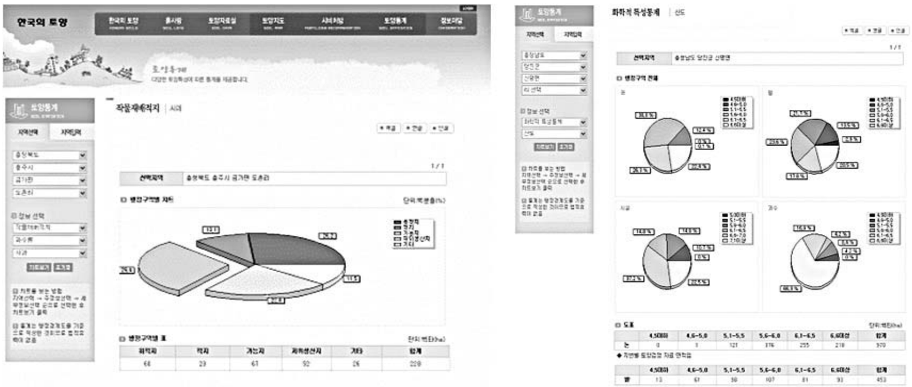

Fig. 6. Soil statistics in the form of pie charts and tables for crop suitability(a) and soil pH(b).

can be queried for statistics are all 62 attributes including soil morphological, physical, and chemical properties. And the system also provides general information on Korean soils.

Soil Monitoring Information Based on agro-environmental resources inventory, development of agro-environmental resources system started by NAAS. The purpose of system development is the establishment of national agro-environmental resources inventory and its rational use. Web-GIS system for agro-environmental resources information will provide a spatial database on soil resources, 3-D soil maps, an image database, statistics, and cyber forum from early 2009.

Spatial and temporal distribution of soil monitoring data in agricultural fields including vulnerable agricultural fields will be provided as shown in Fig. 7 for soil pH and Fig. 8 for arsenic concentration through the web-GIS system to be opened. But soil information collected from vulnerable agricultural fields will not be opened to the public.

Green house gases (GHGs) emission is closely related with soil properties such as soil texture, soil temperature, and N mineral content (Kim, 2009). Soil and cropland type inventory can be established for assessment and mitigation of GHGs emission to meet IPCC (Intergovernmental Panel on Climate Change) standards based on Korean soils database and agro-environmental resources inventory.

Use of Soil Information and Future Direction

Soil information can be applied to map soil functional properties, soil carbon storage and available water capacity which are important for land management, plant production and ecosystem management. Hydrologic soil group, soil erodability, and potential runoff are based on soil map which represents different kinds of soil characteristics. Soil chemical properties statistics can be calculated using soil testing data (Hong et al., 2008).

There is a need for accurate, up-to-date and spatially

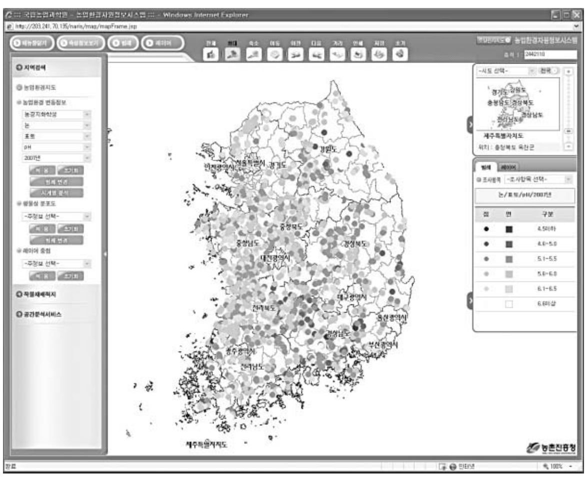

Fig. 7. Soil monitoring sites for agricultural fields(e.g. pH of paddy soils).

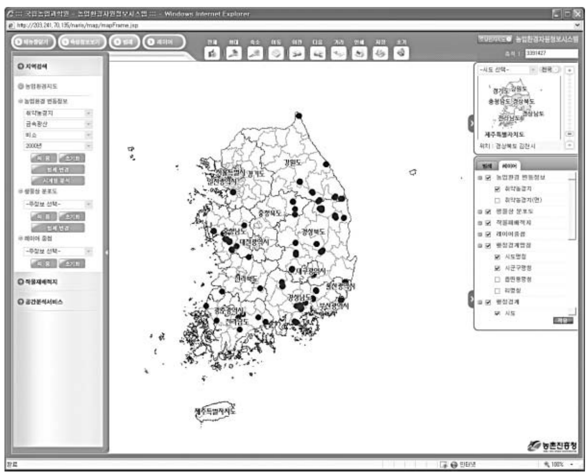

Fig. 8. Soil monitoring sites for vulnerable agricultural fields(e.g. arsenic concentration).

referenced soil information. This need has been asked by the modelling community, land users, and policy and decision makers. This need coincides with an enormous leap in technologies that allow accurate collecting and predicting soil properties (http://www.globalsoilmap.net). Accordingly, there is a global need for making a new digital soil map of the world using state-of-the-art and emerging technologies for soil mapping and predicting soil properties at fine resolution. This new global soil map will be supplemented by interpretation and functional options that aim to assist better decisions in a range of global issues like food production and hunger eradication, climate change, and environmental degradation (http://www.globalsoilmap.net).

Conclusions

Soil inventory based on Korean soils database and soil monitoring database was explained in terms of survey history, data types collected and established, spatial and temporal scope for sampling. Internet-based soil information system of Korea was developed in 2006 that consists of five main parts; digital soil map service such as soil theme maps and crop suitability maps, fertilizer recommendation, soil statistics for selected soil themes, Korean soils, and 'soil love' for kids. Based on agro-environmental resources inventory, development of agro-environmental resources system providing spatial and temporal soil change information also just started by NAAS for the establishment national agro-environmental resources inventory and its rational use. English version of the information systems abovementioned will be necessary for global networking.

Soils database need for further applications to estimate soil carbon storage, water capacity, and soil loss. Digital mapping of soil and environment using state-of-the-art and emerging technologies with soil mapping pedometrics concept and predicting soil and environment properties will lead to future direction. Also, remote sensing plays an important role for the estimation of soil properties as one of emerging technologies to contribute to multi-scale analysis and modeling.

References

Australian Soil Resource Information System. http://www.asris.csiro.au/

Canadian Soil Information System. http://sis.agr.gc.ca/cansis/

European Soil Portal. http://eusoils.jrc.ec.europa.eu

GlobalSoilMap.net consortium. http://www.globalsoilmap.net

Hong, S.Y., Y.H. Kim, K.H. Jung, Y.J. Lee, S.K. Ha, Y.K. Sonn, B.K. Hyun, M.S. Kim, S.O Hur, S.J. Jung, K.C. Song, and S.C. Kim. 2008. Development of soil information system and its application in Korea, In: Proc. Monsoon Asia Agro-Environmental Research Consortium (MARCO) Workshop, pp.158-174, FFTC(Food and Fertilizer Technology Center) supported, October 14~16, 2008, Tsukuba, Japan

Kim, G. Y. 2009. Emission and evaluation of greenhouse gas(CO_2, CH_4, N_2O) in paddy and upland fields. Ph.D. Thesis. Chungbuk National University, Cheongju, Korea

National Institute of Agricultural Science and Technology(NIAST), RDA. 2001. Korean soil and environmental information system

National Institute of Agricultural Science and Technology(NIAST), Youngnam Agricultural Research Institute(YARI), Honam Agricultural Research Institute (HARI), RDA. 2004. First-period report on soil monitoring for vulnerable agricultural fields.

National Institute of Agricultural Science and Technology(NIAST), RDA. 2008. An instruction guide for soil and environmental resources information system.

National Soil Information System(NASIS), USA. http://soils.usda.gov/technical/nasis/

Rural Development Administration(RDA). 2005. Value assessment of major agricultural technology.

한국 토양정보시스템 소개

홍석영[*] · 장용선 · 현병근 · 손연규 · 김이현 · 정석재 · 박찬원 · 송관철 · 장병춘 · 최은영 · 이예진 · 하상건 · 김명숙 · 이종식[1] · 정구복[2] · 고병구 · 김건엽

농촌진흥청 국립농업과학원 농업환경부, [1]농촌진흥청 연구정책국, [2]농촌진흥청 농촌지원국

토양정보는 식량생산, 지속적인 토지이용 계획, 종다양성 평가에 사용되는 기본적인 자료이다. 본 논문에서는 우리나라 토양조사의 역사, 다양한 축척의 토양도 구축과 토양검정, 토양도와 토양검정 자료의 특성, 농업환경 변동 모니터링을 통한 일반농경지 및 취약농경지 토양, 토양정보의 전산화에 따른 토양데이터베이스와 토양정보시스템 소개, 구축된 토양정보의 활용과 향후 방향에 대해 논하였다. 40여년 동안 수행되었던 국책 토양조사 사업 결과 두 종류의 토양 데이터베이스가 구축되었는데, 다양한 축척의 토양도(1:250,000, 1:50,000, 1:25,000, 1:5,000)를 GIS DB로 전산화한 수치토양도 DB와 필지단위로 조사된 화학성 위주의 토양분석 성적을 구축한 토양비옥도 DB이다. 최근에는 친환경농업육성법 시행령에 따른 경작형태 및 오염원별 농경지 토양의 이화학성 및 중금속 함량 조사 자료를 GIS DB로 구축하여 공간적인 분포와 시계열적인 변화를 분석하는 자료로 활용하고 있다. 한국토양정보시스템(http://asis.rda.go.kr)에서 제공하는 토양전자지도는 총 89종으로 토성, 경사, 지형, 모재, 배수등급, 자갈함량, 유효토심 등 토양 GIS 주제도 50종, 사과, 배, 마늘, 수박 등 작물 재배적지 39종 이고, 62종의 토양통계 정보를 제공하고 있다. 토양 변동 정보는 농업환경자원 인벤토리에 기반하여 국립농업과학원에서 구축중인 농업환경자원정보시스템을 통하여 일반농경지의 화학성의 공간적인 분포와 시간적인 변화 정보를 제공될 예정이다. 또한, 기존의 자료를 기반으로 최소한의 실측 자료만으로도 토양의 기능과 환경변화를 예측을 할 수 있는 디지털 지도 작성 기술이 절실히 요구되고 있어 정보시스템은 이를 뒷받침할 수 있어야 할