PRESENT SOIL CONDITIONS OF CULTIVATED LAND IN JAPAN

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Abstract

Soil surveys of cultivated land have been carried out with soil maps at a scale of 1:50,000, covering an area of more than 5 million ha.

In these soil maps, cultivated soils are classified into 320 soil series based mainly on their morphological characteristics and the areas occupied by a kind of soil are further grouped into 4 classes according to the degree of limitation for crop production.

From the results of the soil surveys and classifications, areas with low crop productivity have been identified and soil improvement practices recommended.

The characteristics and problems posed by the main soil groups in cultivated land are described.

Japan is situated between latitudes 24° to 46° N and longitudes 123° to 146° E, and covers a total area of about 37 million ha.

The country consists of a chain of five main islands – Hokkaido, Honshu, Shikoku, Kyushu and Okinawa – and their satellite islands.

These islands have a large number of relatively high mountains which include many volcanoes. Consequently, more than 60% of the land has a slope steeper than 15°.

Mean annual temperature is quite variable from the northern part of the country to the southern part and ranges from 6°C to 22°C.

Precipitation is comparatively high throughout the country and mean annual precipitation ranges from 1100 mm to 2500 mm.

As for the parent materials of the soil, the extensive deposition of volcanic ash and presence of acidic intrusive rocks are the main features of the parent material of the soils in Japan. Consequently, most soils of upland fields are undergoing intensive leaching and have low base status in natural condition.

Soil survey and classification

Japan has about 5.7 million ha of cultivated land. Soil survey of cultivated land was started in 1953 to obtain systematic and basic information on the nature of the soils for improvement of agriculture.

By 1978, the "Soil Survey for Fertilizer Application Improvement Program" and "Soil Survey for Maintenance of Farmland Fertility" and other soil surveys had been carried out by the soil scientists of the whole country.

As a result of these surveys, more than 5 million ha of cultivated land have been evaluated and soil maps at a scale of 1:50,000 have been completed. In these surveys, soils series were adopted as a basic unit of soil classification and mapping. A soil series is defined as a group of soils developed from the same kind of parent material and mode of deposition, and having quite similar morphological characteristics in the soil profile from a pedological point of view.

Establishment of soil series is made on the basis of morphological characteristics as well as physical and chemical properties.

The differentiating criteria used to identify the soil profiles are as follows;

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Thickness and humus content of topsoil
Soil color and texture of subsurface horizon
Presence and depth of gravel layer and hard bed rock
Presence of mottling, concretions and soil structure
Presence and depth of peat layer, muck layer and gley horizon
Soil acidity
Presence of water table in the profile
Nature of soil parent material
Mode of deposition of soil parent material

Soil series are sometimes divided arbitrarily into soil phases on the basis of minor variations in soil characters which may be of considerable importance for agricultural production.

Soil series which have similar features and soil forming process, are included into "a soil group".

At the present time, 16 soil groups and 320 soil series are recognized in cultivated land of Japan.

The correlation between the soil groups of the Japanese soil classification and the suborders of the U S Taxonomy and the Soil Units of FAO Unesco soil map of the world, are shown in Table 1.

Table 1 Correlation of Soil Groups in Japan with the Suborders of U.S. Taxonomy and the Soil Units of FAO-UNESCO soil map of the world

Soil Group	Suborder of Taxonomy	Soil Unit of S.M.W.
Lithosols	Orthents	Lithosols
Sand-dune Regosols	Psamments	Regosols
Andosols	Andepts	Andosols
Wet Andosols	Andepts (aquic)	Andosols
Gley Andosols	Aquepts (And-)	Andosols
Brown Forest soils	Ochrepts	Cambisols
Gray Upland soils	Aquepts Ochrepts	Gleysols Cambisols
Gley Upland soils	Aquepts	Gleysols
Red soils	Udults	Acrisols
Yellow soils	Udults	Acrisols
Dark Red soils	Udalfs	Luvisols
Brown Lowland soils	Fluvents Aquepts	Fluvisols
Gray Lowland soils	Aquepts	Gleysols
Gley soils	Aquents Aquepts	Gleysols
Muck soils	Saprists	Histosols
Peat soils	Fibrists	Histosols

Table 2 provides us with the area of cultivated land classified by soil groups and land use.

The major soil groups found in paddy fields are the Gray Lowland Soils, Gley Soils and Wet Andosols. In ordinary upland fields, Andosols, Brown Forest Soils and Brown Lowland Soils are extensively distributed and in orchards, mulberry fields and tea gardens, Brown Forest Soils, Andosols and Yellow Soils predominate.

Table 2 Area of cultivated land by soil groups and land use

(100 ha)

Soil Group	Paddy field		Ordinary Upland field		Orchard, Mulberry field, Tea garden		Total	
	Area	%	Area	%	Area	%	Area	%
Lithosols	0	0	71	0.4	77	1.7	148	0.3
Sand-dune Regosols	0	0	223	1.2	19	0.5	242	0.5
Andosols	171	0.6	8,511	46.5	861	21.4	9,542	18.6
Wet Andosols	2,741	9.5	722	3.9	25	0.6	3,488	6.8
Gleyed Andosols	508	1.8	19	0.1	0	0	526	1.0
Brown Forest soils	66	0.2	2,875	15.7	1,490	36.9	4.431	8.6
Gray Upland soils	792	2.7	719	3.9	64	1.6	1.575	3.1
Gley Upland soils	402	1.4	43	0.2	0	0	446	0.9
Red soils	0	0	253	1.4	199	5.0	452	0.9
Yellow soils	1,443	5.0	1,060	5.8	760	18.8	3,262	6.4
Dark Red soils	18	0.1	291	1.6	61	1.5	370	0.7
Brown Lowland soils	1,418	4.9	2,311	12.6	353	8.8	4,081	8.0
Gray Lowland soils	10,566	36.6	751	4.1	101	2.5	11,418	22.3
Gley soils	8,894	30.8	132	0.7	21	0.5	9,047	17.7
Muck soils	759	2.6	17	0.1	1	0	778	1.5
Peat soils	1,095	3.8	323	1.8	1	0	1,419	2.8
Total	28,874	100	18,319	100	4,033	100	51,226	100

Soil classification based on the limitation for crop production

The areas occupied by the soils which belong to "a series" or "a phase", are grouped into 4 classes according to the kind and degree of inherent limitation and hazard for crop production as well as risk of soil damage.

Each class is defined as follows:

Class 1: Soils found in this class offer almost no limitation or hazard for crop production and no risk of soil damage. They are regarded as productive good soils having a high potential for crop production without requiring any land improvement practices.

Class 2: Soils found in this class have some limitation or hazard for crop production and some risk of soil damage. They require some improvement practices to achieve good production.

Class 3: Soils found in this class have many limitations, or hazards for crop production and many risks of soil damage. They require fairly intensive land improvement practices.

Class 4: Soils found in this class have greater limitations or greater hazards for crop production and greater risks than those in class 3. But they can be utilized for production of some crops under very intensive land improvement practices.

The inherent soil characteristics used for the above classification of soils are as follows;

(For paddy rice)	**(For upland crops)**
Thickness of top soil	– do –
Effective depth of soil	– do –
Gravel content in topsoil	– do –
Hardness of plowing	– do –
Permeability under submerged condition	X
Status of redox potential	Wetness or dryness of land
Inherent fertility	– do –
(Nutrient absorption power and base status)	
Content of available nutrients	– do –
Presence of harmful substances and physical hazards	– do –
Frequency of disasters	– do –
	Slope of fields
	Erodibility and degree of erosion

Each standard factor is graded as I, II, III, and IV based on the degree of limitation, hazard or risk.

The limitation class of the soil for crop production is assessed at the lowest class value of the enumerated factors.

The area and percentage of cultivated land by classes based on the limitation for crop production in each land use are shown in Table 3.

The percentages of crop land with low productivity in the III and IV classes cover 39% of the total area of paddy fields, 69% of that of ordinary upland fields and 64% of that of orchards, etc., respectively.

Table 4 shows the area and percentage of crop land with low productivity and the major limiting factors of soil.

Main soil groups of such category of land in the case of paddy fields, are the Gley Soils and Gray Lowland soils. The major limiting factors for crop production of these soils are the status of redox potential, permeability under submerged condition and content of available nutrients. In ordinary upland fields, the main soil groups are the Andosols and Brown Forest soils. Their major limiting factors are represented by the inherent fertility, content of available nutrients, slope of field and effective depth of soil.

Main soil groups in orchards, etc. are the Brown Forest soils, Yellow soils and Andosols. Their major limiting factors are the content of available nutrients, hardness of plowing, erosion, thickness of top soil and inherent fertility.

Characteristics and problems posed by the main soil groups in cultivated land.

1 Sand-dune Regosols

Sand-dune Regosols are coarse textured immature soils occurring on well drained sand-dunes along the sea coast. These soils are partly used for vegetable and flower cultivation.

The excessively drained condition of the Sand-dune Regosols is the major limitation for agricultural production.

Table 3 Area and percentage of each soil class based on land use

(100 ha)

(100 ha)

Class	Paddy field Area	Paddy field %	Ordinary Upland field Area	Ordinary Upland field %	Orchard, Mulberry field, Tea garden Area	Orchard, Mulberry field, Tea garden %
I	36	<1	20	<1	19	<1
II	17,480	61	5,617	31	1,422	36
III	11,238	39	11,615	63	2,124	53
IV	121	<1	1,067	6	468	11

Table 4 Area and percentage of soils with unfavorable conditions, and their major limiting factors, as classified by soil groups and land use

(100 ha)

Soil Group	Paddy field Area	Paddy field %	Paddy field Limiting factors	Ordinary Upland field Area	Ordinary Upland field %	Ordinary Upland field Limiting factors	Orchard, Mulberry field Tea garden Area	Orchard, Mulberry field Tea garden %	Orchard, Mulberry field Tea garden Limiting factors
Lithosols	0	0		69	<1	d,g,i	75	3	(w),s,d
Sand-dune Regosols	0	0		220	2	(w),f,n	19	1	(w),f
Andosols	135	1	f,l	5,974	47	f,n	435	17	f,n
Wet Andosols	1,055	9	f	630	5	f,w,n	<1	<1	
Gleyed Andosols	292	3	r,f	190	<1		0	0	
Brown Forest soils	44	<1	p	1,802	14	s,d	1,025	40	t,l
Gray Upland soils	370	3	p	669	5	w,p	37	1	
Gley Upland Soils	280	2	p,l	43	<1		0	0	
Red Soils	0	0		236	2	p,n,w	145	6	n,p,l
Yellow soils	432	4		725	6	p	603	23	n,p,l
Dark Red soils	<1	0		276	2	(w),d,p	61	2	
Brown Lowland soils	417	4		1,048	8		141	5	
Gray Lowland soils	2,810	25	l,n	533	4	w	34	1	w,d
Gley soils	4,622	41	r	100	1	w,n	10	<1	
Muck soils	324	3	r	17	<1		0	0	
Peat soils	581	5	r	323	3	w,n,a	<1	0	
Total	11,360	100		12,683	100		2,592	100	

2 Andosols

Andosols are extensively found on terraces and on gentle foot slopes of volcanoes. Their parent materials are mostly volcanic ejecta. Generally, they have a dark colored humus-rich surface horizon. The clay mineral composition of the Andosols consists mainly of amorphous material with variable charges. Most of the unique properties of these soils chiefly result from the presence of amorphous material. These soils are mostly used as upland fields and pastures. Although andosols have been considered to be inferior in soil fertility, they can be cultivated if improved by liming, heavy application of phosphates and compost. Consequently, they are suitable for crop production and are rather productive soils in cultivated land.

3 Wet Andosols, Gleyed Andosols

These are hydrogenic Andosols with iron mottles and/or gley horizon in their profile resulting from imperfectly drained condition or irrigation for rice cultivation. They occur mainly in valleys between the terraces covered by Andosols and are usually used as paddy fields. These ill-drained Andosols have an excessive accumulation of organic matter and the oxidation-reduction potential of the soil is suddently lowered following the increase of soil temperature in summer. The rice plants cultivated on these soils frequently present "Akiochi" symptoms.

("Akiochi" is the name given to the phenomenon whereby an abnormal growth pattern and low yield affect the rice crop)

4 Brown Forest Soils

Brown Forest soils have a brownish black to dark brown surface horizon underlain by a yellowish brown subsurface horizon.

These soils occur on the slope of hills and on upland fields and are used for the cultivation of ordinary upland crops and for orchards. Brown Forest soils have frequently steep slopes, shallow effective depth of soil and a high degree of erosion as limiting factors for crop production.

5 Gray Upland Soils

Gray Upland soils mainly occur on the upland areas and are characterized by a gray to grayish brown colored subsurface horizon with iron mottling.

These soils frequently have morphological characteristics influenced by the seasonal stagnant water. They are mainly used as paddy fields, upland fields and pastures.

Most of the Gray Upland soils have a very fine texture. Consequently they are hard to plow and the subsoil has a low permeability which creates unfavorable conditions for crop production.

These soils belong to the "heavy soil" group which is considered as a problem soil in Japan.

6 Yellow Soils

The surface horizon of the Yellow soils has a low humus content and is underlain by a yellow subsurface horizon with high chroma and value. They mainly occur on hills and upland areas and are used as paddy fields, upland fields, orchards, etc. Most of these soils are not naturally fertile. Deep ploughing and adequate application of compost and chemical fertilizers are necessary to ameliorate these soils.

7 Brown Lowland Soils

Brown Lowland soils have a yellowish brown to brown subsurface horizon mostly with iron mottling. They occur on alluvial plains where the soils are moderately well drained, and are mainly used as paddy fields and ordinary upland fields. In general, the Brown Lowland soils are productive soils and have few limiting factors for crop production compared to other soils.

8 Gray Lowland Soils

Gray Lowland soils have a gray to brownish gray subsurface horizon developed under the influence of groundwater or waterlogged condition. These soils are the most extensively distributed soils in paddy fields throughout the country and mainly occur on alluvial plains.

Generally, they are productive soils in paddy fields. But in the case of the coarse textured Gray Lowland soils, iron, manganese and other elements are leached down from the surface soil to the subsoil under rice cultivation. This process frequently leads to degradation of young fertile soils which become infertile.

The degraded paddy soils used to be problem soils in Japan. However, improvement of these soils has been carried out for many years and presently degraded paddy soils can hardly be observed in the country.

Recently, some of the paddy fields have been converted so as to enable the cultivation of upland crops owing to the over-production of rice in Japan. In these cases, drainage of the soils is most important for the growth of upland crops and workability of farm machinery. As the very fine textured Gray Lowland soils are generally imperfectly drained, these soils pose major problems for utilization as upland fields.

9 Gley Soils

The common feature of the Gley soils is the presence of a gley horizon which has a bluish to greenish gray color and strong reducing condition. Gley soils are extensively distributed in alluvial plains throughout the country and mostly used as paddy fields. These soils are poorly to imperfectly drained soils. They need to be improved by artificial drainage. Especially, drainage of these soils is indispensable for the cultivation of upland crops.

10 Peat Soils and Muck Soils

Peat Soils and Muck Soils are organic soils with a peat and muck layer, respectively. These soils are found in old bogs and marshes or depressions in hilly regions and are mainly used as paddy fields. The productivity of the Peat soils is generally low, because of their poorly drained condition and deficiency in mineral nutrients. Drainage, dressing with mineral soil have been recommended for improving these soils.

Discussion

Kanwar, J.S. (ICRISAT): What are the second generation problems with which the Japanese soil scientists will be confronted in the future?

Answer: The conversion of paddy fields to upland fields creates difficult problems of drainage which must be solved. Also, soil conservation including erosion control treatment, prevention of contamination with toxic substances and maintenance of soil fertility is very important.

Li, C.K. (China): Is the tile drainage used on the converted paddy fields very expensive? It seems to enable wheat to grow adequately.

Answer: Tile drainage is widely use but very expensive, indeed. This system is very useful for the improvement of soil drainage and contributes to the intensive use of paddy fields.

Ismunadji, M. (Indonesia): How much mineral soil do you apply to reclaim peat soils?

Answer: We usually apply six hundred ton/ha to a depth of 20 to 30 cm.