THE PROBLEMS OF SOILS IN LIMESTONE AREA OF THE NANSEI SHOTO, SOUTHWEST JAPAN

by Kazuko URUSHIBARA-YOSHINO *

Resum

En les terrasses formades a Nansei Shoto (SW del Japó) a causa de l'aixecament de l'escull coral·lí, els sòls més antics tenen les següents característiques: tonalitat rojenca, quantitats més altes d'òxids de ferro lliures (Fe_2O_3 %) així com una major intensitat del pic corresponent a l'hematita. En les terrasses més recents els sòls són groguencs, però els òxids de ferro lliures (Fe_2O_3 %) són encara elevats amb una intensitat més alta del pic de la goethita.

Les àrees cobertes per sòls rojos (anomenats *Shimajiri-mâji)* en els esculls coral·lins aixecats, es veuen sovint afectades per la sequedat en les zones de conreu de canya de sucre. Per evitar els danys causats per l'aridesa s'ha mesclat *Jagar* (originat a partir de roques argiloses terciàries) amb els sòls rojos de les àrees de *Shimajiri-mâji.* No obstant això, la introducció de maquinària agrícola, les millores del sòl a gran escala i l'augment de la superfície conreada, han tengut per resultat una erosió accentuada del sòl en aquests camps. Endemés, els sòls arrossegats pels rius resulten perjudicials per a la pesca costanera i ocasionen l'extinció dels corals.

Abstract

Soils on the terraces formed from uplifted coral reef in the Nansei Shoto, SW Japan, have characters that hue of soils is more reddish, amounts of free iron oxides (Fe_2O_3 %) are higher, and peak intensity of hematite is higher on the older terraces. On the younger terraces, soils become yellowish hue, but free iron oxides (Fe_2O_3 %) are still higher with higher peak intensity of goethite.

The areas covered by red soils, called *Shimajiri-mâji,* on the uplifted coral reef suffer frequently from drought on the sugar cane cultivation. For avoid the damages by drought, *Jagar,* originated from Tertiary muddy rock, has been mixed into the red soils in the *Shimajiri-mâji* areas. However, introduction of machines for cultivation, soil amelioration in a large scale, and enlarging unit area of each fields have resulted in a large amount of soil erosion at the fields. Soils flowed from the rivers hinder coastal fishery and corals become extinct.

1. Characteristics of red soils formed from limestone in the Nansei Shoto and their climatic conditions

There are several terraces composed of uplifted coral reef in the Nansei Shoto. The highest coral terraces seem to be formed older than 230,000yr B.P. and then the formed ages of the coral terraces are; 125,000yr B.P., 100,000yr B.P., 80,000yr B.P., 60,000yr B.P. and 38,000yr B.P. Reddish soils are formed on the older terraces, but reddish-yellow soils on the younger terraces formed in the period from 125,000yr B.P. to 38,000yr B.P. Soil layer is thicker on the older, higher terraces and thinner on the younger, lower terraces.

The older the soils are, (I) the more reddish become, (II) the greater the Fe_2O_3 % and (III) the higher the peak intensity of hematite. These relationship between the properties of soils and hue is shown in Fig. 1. On the younger terraces, yellowish hue becomes stronger, but Fe_2O_3 % is still greater and the peak intensity of goethite is higher. From this, it is suggested that the free iron is contained as hematite in the soils on the older terraces, whereas as goethite in the soils on the younger terraces.

Climate conditions in the Nansei Shoto at pre-

* Department of Natural Sciences, The Komazawa University. Komazawa 1-23-1, Setagayaku. Tokyo, 154 Japan

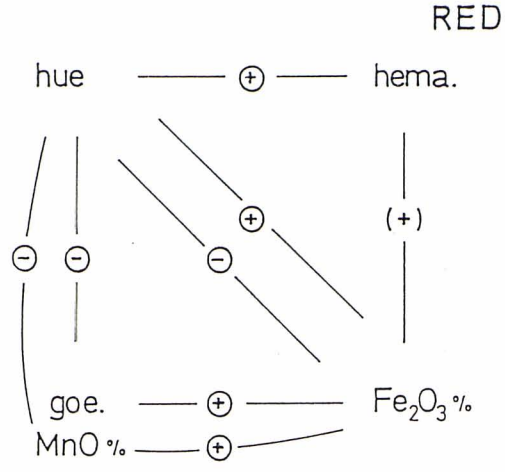

Figure 1. Relationship between hue and properties controlling the hue in the B_2 horizons in the Nansei Shoto.

sent are given by year climate for 1941-1970 by calculating water deficiency for each year based on the method by Thornthwaite (1948). The distribution shown in Fig. 2 reveals a tendency that the water deficiency is greater in the southern part of the Nansei Shoto. The high values of water deficiency in the Nansei Shoto occur in the years with scarce rainfall during the Baiu season, early summer rainy season, and with the infrequent typhoon visit during the months of August and September. If we calculate the normals of water deficiency by the mean values 1941-1970 based on the Thornthwaite's method, it is shown that the whole area of the Nansei Shoto is covered by 0 mm of water deficiency; which means a humid climate as a long-year mean state. However, in some years, there occur water deficiency and drought in the field of the limestone area formed by the uplifted coral reef. This will be dealt with in detail in the next part.

2. Red soils formed from limestone and agriculture

Taking an example from the Okinawa island located in the central part of Nansei Shoto, agricultural landuse is described with special regard to the soil groups. In the Okinawa island, there are four soil groups as shown in Fig. 3(a): (I) the reddish-yellow soil formed from the rocks excepting limestone. This is called «Kunigami-mâji». (II) Red soils formed from limestone. They are called «Shimajiri-mâji». (III) Bluish-brown «Jagar» formed from the Tertiary muddy rock. And (IV) alluvial soil.

Since frequency of drought occurrence is very high in the island in summer, sugar cane, which is

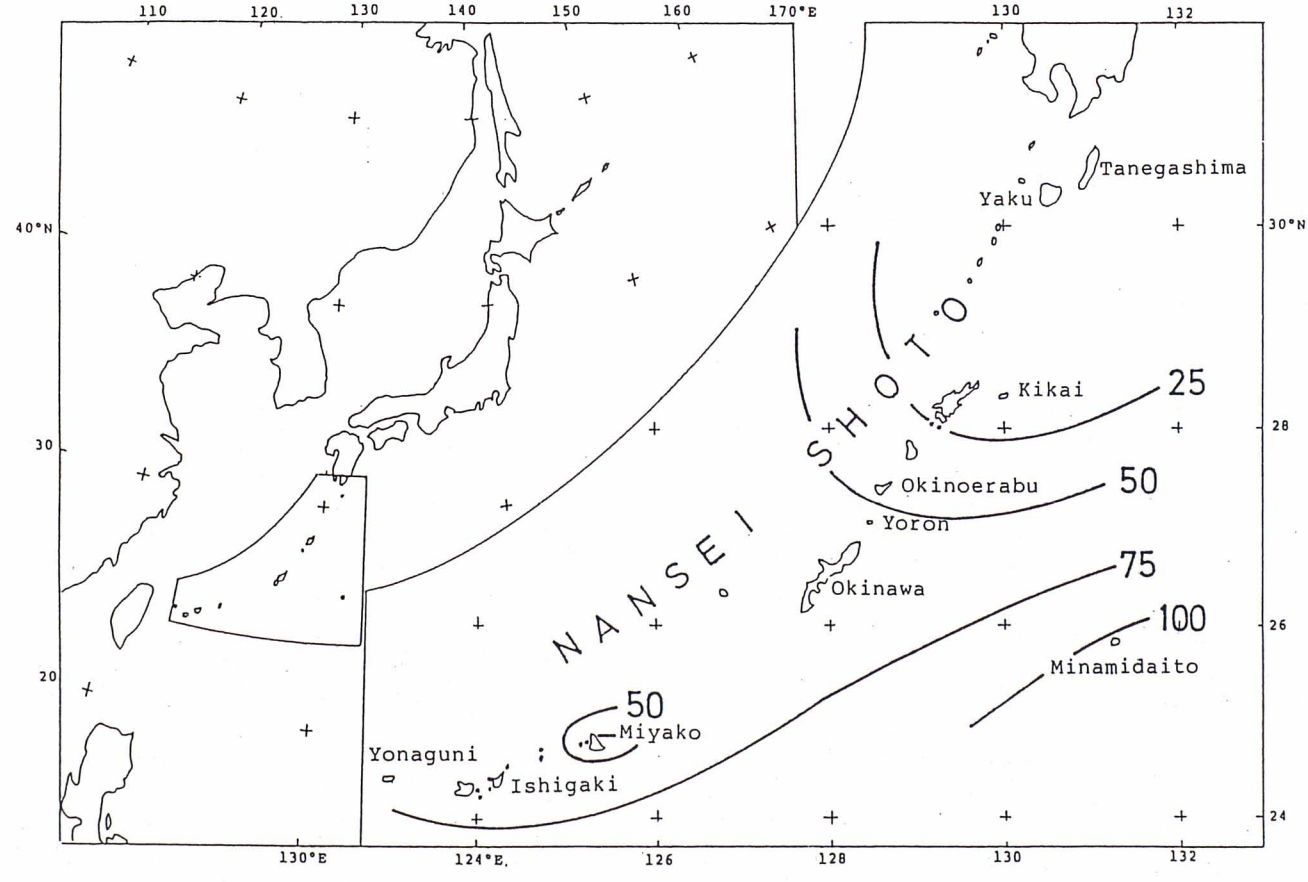

Figure 2. Distribution of water deficiency, d (mm), by the year climates during 1941-1970 around the Nansei Shoto.

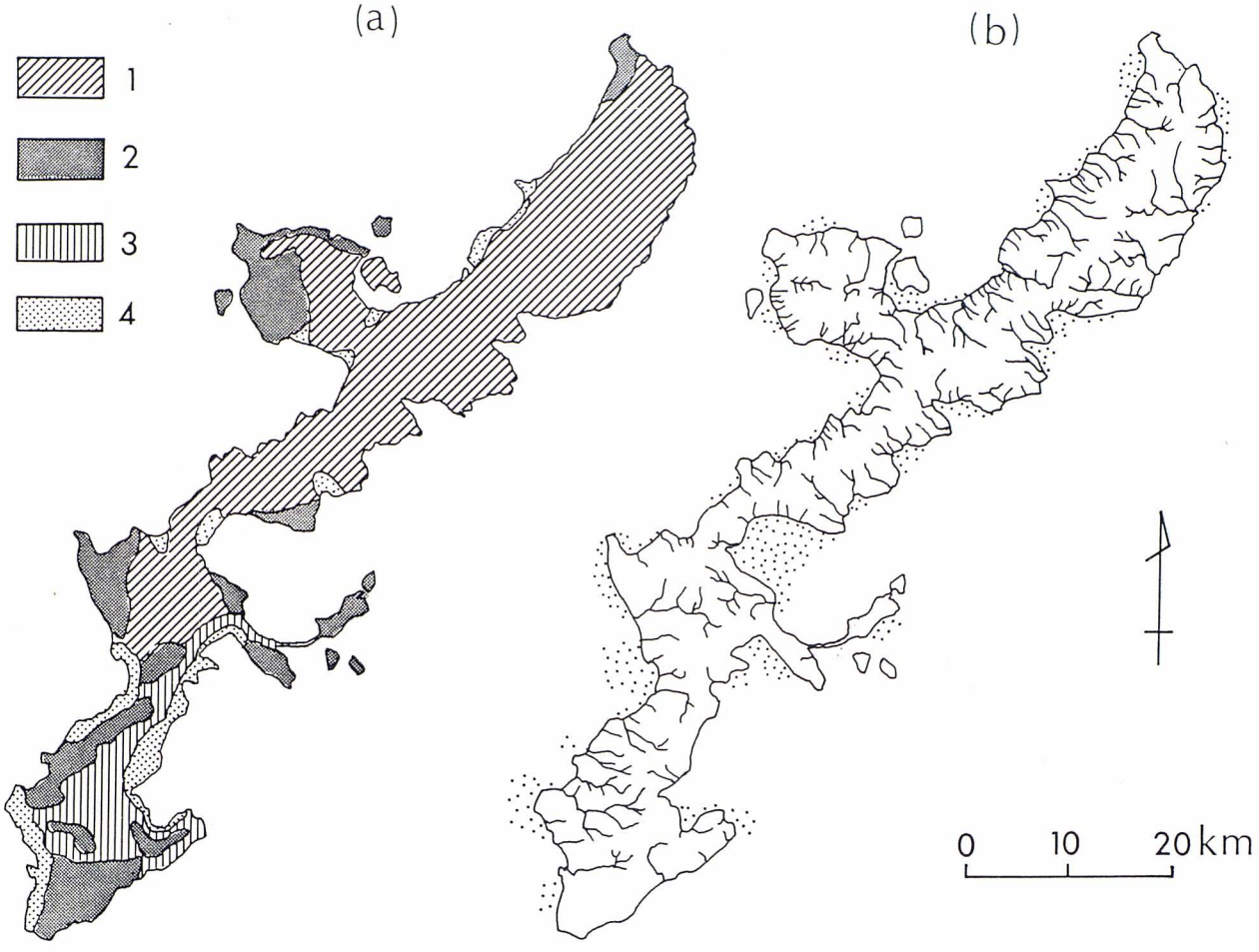

Figure 3. (a) Soil map of the Okinawa island (Okinawa Prefecture, 1978, modified by Urushibara)
1: Kunigami-mâji, 2: Shimajiri-mâji, 3: Jagar, 4: Alluvial soils and others.
(b) The distribution map of the areas where had be polluted with soils (Okinawa Prefecture, 1978).

stronger against drought, has been cultivated in the areas covered by the first three soil groups mentioned above. And rice, the main crops in Japan, cultivated in the area of alluvial soil for long years. However, the relationship between sugar cane yield and precipitation in the areas of each soil groups as shown in Fig. 4. Namely, the yield is the highest in the areas with Jagar, whenever precipitation is scarce or abundant in the summer months from May to September. These months include Baiu season, a rainy season in early summer, and typhoon season from late August to September.

It is said that the Kunigami-mâji is stronger for drought, but yield decreases sharply in the cases more precipitation. The fields in the areas covered by red soils formed from limestone, Karst areas, suffer from drought quite easily, but yield increases gradually up to some amount of precipitation. The Kunigami-mâji has low pH and soil layers are thick. Accordingly, the lower horizon has a higher density. This results in difficulty for drainage and decreases the yield when rainfall is abundant. Mean yield of sugar cane in the areas covered by Kunigami-mâji is 6.44 ton/10a. In this areas, acidophilous crops such as pinapple, tea, and citrus fruits are cultivated in addition to sugar cane.

Shimajiri-mâji in the Karst area shows weak acidity, but the thickness of the soil layer is relatively thin. This makes waterholding-power quite weak. In this connection, drought occurs frequently. Because of thin soil layer, introduction of machines is difficult. Mean yield of sugar cane is 5.07 ton/10a. Crops otherwise sugar cane are sweet potato, tabaco, etc., which have stronger resistance for drought.

Jagar is a weakly alkaline, heavy clay soil. It forms big soil blocks in the case of plowing and becomes very hard under the dry conditions. It is therefore very difficult to introduce machines from the viewpoint of physical features of soil texture. In spite of such unfavorable characteristics, yield of sugar cane in the fields of Jagar is higher; mean

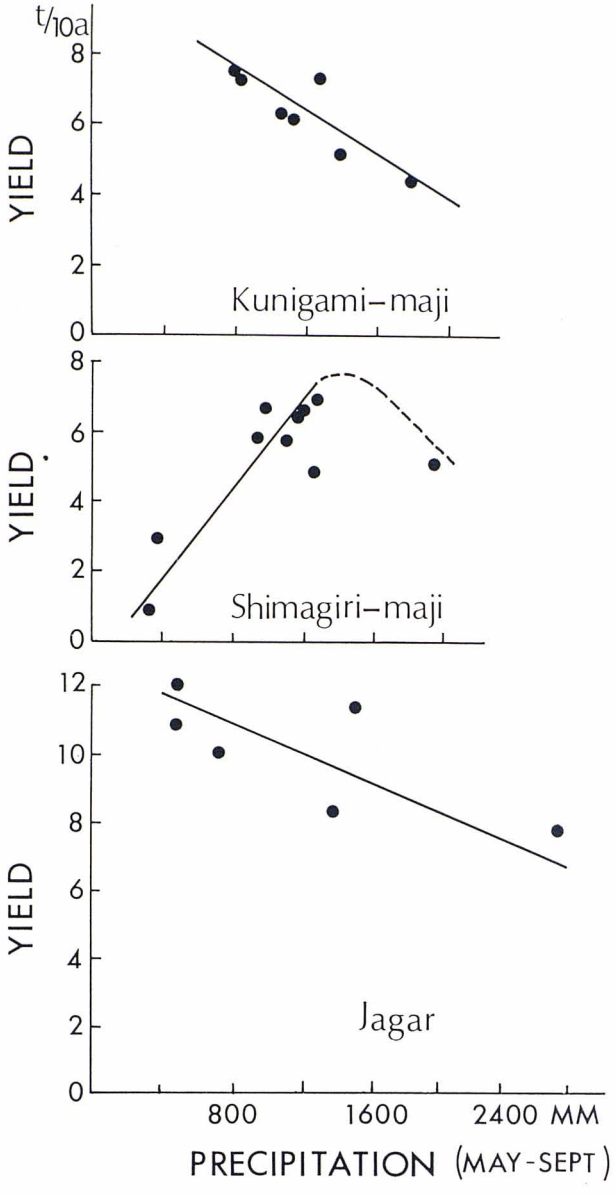

Figure 4. Relationship between yield of sugar canes and the precipitation from May to September (Okinawa Agricultural Cooperative Society, 1977).

yield is 9.64 ton/10a.

In 1950's, compost (artificial manure) was put in this area, but in 1960's, it changed to chemical manure mainly. Accordingly, it caused acidation and serious shortage of organic matters, microelements and available bacteria. Since the later half of 1970's, farmers have been reviving leguminous green manure and dung and urine from animal husbandry.

On the other hand, an attempt has been making to ameliorate soil which is weak to drought since the year about 1976. That is,weathered materials from Tertiary mud was mixed to Shimajiri-mâji in the limestone area where suffers frequently from drought, by the governmental support. These sequence is shown in Fig. 5. As a result, they have

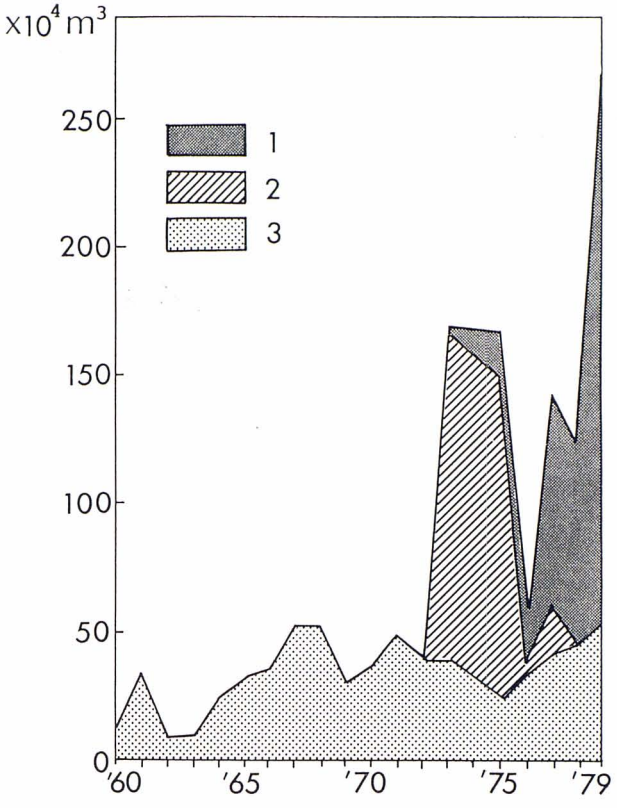

Figure 5. Variation of the estimated volume of transported soils (Mezaki, 1983).
1; caused by soil amelioration
2; from roads etc.
3; from pinapple fields

succeeded amelioration of soil texture and the yields are increasing. When Jagar was brought to improve Shimajiri-mâji, machines were used and the unit areas of the fields were broaden. Traditionally, the unit areas were small and the farmers built stone walls of limestone blocks along the hems of the fields. These way of cultivation protected the soil erosion and prevented the wash-out of soil. In 1980's, the improvement of Jagar into the soils formed from limestone is increasing conspicuously in the other islands in Nansei Shoto.

These result in the following problems: The amount of transported materials, such as sands, soils and muds, through the rivers in the Okinawa Island into the surrounding coast changed as shown in Fig. 5. It is clearly shown in this figure that soil erosion caused by enlarged pinapple fields in the Kunigami-mâji areas since 1960's, washed-out caused by the abrupt development of construction (mainly for Ocean-Expo) during 1972-1975, and washed-out caused by the soil improvement since 1976. The amount of washed-out materials caused by improvement of soils in the Shimajiri-mâji limestone areas is outstanding. These threaten coastal fishery and extinction of coral reef, even though the yields of sugar cane are increasing as a result of soil amelioration.

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