Distribution and Cropping System of Upland Farm Crops in Japan

By KANENORI NAKAYAMA

Upland Farming Division, Central Agricultural Experiment Station

Agriculture in Japan, located in the monsoon zone, had developed with lowland rice production as a core by utilizing plentiful irrigation water, and the upland farming had been regarded to be subordinate. However, in 1960, upland farming area reached 42% of the total arable land, about 6 million ha. The total area planted to upland farm crops (hereafter referred to upland crops) reached about 3.5 million ha, which corresponded to the area cropped to lowland rice.

Although there were many kinds of crops grown as upland crops, such as fruit trees, tea, mulberry, vegetables, forage crops, industrial crops and food crops, the so-called common crops comprised of wheat, barley, sweet potato, potato and soybean, etc. constituted about 60% of the total area planted to upland crops. However, since 1960 great changes have occurred in upland cropping due to a rapid industrialization, rising living-standard and international trade liberalization: namely, the production increase of fruits, vegetables and forage crops and the decrease of common crops, leading a monoculture of selected crops. Such changes exerted great effects on the traditional farming methods, and induced the increased occurrence of diseases, insect pests and crop disasters. On the other hand, the use of chemical pesticides, chemical fertilizers and plastic materials has increased markedly. Reflecting on such a situation, a trend comes out recently to re-evaluate the traditional cropping system.

In the present paper, distribution and cropping system of common upland crops in 1950s, before the transition to industrialization, and the changes occurred thereafter will be described.

Kinds and distribution of upland crops

Although so many kinds of crops are grown, the major crops are as shown in Table 1. Most of the upland farms in Japan are of volcanic ash soil with high water-holding capacity. As annual precipitation is high, there is no place with precipitation less than 500 mm during a summer cropping season (May to September). Therefore the choice of upland crops is determined by the air-temperature.

Upland farms in Japan are distributed in areas with annual mean temperature ranging from 6° to 20°C. Soybean, azuki bean, kidney-bean, corn, and potato are grown throughout the country. But, in southern part of Japan with annual mean temperature higher than 13°C, grain legumes such as soybean suffer seriously from insect pests: lima-bean pod borer (*Etiella zinckenella* Treitschke), Soybean pod gall midge (*Asphondylia* sp.), bean bug (*Riptortus clavatus* Thunberg), common green stink bug (*Nezara antennata* Scott) etc., and corn suffers seriously from typhoon. As there are other suitable crops for that region, the cropping area of grain legumes and corn is relatively small. In area with the temperature above 15°C potato is planted after October as a winter crop.

Sugarbeet is grown in Hokkaido where the temperature is lower than 8°C and the upland farm acreage is great, because disease

Table 1. Distribution of upland farm crops

Region		Hokkaido	Northern part of main land	South from central part of main land
Annual mean temperature (°C)		8>	8~13	13~18
Frost-free period (days)		130~150	160~170	170<
Annual precipitation (mm)		800~1, 200	1, 200~1, 300	1, 300~2, 500
Summer crops	Upland rice	×	○	◯
	Corn	◯	◯	○
	Soybean	◯	◯	○
	Azuki bean	◯	○	○
	Kidney bean	◯	○	○
	Groundnut	×	△	◯
	Potato	◯	◯	○*
	Sweet potato	×	×	◯
	Sugar beet	◯	×	×
Winter crops	Wheat	◯	◯	◯
	Barley	×	△	◯
	Rapeseed	△	○	○

Notes: * Cropped as a winter crop in the area with annual mean temperature above 15°C.
◯ Abundant
○ Few
△ Extremely few
× Not cropped

occurrence is few there and a certain size of production unit is required for processing. On the other hand, upland rice, groundnut, and sweet potato are grown abundantly in areas with the temperature above 13°C. However, upland rice requires more than 150 mm of precipitation during a one-month period before heading, and hence its cultivation is limited even in the warm region. In addition, sugarcane is a main crop in Okinawa Islands with the temperature above 18°C.

As winter crops, wheat, barley, and rapeseed are most popular. Wheat is grown throughout the country whereas barley and rapeseed are abundant in areas with temperature above 8°C. In the area with temperature above 15°C, harvesting time (May–June) of winter crops is rainy so that diseases occur with wheat, barley and rapeseed. Therefore, that area is not regarded as suitable to these crops, but they are grown for the purpose of increasing land utilization intensity. Furthermore, snow cover gives a great influence on winter crops. They are hardly cropped in areas with more than 100 cm of maximum depth of snow cover and more than 120 days of continuous snow coverage (often observed in northern Japan).

The above is the distribution of common upland crops and factors determining it. However, varietal improvement and new production technology have enabled wider choice of crops. For example, the use of upland irrigation facilities enabled the cropping of upland rice to warm areas with frequent drought occurrence, and even the cropping of lowland rice varieties with grain yields more than 4 tons/ha. The use of early varieties and mulching by plastic films enabled the stable production of upland rice and groundnut even in cool areas with temperature of 10–13°C. Particularly the large-grain hybrid of groundnut between Spanish type and Virginian type can reduce largely the growing duration of the crop, and is contributing to the expansion of cropping area of the crop.

Cropping system

The cropping system varies with different regions, because it is determined mainly by seasonal adaptability specific to each crops, natural conditions, farm management factors such as size of holdings and labor availability, and maintaining of soil fertility. However, it can be classified basically into two types: northern type and southern type.

1) Cropping system in northern Japan

In Hokkaido, annual mean temperature is lower than 8°C, with only 130–150 days of frost-free period. Summer crops are sown in May (10–11°C), and harvested in September (15–16°C), while wheat is sown in September and harvested in the beginning of August (20°C), thus resulting in one crop a year.

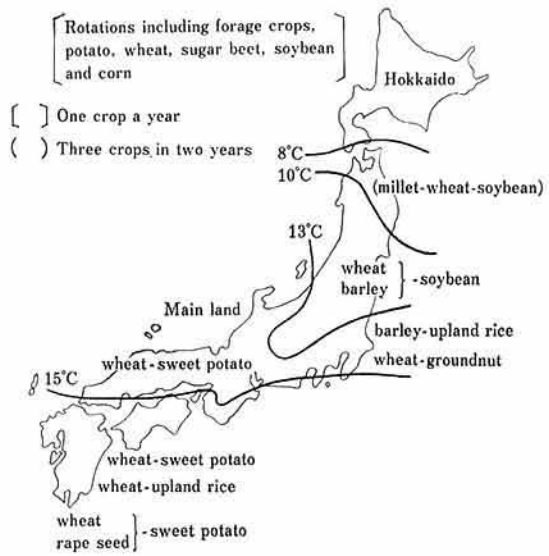

Fig. 1. Units of crop combination in each region

Average holding is about 20 ha, which is larger than the national average. Consequently it has been a key point how to save farm labor and input materials, and how to utilize the land after the harvest of preceeding crops as a measure to maintain soil fertility. Thus, the crop rotation has been adopted. Leguminous crops carry out nitrogen fixation, sugarbeet, potato, and forage crops require deep tillage, and wheat, corn, and graminous forage crops supply organic matter to soil: each crop has its own role in the soil fertility maintenance. Based on this, the following rotations have been practiced:

$$\left.\begin{matrix}\text{Oat}\\ \text{Forage Crop}\end{matrix}\right\} - \text{forage crop} - \text{forage crop} - \text{azukibean} - \text{sugarbeet} - \text{potato},$$

Potato – wheat – sugarbeet – corn – soybean (azukibean, kidney bean)

Introduction of forage crops such as orchardgrass in the rotation is effective in increasing soil fertility, in alleviating cold damage of grain legumes occurring frequently in this region, and also in distributing labor. In recent years, however, the combination of common crops and forage crops became less popular, because farm management was separated into common crop farming and dairy due to the use of large-scaled machines and facilities, and also because the labor-saving cultivation of common crops was made possible by the use of machines. Furthermore, due to the fact that prices of machines are high, and different crops require different harvesting machines the rotation system has been simplified, including only 2–3 crops to which the same harvester can be used commonly. As a result, the rotation system based on the soil fertility maintenance is now disappearing.

In an area with annual temperature of 8–13°C in northern Japan, a rotation system consisted of three crops per two years, millet—wheat (or barley)—soybean, had been practiced. At present, this system still remains, being modified by the use of forage turnip in place of millet, but only to a small extent. In this rotation, soybean is intercropped between rows of wheat or barley. This inter-cropping is an application of the cropping method practiced in southern Japan, that will be described later. Other summer crops are grown as one crop a year, and although there is no definite cropping sequence as observed in Hokkaido, rotational croppings are made by considering the soil fertility maintenance.

2) Cropping system in southern Japan

In the warm region with annual mean temperature above 13°C, two crops (a summer crop combined with a winter crop) are grown a year. Wheat and barley are sown in November–December (10–14°C) and harvested in May–June (20°C). Many of summer crops are sown in May, mostly inter-cropped between rows of wheat and barley, and harvested in October. Distance between rows is 60–70 cm for both summer and winter crops, and the period of inter-cropping is about 1 month.

In the region with two crops a year, there is no long term rotation, but the combination of a summer crop and a winter crop makes an unit of rotation. Because a winter cropping is always made and summer crops are liable to be suffered from drought (e.g. upland rice), insect pests (e.g. soybean) and typhoon (e.g. corn) etc, resulting in the location specific choice of crops, the unit of summer–winter crop combination most adapted to each location has been maintained. The background for that practice is the small holdings, 1–2 ha, and the necessity to maximize land utilization.

In area adapted to the combination of barley–upland rice, this type of rotation is practiced for 1–2 years, and then another unit of combination, wheat—groundnut, is adopted to avoid the damage of upland rice due to continuous cropping. Thus, the whole rotation system comes to be barley – upland rice – barley – upland rice – wheat – groundnut.

Such characteristic croppings have been supported by the plentiful supply of compost. Most of the common crops grown in this area produce 3–4 ton (air-dry weight)/ha of leaves and stems. These plant residues, together with undergrowing weeds and straws taken from riceland, are used as materials for compost to be applied to upland farms. The compost is usually incorporated into soil prior to the planting of winter crops after the harvest of summer crops.

The above cropping system in southern Japan, i.e., two crops a year with inter-cropping and heavy application of compost, has been derived from the farming by the use of hoe, observed in the East Asia, and is specific to humid zones with high temperature, in contrast to the farming system in arid and cool northern Europe.

However, since 1960s, cropping of vegetables has increased to offer more farm income, resulting in a decrease of common crop acreage. Cropping of wheat and barley has also markedly decreased, because the inter-cropping inhibits the farm mechanization. As a result, cropping system has changed toward simplification, centering on vegetable production. Compost application is also decreased due to the shortage of compost materials and labor availability.

Future research problems

1) An increased dependence on chemical fertilizers and severe outbreak of diseases and insect pests, associated with the collapse of traditional farming system, has raised a question on the significance of soil fertility.
2) Various damages occur by continuous cropping resulted from the simplification of cropping system. It is required to elucidate the damages by continuous cropping.
3) Methods to utilize animal excreta and industrial organic wastes in supplementing organic manures have to be developed.
4) To make it possible to sow summer crops after the harvest of winter crops, early-maturing varieties of wheat, barley, and summer crops have to be developed in the two crops a year region.
5) In the two crops a year region, machines adapted to its intensive cropping system, particularly harvesting machines, have to be developed urgently.

References

1) Iwasaki, K., Kodama, S. & Kinoshita, Y.: Researches on the cropping system of up-

land farming in the seven prefectures of Tohoku region. J. Agri. Sci. Conf. Tokyo (1958) [In Japanese].
2) Nakayama, K. & Ozaki, K.: Investigating studies on the cropping system of ordinary upland farm area in Kanto district. *J. Cent. Agr. Exp. Sta.* 11, 85–144 (1967) [In Japanese with English summary].
3) Ozaki, K.: Studies on the crop rotations in Hokkaido, especially on the factors affecting the cropping sequence in rotation. *Bull. Hokkaido Agr. Exp. Sta.* No. 74, 1–158 (1969) [In Japanese with English summary].