Gokoku-imo	Genki × Shichifuku	1938	2477	20.3	light brown	light yellow	food and starch
Norin No. 1	Genki × Shichifuku	1942	2405	22.1	red brown	yellw white	food
Norin No. 2	Toshida × Okinawa No. 100	1942	2573	22.1	yellow white	light yellow	starch
Tamayutaka	Kanto No. 33 × Kanto No. 19	1960	3343	21.0	light pink	yellow white	starch
Konasengan	Kanto No. 33 × Norin No. 1	1962	2862	23.6	light brown	light yellow	starch
Koganesengan	Kakei 7-120 × L-4-5	1965	3490	27.6	light yellow	light yellow	starch

Note. Data were obtained from the yield test under standard Cultivation in Chiba Breeding center, except Kogane sengan and Genji which were obtained from data in Kumamoto Breeding Center.

Irrigated Land Agiculture in Japan

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Histiorical Review.

The history of the irrigated agriculture on the field in Japan is young. The smallest scale irrigated agriculture has been practised by the vegetable producers in the suburb for the last five hundred years but those cases were not many.

Since the Meiji era the European agricultural technique and ideas have been introduced to Japan and affected the field crop management, nevertheless the development in field irrigation lagged behind. The reason is that the paddy rice cultivation is the mainstay in Japan's agriculture and the stress was laid on the use of water for paddy field, moreover, such crops as mulberry, sweetpotatoes, barley and soybeans which are hardly susceptible from water shortage in the soil have been cultivated on the field.

Total yearly precipitation in the main irrigated agricultural areas in the world is less than six hundred millimeters, but in Japan it is from fifteen hundred to thirty hundred millimeters which belongs to humid-wet zone by Klage's geological classification, so it was small wonder that the Japanese took it for granted that the field crops would grow well with natural rainfall without vast expenditure on irrigation projects.

The areas which have total yearly rainfall of over one thousand millimeters are those between the northern and southern twenty degrees latitude; eastern United States, Canadian Pacific coast, England, Norway, East India, Burma, Middle and South China, Japan, Korea, Formosa, Caribbean coast, the Peninsula, Eastern Australia, New Zealand and Middle and South Chili, which occupy about twenty five percent of the land in the world.

The land where the irrigated agriculture is practised among these areas is the eastern United States, and other few countries like Japan or Formosa have primitive irrigated agriculture.

Irrigated agriculture in the eastern United States has developed on vegetable crops and dairy farming, which is practised in smaller scale compared to that of the western United States because the irrigation project is scheduled independently by each farm. But accord-

ing to the 1950's U. S. census, single farm irrigation reached ninety percent of the field irrigation project and the total irrigated areas equaled to that of the big field irrigation in the western United States, which shows the importance of the field irrigation even in the humid-wet zone.

The field irrigation in old Japan has been practised locally in small scale in well pumping fashion. However, it was rather exceptional and not extensively practised. It is natural that the field irrigation has not been practical because the rice cultivation was the mainstay of Japan's agriculture and the field main crops were mulberries, sweet potatoes, barley and soybeans. And there was little progress in the field irrigation in Japan for several years after the World War II when she had to concentrate on the increased staple food production like rice, barley and sweet potatoes.

There was now a new movement in Japanese agriculture motivated by agricultural land emancipation and active agricultural technical renovation. Six or seven years after the war the irrigation project was still directed toward rice cultivation and the project or technique on the field irrigation was barely emergent, while the national field irrigation project was launched in Kanagawa and Aichi, and a few experiment stations began the experiment on the field irrigation. The small scale well irrigation farming has been practised by the farmers on the upland rice and vegetables, but the management was still unstable.

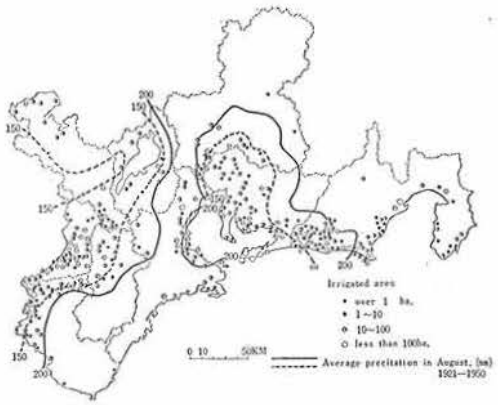


Fig. 1 Irrigated upland field areas in Tokai-kinki by 1960's agricultural census.

The reason why the field irrigation project which had little progress for six or seven years after the war has accelerated its rapid development from 1952 is due to the subsidies by the government toward the big irrigation projects. Many big field irrigation projects were on schedule in 1955 all over Japan, especially in the western district from Kanto Plain, where the upland rice, vegetables and fruits trees (mainly tangerine) are cultivated and the main purpose was for alleviating the damages from drought.

An illustration in Figure 1 by 1960's census shows the fact of the field irrigation in Tokai-kinki district that the total number of the irrigation plot is about three hundred, half of which were after 1956 when the field irrigation project began.

Generally these irrigation districts are small in their scale and only eight out of three hundred are over one hundred hectares.

The field irrigation is generally small scaled all over Japan, and resembles to that of eastern United States which also belongs to the humid-wet zone.

Fig. 2 Field irrigation project in Japan. The figures in the circle are in 100 ha units.

The reason why the scale is small in these areas is that first of all crops usually need no irrigation and it is only a few which need it, and secondly, the grade necessity of irrigation differs locally due to the differences in soil, topography and rainfall and it is only recent that we have such big irrigation projects covering over one thousand hectares, such as the Aichi Project (11,500 ha.), Toyokawa Project (9,500 ha.) and Sagamihara Project (3,000 ha.).

The reason why such big projects came to be realized in Japan is that the paddy field and upland field are mixed in Japan, where small scaled irrigation is practical if we use it only for the upland field, but we have to consider to use it in coordination of paddy field now as the result of the recent big irrigation project.

Technical conditions for the field irrigation

In field irrigation in Japan, we have to take into consideration the following conditions; rainfall, soil and crops. Because Japan belongs to the humid-wet zone, she has rainfall over fifteen hundred millimeters in some areas, and still she suffers from drought from time to time because the distribution of the rainfall is not even. Besides, daily pan-evaporation shows five to six millimeters in summer and two to three millimeters in winter in the middle and south districts in Japan, therefore they suffer from drought as the rainfall distribution in summer in irregular.

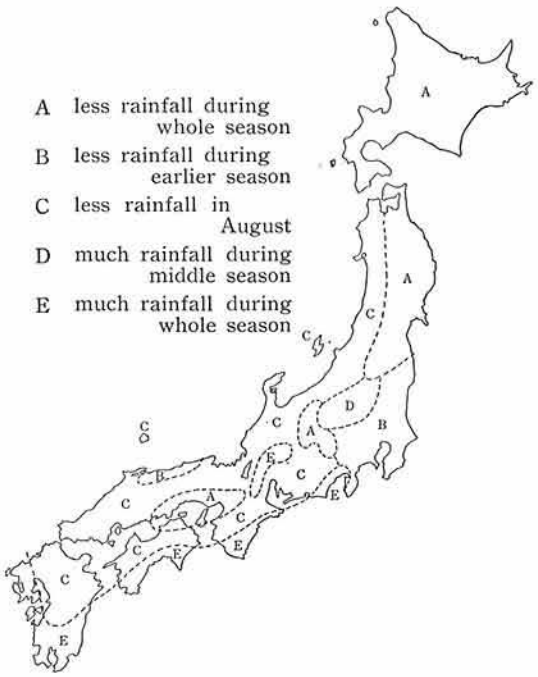


Fig. 3 District classification by the rainfall distribution during summer crop season from May to October.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Assumed daily water requirement (*mm*)	3	3	3	4	5	5	6	6	5	4	3	3
Available rainfall ratio (%)	62	73	67	66	63	50	53	52	49	56	67	68

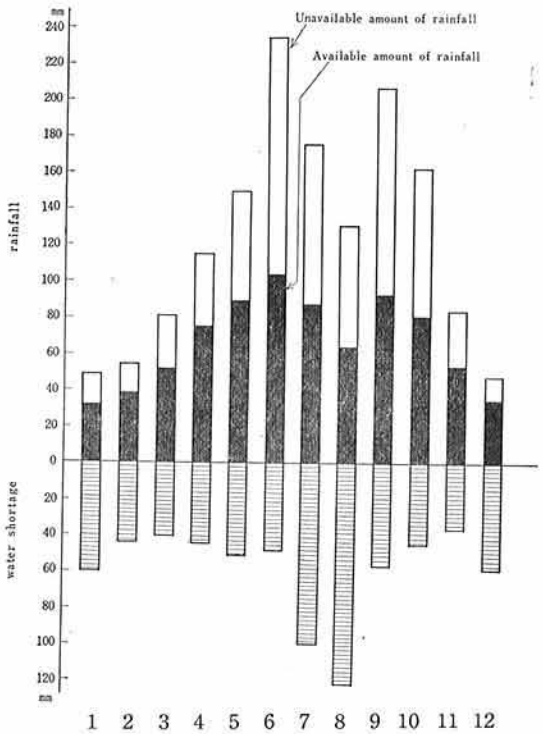


Fig 4 Rainfall distribution in Taketoyo, Aichi pref. Japan. (1963-1966)

The district classification according to the rainfall distribution is summer shows in Figure 3 that in general there are many districts where the rainfall in August is scarce (C). Typical illustration of the C district is in Figure 4 and available ratio of the rainfall from June to September is about fifty percent, and it hardly reaches sixty percent through

the year around. In this district want of water totals one hundred millimeters in July and one hundred and twenty millimeters in August, which shows that daily want of water amount is three to four millimeters. Such low availability of the rainfall is all the more reason why Japan needs field irrigation.

Heavy rainfall in rainny season or with typhoon causes soil erosion on the sloping field of over five degree which occupy forty-five percent of the field and results in shallow plowing soil with poor water holding capacity, which is another reason why Japan needs field irrigation.

The district classification according to the water holding capacity of the soil shows in Figure 5 that not speaking of those sandy, clayey mineral soil which have poor available water holding capacity, even the volcanic soil which has rich water holding capacity sometimes needs the field irrigation where topography causes shallow plowing soil.

Historically, the necessity of the field irrigation was determined more by the kind of crops or from other economical reasons rather than such natural conditions like rainfall or soil.

When the field irrigation began in Japan after the World War II, the main crops for irrigation were the upland rice and taroes then tomatoes, cucumber, watermelon, forage crops, tangerine and grapes were added. At present vegetables and fruits are the main crops for irrigation and they differ in their degree of necessity according to their kind and growing season, therefore we have to pay due consideration when we irrigate.

Because our district is in humid-wet zone in general it is not necessary to irrigate all through its growing season but only for some definite period although this is not fixed depending upon the particular year or the location.

Availble water of the soils.

location	soil type	field capacity	wilting coefficient	available water
Konosu Saitama	Volcanic soil	43	22	21
Ishioka, Ibaragi	〃	42	19	23
Matsuura, Nagasaki	Mineral soil	24	10	14
Taketoyo, Aichi	〃	18	8	10
Yamagata	Sandy soil	11	4	7
Tottori	〃	6	2	4

(volume %)

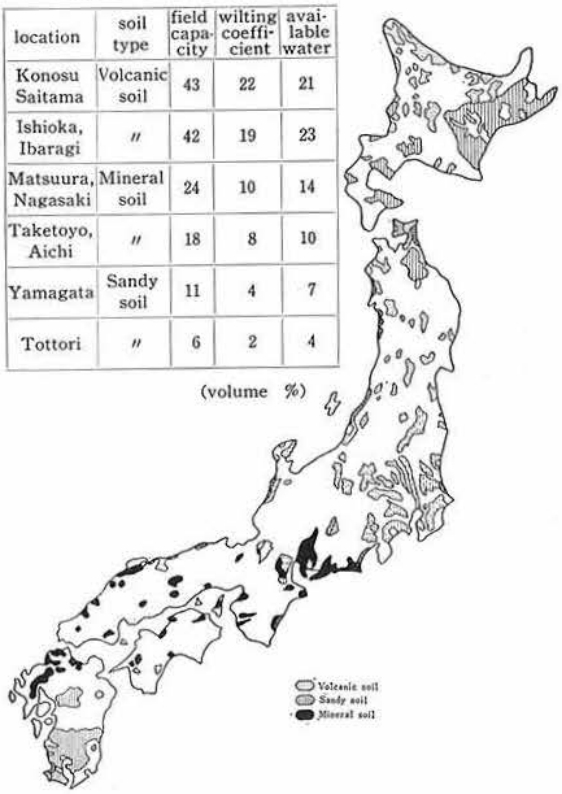
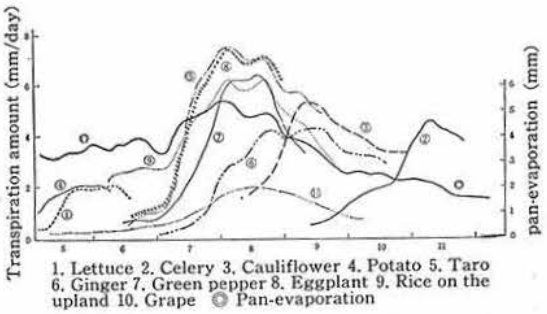


Fig. 5 Main soil types of the upland field in Japan



1. Lettuce 2. Celery 3. Cauliflower 4. Potato 5. Taro 6. Ginger 7. Green pepper 8. Eggplant 9. Rice on the upland 10. Grape ◎ Pan-evaporation

Fig. 6 Transpiration amount of the vegetables.

Fig. 6 shows the water consumption pattern of some vegetables which need irrigation and we have to pay carefull consideration in determining the period, interval and water amount of irrigation in accordance with the characteristics of these crops.

Irrigation practice and its effect

In Japan there are various kinds of irrigation practice. The field irrigation which had been practised on the vegetable crops locally and in small scale before the World War II was the furrow irrigation, letting in well water by the wind mill pumping or by carrying pail water.

Big scaled irrigation project after the war still practised the furrow irrigation until 1955. (Sagamihara Field Irrigation District).

Since then the method was altered from the furrow to the sprinkler irrigation. Why is it that such flood irrigation practices as the furrow, border, basin and corrugation which are widely practised on the field all through the world has not been adopted as the Japan's field irrigation practice?

The first reason is that she has much sloped land, i.e., twenty six percent of the land is with five to fifteen degrees steep gradient nineteen-percent, with over fifteen degrees gradient. The second is that she has shallow plowing soil which has poor water holding capacity and easily erosive from over irrigation. Thirdly poor land preparation and distribution which makes the flood irrigation unsuitable, and the technique of streaming or introducing water from the canal was immature.

The latest field irrigation practice uses sprinkler irrigation mostly, therefore pressed water is delivered through the pipe and many sprinkler methods have been developed.

At first the splinkler type of "Rainbird No. 30" which is portable was much used and recently the nozzle has become larger, pipe of which is fixed on or under the ground. Especially it is much used in the orchard.

No. 30 type sprinklers are still being used on the ordinary field and since the big sprinklers like "Furrow Gun" has been introduced, bigger types seem to be preferred.

Besides the above many sprinkler equipment as nursery bed sprinkler, "Perforain" "Ozzo", to fulfill particular purposes have been introduced. Thus the irrigation practice is making rapid progress, but Japan still has young history of field irrigation and is immature in its practice.

There are a great many kind of crops for irrigation and the effect varies.

Figure 7 shows the yield increase by irrigation in the last fifteen years in Japan, indicating that the irrigation effect differs even on the identical crop. It is one of the unique features of Japan's field irrigation agriculture that the irrigation effect remarkably differs depending on the kind of crops, soil type, meteorological conditions of that year and cultural practice, as well as the general characteristics of the humid-wet zone.

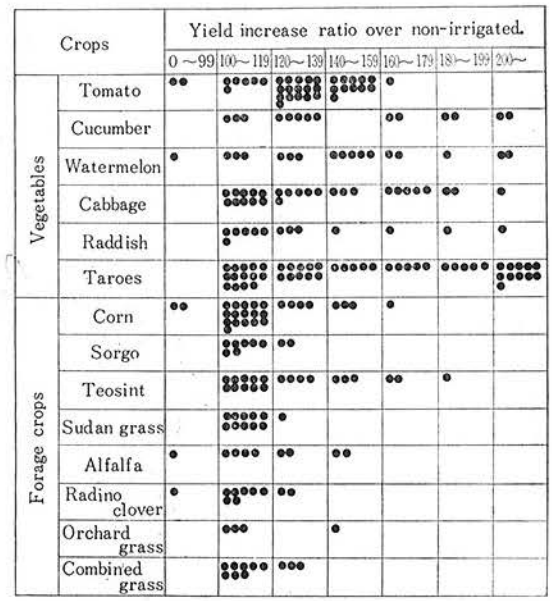


Fig. 7 Crop yield increase by the irrigation.

Performance of Reaper

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Kind of reaper

There are 4 kinds of grain harvester, windrower, dropper, binder and harvester-thresher combine. The first three are called reaper and the last called combine which is not usually classified into reaper in the limited