Hydro-Climatological Features of the Tone River Basin, Central Japan

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INTRODUCTION

Summers of Japan are composed of two unlike seasons, the early summer rainy period known as the Baiu season and the following rainless period. In Central Japan the former lasts for a month from mid-June to mid-July, the latter for some forty days from mid-June to the end of August (Maejima, 1961, 1967). Precipitation during the Baiu season plays an important role in the water supply for crop cultivation during the summer months. Therefore, smaller amount of rainfall in the Baiu season and the following prolonged dry spells of midsummer cause great damage to crops of upland fields, and even to irrigated paddy fields. This dry period exerts a profound influence upon not only agriculture but also on water supplies for domestic and industrial use, and hydroelectric power (Fukui, 1964). The region with an unstable climate which is defined by the standard deviation of occurrence frequency of arid month is closely related to the region which is liable to suffer from summer drought (Yazawa, 1964).

In the middle and lower parts of the Tone River Basin, the wide upland field area frequently suffers from droughts of midsummer lasting for about twenty to thirty days, whereas the area is designated "humid subtropical climate" (Cfa) without an arid month. The purpose here will be to examine the hydro-climatological features, average conditions and year-to-year variations, of the area concerned as expressed in terms of three water balance parameters: soil moisture utilization, soil moisture storage and water deficiency.

AVERAGE WATER BALANCE

According to Thornthwaite's method (1948), water surplus and water deficiency may be evaluated in terms of precipitation, potential evapotranspiration, actual evapotranspiration, and soil moisture storage. Here, maximum storage of soil moisture is also assumed as 100 mm. The data of monthly temperature and precipitation were collected from 54 meteorological stations for ten years from 1951 to 1960.

In this area annual precipitation ranges from 1200 mm in the middle part to 2000 mm in the mountainous area of the uppermost part of the river basin. In general, the primary maximum in the seasonal variation of the mean monthly precipitation occurs in September or October, and the secondary maximum in June. However, a single maximum for July or August occurs within the restricted area in which the rainfall due to thunderstorms amount to a considerable amount during midsummer. On the other hand, mean monthly temperature peak occurs in August, which ranges

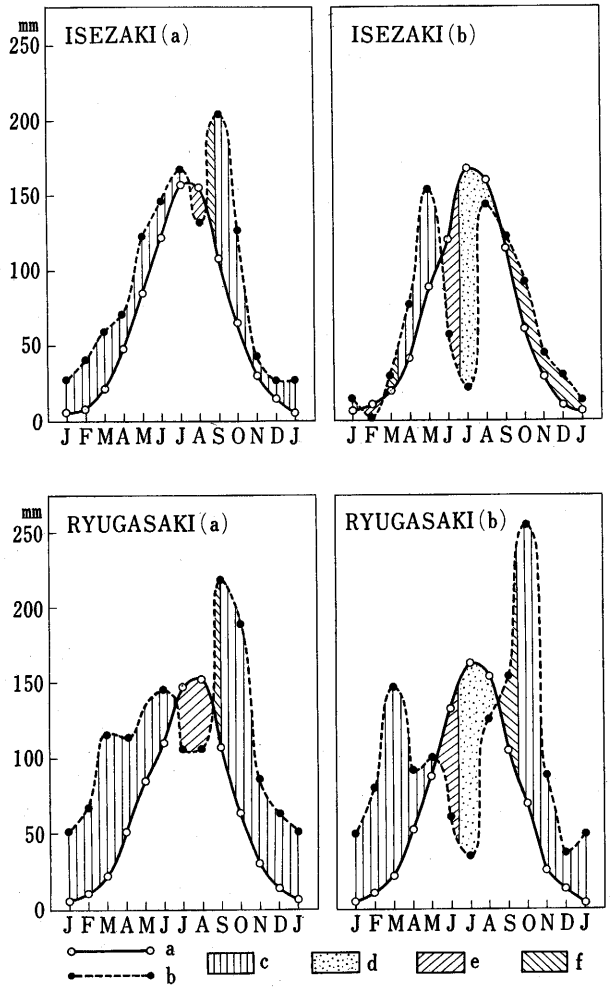

Fig. 1 March of precipitation and potential evapotranspiration for Isezaki and Ryugasaki.

Left graphs indicate average values for 1951-1960.
Right graphs indicate the marches in 1960 for Isezaki and in 1955 for Ryugasaki.

a: Potential evapotraspiration
b: Precipitation
c: Water surplus
d: Water deficiency
e: Soil moisture utilization
f: Soil moisture recharge

from 18° in the mountainous area to 26°C in the middle part of the basin.

By means of "bookkeeping procedures", using mean monthly values, no water deficiency occurs throughout the area in each month. In some places soil moisture utilization is recognized in July and August. In this respect it is true that the area concerned is classified "humid subtropical" (Fig. 1).

The area with soil moisture utilization occupies the middle and lower parts of the river basin, which is greater in August than in July. Also the amount of soil moisture utilization is greater in August than in July, and it increases toward the lower course, but the maximum amount occurs about 60km up river from the estua-

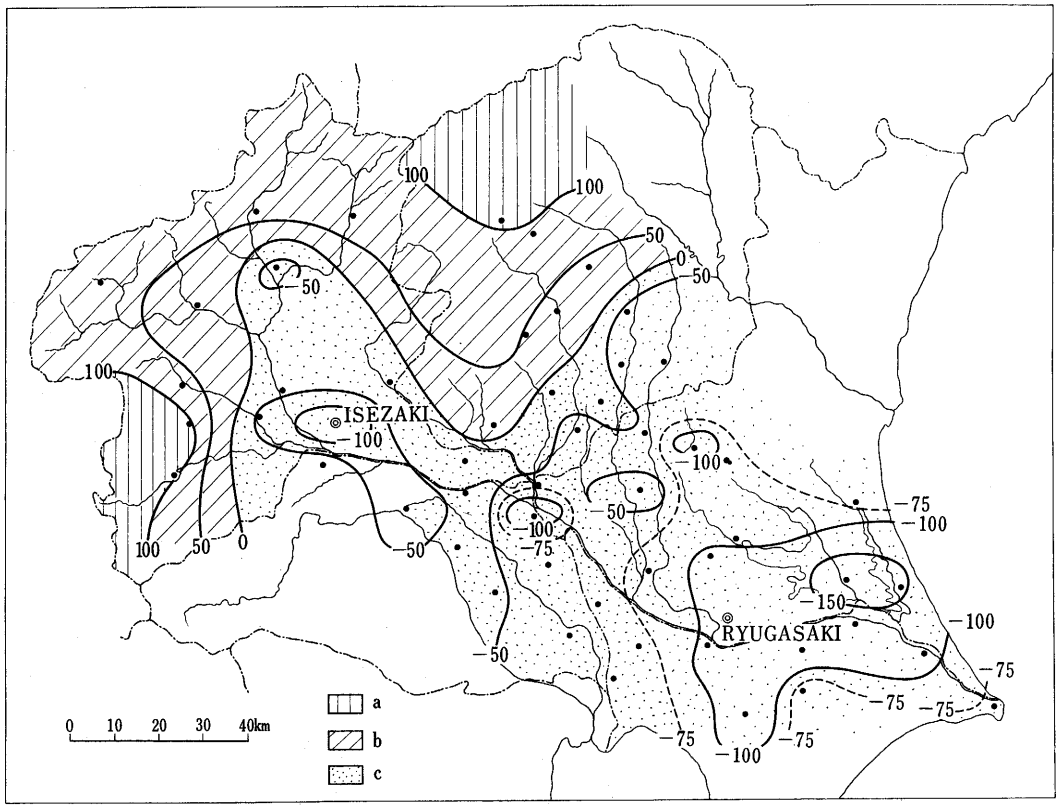

Fig. 2 Average monthly value of soil moisture storage (mm).

a: Water surplus b: Soil moisture utilization

ry, reaching 90mm, then decreases to the coast (Fig. 2).

In July, the maximum appears at the same place and the distribution pattern of the amount of soil moisture utilization is, in general, similar to that for August. But the area with soil moisture utilization is reduced to the lower course, 50km down stream from the boundary for August. The maximum amount of soil moisture utilization in the area is only 40mm. However, average conditions do not indicate the actual weather conditions of midsummer in this area, because the year-to-year variations of monthly precipitation during the summer months are considerably great.

YEAR-TO-YEAR VARIATION OF WATER BALANCE

Based on the potential evapotranspiration estimated by monthly temperature and precipitation, balance sheets of moisture conditions were prepared for each year from 1951 to 1960. Though no water deficiency occurs, as considered from average values, water deficiency frequently occurs during the summer half of the year, especially in July and August. For the period concerned, soil moisture utili-

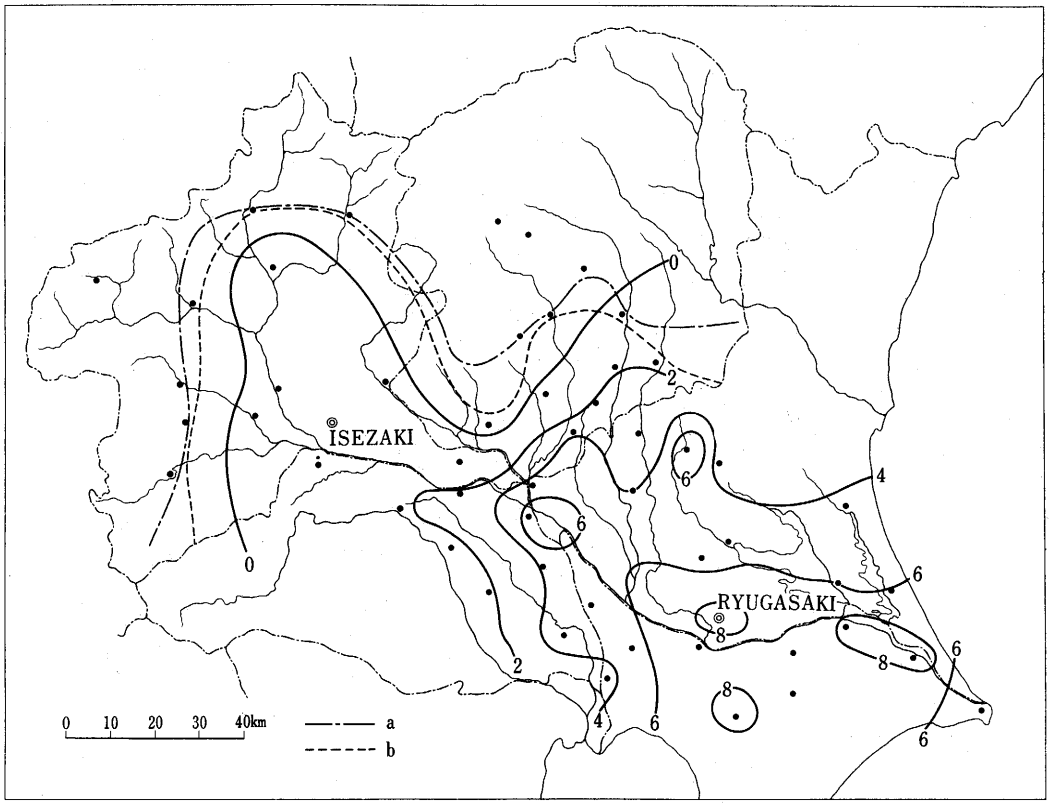

Fig. 3 Occurrence frequency of water deficiency for August.

a: Isopleth of frequency=0 for July
b: Isopleth of frequency=0 for September

zation also occurs during the seasons excluding summer. But it takes place more frequently during the summer half of the year, and it is more acute than in winter.

Fig. 3 shows the frequency of occurrence of water deficiency in August for 1951-1960. In the upper part water deficiency does not take place, while it occurred five to nine times out of ten years in the lower part of the stream. The frequency of occurrence changes abruptly in the middle part of the stream. It is noted that the area where water deficiency tends to occur frequently is distinctly separated from the area where water deficiency does not occur. Within the restricted area in the lower course, water deficiency takes place almost every year. This fact indicates that the average water balance is hardly possible every year in the lower part of river basin.

Two isopleths are also drawn in Fig. 3, which indicate the occurrence frequency of water deficiency=0 for July and September respectively. These isopleths are situated near that of August. This means that the area without water deficiency is confined in the approximate extent during July, August and September. The distribution pattern of occurrence frequency in July and September is similar to that for August, but the frequency itself decreases generally and the maximum frequency

amounts to only five in a specific place in the area.

Water deficiency frequently occurs for two or more months continuously, and the extreme duration reached six months in 1960 in two places of the middle part. In the area with water deficiency for August, in general, the deficiency exists for two or more months in duration. Its frequency is three to four in the lower part. Moreover, water deficiency of three or more months duration appears two or three times out of ten years in the middle and lower parts of the river basin.

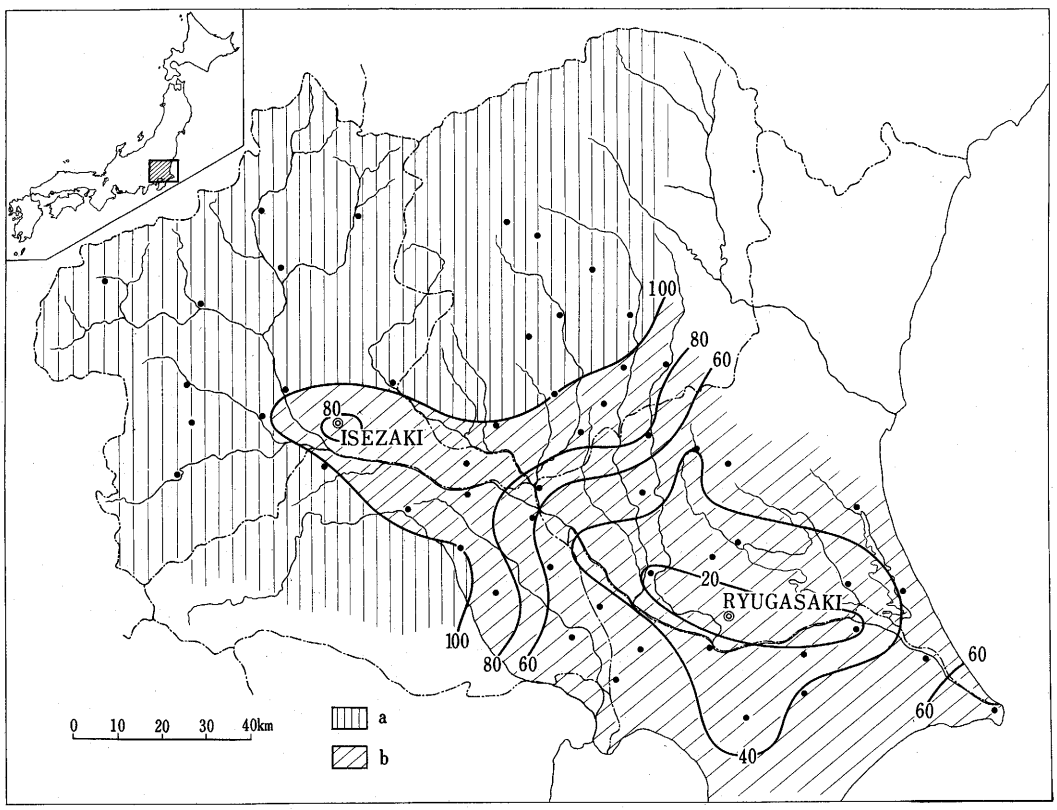

Fig. 4 Minimum soil moisture storage in August for 1951-1960 (mm).

a: Water surplus b: Soil moisture utilization
c: Water deficiency

The minimum value of soil moisture storage in August for 1951-1960 is shown in Fig. 4. The positive values indicate water surplus or soil moisture utilization, and the negative values water deficiency. It is noteworthy that the area with minimum soil moisture storage 0- -50mm occupies a narrow belt in the middle part, while the area under -50mm covers a wide extent throughout the middle and lower parts. The absolute minimum in the area is - 166mm near the coast. For July and September, though both absolute minima amount to - 130mm, the distribution is similar to that of August in spatial pattern.

For the period 1951-1960 severe summer drought took place in 1952, 1955 and 1960. Seriously damaged area roughly coincides with that with soil moisture storage of less than - 50mm in respective years. As mentioned above, severe water defi-

ciency occurs in a definite area, where extensive damage is inflicted on crops. From the average water balance and the climatic type of the area it may be impossible to conjecture the frequent occurrences of water deficiency.

CONCLUSION

The climate of Central and Southwestern Japan is simply designated "humid subtropical" or "humid temperate". The abundant rainfall in summer has been commonly explained by the southwesterly monsoon. However, summer is subdivided into two seasons, rainy and dry from the weather-climatological point of view. In the latter season serious drought so frequently occurs that water supply for cultivation and civil use is deficient. The Tone River Basin affords a good example for frequent drought of midsummer of Japan. Excluding Northern Japan, the areas with mean monthly precipitation of less than 150mm or so in August are similar to the area treated here concerning the features of summer drought.

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