Regional Approach on the Areal Differentiation of Agrar Land-Use Pattern in the Yonezawa Basin

Hydrography and Irrigation Systems in the Yonezawa Basin

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I. Hydrography

The Yonezawa Basin, one of the kettle depressions in the Northeastern Japan, is situated in the upstream drainage area of the Mogami River in Yamagata Prefecture. The basin plain is drained by the Matsu River and its tributaries belonging to the Mogami River drainage area which is originated from the northern flank of the Nishi-Azuma Volcano (2024 m) and runs in the basin plain from south to north. In the northern part of the plain, the Matsu River is joined by the Yoshino River in the northeast and it runs west in to the neighbouring basin of Nagai through the gorge of the northwestern corner of the Yonezawa Basin. In the Nagai Basin, the Matsu River is named Mogami River after it is joined by the Shira River and the No River. The tributaries of the Matsu River in the Yonezawa Basin are the Omono River, flowing into the basin from the southwestern corner of it and running northward to the west of Yonezawa city; the Haguro River, flowing into it from the southeastern corner and joinsing the Matsu River immediately north of Yonezawa city. The Matsu River built an alluvial fan called the Yonezawa fan in the southern margin of the basin together with the Omono River and the Haguro River. (Text-Fig. 1)

In the basin plain, the Matsu River and the Omono River are two major tributaries for irrigation and drainage, and for this reason, the banks of the two rivers have been well embanked in recent years, though not yet completed, to prevent the inundations from taking place in spring owing to the thawed mountain snow and in autumn to typhoons. The breadth of the river bed between the confronting levees is 200–500 m, with design flood of 1,100 m^3/sec in the Omono River and of 2,400 m^3/sec in the Matsu River. Along these levees the sluice-gates have been equipped for irrigation, (Pl. I, Figs. 1–5,) so river water is rather scanty during the agricultural season, except in case of floods. The river bed on both sides of the ordinary narrow stream channel, in other words, the land excluded from the levee protection, is usually left to wild bush of dwarf willows or marsh-reeds (Figs. 7, 8, 9, Pl. II) and it is prohibited to make fields for crop cultivation which can occasionally be seen in the river bed of the downstream tributaries of the Mogami River. But the scouring of the river bed may take place at the bare ground in the fields in case of flood and by this scouring the silt quantity of flood water may in-

crease and impede the river works in the downstream.

The downstream course of the Matsu River in the northern part of the basin, namely, the downward course from the join of the Omono River and the Yoshino River shows a remarkable free meander. Because of this meander and, in addition to this, of the narrow gorge at the outlet of the basin to the Nagai basin, the flood water is retarded and eventually causes inundations in the riverine zone and the lower part of the basin plain as a natural regulator of the flood water of the entire drainage system of the Mogami River at the cost of this area. Recently, by the short-cutting of the meander, the area, facilitating the the discharge of flood water, has become free from flood damages.

Deposits on the river bed of both rivers in the basin are gravels at each entrance to the basin. The size of the gravel on the bed of the Matsu River is larger than that of the Omono River. The diameter of large gravel grains of the former in general is 50–80 cm, while that of the latter is about 20 cm and the former seems to have been contributed mainly to the building of the Yonezawa alluvial fan. However, at the joinning point of both rivers, the diameter of the gravel decreases into 2 cm, at the more downward joining point of the Yoshino River to the Matsu River, the deposit altered into coarse sand and at the outlet of the basin into fine sand and silt.

II. The Peat marsh of Ooyachi

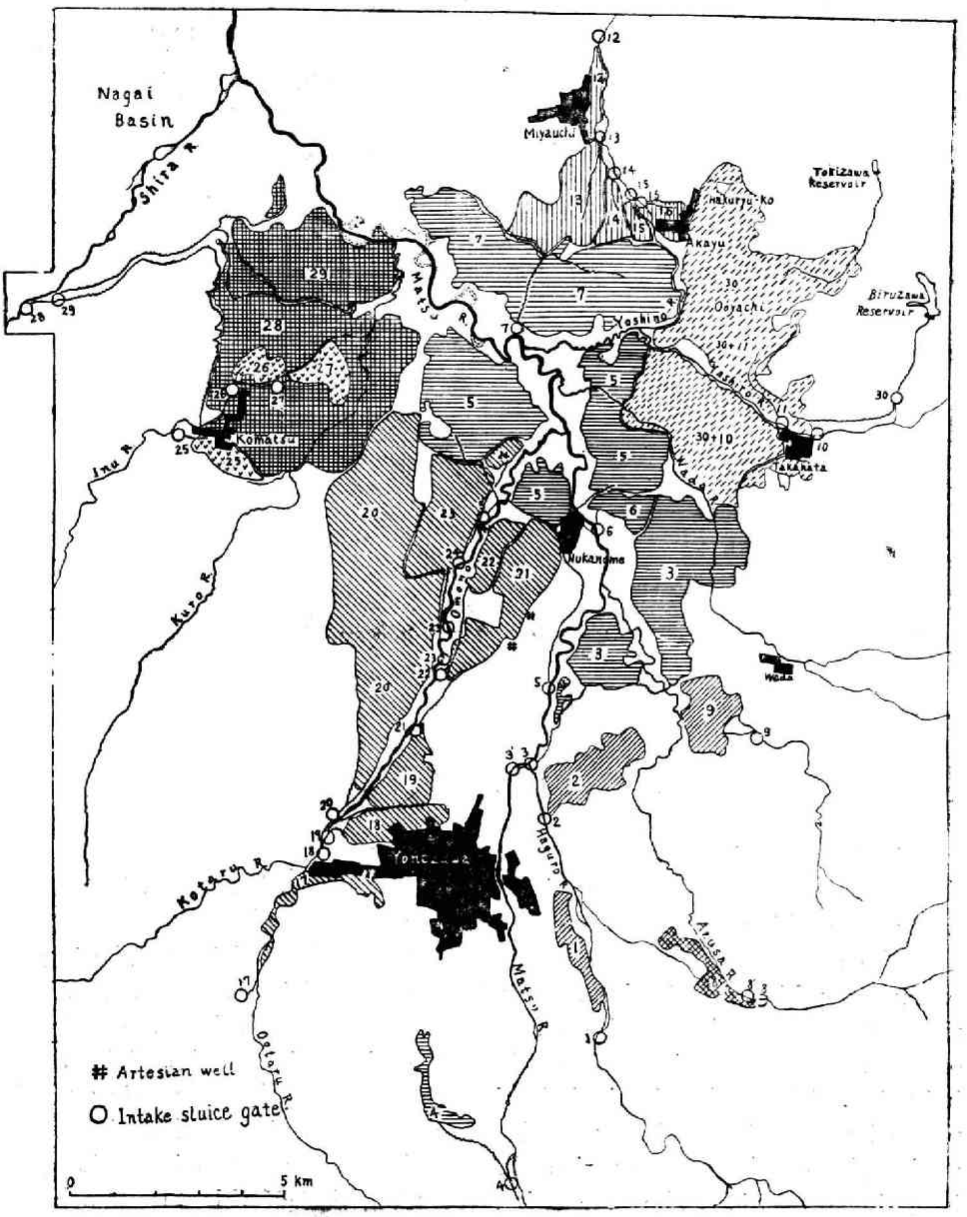
The northeastern part of the basin is occupied by a peat marsh called Ooyachi,* covering about 1,000 hectare in area. At present, the most part of the peat marsh has been reclaimed into paddy-fields, retaining some part of it as a marsh of reeds which are made use of as the material of the roofs of farm houses. In the northern corner of the peat marsh, there is a small lake named Hakuryu-ko. This lake is presumably a remnant of a larger lake which covered the greater part of the peat marsh in the past and the larger lake must have gradually decreased its area from its margin being buried with the development of the peat bed. (Text-Fig.2 and Pl. III, Fig.11)

According to the feature and development of the peat marsh of Ooyachi together with its reclamation to paddy-fields since the feudal age, has already been studied in detail by Yoshinobu Yoshida.[1)2)] The peat bed is classified into two layers, namely upper layer (raw peat) and lower (muddy peat). The thickness of the upper raw peat layer is 1.5–2.0 m in the center, and in the

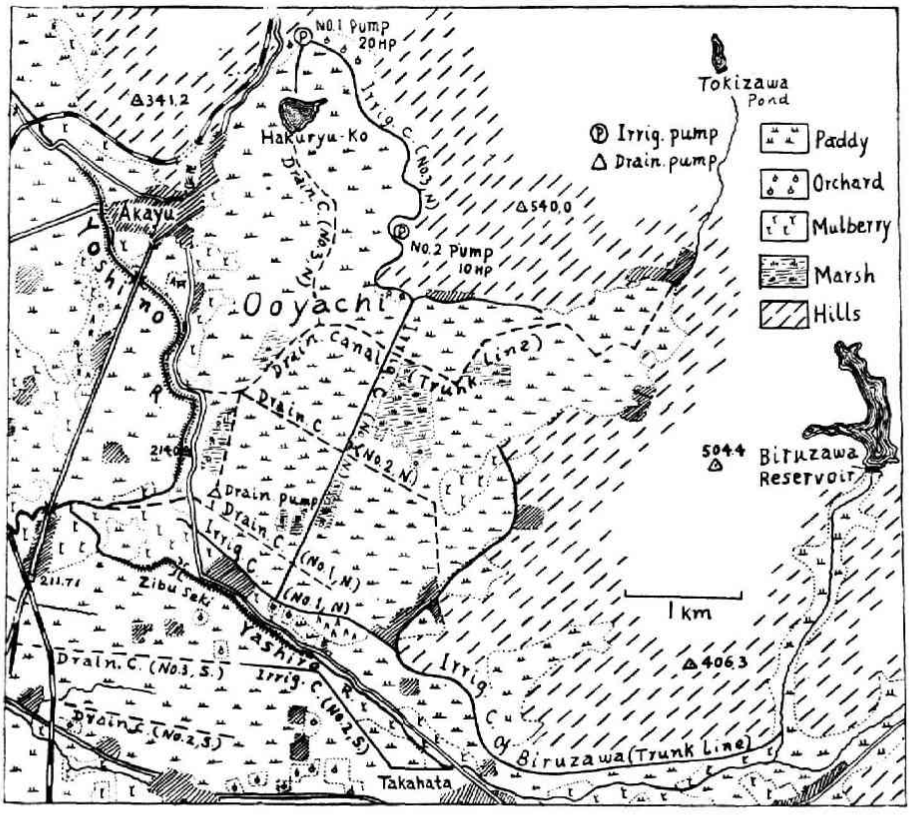
* Ooyachi means Great marsh in Japanese.

1) Y. Yoshida: On the problems of exploitation and irrigation around the lake Hakuryu, Yamagata Prefecture (Japanese)
Annals of the Tohoku Geogr. Ass. (Tohoku Chiri) Vol. 2, No. 1 (1949)

2) Y. Yoshida: Historical geography of the exploitation of the Ooyachi, in the Yonezawa basin, (Japanese) Ann. Tohoku Geogr. Ass. (Tohoku Chiri) Vol. 6, No. 1 (1953)



Text-Fig. 1 Irrigation systems and area in the Yonezawa Basin
(Courtesy the Okitama Local Office at Yonezawa)



Text-Fig. 2 Ooyachi peat marsh area and its vicinity

margin decreases into 1.0 m or less. In case of inundation, a greater part of the raw peat layer floats over the muddy peat layer due to the intervening water zone which permeats through the raw peat layer.

The upper part of the raw peat layer is decomposed by weathering and produces muddy soils with humus suitable for rice cultivation. So, the reclamation of the peat marsh to paddy-fields was already set to work about the beginning of 17 th century, but it was not advanced easily owing to the difficulties in irrigation. The difficulties in irrigation results from the putrefying of rice plants by water immersion at flood owing to the deficiency of drainage and at drought, on the contrary, rice plants wither owing to the insufficiency of irrigation capacities. The retardation of reclamation of this peat marsh area was not alone lying on the difficulties in reclamation technique and cultivation works. Still more, inferior was the productivity of the reclaimed rice-fields. In newly-reclaimed rice-fields in the peat marsh, it is difficult to supply them with irrigation water owing to their "floating fields" on the interven-

ing water zone between the raw peat layer and the muddy peat layer, as above mentioned. Older rice-fields, on the other hand, the upper part of raw peat layer in the fields have been decomposed by cultivation for several years into muddy humus and the surface of the fields setting lower, as a result of it, the fields may submerge into water and make it difficult to drain off water from the fields. These fields are called by the farmers "Yachi-ta" which means the marshy paddy-fields. This stagnant water on the fields, not only impedes the growth of rice-plants and harvest works, but for its depth of water and mud, requires the planting of tall rice-seedlings about 2 feet, and the farmers must work in the Yachi-ta, putting the large wood plates on both feet or in a boat. In some of the oldest paddy-fields, underlying raw peat layer of the Yachi-ta has been decomposed into humus utterly. This field is called "Nuke-ta" by the farmers, which means the field where the peat bed is penetrated which has been suspended over the muddy peat layer by the intervening water zone. The farmers work in the fields, may occasionally sink into the mud 1.0 or 2.0 m in depth, unless they put on wood plates or are in boats.

III. Irrigation system

A greater part of the Yonezawa basin plain is occupied by paddy-fields for rice cultivation as is shown in general in almost all of the plains in Japan. So, the network of irrigation system covers the plains for supplying water to paddy-fields. In the Yonezawa Basin, the irrigation water is conducted mainly from all the rivers flowing in the basin plain through sluice-gates which have been equipped along their banks and scarcely from irrigation ponds or reservoirs which are seen, in general, in the basin plains of the Southwestern Japan.

The rivers which are supplying the basin with irrigation water are the Omono River, the Matsu River and the Haguro River flowing from the south, the Inu River and the Shira River from the west, the latter belonging to the Nagai Basin from which the water is conducted into the western margin of the Yonezawa Basin by irrigation canals through the northwestern corner. The Yoshino River from the north and the Yashiro River accompanying with the Biruzawa Reservoir from the northeast are irrigating the Ooyachi peat marsh area and main canals for the respective areas in the basin are shown in Text-Fig. 1 and the irrigated areas of respective sources are enumerated in Table 1.

As is shown in Text-Fig. 1, each of the irrigated areas is rather narrow because their sources depended mainly on the small rivers and not on any large reservoirs except the Biruzawa Reservoir. This condition of irrigation system seems to be unstable for rice cultivation owing to the irregular discharge of the rivers. But most of the rivers on the basin originated from the southern mountains in which there is a heavy snow-fall every year (lying

about 2.5–3.0 m in depth), so, in spring, these rivers are supplied by them with sufficient amount of water. Though the annual precipitation at Yonezawa city measures 1700 mm in average, in summer, the discharge each river is diminishing remarkably in usual and it used to cause serious drought damages. Some large reservoirs are demanded to store snow water for irrigation in the upstream of any river in the basin. In each of the irrigated areas, the farmers are combined firmly with each other in a village community through irrigation water owing to its importance, and they are managing and keeping themselves the irrigation equipments.

Table 1 List of the irrigation canals in the Yonezawa Basin.
(Irrigated areas less than 50 cho are omitted)

No.	Source	Name of canal	Irrigated area, (cho)*	Remark
1	Haguro River	Katako	80	
2	〃	Kamigo	150	
3	〃	Shikamura	650	partly from Matsu R.
4	Matsu River	Saruo	58	
5	〃	Kuroi	828	partly from Omono R.
6	〃	Hashimukai	90	pump up
7	〃	Shogo	668	
8	Azusa River	Hayama and Ichiro	130	
9	Wada River	Sasawa	80	
10	Yashino R.	Ichino	80	
11	〃	Negishi	70	
12	Yoshino R.	Oo	80	
13	〃	Kuriya-Kawa	390	
14	〃	Ita	60	
15	〃	Nagaoka	50	
16	〃	Akayu	50	
17	Omono River	Tateyama	57	
18	〃	Tatewaki	111	
19	〃	Shinkawa	140	
20	〃	Takayama-Horigane	1,200	
21	〃	Ooe	207	
22	〃	Osonozuka	75	
23	〃	Onagashima	207	
24	〃	Higashi	71	
25	Inu River	Hatahoko	74	
26	〃	Miyachi	148	
27	〃	Ueno	60	
28	Shira River	Nagahori	905	
29	〃	Rokkason	895	
30	Biruzawa & Tokizawa Reservoirs	Yashiro	942	

* cho=2.45 acre.

IV. Irrigation System in the Ooyachi Peat Marsh Area.

The Ooyachi peat marsh area is bounded by the Yoshino River in the west margin, by the Yashiro River in the south and the north and in the east margin by hill-sides which are occupied by a grape area. The difficulties in irrigation in this area as was mentioned in the previous chapter, are due to the deficiencies of drainage at flood and of irrigation at drought. At flood, the levees along the Yoshino River have been broken or overflowed frequently because of the level of the river bed higher than the surface of the peat marsh as a "ceiling river". The bed of the Yashiro River rather lower than the surface of the marsh yet the river can not drain flood water of the Ooyachi peat marsh because its levees are standing higher. During old days, when the Ooyachi peat marsh was scarcely reclaimed for paddy fields, irrigation water for the paddy-fields of the southern area beyond the Yashiro River was supplied from Ooyachi through the sluice-gate and a water canal called "Zibu Seki"* which was built by a pioneer Zibu Yuki, in the 4th of Keicho (1655) and the old natural drainage channel had to be closed in order to lead the water by the new-built canal. However, at flood in Ooyachi, the Zibu Seki used to be closed to prevent the immersion of flood water in the southern fields beyond the Yashiro River. This inconsistency to irrigation between the north area (Ooyachi) and the south area beyond the Yashiro River, frequently caused severe troubles between the farmers of both the areas from feudal age till the Taishyo Era for several hundred years and many of them were brought into litigation.

For dissolution of these troubles, an irrigation plan was carried out over the Yashiro district including Ooyachi, a leading part of it taken by the authorities of Yamagata Prefectural Government from 1935 till 1948. In this plan, the construction of the Biruzawa dam and its reservoir (water capacity 2,191,200 m^3) in the upstream of northeastern tributary of the Yashiro River and Tokizawa Reservoir (water capacity 50,000 m^3) in a small valley in the north hill side, was completed; the former in 1948 and the latter in 1942. By both reservoirs together with pumping up water from the Ooyachi marsh at two places, the irrigation water of the Yashiro District has completely been secured. Besides, the many drainage ditches which have been dug in the Ooyachi marsh with a drainage pump lead to the downstream of the Yoshino River, following the natural drainage channel which had been closed till that time as above mentioned. By these irrigation systems in accordance with drainage system, the irrigation water in the Yashiro District got adequate circulation, and by it the yield of rice has increased more and prevent not only inundation but also

* "Seki" means dam and irrigation ditches in Japanese.

drought damages.

V. Properties of Irrigation Water

a) The poisonous water issued from mines

In the Yonezawa Basin, the water of the Matsu River in the south and that of the Yoshino River in the north, are mingled with the poisonous water issued from mines. The poisonous water of the Matsu River has been studied by Yatsu and Irie[1], it issued from a sulphur mine on the northern flank of Nishi Azuma Volcano and mingled with river water of the upstream of the Matsu River. By this mingling, the river water becomes turbid and is stained in brown colour and has a strong acidity. Hence, the rice cultivation in the paddy-fields irrigated by this water is suffering severe damage in the upstream region of the Matsu River and most of fish breedings which are being carried out on the Yonezawa alluvial fan have been annihilated. The acidity of the river water which is represented by pH has been measured by Yatsu and Irie; the values are respectively 2.3 at the mouth of a pit, 4.0 at the sluice-gate of Oirimizu on the apex of the Yonezawa fan, 5.4 at the middle part of the fan, 6.0 under the Ai-oi Bridge above the Natsu River in the eastern part of Yonezawa city, 6.4 at the joinning point of the Matsu River and the Naguro River. These values of pH show that the acidity of the river water gradually decreases as it flows down the river channel, though at least the irrigated area between the source and the fan can not be escaped from the damages. In addition to this, the above named researchers found that the ground water of the Yonezawa Fan dissolves a larger amount of SO_4 than that of Cl. It shows that the poisonous water of the upstream of the Matsu River permeates into the Yonezawa Fan, hence the ground water of the fan occasionally becomes unsuitable to drink. To avoid these damages, the authorities of Yamagata Prefectural Government has been carrying on an operation in which the poisonous water is conducted into many holes bored in the vicinity of the mine and let permeate through the holes into the ground. In spite of this operation, in every rainy season, a considerable amount of the poisonous water occasionally leaks into the river stream and the measure can not perfectly prevent the damages.

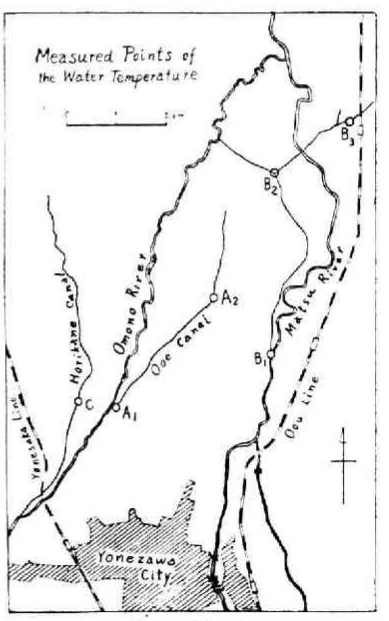
The poisonous water of the Yoshino River is issued from some small copper mines in its upstream region and it contains a remarkable quantity of copper ion with its strong acidity. Owing to this quality, the water of this river, with which the rice-fields of about 750 hectares have been irrigated in

1) E. Yatsu & T. Irie: On the poisonous water of Matsukawa River, Yamagata Pref. Miscellaneous Reports of the Research Institute for Natural Resources, No. 16 1950 pp. 43-46.

the northern part of the Yonezawa Basin, injured the rice culture. However, these copper mines have been out of operation since several years ago, and so the injury has become reduced remarkably at present, and pH of water of the Yoshino River is 5.7 (RpH 5.8) at the mouth of river valley near Miya-uchi town though in the upstream shows 4.6 (RpH 5.7) at the distance of 4 km from this town.

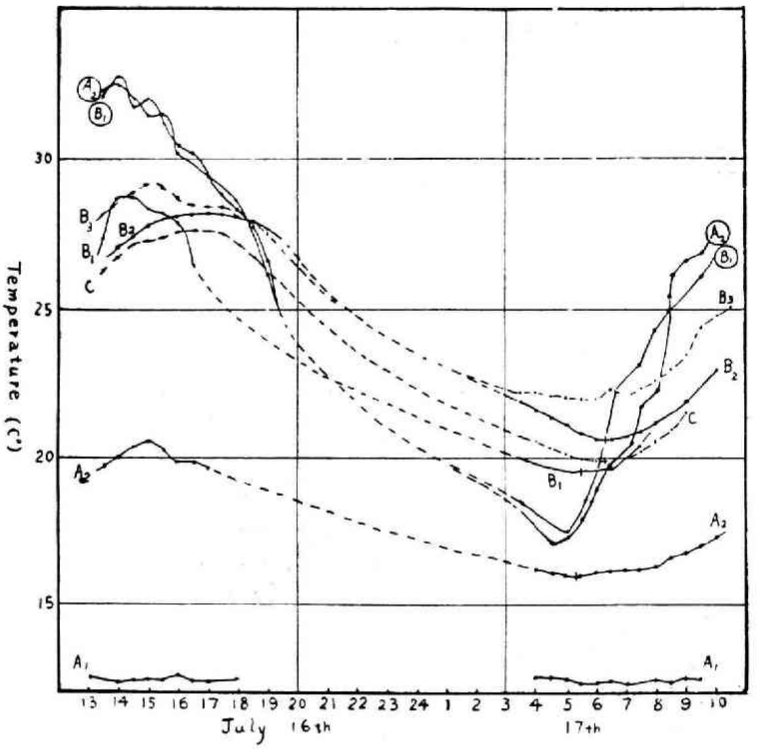
b) Temperature of irrigation water

It is reliably said that if the atmospheric temperature during the rice-growing season in some year is higher than that of the ordinary year, there will be a good harvest of rice in general, and it is also said that rice yield is influenced by the temperature of irrigation water, especially in the cool Northeastern Japan, as the difference of 1°C in water temperature results in that of about 5% in yield. Generally speaking, in the rice plant growing season, especially in early summer, the temperature of irrigation water in paddy-field, must be higher than 20°C (Pl. I,Fig. 10) and between 20°C and 25°C, the rice yield increases as the temperature goes up as above said, but when it is over 25°C, there is no more increase with a higher temperature. If it rises more than 32°C or 33°C, it will be injurious to rice-plants. When the atmospheric temperature is too high throughout the rice-growing season, the temperature of irrigation water also rise too high especially for a cool-resistant, and early maturing variety of rice-plants and in this case the rice plant grows in excess and its yield is rather apt to reduce. So, the temperature of irrigation water ought to be regulated in an optimum for each variety of rice-plant—early maturing, cool-resistant or late maturing, not cool-resistant.—For this purpose,it is more desirous to rearrange the irrigation canals in order to conduct the suitable water all the time in response to the atmospheric temperature in every rice-growing season. For this reason, the writer intends to obtain the data of the maximum and minimum temperatures of a day in the irrigation water of several canals in the Yonezawa Basin. The measurement of water temperature was carried out on July 16–17th 1955, by H. Fukui, 4 students and the writer at respective 6 points as is shown in Table 2 and Text-Fig.3 and 4.



Text-Fig 3

The Kuroi canal conducts its water from the Matsu River, the Horikane canal from the Omono River, and the Ooe canal from a spring near the margin of the Yonezawa Fan. The measuring point of the Ooe canal (A_1 in Table 2)



Text-Fig. 4

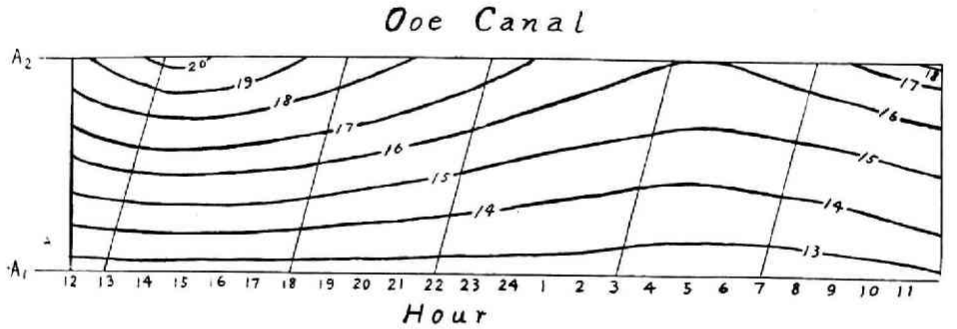
Table 2 Temperature of irrigation water in the Yonezawa Basin

Canal	Point	Distance from Sluice gate (km)	Discharge (f^3/s)	Max. Tem. (°C)	Hour	Min. Tem. (°C)	Hour	Tem. difference (°C)
Kuroi	B_1	0	12	28.6	14.20	19.5	5.30	9.1
	B_2	4	17	28.0	16.45	20.5	6.15	7.5
	B_3	6	3	29.0	15.10	21.9	5.30	7.1
Atmospheric Temp.		—	—	32.6	14.00	17.5	5.00	15.1
Ooe	A_1	0	9.6	12.5	—	12.3	—	0.2
	A_2	3	13.3	20.5	15.00	16.0	5.15	4.5
Atmospheric Temp.		—	—	32.4	14.00	17.1	4.30	15.3
Horikane	C	3	—	27.5	16.30	19.9	6.15	7.6

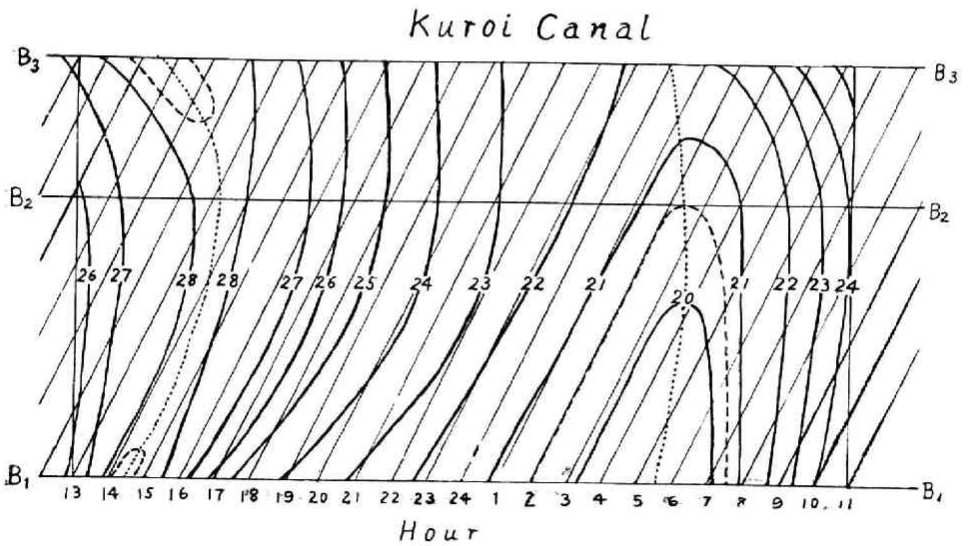
is at the opening of the under canal about 200 m long from the spring.

The change in the temperature of irrigation water in the course of flowing in the canals according to distance and time is shown in Text-Figs. 5 and 6 with regard to the Ooe and the Kuroi canals. The water temperature of the Ooe canal shows a very small change, daily or presumably annual, because it is generated from the spring. So, the water is too cool to lead to paddy-fields immediately for irrigation, but in an unusual hot season, it is rather available for the regulation of the water temperature in the paddy-fields in which it may rise too high.

They say that the Ooe canal was opened for irrigation in the Age of Ooe, a lord of this region about 700 years ago. The canal is noted because



Text-Fig. 5



Text-Fig. 6

its discharge is almost constant all the year round even at drought and in spite of its cool water temperature, has been utilized for irrigation. At present, the water is supplied into the paddy-fields at the distance of 2km from its source by a canal, but on the way, the water is mingled with warm water of the Sikamura canal. The water is, moreover, utilized for trout breeding by a farmer near the conduit mouth for the sake of its constant temperature.

The water of the constant temperature is derived from several small artesian wells distributing in the middle area of the basin between the midstream of the Matsu River and of the Omono River. The water of the artesian wells are utilized mainly for drinking and domestic use not for irrigation due to its small quantity and coolness.

Postscript

The present survey was done by the writer as a part of "the study of the land utilization in the Yonezawa Basin", which was carried out by the members of our Department of Geography in the Tohoku University under the Grant in Aid for fundamental scientific research for 1954 delivered by the Department of Education to the writer under the above mentioned title.

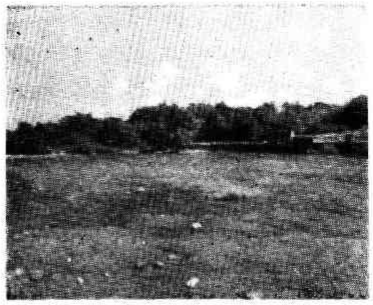


Fig. 1 Intake sluice-gate (19) at the east bank of R. Omono.

Fig. 2 Intake sluice-gate (20) at the west bank of R, Omono

Fig. 3 Intake sluice-gate and ditch at the east bank of R. Omono.

Fig. 4 Intake sluice-gate (3) of the Shikamura canal and its monument at the east bank of R. Matsu.

Fig. 5 A ditch of Shikamura canal.

Fig. 6 Intake sluice-gate (4) of the Oirimizu canal in the upstream of R. Matsu.

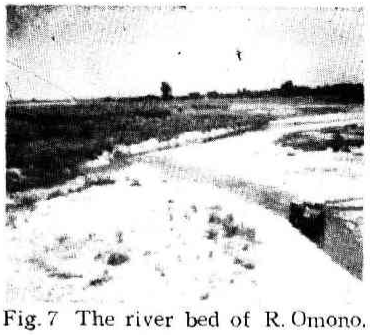


Fig. 7 The river bed of R. Omono.

Fig. 8 The wild bush on the river bed in R. Omono.

Fig 9 The stream channel and the wild bush on the river bed of R. Matsu.

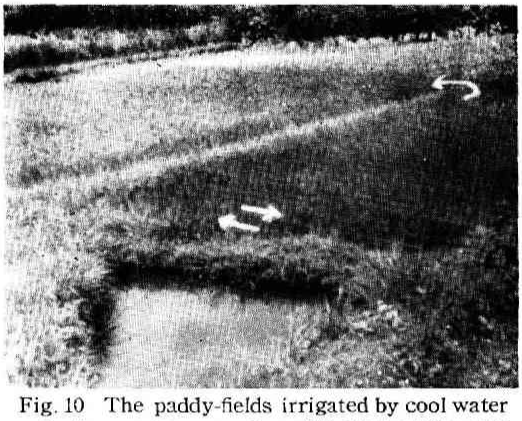


Fig. 10 The paddy-fields irrigated by cool water in the upstream region of R. Matsu. The ears of rice plants are erecting in the right hand field or lower water temperature but in the left the ears are bending lower owing to the warner water via the right hand field(arrows indicate) (Sept. 11, 1955)

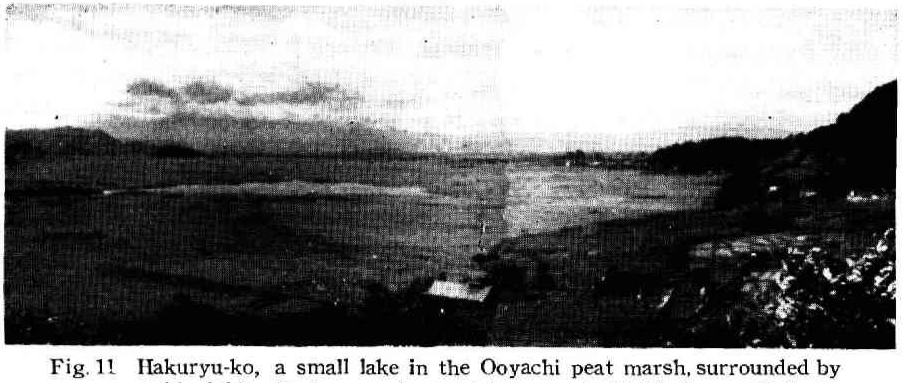


Fig. 11 Hakuryu-ko, a small lake in the Ooyachi peat marsh, surrounded by paddy-fields. Back ground mountain range is Nishi Azuma Volcano (clouds gethering).