9. REGIONAL PATTERNS OF FERTILIZATION IN JAPAN

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Regional differences in the climatic conditions during the rice growing season, and the growth of paddy rice.

Rice growing belt in Japan ranges in the wide area lying north and south, from Hokkaido to Kyushu. Therefore, the yearly differences in temperature are large at the individual regions. In the warm regions, in connection with a winter cropping, rice cultivation starts often after the temperature rises, and, the transition of temperature and the accumulated daily mean air temperature during rice season vary widely with the regions. The temperature conditions of various places surveyed by Ishizuka and Tanaka (1956) are as in Table 1.

Table 1. Temperature at each growth stage and other climatic conditions in National Agricultural Experiment Stations.

Item	Hokkaido	Tohoku	Hokuriku	Kanto	Tokai	Chugoku	Shikoku	Kyushu
Sowing	9°C	10	12	17	16	17	17	18
Transplanting	14°C	16	18	22	23	24	24	24
Maximum tiller-numbering stage	21°C	21	24	25	26	27	27	27
Panicle initiation stage	21°C	22	24	25	26	27	27	27
Heading stage	22°C	24	25	25	24	24	24	24
Maturity	13°C	19	17	14	15	14	13	13
Day-length at panicle initiation stage	14. 9hrs.	14. 7	14. 2	13. 8	13. 7	13. 3	13. 3	13. 2
Accumulated temp. in rice season	2, 100°C	2, 210	2, 679	2, 550	2, 690	2, 830	2, 880	2, 840

The rice plants cultivated in various regions show great differences in the growth. Ishizuka and Tanaka, taking notice early to the differences in the phases of grwth of paddy rice in various regions, pointed out that the early growth is liable to delay in cool regions and, in warm regions, on the other hands, it is vigorous and liable to be a type of decline in the later stage. In the rice plant of relatively warm regions the panicle initiation stage drops usually behind the maximum tiller-number stage, but in cool regions, especially in Hokkaido, it it characteristic that the stage is inverted (Fig. 1) and the response of rice plant to fertilizers also shows a different phase. Even in the rice plant cultivated under the same fertilizer conditions the seasonal change of the nutrients content varies widely with the place; for instance, as in Fig. 2, in warm regions nitrogen content in rice is usually low and their nutrients conditions are the type of decline in the later stage. On the basis of these findings they divided the growth types of paddy rice into cool area type and warm area type, and indicated the distribution of the types in Japan as illustrated in Fig. 3.

After that, Yanagisawa and Takahashi (1964) further studied the regional differences

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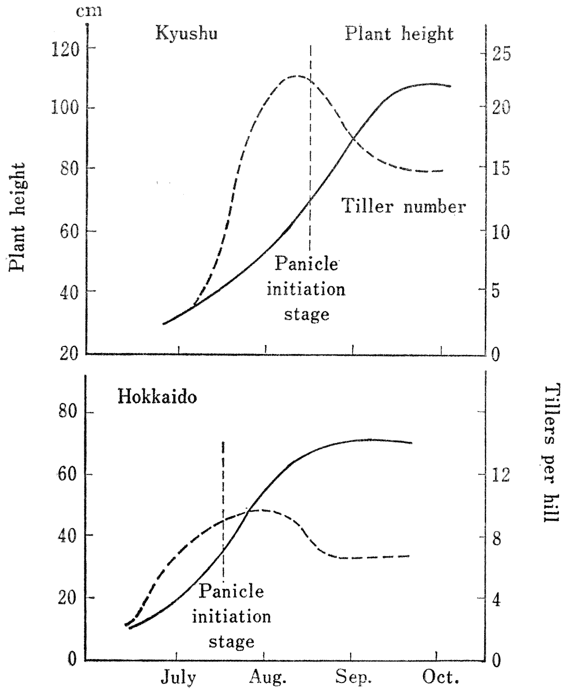

Fig. 1. Difference of the growth phase between the rice in warm and cool regions.

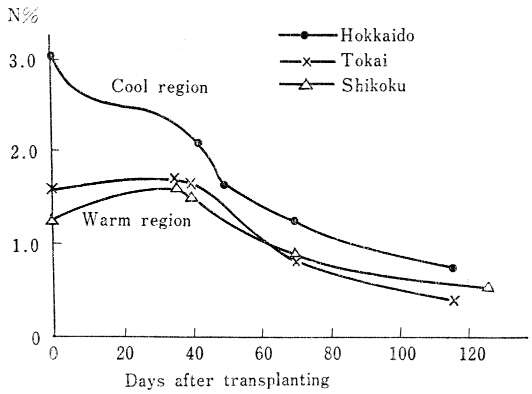

Fig. 2. Nitrogen content of straw.
(N% of dry basis)

including the soil conditions in various places. Fig. 4 is a graph showing the various phases of growth in cool and warm regions by a transition in dry matter production and indicating that the growth in warm regions is vigorous in the early stage and decline in the later stage.

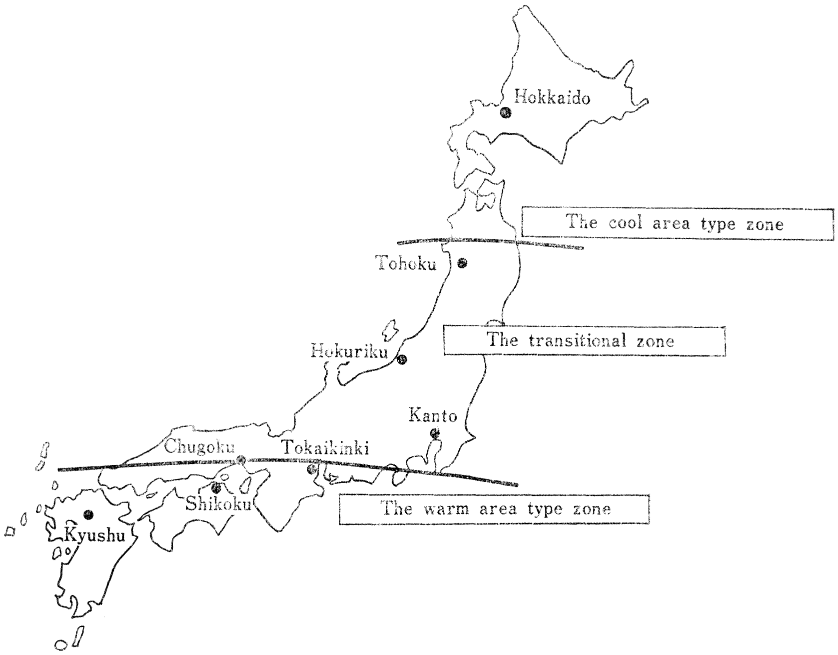

Fig. 3. Location of National Agr. Exp. Stations.

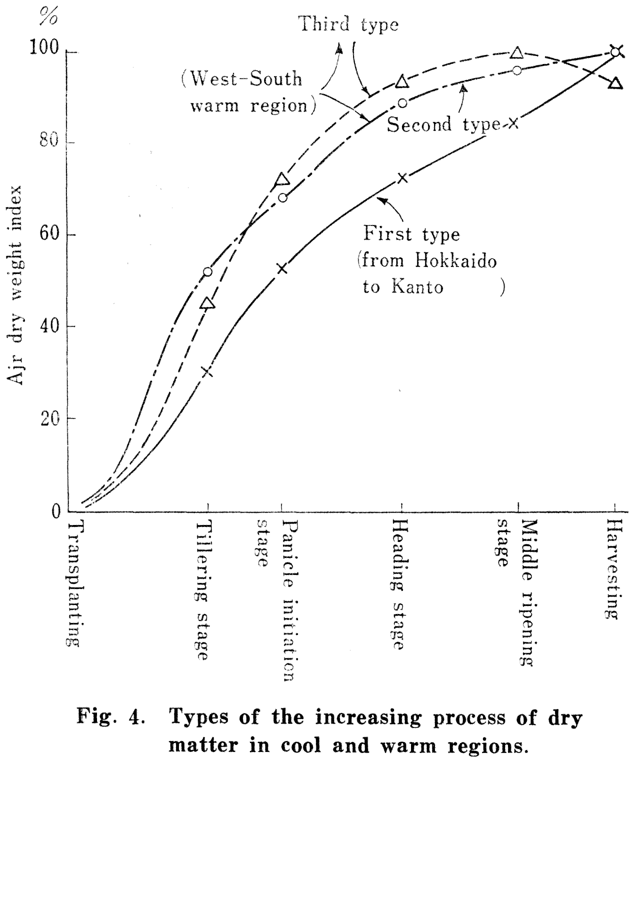

Fig. 4. Types of the increasing process of dry matter in cool and warm regions.

Regional characteristics of fertilization

As in the case with growth phases, fertilization also varies distinctly with regions. Great differences are found especially in the application of nitrogen; northern regions have a tendency to lay emphasis on the basal application, and southern regions the split application. This has been pointed out by Ishizuka and Tanaka (1952, 1954), and Saito (1963).

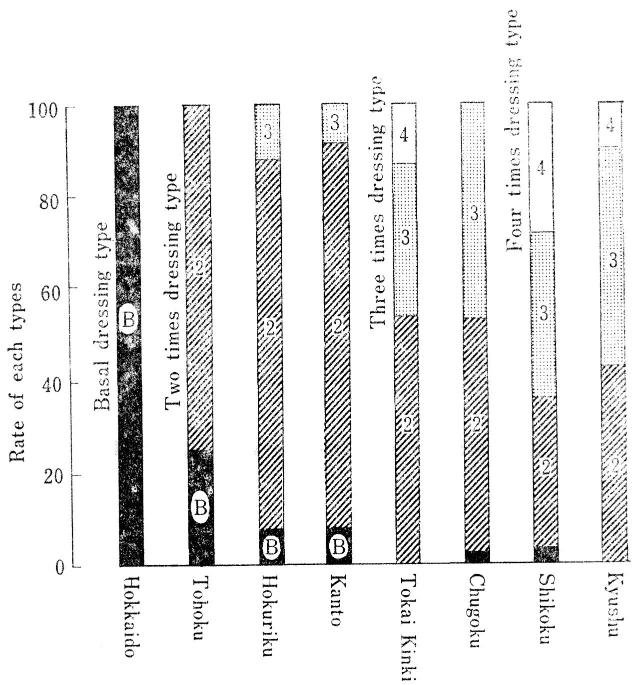

Fig. 5. Types of nitrogen application indicated in standard fertilization of the prefectures in individual region.

Saito reports that the application methods of nitrogenous fertilizers can be roughly classified into three types; type I, entire amount in basal application; type II, basal and one top-dressing at panicle initiation stage; type III, basal and two times top-dressing at tillering and panicle initiation stages. The first type is applied in cool regions such as Hokkaido and the third type chiefly in warm regions.

According to the nation-wide tendency in the standard fertilization (Nippon Ryuan Kogyo-Kyokai, 1967) in recent years, in Hokkaido the first type, and in Tohoku, Hokuriku and Kanto districts the second type is mainly applied. In Tokai-Kinki and Chugoku districts, both the second and third types, and in Shikoku and Kyushu districts the third type is predominant, and in some of these southern districts the application dividing in four parts is sometimes recommended.

Fig. 6 is a graph showing the comparison between the effects of the fertilization methods on yield of various regions in the same year. (Yanagisawa and Takahashi, 1964). It can be read in the graph that split application is more effective in warm regions than in cool regions.

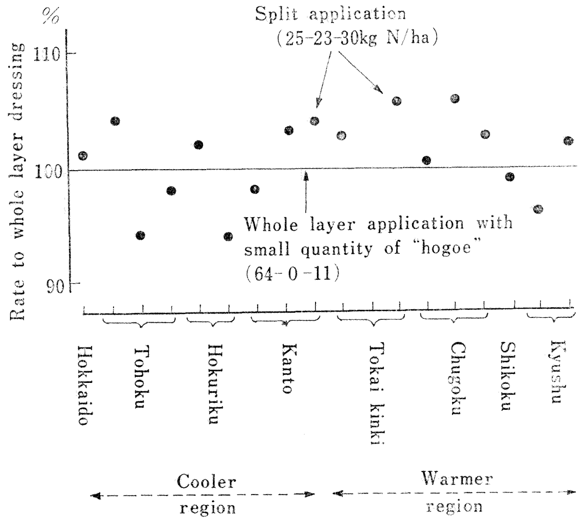

Fig. 6. Comparison of the yield in the different application methods of nitrogen in various regions (tatal N 56kg in Hokkaido). Solid circles indicate the percent increase or decrease of yield in three times split application of nitrogen versus the application method where the greater part of entire amount was mixed with whole layer of furrow slice and small quantity was left for *hogoe* top dressing.

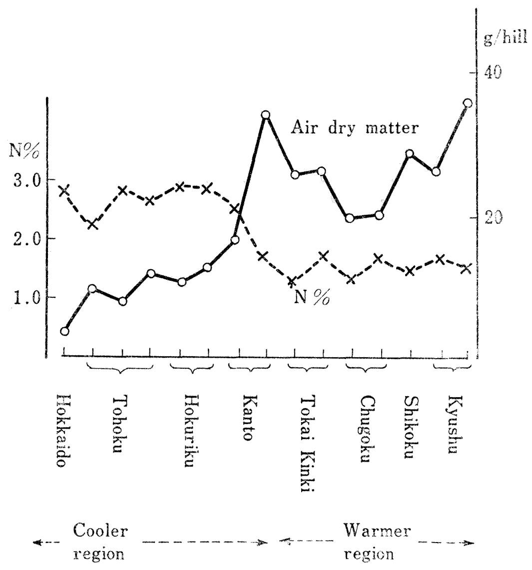

Fig. 7. Regional differences of the dry matter and nitrogen contents of the rice plant, cultivated under same fertilizer condition, at the panicle initiation stage.

Note: N application was 64 kg/ha for basic except Hokkaido where it was 45 kg.

The fact that the types of fertilization correspond to the regional characteristics of growth has been pointed out by Ishizuka and Tanaka (1954). As stated before, in case of the rice of cool region type the panicle initiation stage precedes the maximum tiller-numbering stage. Therefore, after top-dressing at the panicle initiation stage is applied, the unfavorable factors such as late tillering, non-bearing tillers, poor ripening of grains, and sterility injuries in the year of low temperature are frequently observed. Since the nitrogen concentration in and after the panicle initiation stage in cool regions is higher than in warm regions, it has been thought that the necessity of nitrogen top dressing is not so great as in warm regions.

In warm regions the panicle initiation stage falls in a fairly long time after the maximum tiller-number stage, and so the nitrogen content is distinctly low at that time (Fig. 7. Yanagisawa and Takahashi, 1964). Kiuchi (1960) reports that in order to grow more than 70 grains per panicle it is necessary to keep the nitrogen concenteation of the straw over 1.29% during the panicle initiation stage through the heading. The fact that the rice plant of warm regions drops in nitrogen concentration below this limiting value immediately when no top-dressing is applied indicates distinctly the necessity of top-dressing. Fig. 8 is a graph showing the relation between the straw weight and the yield in both cool and warm regions (Murayama, 1966). In both regions the yield increases until the straw weight reaches 8.0 tons. In warm regions, however, the increase in the yield with the increase in the straw weight is very small, the yield reaches the maximum at 8.0 tons of straw weight, and there is no increase in yield thereafter. Consequently, in warm regions it is not reasonable to

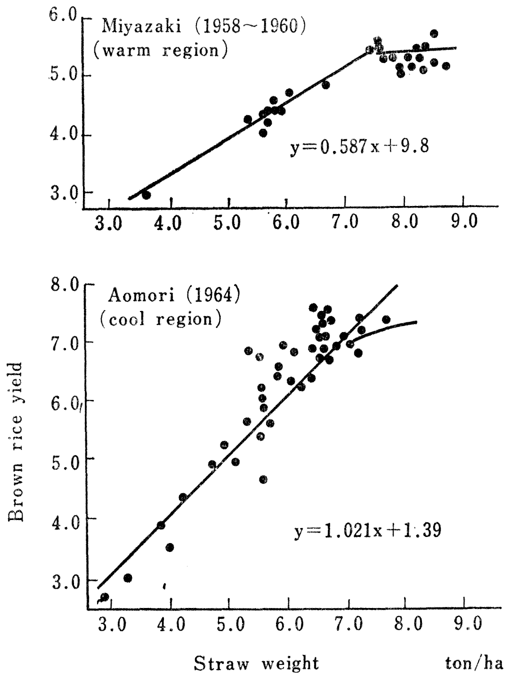

Fig. 8. Relationship between straw and brown rice weights (ton/ha) **in cool and warm regions.**

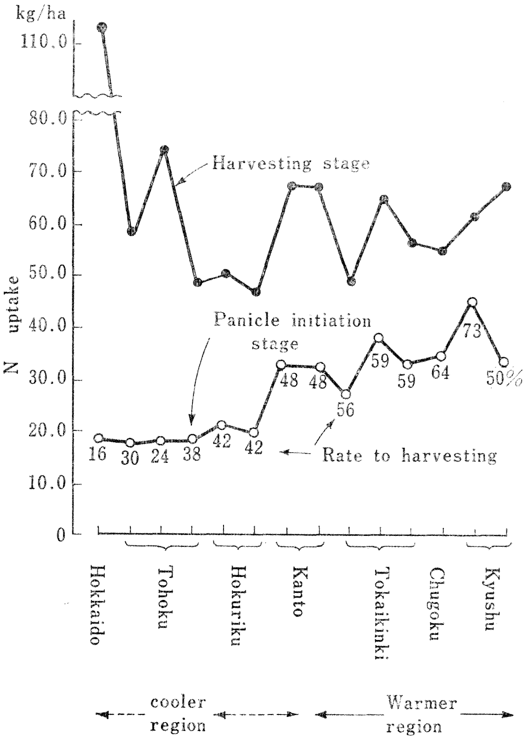

Fig. 9. Nitrogen uptake of the rice plant at the panicle initiation and the harvesting stage in case of non-application of nitrogen.

perform an early, heavy application of fertilizer which promotes the luxuriant growth of stem and leves. On the contrary, it is advisable to think of using the top-dressing which is affective to increase the spikelet numbers.

The regional differences in the temperature transition have great influence on the supplying pattern of soil nitrogen. As seen in Fig. 9 (Yanagisawa and Takahashi, 1964) in warm regions the rice plant absorbed more than half of the nitrogen released from soil, while in cool regions only about one third by panicle initiation stage. This shows that in North Japan the nitrogen supply from soils continues up to the later stage, and in warm regions less amount of soil nitrogen is available for the later period of plant growth, indicating the necessity of top-dressing.

Transition of the fertilization tendency in various regions

Each region has been trying to improve the cultivation under the different climatic conditions, and so the fertilization method has also been changing gradually. In cool regions the promotion of the growth in the early stage has becoms possible owing to the development of protected nursery beds, selection of cold resistant varieties, and improvement of cultivation techniques. The growth type of the rice plant is also shifting to that of warm regions. Tohoku district is regarded as the south limiting zone in the growth of cool region type, and when the effects of top-dressing at panicle initiation stage were investigated by Kiuchi (1954. Fig. 10), the district was considered only to have possibility of that application. But

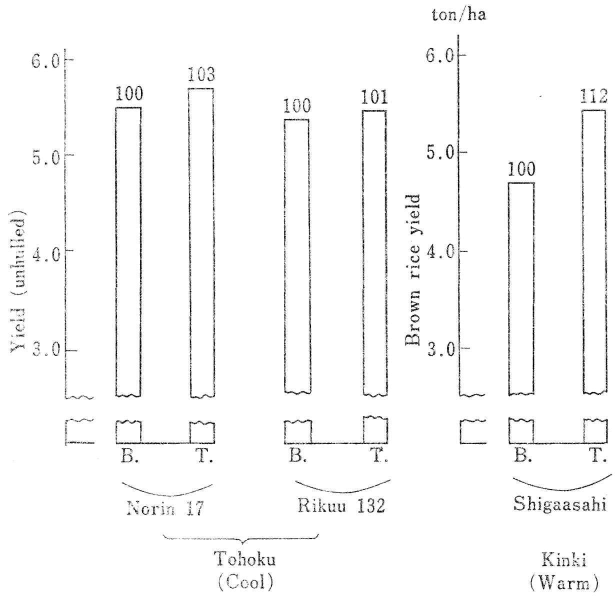

Fig. 10. Effect of the top dressing at the panicle initiation stage in cool and warm regions (1954).

Note: B., basal dressing 70kg/ha nitrogen in Tohoku
60kg/ha nitrogen in Kinki
T., basal dressing+top dressing at panicle initiation stage 15kg/ha nitrogen in both Tohoku and Kinki

Table 2. Effects of the top dressing at the panicle initiation stage in Agricultural Experiment Stations of six prefectures in Tohoku district (1959)

Prefecture	Treatment	Brown rice yield (ton/ha)	Percentage to control (%)
Aomori	B.	5.46	100
	T.	5.71	105
Akita	B.	5.36	100
	T.	5.68	106
Akita (National)	B.	5.32	100
	T.	5.90	110
Yamagata	B.	6.06	100
	T.	6.27	104
Hukushima	B.	5.12	100
	T.	5.54	114
Iwate (National)	B.	4.13	100
	T.	4.52	109
Iwate	B.	5.88	100
	T.	6.10	104
Miyagi	B.	4.54	100
	T.	4.80	106

Note: B.; Basal dressing
T.; With top-dressing

now, since basal dressing of whole nitrogen tends to cause rather luxuriant growth in the early stage, the split application is found to be highely effective (Honya, 1967. Table 2). Then most places in this district come to accept the application of 15.0-20.0 kg/ha of nitrogen at the panicle initiation stage in their standard fertilization. In Hokkaido also the problem of top-dressing is being investigated in connection with stable cropping of rice. (Shiga, 1967).

In warm regions the split application has been performed since long before. Saito has investigated in detail the most favorable quantity and rate of fertilizers. In the split application of ammonium sulphate, if the rate of basal application increases, the rice plant grows vigorously in the tillering stage with the considerable delay of growth around the panicle initiation stage, and the grain to straw becomes low. On the contrary, it is indicated that if the rate of basal fertilizer reduced and those of top-dressing and *"hogoe"* is increased, the grain-straw ratio increases, and that even in case of application of a much greater quantity of *"hogoe"* than in a general concept, it helps the efficient production of grain. The

Table 3. Effect of the top-dressing of various amount of nitrogen.

Hills/m²	1955					1950～1954 average			
	N. application (kg/ha)			Borwn rice yield		N. application			Brown rice yield (ton/ha)
	B.	T.	H.	Weight (ton/ha)	Percentage	B.	T.	H.	
15.4	15.0	37.5	22.5	4.50	100				
	15.0	45.0	30.0	4.85	108				
	15.0	52.5	37.5	5.20	116				
21.8	15.0	37.5	22.5	5.18	100	37.5	26.3	11.2	4.12
	15.0	45.0	30.0	5.09	98	45.0	33.8	11.2	4.22
	15.0	52.5	37.5	5.41	104	52.5	41.3	11.2	4.77
27.3	15.0	37.5	22.5	4.85	100				
	15.0	45.0	30.0	5.24	108				
	15.0	52.5	37.5	5.46	113				

Note: B.; Basal dressing
T.; Top-dressing at tillering stage
H.; Top-dressing at panicle initiation stage

Table 4. Changes of the standard fertilization in the plain area in Saga Prefecture.

Year	Plant type	Soil	Standard yield (ton/ha)	Total N (kg/ha)	Rate of application(%)			
					Basal	tillering	Panicle initiation	Heading
1960	—	Clay	5.4	84.0	50	30	20	—
		Clay～Clay loam	5.1	75.0	50	30	20	—
		Loam	4.7	75.0	50	30	20	—
1961～1963	—	Clay～Clay loam	5.4	85.0	40	30	30	—
		Clay loam～Loam	5.1	75.0	40	30	30	—
1964	Long or medium culm varieties	Clay～Clay loam	5.4	85.0	40	30	30	—
		Clay loam～Loam	5.1	75.0	40	30	30	—
	Short culm varieties	Heavy Clay type	6.0	120.0	40	20	40(30)	(10)
		Clay type	5.6	110.0	40	20	40(30)	(10)
		Heavy Clay type (Gley)	5.6	100.0	40	20	40(30)	(10)

part of the results is indicated in Table 3. It is clear that the yield level is higher in the application which lays emphasis on top-dressing.

In recent years the short stem, lodging-resistant, varieties such as Hoyoku have spread in warm regions. With it as a momentum the rational quantity of applied nitrogen has increased. Saga Prefectural Agricultural Experiment Station, investigating the rate of nitrogen, indicated that such a variety has a good harvest, preventing excessive vegetative growth, when the rate of *"hogoe"* is greater (Ezoe, 1966). On the basis of the results the standard fertilization method of Saga Prefecture has been improved in a short period of time (Table 4) and, since most of the increased quantity of fertilizer have been applied for *"hogoe"*, it has become a clear type of top-dressing priority fertilization. After that the yield per unit acreage in the Prefecture increased rapidly and become the highest in Japan in 1965. Such a trend is found in every warm region and the fact shows that a rational fertilization system is being established on the basis of the understanding of growth characteristics of warm region's rice plant. Yamashita (1969) indicated that rice plant of Kyushu where such a fertilization system has been introduced is quite different from the former one of late decline type. (Fig. 11).

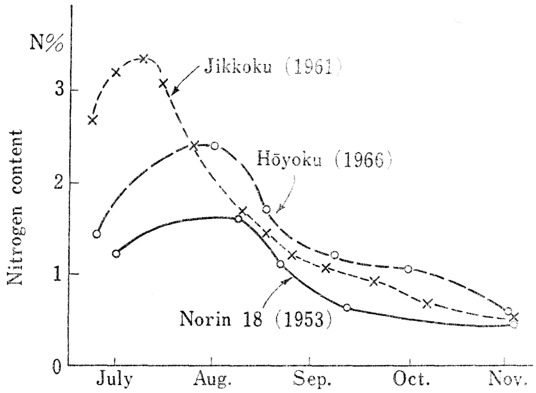

Fig. 11. Differences of the nitrogem content of rice plant in the different years in Kyushu.

Nagano Prefecture, located in the intermediate zone of the rice growing belt, has the favorable soil and climatic conditions and has kept a high yield level for a long time, but recently the yield has been sluggish. In this area the excessive number of tillers grows becouse the emphasis has been rather put on basal dressing. Therefore, ripening of grain becomes unsatisfactory. The improving tests on split application were also carried out in the Prefecture (Iida, 1967). As the result it has been indicated that 50.0–70.0 kg nitrogen per hectare as basal fertilizer brings about a satisfactory number of stems, and that top-dressing of about 50 kg is favorably given as *"hogoe"* at 18 to 25 days before heading(Table 5, 6).

This method is found to correct the former defects and increase the yield, and is spreading throughout Nagano Prefecture. In 1967 a case was reported of having a good harvest (9.24 ton/ha) by the adoption of this new fertilization method (Iida, 1969). In case of aiming at high yielding, the method is found to be applicable satisfactorily. The quantity of *"hogoe"* which is prescribed in the method is remarkably large in comparison with the usual levels

Table 5. Grain yields as affected by the various combinations of basal dressing and "*hogoe*" in Nagano Prefecture.

(Rate to standard fertilization : 80.0kg basal dressing and 20.0kg "*hogoe*" per hectare)

"*Hogoe*" / Basal dressing N (kg/ha)		N (kg/ha) 0	20	40	60	80
Nagano city	40	79	88	100	101	108
	60	81	96	102	110	
	80	89	100	103		
	100	96	104			
	120	97				
	0	70				
Misato village	40		97	101	107	
	60		100	104	108	
	80	95	101	103		
	100	95				
	120	97				
	0	79				

Table 6. Time of top-dressing and yield index (Experiments in Nagano Prefecture).

Basal (kg/ha)	Top-dress-ing(kg/ha)	Time of top-dressing (Number of days before heading)	Nagano city	Misato village
N : 100	N : 0	—	—	95
85	20	25	100	100
50	50	35	101	88
50	50	25	105	102
50	50	18	112	95
50	50	25, 18	110	99
50	50	25, 18, 0	107	—

and exceeds even that of warm regions stated before. From this case it can be seen that the regions where the emphasis is placed on the late stage application are on gradual increase.

Direction and problems of development of the fertilization methods in various regions

In recent years, owing to the improvement of the cultivation techniques and the release of high yielding varieties, the target yield has been set in a higher grade. Accompanied with it the techniques with regional characteristics has been developed, and the problems taken no notice in the past come to the front. As one example, there is a problem of late stage nutrition for rice plant in cool regions.

Top-dressing to the paddy rice of cool regions is thought to be less effective from the reason stated before, but in recent years the cultivations applying a large quantity of nitrogen in the later stage is frequently seen. The individual method may not be mentioned here. It was found, however, that in cool regions also the application of a fairly large quantity of nitrogen in the later stage is not disadvantageous if the time and method of application are carefully selected, and that there are various aspects where nitrogen application in the

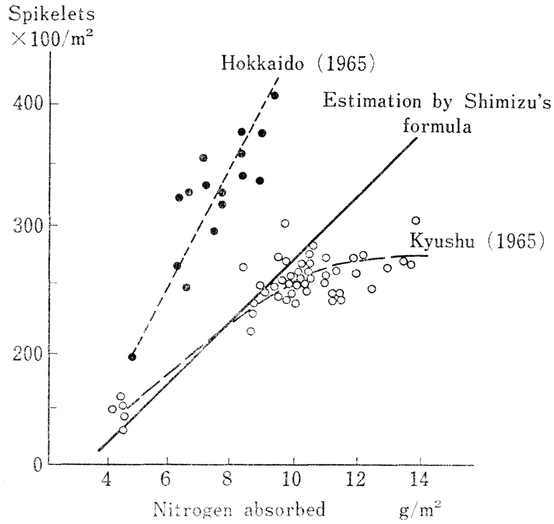

Fig. 12. Regional differences in relations between the amount of nitrogen in the rice plant at heading stage and the number of spikelets.

Table 7. Examples of the fertilization of the paddy field getting high yield in warm region.

District	Year	Farmer	Brown rice yield (ton/ha)	Basal dressing (kg/ha)			Top-dressing(kg/ha)		
				N	P_2O_5	K_2O	N	P_2O_5	K_2O
Chugoku	1962	Mr. Fukuma	8.45	35.0	236.0	116.0	105.0	0	115.0
Kyushu	1965	Mr. Yamada	8.50	10.0	10.0	10.0	76.0	76.0	76.0

Note : In the case of Mr. Yamada 2 ton/ha and 1 ton/ha of chicken feces were applied as basal and top dressing respectively.

later stage works effectively on the yield of grain (Shimada, 1969. Shiga *et al.*, 1968). Investigation of the effective use of late stage fertllization seems to be necessary because the fertilizer application is one of the means to make thoroughly ripen the yield components which have been enlarged by the promotion of early growth.

In warm regions the number of grain to the amount of nitrogen in the rice plant at heading stage is small and there is a tendency of reaching the upper-most limit of grain number as the nitrogen amount increases (Fig. 12. Murayama, 1969). Consequently, when a higher level of yield is aimed in a warm region the first problem to be solved is how to insure efficiently a large number of grain, preventing the excessive vegetative growth. In Chugoku and Kyushu districts there are few examples of recording high yield, one or two of them was applied an extremely small quantity of basal fertilizer and a large quantity of nitrogen for top-dressing (Table 7. Yamashita, 1968). Kyushu Agricultural Experiment Station harvested 7.5 ton/ha of brown rice yield, using "the deep layer application method" at tillering stage. These cases may give a suggestion to the methods for insuring the grain number in warm regions. According to the recent tests in the several agricultural experiment stations of Kyushu when more than 30,000 grains/m^2 are insured the rice plant frequently brings luxurient growth, and it is said that a stable method producing more than 7.0-7.5 tons/ha of yield in warm region is not established yet (Yamashita, 1969), it is necessary to study a fertilization method which keeps the nitrogen concentration in the leaf blades high and insures the grain number without increasing the weight of leaves. This subject must be investigated in the future, in connection with the cultivation managements (Sakai, 1968).

Discussion

S. **Matsusuima**, Japan: You did not mention at all the top-dressing after heading stage. Top-dressing is the characteristics of fertillization in recent years in Japan. Many advanced farmers in Japan practice it and not a few prefectural experimental stations are recommending it to farmers. So you had better refer to it.

Answer: Many experiments concerning top-dressing after or at heading time have heen conducted in various places in Japan. As pointed out by Matsushima and Wada, it is recognized that the top-dressing was effective to more grain yield by increasing the percentage of ripened grains or the weight of 1,000 grains, if the percentage of ripened grains was low ant the nitrogen content of rice plant at the heading stage was below the certain limiting value, which might vary in various region, and if nitrogen supply from soil at later stage was not sufficient to maintain the nitrogen content required for rice plant.

According to the recent experiments, however, it became clear that in warm regions when considerable amount of *"hogoe"* (top-dressing at panicle initiation stage) was applied, the top-dressing at heading stage scarecely or slightly affects grain yield, and the very late top-dressing, 10-20 days after heading, which have been practiced by considerable farmers in Tohoku distirict and so-forth, was also noneffective. On the other hand, it was known that the top-dressing near heading stage in cool region was effective under certain condition. Hence, it has been desired that the method should be used under the conditions of which effect to increased grain yield are expected. However, in order to decide exactly practical standards of top-dsessing near heading stage in various regions, it seems necessary to examine further about conditions of rice plant or soil properties in various places.

H. **Fukui**, Japan: Many of the differences observed in the growth behavior of rice plant in the North and South of Japan seem to indicate a similarity of the difference between *japonica* and *indica* varieties at least to some extent. To which extent can this hypothesis be extended?

Answer: I also think that there seems to be similar relations between the both relationships. However, it is difficult for me to indicate to what extent your hypothesis can be extended. I would like to ask Dr. Tanaka's comment about this problem.

(Comment) A. **Tanaka**, Japan: Our data (Ishizuka and Tanaka) were collected by using medium duration varieties in various locations in Japan. There are differences in the growth duration among varieties being grown by farmers in a given location, especially in the tropics. The growth patterns are different depending upon the gorwth duration of varieties. Thus, there are, in general, the tendencies as to the difference between the cool and the warm region as you referred. However, if we are discussing more details, it should be necessary to consider the growth duration of the varieties being discussed. The other point I wish to mention is that there is no clear physiological differences between japonica and indica. Thus, the words of japonica and indica should not be used in discussing at least physiological problems.

T. **Kiuchi**, Japan: In northern Japan, cold damage frequently occurs. I wonder if the very late application of nitrogen is dangerous, because of the delay in ripening. Can you top-dress the nitrogen without any such risk?

Answer: According to the experiments in Hokkaido, the top-dressing of fairly large amount of nitrogen after emergence of flag leaf did not only delay ripening but increased the filled grain in many cases, and it is effective in the yield especially in low fertility soil.

(Comment) **W. W. Thenabadu**, Ceylon: In Ceylon we have found that top-dressing of nitrogen at heading gives yield increases in rice. Therefore this was recommended to farmers. But we find that farmers are reluctant to step in to their fields at heading time and this application is, threfore, not recommended at present.

Y. Ota, Japan: You mentioned the importance of keeping the leaf blades nitrogen concentration high and insuring the grain number without increasing the blade weight to obtain high yield. I am quite agree with you. You cited Dr. Sakai's experiment to control the plant growth. Please explain the cultural method adopted by Dr. Sakai.

Answer: Dr. Sakai harvested 7.4 ton/ha of brown rice in Chugoku by the following method in which the deep placement of guanylurea (slowly available nitrogen fertilizer of which decomposition to ammonium begins after soil reduction under submerged condition) and the drainage after effective tillering stage to just before panicle initiation stage were combined. He described that the method could control the growth of rice plant and maintain the nitrogen content high. I suppose that such a method gives a suggestion to control growth favorably.

References for Paper 9

1. Ezoe, H. 1967. Technical ground in the development of the rice crop in Saga Prefecture. Nogyo Gijutsu, 21: 306-310.
2. HONYA, K. 1967. Effect of nitrogen top-dressing in the rice plant in Tohoku district. A collection of studies on top-dressing in rice plant, 1967. Nippon-Ryuan-Kogyokyokai, pp. 11-24.
3. Iida, I. 1967. *"Hogoe"*. and *"Migoe"* Abstruct of the meeting, the Society of Soil and Manure Resarch, Chubu district, 24: 19-31.
4. Iida, 1969. The rice crop getting greatest yield in Japan and the method of fertilizer application. Nogyo Gijutsu, 24: 257-261.
5. Ishizuka, Y. and Tanaka, A. 1952. Comparison of rice cultivation technique in cool and warm region. Agr. and Hort. 27: 503-541.
6. Ishizuka, 1954. Problems in nitrogen top-dressing at the panicle initiation stage in rice, with special reference to the regional differences. Agr. and Hort. 29: 599-605.
7. Ishizuka, Y. 1956. Studies on ecological characteirstics of rice plant grown in different localities, especially from standpoint of nutrio-physiological characters of plant. Part 1. Outline of morphological growth process of rice plant in different localities in reference to its climatic environment. J. Sci. Soil and Manure, Japan, 27: 1-6.
8. Ishizuka, Y. 1956. Studies on ecological characteristics of rice plant grown in different localities, eapecially from standpoint of nutrio-physiological characters of plant. Part. 3. Nutrio-physiological characteristics of growth process of rice plant in different localities. J. Sci. Soil and Manure, Japan, 27: 95-99.
9. Kiuchi, T. and Ishizaka, H. 1960. Effecct of nutrients on the yield-constituting factors of rice (Nitrogen). J. Sci. Soil and Manure, Japan, 31: 285-291.
10. Kiuchi, T. 1968. Fertilization for the rice plant in cool region. Ishizawa, S. Egawa, T. and Murayama, N. supervised, New techniques in relation to soil and fertilization, 1968. Gihodo press, Tokyo, pp. 101-117.

11. Murayama, N. 1966. A consideration on rising grain-yield level of rice. Nogyo-Gijutsu, 21 : 101-106.
12. Murayama, N. 1969. Nutriophysiology in relation to fertilization and ripening in rice plant. Nogyo-Gijutsu, 24 : 71-78.
13. Saito, B. 1963. Investigation on improving the fertilizer procedure of paddy fields in the warm district of Japan. Kyushu Agr. Expt. Sta. Bull. 8 : 435-532.
14. Saito, H., Komoto, Y. and Oyama, N. 1968. Studies on high-yielding fertilization method for rice plants in warmer region, Bulletin of the Chugoku Agr. Expt. Sta. E No. 2 : 145-189.
15. Shiga, H. 1967. Effect of nitrogen top-dressing in the rice plant in Hokkaido district. A collection of studies on top-dressing in rice plant, 1967. Nippon-Ryuan-Kogyokyokai, pp. 1-10.
16. Shiga, H. and Endo, K. 1968. Studies on nitrogen application for the rice plant in cool region, with special reference to the application at the late growth stage. Abstract of annual meeting, Soc. Sci. Soil and Manure, Japan, 14 : 145.
17. Shimada, N. 1969. "The deep layer dressing" in Aomori Prefecture. Abstruct of annual meeting, Soc. Sci. Soil and Mannrue, Japan, 15 : 175.
18. Yamashita, K. 1968. Fertilization for the rice plantin warm region. Ishizawa, S., Egawa, T. and Murayama, N. supervised, New techniques in relation to soil and fertilization, 1968. Gihodo press, Tokyo, pp. 84-100.
19. Yamashita, K. 1968. Relation between productivity of paddy field and fertilization, with special reference to effects of top-dressing. Advance in investigation of soil and fertilizer in Japan. Soc. Sci. Soil and Manure, Japan, pp. 127-132.
20. Yangisawa, M. and Takahashi, J. 1964. Studies on the factors related to the productivity of paddy soils in Japan with special reference to the nutrition of the rice plants. Bull. National Instit. Age. Sci. B. 14 : 41-172.