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RICE CULTURE IN MALAYA

Summary of Symposium on Rice Culture in Malaya

KYOTO
September 1964

Overseas Technical Cooperation Agency
Tokyo, Japan

RICE CULTURE IN MALAYA

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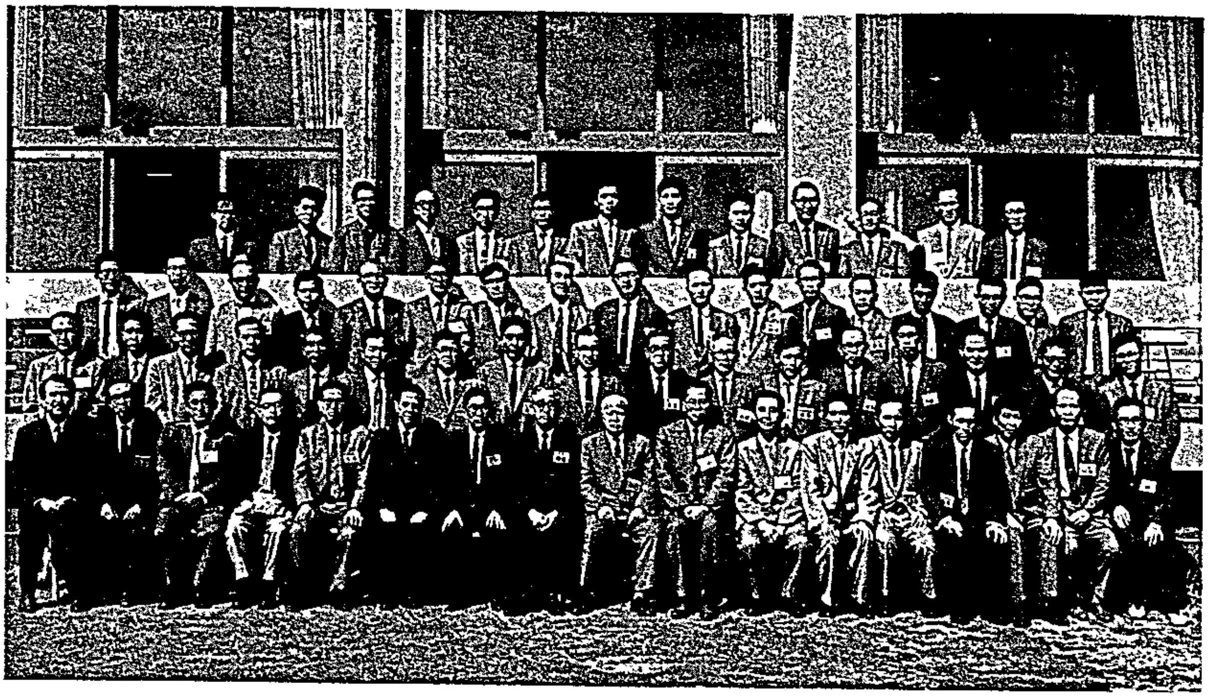


Participants of the Symposium September 1964

List of Colombo Plan and FAO experts dispatched to Malaya and period of their stay

K. Fujii	Sep./'59—Jan./'61	National Agricultural Experiment Station
H. Ishikura	May/'58	Ministry of Agriculture and Forestry
J. Kawakami	Dec./'60—Jan./'62	Hokuriku National Agricultural Experiment Station
E. Kawase	Jul./'60 —Jul./'62	Ishikawa Prefectural Agricultural Experiment Station
N. Kawata	May/'58	Ministry of Agriculture and Forestry
N. Kimura	Jun./'59 —Aug./'60	Ministry of Agriculture and Forestry
T. Koyama	Aug./'58—Jul./'59	Tohoku National Agricultural Experiment Station
Y. Kunii	May/'63—May/'64	National Agricultural Experiment Station
S. Matsushima	Apr./'60—Dec./'61	National Institute of Agricultural Sciences
M. Miyake	Nov./'62—Mar./'65	Hokkaido National Agricultural Experiment Station
M. Mochizuki	Nov./'62—Nov./'64	Toyama Prefectural Agricultural Experiment Station
M. Moriya	Aug./'58—Sep./'59	Tohoku National Agricultural Experiment Station
M. Nagai	Jul./'60 —Jul./'62	National Agricultural Experiment Station
S. Samoto	Feb./'62—Mar /'65	Hokkaido National Agricultural Experiment Station
S. Sato	Aug./'58—Aug./'60	Kanagawa Prefectural Office
T. Sato	Jul./'60 —Oct./'61	Yamagata Prefectural Agricultural Experiment Station
D. Shiraishi	May/'58	
K. Sugimoto	Mar./'62—Mar./'64	Tokai-Kinki National Agricultural Experiment Station
Y. Takahashi	Nov./'59—Aug /'60	National Agricultural Experiment Station
S. Tsukibayashi	May/'59 —Dec./'60	Ministry of Agriculture and Forestry
Y. Yamakawa	Aug./'58—Jul./'59	Saga University

List of discussants (except the above-mentioned)

S. Akai	Kyoto University
I. Baba	National Institute of Agricultural Sciences
Y. Chiba	Ministry of Agriculture and Forestry
F. Ebara	Ministry of Agriculture and Forestry
A. Fujiwara	Tohoku University
H. Furukawa	Kyoto University
Y. Goto	Nagoya University
H. Hasegawa	Kyoto University
S. Ishii	Kyoto University
Y. Ishizuka	Hokkaido University
H. Ito	National Institute of Agricultural Sciences
A. Kawada	National Institute of Agricultural Sciences
K. Kawaguchi	Kyoto University
K. Kitagawa	Overseas Technical Cooperation Agency
K. Kyuma	Kyoto University
T. Motooka	Kyoto University
T. Nagamatsu	Kyushu University
K. Nagato	Nagoya University
H. Oka	National Institute of Genetics
T. Ota	Overseas Technical Cooperation Agency
M. Oto	Overseas Technical Cooperation Agency
T. Sato	Hyogo University of Agriculture
K. Shakudo	Kyoto University
M. Takamura	Ministry of Agriculture and Forestry
Y. Takamura	Kyoto University
A. Tanaka	The International Rice Research Institute
S. Utida	Kyoto University
T. Watabe	Kyoto Prefectural University
I. Yamada	Kyoto University
N. Yamada	National Institute of Agricultural Sciences

Foreword

Among the numerous fields of science and technology in which Japan extends her technical cooperation to developing countries, agriculture including forestry and fishery plays the most important part, accounting for about one third of the total amount of cooperation.

Many countries in South and Southeast Asia, where rice is the dominant crop, are endeavouring to increase their rice production through technical improvement. Japan, being the most advanced country in rice production, is in a position to assist these countries by imparting her experience and techniques.

The Japanese Government, as a part of its technical cooperation, conducts every year three groups training courses in rice culture for trainees from developing countries; one for research workers at the Central Experiment Station of the Ministry of Agriculture and Forestry, and two courses for extension workers at the International Agriculture Training Centre of the Overseas Technical Cooperation Agency (OTCA).

In addition to the training programs in Japan, the government also provides the services of rice experts to various countries.

In India, four rice demonstration farms have been established with the donation by the Japanese Government of equipment. Four Japanese experts at each farm are demonstrating improved methods of rice culture, the yields of rice being about three times that of local farmers'. In view of the remarkable success of these farms, four additional farms are to be established soon.

At the Agriculture Training Centre in West Pakistan, Japanese experts are training the agriculture extension officers in rice production. An Agriculture Training Centre has also been established in Cambodia with Japanese cooperation.

Since 1958, the Japanese Government has continued to provide the services of experts to Ceylon and Malaya to assist in research and experiment on rice. They have already amounted to about twenty in number for Ceylon and Malaya; each for their fields of speciality range from breeding, physiology, soil chemistry, pathology and entomology to rat damage prevention.

One of the outstanding achievements of the joint effort of the Japanese experts and Malaysians was the hybridization between *Japonica* and *Indica* varieties of rice. The first new variety was named "Malinja", by the Malayan Minister of Agriculture, which stands for Malaya, India and Japan. The Malinja and the second new variety "Mashuri", possessing the qualities of higher yields and shorter maturity period, are gaining popularity among farmers for second crop in irrigated areas.

The experiences of technical cooperation activities in agriculture underline the importance of the interaction of multiple factors for successful agricultural programs, such as the rice improvement program in Malaya. It was also recognized that careful and detailed analysis of the natural conditions was essential for any useful application of technologies to specific areas.

It was against this background that the Ministry of Agriculture and Forestry, the Center for Southeast Asian Studies of Kyoto University and the Overseas Technical Cooperation Agency (OCTA) jointly sponsored the Symposium on Malayan Rice Production.

The Symposium was held in Kyoto from 30 September to 2 October, 1964, with about 40 participants including 16 experts who had served in Malaya

The purpose of the Symposium was to assemble information on research and experiments on rice carried out in Malaya with the participation of Japanese experts, and to make systematic and interdiscipline examinations of the problems. It was intended that from such examinations some useful criteria for effective technical cooperation in Agriculture, especially rice production, might be derived.

The following chapters summarize the information presented by the reporters on various items and discussions which followed on the respective subjects. The effective methods of technical cooperation in agriculture, especially rice production, were discussed at the final session of the Symposium and the suggestions formulated on a broad concensus of the participants are summarized in the last chapter.

GENERAL ASPECT OF THE RICE CROP IN MALAYA AND THE OUTLINE OF OUR TECHNICAL COOPERATION

Seizo MATSUSHIMA*

I Importance of the Rice Crop from the Viewpoint of National Policy in Malaya

According to the Monthly Statistical Bulletin issued in 1963, the total population of Malaya as of 1962 is 7,250,000. As shown in the Table 1, it consists of the following races: Malay (50%), Chinese (37%), Indian and Pakistani (11%) and others (2%). Ninety per cent of the Malay are chiefly engaged in rice crop on a small scale, while the Chinese and Indian are economically active in major cities. In this connection, it is necessary for the Malayan Government to promote the rice crop, a main industry of the Malayan people to improve their economic and living standard per head. Thus the Government is more earnest about the improvement of the rice crop than would be found in any other country.

On the other hand, it is a well-known fact that rubber and tin are two major products supporting the economy of this country. Especially, the rubber occupies almost half of the total exports. At present when the future of the world market of natural rubber and tin does warrant optimism, however, everybody would be aware of the necessity of increasing the production of paddy, one of the most promising crops as described hereunder, and self-supplying the rice, which occupies 10~12% of the total imports of this country at present. From this point of view, too, the Government is forced to make much of rice cultivation.

When the self-supply condition of rice in this country is further observed, only 65% of the rice is self-supplied, though no less than 99% the inhabitants of Malaya live on rice (refer to Table 2). Accordingly, the Government has vigorously promoted its important agricultural policy for the self-supply of rice, and laid stress upon the increase of rice yield per unit area, and the expansion of cultivation area (especially the increase of the area of off-season rice plants by means of improved irrigation facilities). As revealed in Table 2, the rice imports have not so much decreased, though there is found an evident trend of rice production increase, because the population has greatly increased, and the annual rice consumption has also increased year by year. In fact, approx. 300,000-350,000 tons of rice has been imported, while 920,000 tons of rice has been yearly consumed. In terms of money, it actually accounts for 10-12% of the total imports of Malaya. From the above fact, too, it would be conceivable that the increase of rice production is one of the most important problems in the agriculture in Malaya.

II Significance of the Rice Crop in Malayan Agriculture

From a viewpoint of the cultivation area of major farm products, we shall hereunder study the position of the rice crop in Malayan agricul-

Table 1 Composition of the population of the Federation of Malaya in terms of race (unit: 1,000 persons)

Malay		Chinese		Indian and Pakistani		Other		Total	
Population	Percentage %	Population	Percentage %	Population	Percentage %	Population	Percentage %	Population	Percentage %
3,629	50.1	2,678	37.0	806	11.1	134	1.9	7,250	100

* Rice physiologist, National Institute of Agricultural Sciences

Table 2 Production, import and the self-supply ratio of rice in the Federation of Malaya

	Annual consumption (ton)	Production (ton)	Import (ton)	Self-supply proportion (%)
1953	793,085	441,000	352,085	55.6
1954	606,102	408,170	197,932	67.3
1955	756,077	410,590	345,487	54.3
1956	782,700	420,070	367,630	53.7
1957	838,096	497,580	340,516	59.4
1958	841,604	495,450	346,154	58.9
1959	802,546	442,950	359,596	55.2
1960	917,116	560,150	356,966	61.1
1961	920,679	604,970	315,709	65.7

Source: Monthly Statistical Bulletin, Federation of Malaya, 1962

Table 3 Cultivation area of the major crops in the Federation of Malaya (unit: 1,000 acres)

Year \ Crop	Rubber	Rice	Coconut	Fruits	Oil palm	Food crop	Spices	Tea	Miscellaneous
1956	3,694	876	517	212	115	102	54	9	61
1957	3,721	897	517	214	116	107	51	10	63
1958	3,747	909	518	219	122	117	52	10	62
1959	3,783	924	520	210	126	116	47	9	60
1960	3,840	941	520	213	135	118	48	9	63
1961	3,923	954	520	214	141	129	46	9	64

Source: Monthly Statistical Bulletin, Federation of Malay, 1963.
Note: The item "Food crop" includes tapioca, sweet potato, sago, sugar cane, etc. The item "Miscellaneous" includes cocoa, derris, ramie, etc.

Table 4 Temperature in various places of Malaya

	Max. tepmerature (mean)	Min. temperature (mean)
Alor Star	30—33.5°C	22—24.5°C
Kota Bahru	29—32.5	22—24
Butterworth	30.5—32	23—24
Kuala Lumpur	31.5—33.5	22—23
Malacca	29.5—32	23—24
Kluang	29.5—32.5	21.5—23
Singapore	29.5—32	23.5—25.5

Source: Data of the Department of Agriculture in Malaya.

ture.

The Monthly Statistical Bulletin issued in 1963 by the Statistics Bureau of the Malayan Government has disclosed the following data as shown in Table 3. Rubber occupies most of the cultivation area, an area far larger than the other crops, approx. 4 times as large as the second ranking rice plant. Next to the rice plant come the coconut, fruit, oil palm, food crops other than the rice plant, pungent herb and tea. In the meantime, the important point observed is as follows: the increase of the cultivation areas for the rubber, coconut, fruit tree, pungent herb, tea and other crops has become dull or stopped, while the oil palm and food crops other than the rice have shown a slight increase. In contrast with them, only the rice plant has evidently increased its cultivation area steadily year by year, in short, we can conclude that the rice plant is not only the second-ranking important crop but also a crop of great promise.

III Natural Environment of the Rice Crop in Malaya

1. Temperature

As Malaya is a small peninsula close to the equator in the monsoon zone, little yearly variation is observed in its temperature. As for the mean temperature, little difference is found locally in the level land, Throughout the year, it is a little lower than that in midsummer in Tokyo (refer to Table 4). In the daytime, the max. temperature seldom exceeds 34°C. At night, it falls to 22-25°C. In relation to the environment for the rice crop, therefore, we can conclude that the atmospheric temperature is not an influential factor. During the maturing period, however, the temperature at night seems to be rather higher.

2. Day-length

Annual change in the day-length is also very small. Table 5 shows the max. and min. day-length in 3 points in the southest, middle and northest areas. As compared with the annual day-light difference, 4 hrs. 51 min. in Urawa City, Japan, it is 10 min. in Singapore, 20 min. in Kuala Lumpur and only 38 min. even in Alor Star where the day-length is longest. Thus the day-light difference throughout the year is very small. Though the annual day-light difference is so small, the varieties of rice used in Malaya are so sensitive that they react to so small a difference in day-length as one of several minutes. It is a wonder to the Japanese agricultural experts. Though the change in day-length throughout the year is thus so small, the day-length has become an undeniable factor in setting the growing season and selecting the varieties of rice.

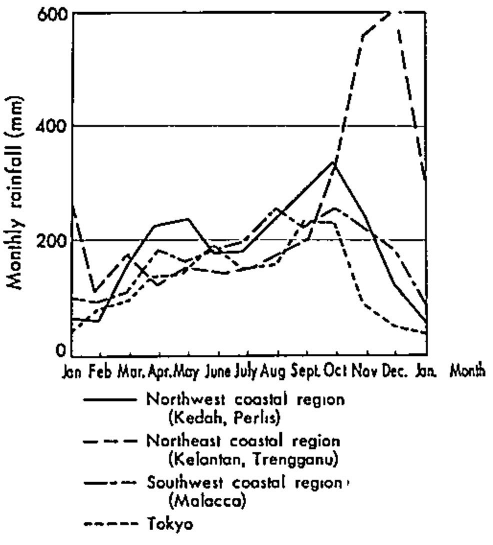
3. Rainfall

The most important weather element, which directly affects the rice crop in Malaya, is the rainfall. In Malaya, the amount of rainfall and the number of rainy days are large. The former is 2500-3500 mm. and the latter more than 200 per year. But the rain is mostly a squall, not a long spell of rain. As disclosed in Fig. 1, an almost clear distinction can be drawn between the dry and rainy season in some regions on the east coast, while it cannot easily be drawn in many regions. In general, it rains during Sept.-Dec. In relation to the day-length, too, this period is the prime for the rice crop. In some districts, however, the peak of rainfall is observed in two seasons, spring and autumn. It would be, therefore, natural that the season and condition of the rice crop have been greatly affected by the rainfall, when the fields were hardly provided with any irrigation facilities, which could make the rainfall distribution throughout the year even and improve the efficiency of the rice crop. But the Malayan Government has recently become zealous for the expansion and completeness of irrigation facilities. In this connection, the area of the off-season crop, which had accounted for only 1-3% of the total, has also begun to increase gradually. In the past, when the rainfall was large, the rice crop suffered from a flood. When it was small, on the other hand, it sustained heavy damage from drought. One such damage was generally found in some regions every year.

4. Geological condition and the soil

The Malaya Peninsula is chiefly made up of granite and andesite of the tertiary period geologically. Therefore, most of the soil in Malaya is said to have originated therefrom.

The soil in Malaya can be reportedly classified



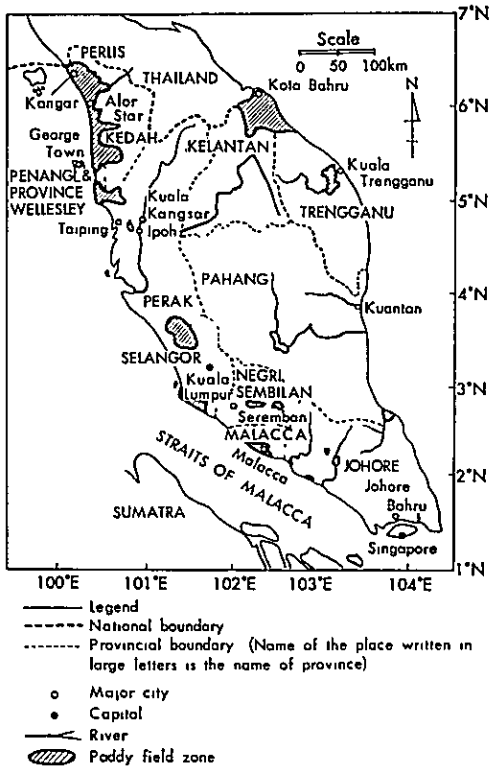


Fig. 1 *Comparison of the rainfall between various regions in Malaya and Tokyo.*

Fig. 2 *Rice crop area in Malaya*

Source: The above was made, when the data of chronological table of science was added to that of Malaya Ministry of Agriculture and Cooperatives.

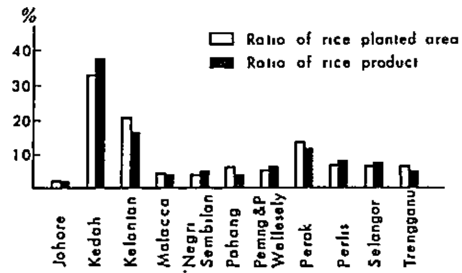


Fig. 3 *Ratio of the rice cultivation area of the states, and the production*

Source: Diagram plotted on the basis of the "Monthly Statistical Bulletin, Federation of Malaya, 1962", quoted from the research data, No. 15 of the Technique of Central Agricultural Experimental Station.

roughly as follows:

1) Granite soil: This soil drains well. The ratio of sand to clay is almost equal.
2) Quartzite soil: It consists of fine sand silt and clay. The percentage of these three varies.
3) Raub series soil: It contains a ferrous layer. The soil is dark brown, and includes a good clay.
4) Coastal alluvium: It is a soil consisting of seashore clay, silt and organic matter, which is said to be the most fertile soil in Malaya. Most of the places of this soil drain badly.
5) Pahang volcanic and dolorite: They are chiefly found in Pahang. The former is reportedly rich in potassium, while the latter in phosphate. But the area containing these elements is very small.
6) Highland soil: It contains much granite generally, and is more immature than the lowland soil made of similar rocks. It is rich in inorganic matter, and its surface is said to be also rich in organic matter. In many regions, the pH of the soil in Malaya is 4.5-5 5.

Most of the paddy fields are scattered over the alluvial zone along the coast and rivers.

IV Major Rice Zones in Malaya, Area under Cultivation and the Production in Terms of State

Main rice crop regions in Malaya are as shown in Fig. 2. The area under cultivation in 1961-62 was 390,000 ha. Of the rice crop, the main season paddy was 90%, the upland rice 6% and the off-season paddy less than 4%. Of the production, 93% was the main season paddy, and the off-season paddy less than 4%. Rice crop regions are mostly developed in the lowland close to the river basins and the coast. As for the major rice crop zones, approx. 50% of the paddy fields are located in four states on the northwest coast, and approx. 40% mostly in two states on the northeast coast. Thus they concentrate in the zone in a latitude of 5.0-6.5°. This distribution is in contrast with that of the rubber plantations, which chiefly concentrate in the southern region.

The area under cultivation and the production in various states are as shown in Fig. 3. The state where the area under cultivation is largest is Kedah (30%). Next to Kedah come Kelantan (20%), Perak (13%), Perlis and Trengganu (7%), Selangor and Pahang (5%), Penang and Province Wellesley (4%), Negri Sembilan and Malacca (3%) and Johore (less than 1%). In relation to the production, as shown in Fig. 3, Kedah produces most, and Kelantan is next. Their production accounts for 37% and 17% of the total respectively. In other states, the production is roughly proportional to the cultivation area. (The mean yield of upland rice per unit area is approx. 50% that of low land rice. But the yield of the off-season paddy is 97% of that of the main-season paddy on average. In some regions, it is sometimes higher than that of the main-season.

Table 5 Daylength in various places of Malaya.

		Singapore (N.1°18′)	Kuala Lumpur (N.3°08′)	Alor Star (N.6°09′)
Longest daylength (in late June)	Sunrise	6 : 30 a.m.	6 : 36 a.m.	6 : 37 a.m.
	Sunset	6 : 39 p.m.	6 : 50 p.m.	7 : 00 p.m.
	Daylength	12 : 09	12 : 14	12 : 23
Shortest daylength (in late December)	Sunrise	6 : 30 a.m.	6 : 41 a.m.	6 : 51 a.m.
	Sunset	6 : 29 p.m.	6 : 35 p.m.	6 : 36 p.m.
	Daylength	11 : 59	11 : 54	11 : 45

Source: Data of the Department of Agriculture in Malaya.

V Development of the Rice Crop Yield per Unit Area in Malaya

The rice crop yield per unit area in Malaya is, generally speaking, approx. one-third that in Japan. As disclosed in Table 6, however, there is evidently a trend for it to increase year by year. This could be attributable to the expansion and improvement of irrigation and drainage facilities, diffusion of varieties of excellent ability, improvement of the growing methods, etc. In this connection, it is worthy of note that the yield per unit area in Malaya is higher than that in any other country in Southeast Asia, and that its increase rate (1945-'50 versus 1950-'55) has reached the highest, being 25%.

VI Problems in the Rice Crop, and Limiting Factors in the Yield Components

In the first place, the most important problem in the rice crop is the completion and expansion of irrigation and drainage facilities, because some regions have been damaged by flood or drought every year as mentioned above, and the expansion of watering facilities in the off-season has become an important issue, since the double cropping system for rice was promoted by the Government. In connection with the above, researches in the water requirement for various kinds of soil, the most economical use of water, etc. have been taken as the urgent problems. Several years ago, the national soil-water research station was established in Tanjong Karan.

The problem of production increase based upon rice breeding has been taken up early. Especially, stress seems to have been laid upon the breeding of suitable varieties in the off-season with the development of double cropping system for rice. But very little work has so far been done. It is, however, encouraging that Japan's technical aid under the Colombo Plan grant has made success in breeding such excellent varieties as mentioned in another chapter. As in case of other countries, the chief objective of the rice-breeding in Malaya is to improve the yielding ability, manuring resistance, lodging resistance, disease resistance, and the quality of kernels.

The problems on the improvement of growing methods are as follows: the raising of seedlings, preparation of soil, time and method for transplanting (including the density, depth, etc.), fertilization method, care of the fields (watering and drainage method, intertillage, etc.), cropping system, etc. In these tests and researches, the Japanese technical experts have co-operated with the Malayan scientists on the basis of the Colombo Plan.

As for the injurious insects, the damage of rice stem borer was most serious. In this connection, too, the Japanese technical aid has given the first ray of hope for the settlement of this difficulty. As for disease, the so-called "Penyakit Merah" is most rampant. For four years before the start of Japanese technical aid, a Canadian expert tackled the problem on this disease exclusively under the Colombo Plan. In fact, however, this problem has not been settled at all. Under suspicion of the nematode parasites being related to the occurence of this disease, researches have been made in co-operation with the Japanese experts. While no conclusion has yet been drawn, International Rice Research Institute, in the

Table 6 Increase trend of the rice yield per unit area in Malaya.

Year	Gantang/acre	Year	Gantang/acre
1954—'55	309	1958—'59	326
1955—'56	319	1959—'60	392
1956—'57	358	1960—'61	416
1957—'58	358	1961—'62	391

Source: Monthly Statistical Bulletin of the Federation of Malaya, 1963.
Note: 300 gantangs/acre is equivalent to one koku of hulled rice per tan in Japan.

Table 7 Mean values and ranges of yields and yield-components viewed from the yield diagnose.

Item	Max. value	Min. value	Mean value
Gantang/acre	999	170	585
No. of panicles/m²	199	65	109
No. of grains/panicle	226	39	162
Percent. of ripened grains	93.1	77.6	84.7
1,000 grain weight	28.1	19.8	24.3
Percent. of degenerated grains	45.5	32.1	37.6
Percent. of nonfertilized grains	13.9	5.5	10.6

Note: As for the percentage of ripened grains, grains greater than 1.06 specific gravity have been taken as ripened grain.

Philippine which had researched this problem, has recently made public that the Penyakit Merah in Krian district, Perak State, is probably caused by virus.

In addition to the above, the pest, which has done most harm to the rice crop, is the field rat. It is strange that neither test nor research has so far been made into the field rats. When the recommendation of the author was adopted by the Malayan Government, a Japanese expert was invited on the basis of the Colombo Plan, and scientific researches have been started for the first time. With the help of the Malaya Department of Agriculture and the officials of various state governments, the author conducted a yield diagnosis on the paddy fields in every rice-growing state in Malaya to check the characteristics and defects in constituting the grain-yield. As a result of this survey, such nation-wide mean values as shown in Table 7 have been obtained, and the following items have been disclosed:

1) Though the yield has no necessarily high correlation with each yield component, it is very highly correlative to a product (number of the grains per unit area) of the number of panicles per unit area, and that of grains per panicles.
2) High percentage of the ripened grains seems to be a general characteristic of the rice crop in Malaya.
3) As the rice yield in Malaya is chiefly dependent upon the number of grains per unit area, the increase in the number of grains per unit area would be a key to the production increase of rice in Malaya.
4) From the above viewpoints, it is probable the following measures would be effective in improving the rice cultivation for the present;
   (i) Application or addition of the basic fertilizer, especially the nitrogen fertilizers.
   (ii) Additional application of fertilizers 2-3 weeks after the transplanting.
   (iii) Use of healthy and young seedlings.
   (iv) Narrow spacing.
   (v) Shallow transplanting.
   (vi) Shallow watering.
   (vii) Prevention of the degeneration of spikelets (additional application of nitrogen fertilizer immediately before the stage of reduction division, prevention of the soil reduction at the stage of reduction division, prevention of flood or drought, measures against water with high temperature, prevention of diseases and insect pests, etc.).

VII Outline of Japanese Technical Cooperation

In May 1958, our survey team headed by D. SHIRAISHI, the then head of Kanto-Tozan Agricultural Experimental Station (expert on crop science) with the membership of H. ISHIKURA (pests) and N. KAWADA (soil and fertilizer) went over to Malaya. Throughout the country, they made an inspection of the rice crop situation for about one month and discussed with the Malayan agricultural department authorities concerned. After that, it was decided that in our technical cooperation, stress should be laid on four points: improvement of rice culture, improvement of fertilizer application and the prevention and extermination of the rice stem borer. In August 1958, our technical cooperation was started on the basis of the Colombo Plan.

As members of the 1st cooperation team, H. YAMAKAWA (breeding), T. KOYAMA (pests), M. MORIYA (rice culture) and S. SATO (soil and fertilizer) were elected. After the difficulties of trying to star the work based on their own specialities, they have built a foundation of our technical aid. Of the above members, SATO stayed for two years, while the other three remained for about one year. After that, the latter were relieved by members of the 2nd team; N. KIMURA (pests), Y. TAKAHASHI (rice culture) and K. FUJII (rice breeding). Under the guidance of SATO, who had been staying there, they could get accustomed to the Malayan way of living more quickly and devote themselves to their respective specialists task. After their stay of about one year, these three members of the 2nd team returned, and S. SATO, member of the 1st team also returned home. When they were relieved by members of the 3rd team, the Malayan authorities of the Ministry of Agriculture and Cooperatives greatly desired: "Minimum stay period for Japanese technical experts should be two years because their one-year sojourn is too short. As soon as they become familiar with the environments in Malaya, and start their tasks on the right lines, they go back home," and the Malayan Government requested formally the Japanese Government to extend the minimum sojourn period to two years. Since the 3rd time, therefore, many team members have been staying for almost two years. As members of the 3rd team, M. NAGAI (soil and fertilizer), T. SATO (rice culture) and E. KAWASE (pests) went over to Malaya in July 1960. Later in November 1960, J. KAWAKAMI (rice breeding) went over to Malaya. As these 3rd team members lived with the former members for approx. 3-5 weeks respectively, the situation was favorable both publicly and privately. In their respective fields of speciality, they did their best, and gradually achieved their remarkable specific results. Of the 3rd team members, SATO and KAWAKAMI returned home after their stay of one year and three months, while NAGAI and KAWASE were staying for a full two years. As the 4th team members, S. SAMOTO (rice breeding) first left for Malaya in January 1962, K. SUGIMOTO (rice culture) in March and further M. MIYAKE (soil and fertilizer) in November the same year. They examined the achievements of the previous teams and added valuable results thereto respectively. SAMOTO has had special success in breeding the new varieties, Malinja and Mashuri from the crossing system, which he had taken over from his predecessors of the former three teams. M. SUGIMOTO has also completed his new work together with the achievements of his predecessors of the former three teams, and returned home in March 1964. In contrast with the former members who had chiefly made farm tests, MIYAKE has made researches into the nitrogen in the soil of paddy fields mainly in the laboratory of the Department of Agriculture. On the other hand, he made efforts to establish chemical analysis methods and to give useful instruction, and then returned home in March 1965. In the 4th team, KAWASE (pests) was not relieved by any successor because we considered that the efforts of technical experts of three teams had almost enabled the Malaya Government to establish measures for preventing and exterminating the stem borers. In place of the problem on rice stem borers, the Malayan Government took up the problem of the field rat and the nematode parasites of the lowland rice, which the author had proposed, and asked the Japanese Government to dispatch experts in these problems. In consequence, M. MOCHIZUKI, expert on the field rat was sent to Malaya in November 1962, and Y. KUNII, expert on the nematode parasites of the lowland rice, in May 1963. MOCHIZUKI completed investigation of the species and distribution of field rats in preparation for their extermination, and found effective poison experimentally in the laboratory. After his stay of two years, he returned home in November 1964. During his stay for one year, meanwhile, KUNII investigated the damage of nematode parasites of not only the rice but also various agriculture products in all the regions of Malaya, and pointed out that the low yield of

Fig. 4 *Major rice experimental stations in Malaya. (N) shows the national, while others the state.*

rice in Malaya could be partly attributed to the damage of nematode parasites, and that the disease of cocoa is also attributable to these parasites, etc. Samoto, who returned in May 1965, has been relieved by J. Kawakami (rice breeding), member of the 5th team, who had been previously staying in Malaya. (refer to Fig. 4)

Aside from the technical cooperation based upon the Colombo Plan, the Malayan Government has been given technical aid from the FAO (Food and Agriculture Organization of the United Nations). In this connection, M. Tsukibayashi has since 1959 been staying in Malaya for about one year and half to work out a program for the agricultural census, while the author (rice physiology) has since 1960 been stationed there for the same period to work out and put into practice a test program and train the rice experts in Malaya, etc. in relation to the establishment of soil-water research station.

The author has made experiments and researches on the rice, soil and water. My major work has been made public in an article entitled "Some Experiments on the Soil Water Plant Relationship in Rice" in the "Division of Agriculture Bulletin, No. 112, Ministry of Agriculture and Cooperatives" issued by the Malayan Government. On the other hand, my lecture with the heading, "Theory and Technique of Rice Cultivation" has been distributed among the scientists working with rice in Malaya as a book. Meanwhile, Tsukibayashi has made success in having the Malayan Government put in practice the first modern statistical agriculture census throughout the country.

At present Japanese technical cooperation with Malaya has been continued only in rice breeding, not in other spheres of agriculture. As many problems remain unsettled in all spheres, however, it is desirable that the experts of both countries should further collaborate with one another in promoting their research. In this connection, I am sure that such a collaboration could greatly promote the solution of various problems.

From the above, we can conclude as follows: Malaya is the country where Japan's technical cooperation in rice crop is the greatest. Its achievement also seems to be larger than that in any other country of Southeast Asia. In examining what form our future technical cooperation should take, therefore, our technical cooperation in Malaya would be a useful example.

RESULT OF STUDY ON RICE CULTURE

Katsuo SUGIMOTO*

I Development and Outline of Our Technical Cooperation

About 1943, our senior experts were successful in a trial off-season crop on the northwest coast of Malaya for the first time, by using rice varieties introduced from Formosa. Taking advantage of this test, an off-season crop was started in Province Wellesley after the Second World War. Because of the good irrigation facilities, this area has become a center of off-season crop in this country. On the basis of the Colombo Plan, Japanese rice experts have since Aug. 1958 been sent from Japan to Malaya after national independence. As for the agronomical branch, M. MORIYA, first stayed for one year and one month at the Bukit Merah Padi Experiment Station, Province Wellesley. He arranged the system of rice cultural experiments in this station, guided his assistants in the fundamentals of rice culture and the survey method, and gave the following tests over two crops:

1) Observation of the characteristics of the growing phase of the *Indica* paddy plant
2) Effect of the qualitative difference between the upland and lowland seedlings, and the shallow planting upon the rooting ability
3) Study of the proper transplanting density and system in relation to the nitrogen quantity applied
4) Investigation of the ploughing and irrigation for the improvement of the conventional rice crop, and experiments on the ridge rice culture
5) Tests on the application of herbicide 2, 4-D and PCP
6) Analysis of the reason for low yield by means of a survey on the rice yield in farmers' in the main season.

* Agronomist,
Tokai-Kinki National Agricultural Experiment Station

Though he was staying for such short a period as nine months, Y. TAKAHASHI then improved the available land of the B. Merah Padi Experiment Station, partitioned it off into sections, 10 acres each and laid watering and drainage channels. The chief experiments, which he made, are as follows:

1) Investigation of the allotment rate and proper application period for nitrogen.
2) Varietal difference on nitrogen response and planting density
3) Study of the proper planting density and system
4) Tests on the proper weeding method
5) Effect of the difference of submergence duration before the transplantation upon the rice yield
6) Observation of the physiological disease of Penyakit Merah

Also during his term of office, the Bumbong Lima Padi Test Station, which could easily irrigate and drain the northern part of Province Wellesley, was established.

T. SATO was stationed for one year and three months from July 1960. In order to make clear the technical standard of the off-season rice crop to meet future development, he surveyed the actual state of the off-season crop. During his terms of service, he went to Kedah, a granary of the Federation of Malaya, where he was engaged in guidance for the improvement of rice culture technique. The tests, surveys and observations he made are as follows:

1) Survey of the actual state of the off-season rice crop, and measures for its improvement
2) Experiments upon the varietal differences of the fertilization and the planting density
3) Test of the application method for nitrogen
4) Observation of the vertical distribution of atmospheric, water and ground temperature of the paddy field, and the flowering of rice plants
5) Survey of the rate of stem borers remaining in the culms of rice plants, and the rate of

the falling of grains subsequent upon the harvest operation

Though there was a gap of five months from the return of SATO until the arrival of the author at his post, there was no gap in the research work, as M. NAGAI, soil chemist, who had been in B. Merah and B. Lima, also continued the agronomical experiments. As the soil chemist, who succeeded M. NAGAI in his post, was stationed in Kuala Lumpur, the agronomy branch took over the outdoor tests, which had been given by the soil chemist in Province Wellesley.

In relation to the agronomical field of study, a test, which could be a recommended technical standard for the general rice culture, is more keenly desired than fundamental experimental research which requires much time. In this connection, the following defects for the low yield of rice crop in Malaya can be mentioned: paddy fields are little fertilized, timing of the fertilization is not correct. Imperfect fertilized response of the varieties, rough planting density, shortage of the number of panicles and subsequently grains per unit area, no water control and few irrigation facilities, deep water in rainy season, etc., no prevention and extermination measures against insect pasts, rats, Penyakit Merah, etc. In order to cope with these difficulties, Japanese agronomists have conducetd experiments on the rice culture technique, which could directly connect with high yield in the near future. As the author was a final member of the 4th team, he made efforts to draw a conclusion in relation to the tests in the agronomical researches. With reference to the records of the author and his predecessors, the test records of the agronomy branch will be described hereunder.

II Results of Study of the Agronomy Branch

Double crop in Malaya is divided into the main season crop (Sept.-Feb.) and the off-season crop (Apr.-July). In the former season, the medium-term variety of growing period, 5-6 months is cultivated. In the latter season, however, the short-term variety of growing period, 4 months, Pe Bi Fun, a conventional Formosan variety is cultivated. Though it has gradually increased, the area of double cropping occupies only 5% of the total, while the single cropping area is 95% thereof. In the single cropping the longmedium-term variety of growing period, 6-7 months has been cultivated. In the tests the author et al. have used a variety typical of the double cropping area. Though the British system of weights and measures, yards and pounds is employed in Malaya, units in this report are shown in terms of C.G.S., while the yield is expressed by the weight of refined grains common to Southeast Asia.

1. Study of the growing phase
1) Growth of the Malayan rice above and below the ground.

One example of the growth development is shown in Fig. 1. In both seasons, the valid tillering stage comes 30-35 days after the transplanting, and the stage of maximum number of tillers 40-42 days thereafter. These stages are almost constant in the short-and medium-term varieties. In the short-term varieties, therefore, the interval between the stages of maximum number of tillers and the spikelet differentiation stage is very short. MATSUSHIMA has reported that the valid tillering stage was 41 days after the transplanting on average, and the stage of maximum number of tillers 55 days. In this case, however, the long-term varieties were included.

In general, there are many varieties of small

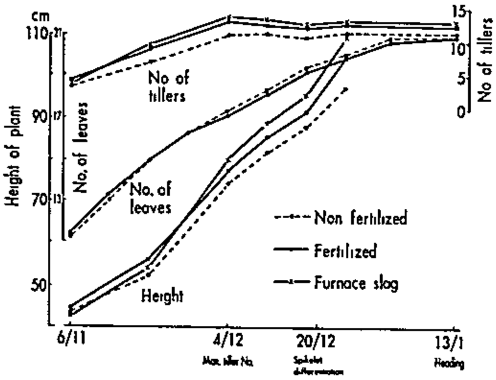


Fig. 1 *Changes in growth* (R. China 4)

Note: Furnace slag means the combined use of furnace slag with other fertilizer.

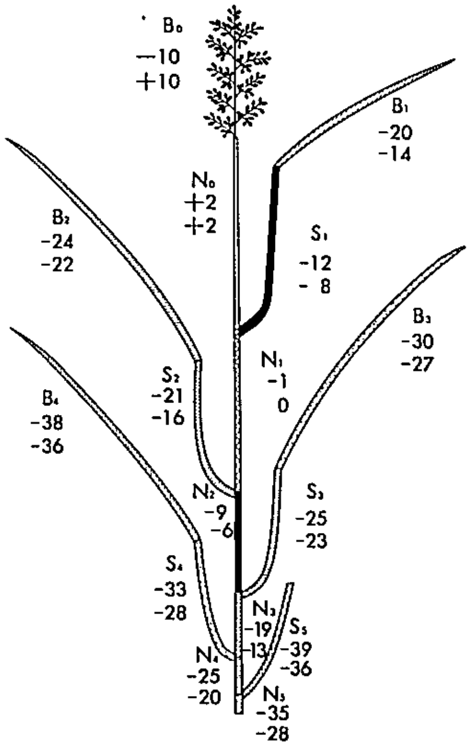


Fig. 2 *Illustration showing the process of the elongation and increase of dry weight of each organ* (Radin China 4)

Note: Upper figures; peak date of principal period of elongation
Lower figures; peak date of principal period of weight increase

tillering types. Probably because the maximum number of tillers is small, the percentage of effective tillers is higher than expected. The number of main leaves (excluding the coleoptile) of the short-term varieties was 17-20, and that of the medium-term varieties of growth, approx. 150 days long, 19-21. From the change of dry weight, it is conceivable that the matters stored in the stems and leaves are transferred to the panicle immediately after the heading stage. As the plants grows at a constant temperature of 27°C on average, they reach the maturing stage in more than 30 days after the heading stage.

Rooting dry weight gradually increases after the transplanting reaches its peak at the stage from the maximum number of tillers to the spikelet differentiation stage, and then gradually decreases. Rooting rate is highest at the transplanting, or immediately thereafter, and then gradually decreases. After the spikelet differentiation stage, it decreases remarkably at the heading stage. It is conceivable from this that the vitality of the roots is on the wane. Such a trend in the rooting development is almost the same as that of the rice plants in Japan. In the main season, the soil Eh_6 is $-60\sim+60$ mV in B. Merah. In the off-season, it is $-90\sim+50$ mV. As compared with Japan, the plants grow from the early stage of the paddy field at a higher temperature and under abnormal soil reduction.

2) Elongation and changes in dry weight of the various organs, and the interrelation between them.

On the basis of the heading stage, the elongation of all organs above the ground, change in the dry weight and their correlation are almost the same as those in Radin China 4 and Pe Bi Fun. The records of the R. China 4 especially almost fully agreed with those of the Aichiasahi in Japan. Elongation of the leaf-blades, leaf-sheaths and internodes, and the increase in dry weight reach a maximum, forming S-shaped curves. Except in the dry weight increase of B_0, as shown in the same marks of Fig. 2, the organs, whose peak date principal period of elongation (peak date of principal period of dry weight increase) is almost the same, correspond to one another as follows: B_0: S_1: N_2, B_1: S_2: N_3, B_2: S_3: N_4

In other words, a certain regularity is observed among all organs. As for the relation between the elongation and the dry weight increase, the dry weight begins to increase generally; when the elongation velocity of the organs reaches the maximum. When the dry weight increase reaches the maximum, the elongation approaches its end. Both of them are found alternative and regular. They extend from the lower to the upper organs in sequence.

As in the *Japonica* rice plants, the panicle weight increase is found to remain at the same level for a while immediately after the heading stages. Such a phenomenon seems to come

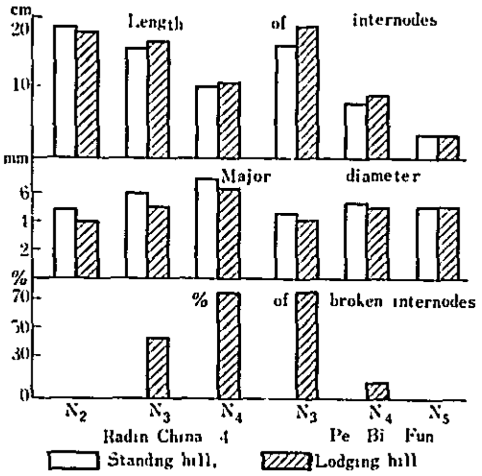


Fig. 3 *Characteristics of internodes*

from the consumption, based upon the increase in respiration at the flowering and fertilization period. After the heading stage, the dry weight increase of only the panicle is remarkable. From this, it is conceivable that the assimilated products translocate from the reserve organs to the panicles.

3) Morphological characteristics of lodging rice plant and its lodging index.

As the Malay rice plants are generally low in fertilizer response, a higher yield cannot be expected, unless they are slightly lodged. In relation to the time of top-dressing, however, the reduction of lodging is a key to the yield increase. As shown in Fig. 3, the broken portions are the internodes close to the soil surface, or less than 15cm high above the ground, mostly N_3 (the 4th internode below the neck-node) and N_4. When these internodes are compared with those of the sound rice plants, they are longer and their width is thin. As shown in Fig. 4, the bending moment and the breaking strength increase after

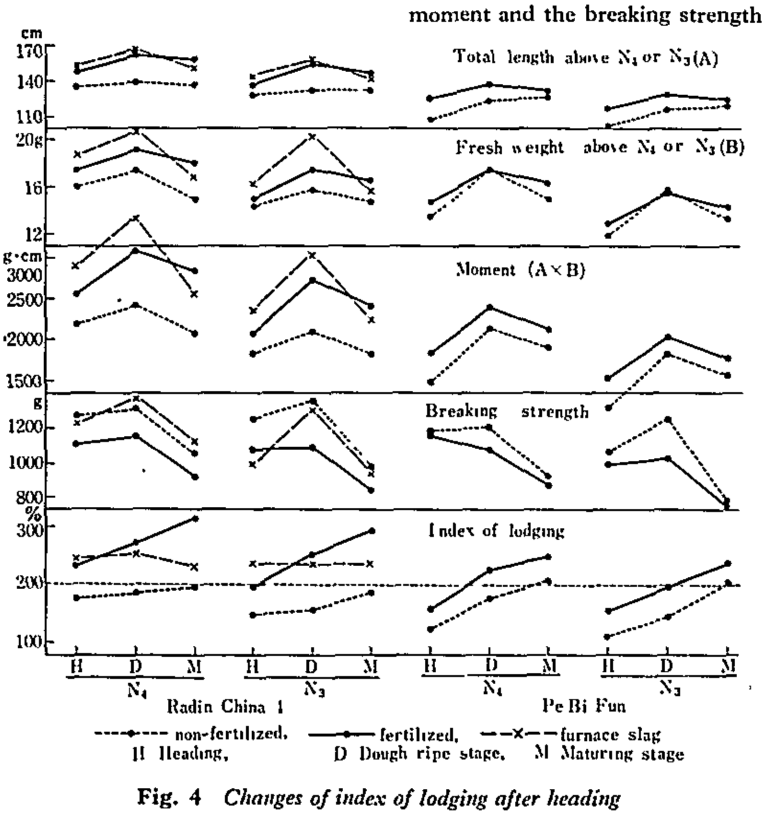


Fig. 4 *Changes of index of lodging after heading*

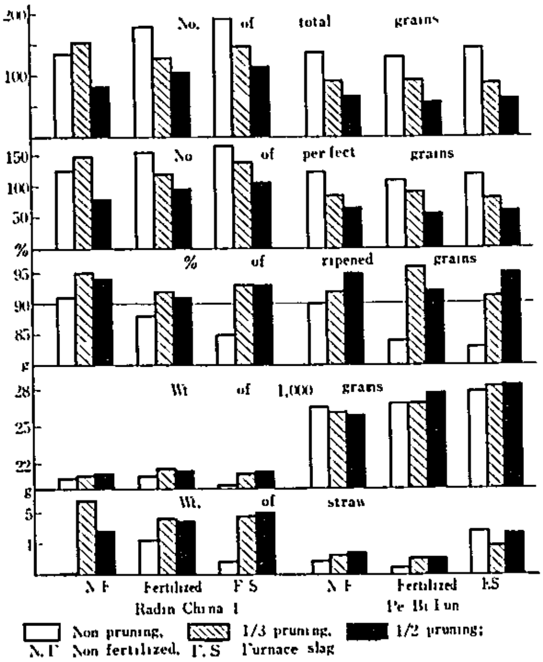


Fig. 5 *Comparison of percentage of ripened grains among different plots when the number of spikelets was reduced by pruning the primary rachis branches*

the heading, reach the peak at the stage of dough ripe and then decrease. Lodging index (moment /breaking strength × 100) gradually increases after the heading stage. In the case of the Japanese rice plants, the danger limit for lodging is reported to be the lodging index of 200. In the case of the Malayan rice, however, the lodging index showed 200 at the heading stage or dough ripe stage. Even in the non-fertilized plot, it reached 200 at the maturing stage. After the heading, there is thus a great danger of breaking and lodging.

In relation to the N_3 and N_4 affected by lodging respectively, their principal elongation begins 24-28 days before the heading. Initial elongation begins several days before that. When high temperature promotes the elongation, and then nitrogen nutrient in the rice plant or in the soil is excessive, they become the main reasons for lodging. In some cases when the silicic fertilizer or 2, 4-D is applied, a control effect against lodging is observed, but a decisive effect cannot be expected. As the dry season comes after the heading in the main season, there are fewer occasions for lodging caused by rain than in the off-season.

4) Analysis of the percentage of ripened grains and the yield components.

According to the nation-wide survey made by MATSUSHIMA, the percentage of ripened grains is 85% on average. According to the MORIYA's survey in the main season, it is 89% on average. According to the survey made by the author, it is 81-91% in the nonfertilized plot, and 76-88% in the fertilized plot throughout four seasons of Bukit Merah. Though it is a little lower than that of Japanese rice plants, it seems to be higher than that in the near-by countries. MATSUSHIMA has reported that there are many degenerated spikelets, and that the percentage of ripened grains is not influenced by the percentage of abortive grains, but by that of non-fertilized grains. When the number of spikelets is extremely limited to increase the allotment of the assimilated products per grain as shown in Fig. 5, the percentage of ripened grains increases to approx. 95%. Such a trend is more remarkable in a fertilized plot, where the number of grains per plant is larger than in a non-fertilized plot. The trend of the decrease in the percentage of ripened grains due to the excess of spikelets, which had been discussed in various countries in Southeast Asia, is observed to be slight here. From these records, it was expected that the 1,000 grain weight increase would be 4-5% at maximum, when the cultivation technique was improved.

In the meantime, MORIYA has reported that of the yield components, the number of panicles per sq. m., and subsequently the number of grains is in the closest correlation with the yield as shown in Fig. 6, not in any correlation with the percentage of ripened grains. MATSUSHIMA has also reported that the increase in the number of grains per unit area is a key to the high yield. It seems difficult to enhance the percentage of ripened grains and the 1,000 grain weight greatly in order to grow the plants at heavy soil reduction and ripen them at high temperature. Anyway, the shortage of the number of panicles per unit area due to sparse planting seems to be one of the reasons for the low yield in Malaya.

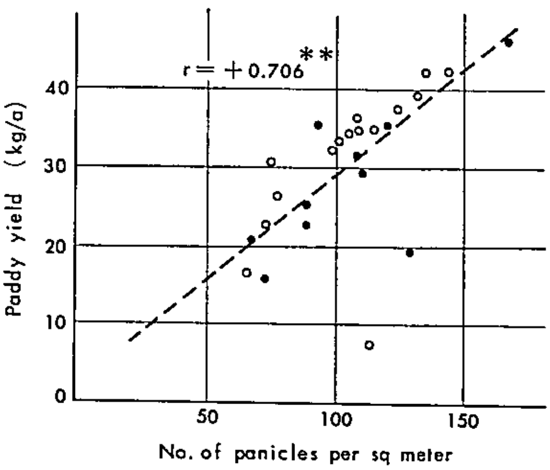


Fig. 6 *Correlation between the paddy yield and number of panicles per square meter* (Main season, MORIYA)

2. Fertilizer response of the typical medium-term variety.

When each component is less than 0.68 kg/a (60lbs/acre), the fertilization increase would increase the number and length of panicles and also the paddy yield. But the increase in the 1,000 grain weight is unknown. The Sigadis, Mayang Ebos 80 and Subang Intan 117 are high in fertilizer response. As for the S. Intan 117, it would be a fault that the number of growing days is a little larger in the double cropping area. The mean number of panicles is 12, when the rice is planted at a distance of 30cm×30cm. The variety with the highest number is the Anak Kuching, whose panicle is 16. On the standard of Japanese rice, these varieties are the "panicle-weight type" or "semi-panicle-weight type".

In Bukit Merah where the fertility of the soil is high, the later maturing variety of the medium-term is higher in yield. In the B. Lima where the fertility of the soil is low, the medium maturing variety is desirable. Even when three elements of the fertilizer are less than 0.68 kg/a, considerable lodging is found at the maturing stage. If more fertilizer is applied, most of the varieties would break and lodge reducing the yield.

3. Suitable application of nitrogen (amount and time).

NAGAI's report has disclosed that of the three elements, the nitrogen is the most dominant in the yield. In relation to the nitrogen alone, therefore, experiments have been made in Bukit Merah, Bumbong Lima and in five farmers' fields of various soil types. Though the records did not necessarily agree with one another in their trend, they will be summarized and observed hereunder. In B. Lima where the fertility of the soil is low, the nitrogen effect is naturally high. Mostly in the main season when the varieties of longer growth period are cultivated, fertilization at twice as much as the recommended standard, 0.34kg/a would often yield highly. In the off season when the short-term varieties are used, on application of approx. 0.34 kg/a would be safe.

In relation to the application time, the basic fertilizer, or the tillering fertilizer approx. one month after the transplanting is effective to increase the ,number of panicles. Under the influence of lodging, however, the number of panicles does not necessarily coincide with yield. In the main season, fertilization for sprouting the panicle at the spikelet differentiation and the reduction division stages increases the number of perfect grains, and consequently its effect is high. Especially in B. Lima, the fertilizer effect is high at the reduction division stage. TAKAHASHI also recognized the fertilizer effect at the reduction division stage. On the other hand, NAGAI has reported that in the off season, the tillering fertilization connects with the increase in the number of panicles, and the fertilizer effect is high. According to the records of the author, no great difference is observed in yield in relation to any certain specific stage. In some test farmers' fields, the fertilization for sprouting the panicle is moderately effective. As for the application time, therefore, the author cannot draw any evident conclusion for the off season. In all areas when the furnace slag was applied, the maximum yield was recorded, and the application effect was almost observed.

In short, the suitable amount of applied nitrogen is dependent strictly speaking, upon the fertility of the soil, but it can be concluded that the effect of additional fertilization is more effective in the main season. Opinion is divided whether efforts should be made to secure the number of panicles by fertilizing to promote the growth at the early stage, or whether stress should be laid upon the fertilization for sprouting the panicle, by controlling the nitrogen concentration in the soil at the early stage of growth. If the growth at the early stage is promoted, the rice plant could grow excessively thick to bring about lodging and bear poor grains. Accordingly, somewhat controlled fertilization methods are desirable at the early stage. In order to secure the number of panicles, it is more desirable to increase the number of plants than to rely upon the fertilizer.

4. Effect of the application of silicic fertilizer (furnace slag)

As a step for enhancing the fertilizer response of the Indica variety, the effect of the application of furnace slag (fertilizer containing the SiO_2 35%, CaO 35% and MgO 10%) has been examined. When only the furnace slag was used, no effect was observed. When it was applied in combination with nitrogen, a higher yield was found. Not the number of panicles but rather the number of grains and the increase of 1,000 grain weight relate to the above high yield (Fig. 7). According to the chemical analysis of MIYAKE, the concentration and amount of silica in the rice plants are usually increased, when the furnace slag is applied. In relation to other nutrients, however, the amount of nutrient uptaken is increased, while no difference is observed in the nutrient concentration. From this fact, it is conceivable that of the furnace slag, the silicate plays a major role. As there is no great difference between the applications, 17kg and 34kg/a in yield, the former application is more economical.

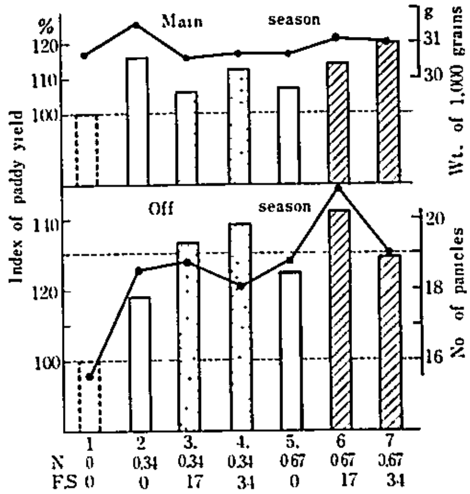


Fig. 7 *Effect of furnace slag in combination with nitrogen*

As in the case of Japan, the application of furnace slag is effective in enhancing the application limit of nitrogen and increasing the yield. Though the effect of the addition of lodging resistance is unknown in Malaya, the control over the growth at the early stage is hardly observed probably because of high temperature. In the paddy fields in Bumbong Lima, where

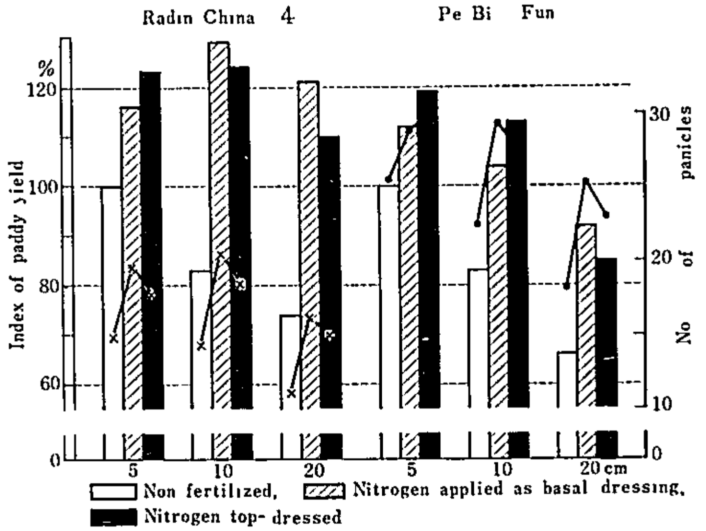


Fig. 8 *Relation between the depth of water and the method of nitrogen application* (Frame test)

the fertility of the soil is low, the effect is more evident. In the test farmer's fields, too, the maximum yield was observed in many cases. It was approx. 20% higher than that in the control plot (non-fertilized), and approx. more than 30% higher than that in the localized sparsely-planted plots. When the application is 17kg/a, additional experiment is required for the residual effect in the following season.

5. Relation between the water and transplanting depth and the fertilization (frame test).

In badly-irrigated Malaya, paddy fields of a water depth of more than 20cm are found, while many non-fertilized paddy fields are also found. When the "Kuku kambing" is used in the transplanting rice plant is transplanted as deeply as more than 10cm. Under the same fertilized condition, the effect of the water depth upon the yield is larger than that of the transplanting depth, because the growth, which had been poor at the early stage, gets better after the middle stage in the paddy fields. From this fact, it is conceivable that Malayan rice is ecologically insensitive to the bad condition.

Under the non-fertilized condition, as revealed in Fig. 8, the yield in 10cm of water decreases by approx. 20% as compared with the standard, and that of 30cm of water depth decreases by approx. 30% when comparison is made with the standard. Thus the adverse effect of the water depth is remarkably apparent. In the fertilized plots, meanwhile, yield decrease of 6% and 29% were observed at the water depth, of 10cm and 20cm respectively in the off-season when little nitrogen was applied. In the main season, however, when the nitrogen application was doubled, the yield was very much the same as that in the case of the standard water depth, probably because of the compensation effect of fertilizer. It has been suggested that the effect of nitrogen is higher in the main season. In this connection, it is desirable that more stress should be laid upon the basic fertilization than the top dressing in applying nitrogen to the fields of excessively deep water.

In consideration of such poor conditions as non-fertilization, deep water, etc. in the paddy fields in Malaya, the significance of the preventive effect of the fertilizer especially the nitrogen against yield decrease must be emphasized.

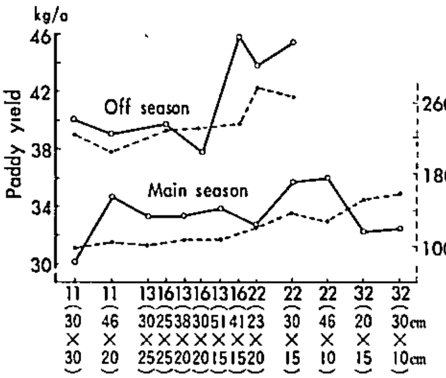


Fig. 9 *Comparison of the plant population per square meter and the planting pattern* (TAKAHASHI)

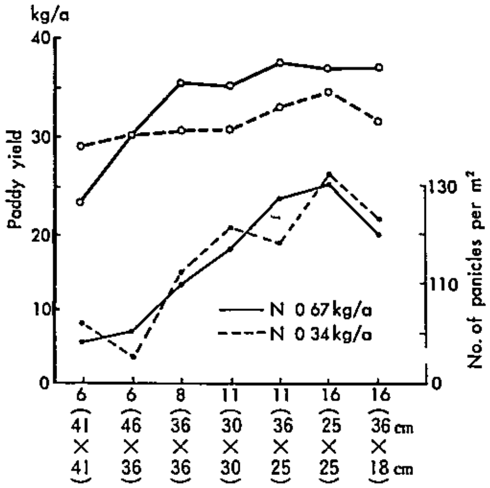


Fig. 10 *Relation between the plant population and the amount of nitrogen* (Main season) NAGAI)

6. Relation between the number of days for nursery and the sowing density.

In Malaya, where the temperature is high, the seedling of 25-day growth is as large as that of approx. 45-day growth in Japan. A sowing density of as low as 55 g/m² (1 gallon/500 sq. ft.), and the employment of young seedlings of approx. 20- and 30-day growth for the short- and medium-term varieties are recommended in accordance with the growing period of varieties respectively. In general farms, however, seedling 2-3 times as thick as the above sowing density have been employed, and ripened seedlings have been used. The propriety of the sowing density and nursery period has been investigated, when the transplanting date was designed to be the same. The investigation has disclosed the following fact: the rooting ability and the initial-stage growth in paddy field for the thinly sown young seedlings are generally larger than those of the thickly sown and ripened seedlings. After the middle period, however, the latter is larger than the former in the number of panicles.

Apart from the over-ripened seedlings, which could cause their immature heading, in the main season, even the seedlings of poor quality makes no great difference in the yield from the recommended seedlings of 30-day age, because the compensation is effective during the paddy field period. Even in the off season when the growth period is short, such a trend is observed. It cannot necessarily be, concluded therefore, that the ripened seedlings of thick sowing are inferior in yield. As only a difference of several days is observed in the heading dates, though there is a difference of 10-20 days in the sowing dates, the growth period of the ripened seedlings becomes longer, and seems to be favorably effective in the recovery of growth. In relation to the rice cultivation of Malaya, therefore, it can be concluded that the quality of seedlings has no large effect upon the yield.

7. Planting density, weeding method and herbicide.

The records of the plant population are shown in Fig. 9 and 10. Due to the dense planting, the number of panicles per m² shows an almost linear increase. In the main season, the max. yield is observed in the plant population, 16-22. In the off season, however, it is observed in the plant population of 16. In the main season, no great difference in yield is made from the plant population of 11. Even a plant population of 16 is more than twice as large as the conventional

Table 1 Effect of weed control and herbicides (Pe Bi Fun)

Treatments	Cover degree of weed	No. of panicles	Wt. of 1,000 grains	Paddy yield	Ratio
	%		g	kg/a	%
1. Non weeding	86	17.5	22.0	37.8	100
2. *Keri* (localized)	33	19.0	21.6	41.0	108
3. Weed roller	38	19.9	21.7	42.3	112
4. 20 days 2,4-D	48	18.5	21.5	41.3	109
5. 30 days 2,4-D	66	16.6	22.3	41.8	111
6. 40 days 2,4-D	80	17.2	22.3	39.4	104
7. MCPCA	62	16.3	21.5	39.3	104
8. MCPCA—2,4-D	25	17.9	21.6	40.1	106
9. PCP compound fetrilizer	66	19.2	22.2	43.4	115

Note: No. 7 was treated 10 days after transplanting, No. 8 was treated 10 days and 40 days after transplanting, No. 9 was treated 1 day before transplanting.

one of 6-8, and the danger of lodging becomes greater. Considering the transplantation labor and the future rise of fertilization level, a plant population of 11 would be proper in the double-cropping area. The present recommendation standard, accordingly, seems to be reasonable. In merits and demerits of the square, rectagular and row transplanting systems, no definite trend is observed.

The weeding roller in Japan is far more efficient than the conventional weeding sickle "keri" in weeding. Only when it runs on one side at intervals of approx. 10 days, is remarkable weeding effect observed, and the yield is also higher than that in the non-weeded plot (Table 1). TAKAHASHI has also confirmed the following effect of a weed roller. In using the weed roller, it is necessary to employ one-side regular planting system in place of a random planting system.

The weeding effect is naturally high in the plots, where the weeding is thrice given by means of "keri", by roller, and also the MCPCA. 2,4-D, From various records, the yield decrease due to the weeds in the nonweeded plot is estimated as approx. 10%. There is little barnyard grass in poddy fields.

As the Malayan rice plants grow quickly high at temperature, the application of 2,4-D is possible soon after the transplanting, and the length of the proper application period is also long (Fig. 11). Though the weeding effect is higher in the case of earlier application, control over thenumber of tillers and subsequently of panicles must be taken in consideration. As the application approx. 20 days after the transplanting is higher than that at other periods in weeding effect, the number of panicles and the yield, it seems to be a proper application period. In the Malayan paddy field where the use of herbicide poisonous to fish is prohibited, irrigation is difficult, and the weed roller cannot be used because of the irregular planting, weeding by aquatic 2,4-D is economical and very suitable

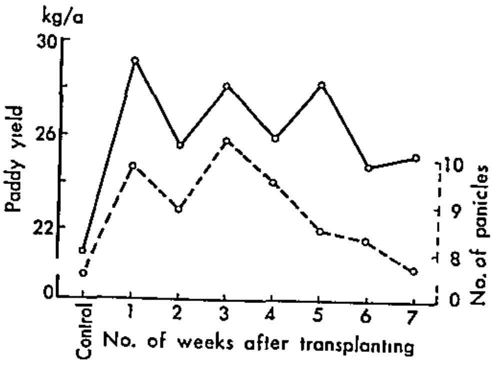


Fig. 11 *Suitable application time of* 2,4-*D* (Main season, MORIYA)

8. Direct sowing in mud.

Direct sowing is conducted only if there is a water shortage on the northeast coast. When the amount of sowing seed increases, the number of panicles increases, the length there of decreases, and the number of weak panicles increases remarkably. As compared with transplanting, no great difference is observed in yield. Little difference due to the sowing quantity is observed between the drilled and dotted sowings. In Malaya, direct sowing, which chiefly aims at saving labour, should not be made much of, but the technique aiming at high yield is desirable. From this point of view, the significance of direct sowing cannot be over emphasized. It, therefore, seems reasonable to employ the direct sowing system as an emergency step in the case of the sowing being very late because of water shortage, or rice plants in nurseries or paddy fields being completely destroyed by flood.

9 Ploughing method, and the drying of soil before the transplanting.

In many submerged paddy fields in Malaya, stubbles on the field surface, and weeds are mown down manually by means of "Tajak's", rotted and mixed with the surface soil in ploughing and puddling. MORIYA has reported the effect of inverse ploughing of soil, and the soil crushing of dried fields for the prevention of soil reduction. TAKAHASHI has reported that the effect of mitigation of soil reduction is higher in the fields submerged immediately before the transplanting than in those submerged approx. 20 days, after, and the yield increased by 39% MATSUSHIMA has also disclosed that soil drying for one month before transplanting is necessary at least for the max. yield, and that soil drying increased the soluble nitrogen and the number of panicles after the submergence.

10. Experiments on various kinds of water.

When MATSUSHIMA, an expert of the FAO, investigated the efficient utilization of water and the ideal system of irrigation and drainage, he made public many useful pieces of information. For want of space, the summary of their major achievements will be introduced hereunder.

It is during the reduction division stage of pollen mother cells when the damage due to the shortage of water is serious. After it, the heading and spikelet differentiation stages are most remarkable for damage. This can be attributed to the reduction of the percentage of ripened grains, which is based upon the non-fertilization. As for the damage of flood, this is also above. There is a great difference in damage between the complete submergence of rice plant and the partial submergence in which the blade tips and panicles are above the water surface. Damage from the latter was slight.

Transpiration, 5 cc per day is required for the dry matter production, 1 g. Between the water requirement and the growing period, there is a close correlation of $r=0.977$. Thus the water requirement is chiefly influenced by the length of growing period of varieties. If it is assumed that the water requirement is Y cc, and the number of growing days of varieties is X, it follows, $Y=491X+11.1$. In the case of the short-term variety, a transpiration of water of 808 cc is required for the production of grains, 1 g, while 2,504 cc is required in case of a long-term variety. From the viewpoint of water consumption, too, the short-term variety can be more efficiently produced.

In relation to the optimum water depth in tropical zones shallow water of depth shows the max. yield so long as the field surface is not exposed. When the water level is below the field surface, a higher yield is observed than if the water level is higher. The shallow water would increase the water temperature difference between day and night, and also the number of panicles. When the field surface is exposed, however, yield would decrease due to the denitrification. In this connection, MORIYA and the author have studied the effect of mid-drying. When mid-drying was applied after securing the valid tiller, its effect upon the improvement of yield was not clear. But the effect in different soil types will be further investigated. In Malaya, mid-drying would be significant in the event of abnormal reduction of soil, for controlling the overgrowth of rice plants and preventing lodging.

As an ideal irrigation method, MATSUSHIMA has recommended the following system: Water depth of 5 cm should be kept from the transplanting to the end stage of valid tillering. Then the field should be kept drained until the spikelet differentiation stage. After that, shallow water should be retained until the initial stage of yellow maturing. If the soil moisture is kept at 100% during the important period from the spikelet differentiation stage to the milk ripe stage, the yield decrease would be small even when water is saved in other periods. Thus 30-40% of the water, can be saved. If there is a saving of water of 15-20%, yield increase can be expected, so he reported. But such on irrigation method is impossible without any complete drainage facility. On the other hand, the control effect of deep water upon weeds cannot be neglected.

11. Penyakit Merah

Penyakit Merah is chiefly found in the low and wet Kurian district on the northwest coast. It seems to be a physiological disease caused by the soil of submerged paddy fields. Its details are as yet unknown. It has two types of symptoms. In one type, dark-brown stpots appear on the tips of lower leaves and gradually spread to kill the plants. In the other type, no spot appears, the tips of the lower leaves become red-yellow and then the discolorment ranges all over the blades. Either easily outbreak at the tillering and heading stages. In some case, the two of them are found mixed together.

LOCKARD (in 1955) concluded that the outbreak of this disease is not attributable to the excess of ferrous component, but to the abnormal nitrogen metabolism based upon the shortage of nitrogen, phosphate and calcium, and the spot type is additionally attributable to the shortage of manganese. But the question, (which could not be simply attributed to the shortage of inorganic nutrients) remains still, MATSUSHIMA has presumed that the nematode parasites would be one origin of this disease, because a very large number of nematode parasites were found in the rice plants attacked by this disease. PHILLIS (in 1963) concluded that the disease was chiefly caused by the organic acid, which had been made by catabolism of the weeds, etc. in the water, as the absorption of necessary components was prevented. TAKAHASHI has observed that there is no reason, which could be attributed to the shortage of nitrogen, and that the coloring phenomenon would come from the abnormal conversion and acceleration of the respiratory system through the absorption of harmful matters based on the soil reduction in the water, or the interruption of nutrient absorption. As a countermeasure, for instance, irrigation has been suspended for a time to dry the field surface and reduce the damage. The recent survey of the botanical physiologists of IRRI has disclosed that virus disease carried by insects could be one of the origins of Penyakit Merah.

III Improvement Measures for the Rice Cultivation in Malaya, and the Outlook

The paddy rice yield in Malaya is approx. 150 kg/a, the highest in Southeast Asia. Production increase in recent ten years is so remarkable that the increase rate of production has shown 47%. As the increase rate of yield per unit area is 29%, the expansion of the area under cultivation also has contributed to the above production increase. As the rate of population increase is as high as 3.2% per year, however, the rate of rice self-supply is 65%, and has not been more greatly improved than before. Even if it is difficult to achieve complete rice self-supply, the production increase must be maintained at a rate higher than that of the population increase. For this purpose, the improvement of yield per unit area, and the expansion of the cultivated area based upon double cropping are desirable.

In order to correct primitive rice cultivation dependent upon rain water, water sources in dry season must be first secured, and the flumes must be completed. In this connection, national longterm construction works are required. In paralled therewith, the improvement of rice varieties must be promoted energetically. On the other hand, the completion of the extension system and farmers' organization, reduction of the farm rent, and increase in rice price as on incentive to farmers' production increase are also parts of the agronomist's concern. Low cost and high safety are practically required for the acceptance of new techniques among farmers. Any technique not complying with these requirements would not be reasonable, even if it is advantageous.

The technical improvement measures, mentioned above and the results of study, can be summarized as follows:

1 Diffusion rate of the present recommended varieties among farmers is still low. The characteristics of the excellent varieties (fertilizer response, lodging resistance, resistance to disease

and insects, and the quality) will be made more public, and the multiplication of their seeds and the distribution will be speeded.

2 Fertilizer effect is 20-25%. Above all, the nitrogen effect is dominantly high, especially in the yield at present when nonfertilized growing is prevalent. The safe application amount is 0.34 kg/a. In some case when the application is doubled, however, yield increase is observed in the main season. In the meantime, the additional application of silicic fertilizer (furnace slag) is generally effective in improving the fertilizer response. In the main season, stress should be laid upon the fertilization for sprouting panicles during the spikelet differentiation stage, and the reduction division stage when there is little danger of lodging rather than on basic or tillering manuring for increasing the number of panicles. In this connection, the Padi Fertilizer Subsidy Scheme (1961-65) will be further extended.

3 At present, the planting is as coarse as 6-8 plants per m^2. If it is increased to the recommended standard, 11 plants per m^2, the increase in the number of panicles per unit area would increase the yield. From this dense planting, a yield increase of approx. 10% can be expected. In Malaya, where there are a large number of rice plants of "panicle-weight type", it is more desirable to employ a fertilization method which aims at an increase in the weight of panicles by securing the number of panicles through the dense planting, than to aim at an increase in the number of panicles by means of tillering fertilization.

4 Damage of weeds due to non-weeding is estimated at approx. 10%. The present "keri" weeding method is so inefficient that it must be corrected. When efficient weed rollers are used, however, a one-side regular planting system must be employed. At present when the planting is made at random, and the watering is very difficult, the aquatic 2,4-D weeding in approx. 20 days after the transplanting is low in cost and desirable.

5 In relation to the reduction of the seedling age and the thin sowing, the overripening of more than 40 and 50 days for the short-and medium-term varieties would result respectively in a production decrease due to the immature heading. A seedling age of less than 30 and 40 days for the short- and medium-term varieties respectively is desirable. In general farms, sowing 2-3 times as dense as the recommended rate, $55g/m^2$ (1 gallon/500 sq. ft) has been employed. Even though a sowing less than 2 times as dense as the recommended is tolerable, a sowing of more than 3 times as dense as that is improper, as it results in yield decrease in the case of the overripened seedlings. But the effect of the quality of seedlings upon the yield is lower than that of the above-mentioned techniques.

6 As the rice cultivation begins in the rainy season, the latter half of the growing period is in the dry season, when the water runs short. In order to utilize the water reasonably and efficiently, drainage after securing the valid tiller, mid-drying, and irrigation from the spikelet differentiation to the late stage of milk ripe are desirable. In low and wet fields, which would often be submerged deeply, the effect of nitrogen is maintained for preventing yield decrease due to the super-deep water.

7 As tests have not been fully made, the following subjects of study should be examined in future: Effect of the supply of organic matters to promote the fertility of soil, effect of mid-drying in paddy fields of different soil types, varieties of resistance against abnormal soil reduction, proper ploughing period, effect of deep ploughing and economy of the introduced technique, etc.

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RICE BREEDING

Shiro SAMOTO*

I Introduction

Since 1915, when rice breeding in Malaya was started by H.W. JACK in the Titi Serong Rice Experiment Station, breeding based upon the comparison test of local varieties, and the subsequent pure line selection system has been chiefly conducted by British technical experts. In consequence, several excellent varieties have been bred. During the latter period, meanwhile, cross breeding was started on a small scale, but interrupted by the Second World War. There was lack of all the breeding materials. Breeding tests, which were resumed in post-war days, are chiefly breeding tests based on the pure line selection tests for local varieties, which have been systematically given in 50 rice experiment stations throughout the country in combination with adaptability test on varieties introduced from oversea.

On the other hand, the cross breeding, which had been conducted in pre-war days, bore no remarkable fruit. Since 1950-1951 after the War, when the cross breeding was resumed, mating has been conducted in the Botany Division, Kuala Lumpur, its hybrids have been group-selected in two experiment stations, Pulau Gadon and Telok Chengai, and their seeds in following generations have been sent to several test fields to undergo aptitude tests continuously. But no new variety has yet been produced therefrom. Very recently in the Telok Chengai Experiment Station, where a Malaya botanist had assumed his post, cross breeding, which aims at the breeding of long-term varieties for the main season, has been started.

As for the development of double cropping, meanwhile, the Formosan varieties, Pebifun, Ryushu, etc., which had been introduced by the Japanese during the Second World War, have been cultivated in the off-season in Province Wellesley achieving a large yield, and subsequently the fundamental double crop system has been established. In this province, the double crop has thus greatly spread from the termination of the war up to the present, with the completion of irrigation facilities. Because of its long-day condition, however, the variety cultivated chiefly in the off season is only the Formosan variety, Pebifun of nonphotosensitivity, while the cultivation of local photosensitive varieties of Indica type is impossible. As the variety in the main season in the case of the double crop must be a medium or short-term variety, meanwhile, the usable variety is restricted. In this connection, the breeding of varieties suitable for a double crop has come an important subject of breeding. From an agronomical viewpoint, too, the expansion of the double cropping area is most relevant in enhancing the rate of rice self-supply. With the annual program for irrigation facilities, therefore, the breeding of varieties for the double cropping has become an important factor for the production increase in rice. Against such a background as rice breeding and cropping in Malaya mentioned above, the Japanese technical experts in rice breeding, who were sent to Malaya at the request of the Malayan Government on the basis of the Colombo Plan, have carried out the breeding work, which chiefly aimed at breeding new varieties suitable for the double crop, in the Bukit Merah Rice Experiment Station in the middle of Province Wellesley, center of the double cropping, and in the provincial rice experiment station newly established in Bumbong Lima.

In close connection with the head of the breeding section, Research Division in the Department of Agriculture in Kuala Lumpur, and in cooperation with the officials of breeding section on the job site, the breeding work has been developed. As a result of this work, Malayan employees have mastered the breeding technique, and the breeding system and method

* Plant Breeder,
Hokkaido National Agricultural Experiment Station

have been gradually established.

As the breeding materials, crossing hybrids of the Malayan local varieties of *Indica* type and the varieties of *Japonica* type have been mainly used. After the selection tests, the varieties Malinja and Mashuri were respectively released as excellent varieties in Feb. 1964 and in Jan. 1965, and have been diffused among general farmers. The great efforts of four experts, during 4 years have borne fruit. In this connection, the development shall be described hereunder.

During the investigation period, the following Japanese experts were engaged in selecting the varieties;

Aug. 1958—Jul. 1959 H. YAMAKAWA
Saga University

Nov. 1959—June 1961 K. FUJII,
Kyushu National Agricultural Experiment Station

Dec. 1960—Jan. 1962 J. KAWAKAMI
Hokuriku National Agricultural Experiment Station

Jan. 1962—Mar. 1965 S. SAMOTO
Hokkaido National Agricultural Experiment Station

II Breeding Material

The breeding material chiefly treated was a combination of the *Indica* and *Japonica* types called the "Cuttack hybrid". During the latter period, a hybrid of *Indica* × *Indica*, which had been obtained by mating in Malaya, was also treated. In 1964, however, all the *Indica* crosses were discarded, because they were not suitable for breeding new varieties for the double crop. In parallel with the breeding work, a large number of ecological experiments necessary for breeding were made. For want of space, however, all of them cannot be described hereunder.

As shown in Fig. 1, 74 combinations of hybrids including 12 varieties of *Japonica*, 13 varieties of *Indica* and other back crosses were sampled for tests. Of them, the Malinja and Mashuri have been selected from the Siam 29 × Pebifun and the Mayang Ebos 80 × Taichung 65 respectively, and graded as the most excellent varieties.

III Targets of the Breeding

Targets of the breeding are as follows:

1) Non-photosensitivity
2) Short-term maturation period
3) Long grain, and non-sticky rice
4) Response to fertilizer, and high yield
5) Stiff straw

The main objective is to produce a substitute for Pebifun, the only variety suitable for the double crop. The important requirement for a variety for the double crop is the possibility of continuous culture in the main and off seasons. Because of their photosensitivity, however, the present local varieties cannot be cultivated in an off season when their growth is tardy. In the meantime, the Pebifun is inferior to other local varieties in yiled in the main season. In addition, it is a sticky rice of short grain so that it is sold cheaply on the market, and does not suit the taste of consumers. Recently in Malaya when the fertilization technique for the rice crop has begun to penetrate to the farmers, the demand for improvement in fertilizer response of the rice varieties, i.e. the varieties of much fertilization, high yield, high lodging resistance and higher resistance against rice blast disease has become more keen than before.

In relation to the combination of *Japonica* and *Indica* types for such a demand as mentioned above, the response to fertilizer, short-culm, tillering type, growth habit and high yield prop-

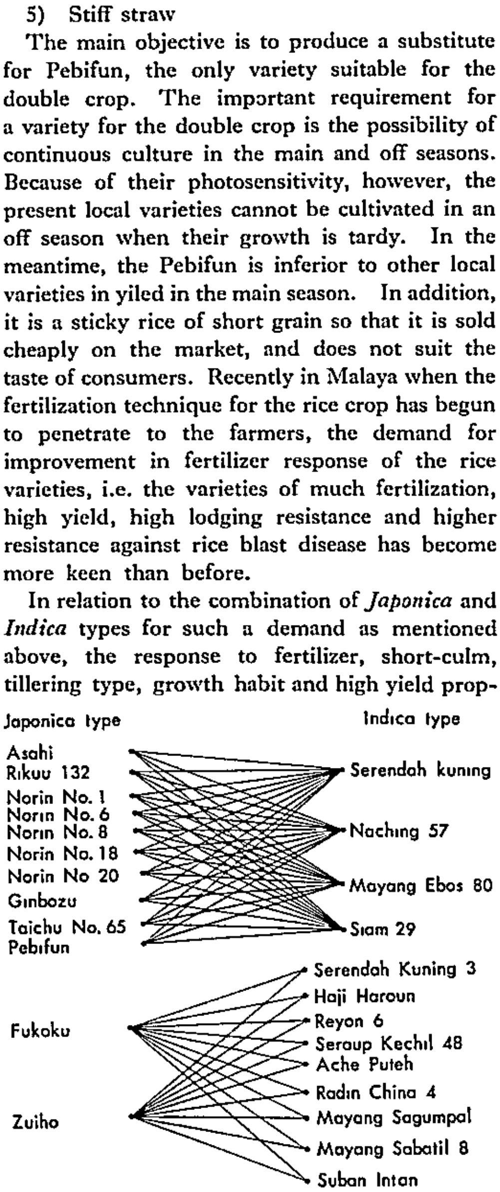


Fig. 1 *Combinations of Cuttack hybrid*

erties could be expected from the *Japonica*, while the adaptability to high temperature, long grain and good quality could be expected from the *Indica*. Ideal types, in which these properties were recombined, have been selected.

IV Process of the Breeding

In conformity with the International Hybridization Scheme worked out by the International Rice Commission of the FAO, a mating of *Japonica* and *Indica* was made in the Central Rice Research Institute Cuttack in 1950. In Malaya, its F_2 seeds were received, and grown in the rice experiment stations, and then the selection was started. These hybrids were termed "Cuttack Hybrids". Some seeds were received as early as 1951. In 1956, 13 combinations were grown as the bulk plot in the Padi Experiment Station in Malacca, and mass selection was conducted. This mass-selected hybrid population was sent over to the Bukit Merah Padi Experiment Station, where Japanese experts had been working.

1. First Period (1958-1959, K. YAMAKAWA)

In the main season of 1958-1959, 26 combinations of sent Cuttack hybrids were grown. The number of planted individuals was 10,000, and 3,600 per combination on the average. These populations were cultivated in the areas where the nitrogen application was doubled. Individual selection was made therefrom. Selection was then conducted chiefly in relation to the short term, short and stiff straw, fertilizer response, grain shape, shattering, plant type, panicle style, resistance to disease and pest, awnlessness etc. Generally speaking, few individuals meeting the above breeding requirements were found. The number of finally selected individuals was 926. They were grown as pedigrees at the next period. Original populations remained as reserve populations until a considerably later stage so as to be the following selection source.

In the off season of 1959, 26 combinations and 926 lines were individually planted to form pedigrees According to the breeding target, the lines of 13% of them were selected. In the off-season, when the day length was long, many photosensitive plants did not sprout their heads. Almost all of them were, therefore, discarded.

2. Second period (1959-1960, K. FUJII)

The materials, which had been taken over to the main season of 1959-1960 and the off season of 1960, were selected. At two stages of the nitrogen application standard, some selected lines were given the yield trial and lodging test. In the off season of 1960, the lodging was so serious at the maturing stage that most of the lines lodged even in the ear row plots, and the harvest was not so easy because of panicle germination. Under such a situation, seeds which had passed the yield trial and the lodging test, had to be used at the next period, and subsequently most of them had to be grown as the derived lines.

3. Third period (1960-1962, J. KAWAKAMI)

Materials, which were transferred to the main season of 1960-1961, were 810 lines of 25 combinations, 112 derived lines of 29 combinations, and the bulk plot of 18 combination besides. In the off season of 1961 when 817 lines of 25 combinations were grown, 419 individuals of 65 lines were selected ultimately. In the meantime, yield trial was given.

4. Fourth period (1962-1965, S. SAMOTO)

419 lines of 25 combinations of Cuttack hybrids were transferred to the main season of 1961-1962. They were given ear rows, while 40 families were given the yield trial. On the basis of the yield data and farm observations of the lines, 110 lines of 23 combinations, 1,110 individuals were selected. At this period, when the author was still little experienced in the rice crop in Malaya, he was moderate in making a severe selection. Generally speaking, he received an impression that these Cuttack hybrids were mostly the early maturing varieties like the Pebifun at the maturation period, their grain shape was approximate to the Pebifun in shortness, and their quality was mostly poor. Accordingly it seemed to be necessary to select them drastically.

In the off season of 1962, 1,110 lines were given the ear rows, and 60 families were given the performance trial. Fertilizer reaction was then also observed at two level doses of the nitrogen application, 30 lbs./acre and 60 lbs./acre. After that, 560 individuals of 56 lines were selected. The characteristic of the then selection was to dismiss as many individuals as possible of short grain type and poor quality. In the main season of 1962-1963, 560 lines were given the ear rows, and 23 families were given the performance trial. Two-level doses of nitrogen application were then given. In the yield test, not only the yield ability but also the rice grain quality and shape were observed. Meanwhile, the empty grain ratio was measured to find the maturity, and the ratio of the grain to the straw was also measured. At last, when the records of yield trials in two seasons, which had been put into practice, were summarized, compared and investigated, only the promising materials of excellent quality, 400 individuals of 40 lines of 18 combinations were selected and sampled for the test of the next period. In the off season of 1963 these lines were given the ear rows. In addition to the performance trial for the observation of yield, these promising lines were given the adaptability trial to check their adaptability in the Bumbong Lima Test Station in the northern part of the province.

In order to observe their ecological characters, these selected lines were further given the spacing test at three stages of 6" × 12", 12" × 12" and 18" × 12". In order to examine the response to fertilizer more accurately, the effect of fertilizer upon the yield was checked at four stages of nitrogen application standards, 0, 40, 80, and 120 lbs./acre, while the lodging was investigated. On the basis of the grains obtained from the yield trial, husking and milling test were given to these lines, while the white rice was given the cooking test to analyze and examine the shape and quality of these lines perfectly.

As these materials had reached F16 at this period, it was natural from a general genetical viewpoint that the purity should genetically be increased and fixed. For caution's sake, the fixation survey was given by using the ear row material, in order to confirm the sufficient fixation of the lines. After giving a large number of such complete trials and test as mentioned above to ascertain the quality of line thoroughly, and comparing their data so far obtained, the promising lines were finally decided. Thus 11 families extracted from 8 combinations have been sorted out as the most promising ones.

In connection with the above, a recommendation entitled the "Report on the Rice Variety Improvement in Malaya" (1958-1963), in which the above records had been summarized throughout the years, has been submitted to the Ministry of Agriculture and Cooperation through the Director of Research Division. In further consultation with the Senior Botanist of the Headquarters, these 11 promising lines have been labelled with the double cropping numbers, DC Nos. 1-11 to be classified as the expected lines of excellent varieties. In the experiment station yard, too, these lines were thereafter given various tests supplementarily. On the fields of major entrusted farmers outside the station, meanwhile, adaptability trial was given to confirm the adaptability of the lines.

5. Main season in 1963-1964

Of these promising lines, the DC No. 4 (Siam 29 × Pebifun) was named the Malinja in the Bukit Merah Padi Experiment Station. Its seeds were delivered to the representative of famers by the Minister of Agriculture and Cooperation. The bred seeds were widely distributed among the double crop areas in various provinces. Being supported by the positive promotion of the Malayan Government, this new variety has gradually replaced the Pebifun of local variety, and the expansion of its cultivation area has also greatly contributed to the increase of farmers' incomes. As this variety is also high in yield in the main season, and excellent in quality, it has been cultivated in the rainy season, too.

6. Off season in 1965

In Jan. this year, the DC-7, (Taichung 56 × Mayang Ebos 80) × Mayang ebos 80, was named the Mashuri, and made public by the Minister of Agriculture and Cooperation in the Telok Chengai Padi Experiment Station in Province Kedah. Its seeds were handed over to farmers. As this variety has strong culms, does not easily lodge, is high in response to fertilizer and in yield, it has rapidly spread over the double crop areas.

V Summary of the Characteristics of the Recommended Varieties and Selections.

1. DC No. 1 (Siam 29 × Norin No. 1)

DC-1 is a hybrid line of very high grain quality as well as cooking and eating quality. Although it has not been a consistently good yielder it has shown considerable promise lately. However, it is slightly too long in maturation for the off season. It responds well to fertilizer and it products very much bearing tillers and can stand up to 80 lbs. nitrogen per acre without lodging. The yield at high level of nitrogen when compared with control variety, Pebifun exceeded that of the control variety but the difference of yield at low level was very small indeed. The height of the plant is quite suitable too but the panicle is not so compact as desired. This hybrid does very well when planted at close planting distance. The yield at the close distance when compared with Pebifun is well above that of Pebifun.

2. DC No. 2 (Norin No. 20 × Siam 29)
DC No. 4, Malinja (Siam 29 × Pebifun)

While DC-2 and DC-4 are more or less the same in their characters, being of about the same height, producing bearing tillers, having good heavy and fairly compact panicles, and of good quality though not as good in quality as DC-1, they differ in that DC-4 has longer and narrower grains than DC-2 and also DC-4 is a more consistently higher yielder than DC-2. DC-4 has short awn in the grains. Both DC-2 and DC-4 cannot stand up to high N levels. They tend to lodge at 80 N lbs/acre and above. Both DC-2 and DC 4 show increase in yield when planted closer than 1′ × 1′ but do not respond as well as DC-1 or DC-7 to close planting. The process of selection of Malinja is showed in Fig. 2.

3. DC No. 3 (Pebifun × Siam 29)

DC-3 is a promising hybrid which is a good yielder, shows good response to fertilizer and has all desirable character except for grain character. The quality is just like that of Pebifun the present standard off season variety in Malaya which is not liked for its grain character. The aim is to get variety to replace Pebifun but here we have a variety otherwise good except for exactly the same grain characters. This is being retained for future breeding material.

4. DC No. 5 (Pebifun × Serendah Kuning)

DC-5 is another hybrid with undesirable grain character but otherwise having good qualities. However, it is also too short a plant and is unsuitable for the present system of harvesting. The yield also is not as good as Pebifun but is slightly less. It would be very useful material when mechanical cultivation is brought about. This line can stand up to fairly high nitrogen applications. This is also slightly too long for the off season cultivation.

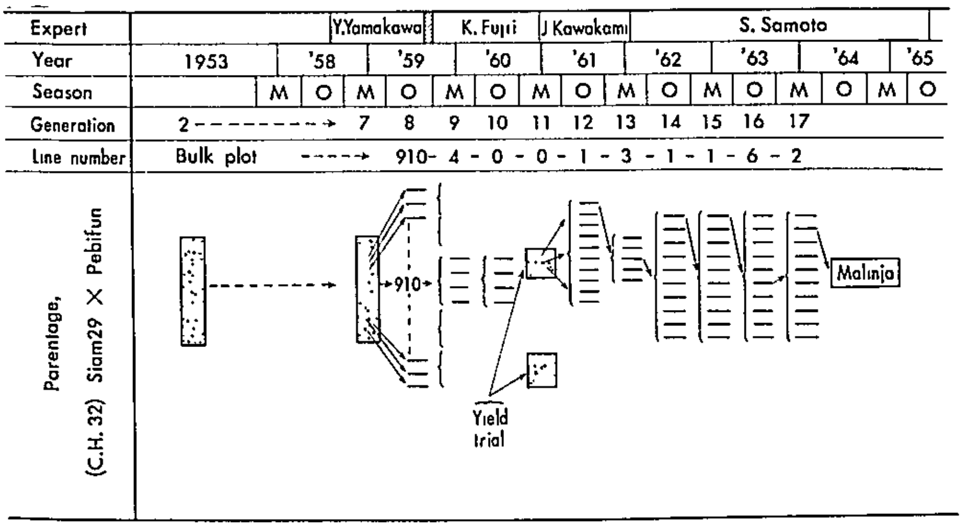


Fig. 2 *Process of selection of Malinja*

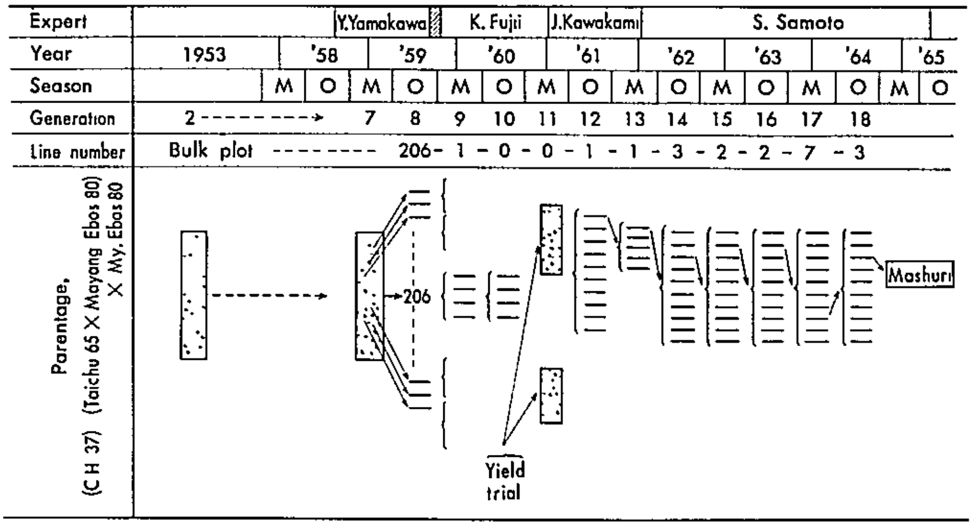


Fig. 3 *Process of selection of Mashuri*

5. DC No. 6 (Pebifun × Serendah Kuning)
DC No. 8 (Taichu 65 × Mayan Ebos 80) × Mayang Ebos 80

DC-6 and DC-8 are another 2 lines with poor grain characters. They are not so good yielders when compared with the standard varieties. They are not promising material and are being eliminated.

6. DC No. 7, Mashuri (Taichu 65 × Mayang Ebos 80) × Mayang Ebos 80

DC-7, one of the most promising of all the hybrids satisfies almost all the requirements in our aim of getting a new variety to replace Pebifun. It shows good response to fertilizer but may lodge if given too much nitrogen. Its maturation is quite well suited for the off season. It is of good height, produces many bearing tillers, average length panicle and very compact panicles. However, the size is a bit small and not as desired. The eating quality is good. It has been a consistently good yielder also but it does not to very well without fertilizer or in low fertility places. It has also the weakness of being susceptible to blast if given too much nitrogen in the nursery. The hybrid also gives good response to spacing the yield being again much higher than that of Pebifun but is not so good as DC-1 at the same close planting. The Process of selection of Mashuri is showed in Fig. 3.

7. DC No. 10 (Serendah Kuning × Asahi)

DC-10 has a very long, fairly compact panicle which is fairly heavy but is not a good yielder. It does not tiller well.

8. DC No. 11 (Nachin 57 × Rikuu 132)

DC-11 is the shortest term hybrid of all the lines but is not a very good yielder neither does it show response to fertilizer. However, it has much better grain characters than Pebifun and has good growth habits. DC-11 is about the same maturation as Pebifun and BM5 in the off season. However, the panicle is not so compact or heavy.

All the hybrids are of average height, have average to fairly long length and fairly compact panicles unless specifically mentioned above.

It can be seen that some of the hybrids are undesirable while DC-1, 2, 4, and 7 are the more promising of the remaining lines, DC-2, 4, and 7 in particular has yielded on the average some 10 or more over the standard variety in the tests. Blast has been noticed in the nursery for the first time this season in the case of DC-2, 4, and 7, this is in places where there appears to be an excess of nitrogen and is fairly severe in certain cases. Over application of nitrogen especially in the nursery is to be avoided. Rather low

Table 1 Main characteristics of varieties

Variety	Maturation period (days)				Culm hight (cm)				Ear length (cm)				Ear number per hill			
	M '61/62	O '62	M '62/63	O '63	M '61/62	O '62	M '62/63	O '63	M '61/62	O '62	M '62/63	O '63	M '61/62	O '62	M '62/63	O '63
Malinja	130	136	139	143	105	122	101	112	24.1	25.5	24.4	25.6	18.1	18.0	16.8	16.3
Mashuri	135	137	139	138	100	115	95	106	23.9	24.4	23.7	24.0	17.0	18.5	16.3	15.5
DC No. 1	130	135	139	146	87	105	86	96	24.3	26.0	26.0	25.6	19.1	22.3	16.4	22.3
DC No. 5	135	138	142	145	79	90	75	75	23.5	25.6	24.1	24.2	16.7	17.0	16.3	15.8
Pebifun	125	128	128	124	92	118	97	113	23.0	23.0	23.1	24.0	16.3	20.0	14.4	17.5
Radin China 4	140	—	151	—	115	—	116	—	28.1	—	30.1	—	11.1	—	11.4	—

Variety	Grain shape		1,000 grain weight (gr.)	Shattering	Rice quality	% of husking	% of milling	Stickiness of boiled rice
	Length (mm)	Width (mm)						
Malinja	9.3	2.5	24.7	E	H	78	70	2.8
Mashuri	7.9	2.6	16.6	VE	HH	77	69	2.0
DC No 1	9.1	2.2	20.6	E	HH	76	71	2.7
DC No. 5	7.8	2.8	21.2	E	M	—	—	—
Pebifun	7.5	3.0	19.6	E	L	79	69	3.0
Radin china 4	8.8	2.8	19.7	E	H	78	70	—

Note: M...main season O... off season
Shattering E ..Easy VE...Very easy Rice quality H...High M ..Medium L ..Low
Stickiness of boiled rice is expressed in a relative value based on the taste of the inhabitants.

Table 2 Fertilizer response of varieties (lbs./acre)

Season / Nitrogen / Variety	O '61	M '61/62	O '62		M '62/63		O '63	
	M-1	M-1	M-1	M-2	M-1	M-2	M-1	M-2
Malinja	3,773	3,732	3,615	3,299	3,603	3,898	3,852	3,929
Mashuri	4,317	3,886	3,384	2,981	3,678	3,899	3,705	4,286
DC No. 1	3,734	3,234	3,160	3,379	2,625	2,836	4,178	4,118
DC No. 5	3,143	3,813	3,255	2,806	3,143	3,374	3,212	3,559
Pebifun	3,029	3,118	3,577	3,437	2,814	2,696	3,342	3,838
Radin China 4	—	3,354	—	—	2,932	3,033	—	—

Note: M-1; 30N, 60 P_2O_5, 25 K_2O lbs./acre
M-2; 60N, 60 P_2O_5, 25 K_2O lbs./acre

Table 3 Photosensitivity of main varieties

Sowing date	Number of growing days							
	B.M.5	Siam 48	Radin China 4	Radin Siak 34	Radin Kling	Engkatek	S. Kuning 60	S. Intan 117
1/Jan.	130	313	313	164	137	282	282	313
1/Feb.	124	282	282	166	156	251	273	277
1/Mar.	124	257	257	166	156	249	259	259
1/Apr.	125	234	230	166	148	218	234	230
1/May	130	211	207	157	146	207	211	211
1/June	122	196	196	157	136	188	196	196
1/Jul.	127	166	171	146	127	167	171	171
1/Aug.	112	158	148	135	112	158	158	148
1/Sept.	108	143	143	135	108	143	147	135
1/Oct.	113	135	142	142	115	147	142	135
1/Nov.	118	160	147	146	118	165	142	165
1/Dec.	122	174	157	151	122	174	174	174
Max.	Jan.	Jan.	Jan.	Feb.	Feb.	Jan.	Jan.	Jan.
Min.	Sept.	Oct.	Oct.	Sept.	Sept.	Sept.	Oct.	Sept.
Different days	22	178	171	31	48	139	140	178

1963. Bukit Merah

temperature and little sunshine with occasional showers have been the conditions while the plants were in the nursery this season. This weather has been very favourable for fungus growth. But the indication is that the hybrids are susceptible to blast; this point will be investigated further.

Main characteristics and fertilizer response of varieties are shown in Tables 1 and 2.

VI Variety Trials

In both off and main seasons, variety comparison tests have been continuously given to a large number foreign introduced and Malayan local varieties. Their objective was to select the mating parents for breeding and to diffuse the promising varieties more widely. As both of these objectives were restricted to the double crop areas, it is very difficult to obtain excellent varieties, especially those suitable for the off season when the daylength is long.

As promising varieties for the main season, BPI-76 of the Philippines and the Remadja of Indonesia were recognized. Many Formosan varieties were also investigated. But there was no recommended variety, because they had generally too short culms, were inferior in growth and yield, and had mostly short grains, though they were suitable for the off season in their non-photosensitivity and short term. They could not display their ability until such technical improvement as dense planting, much fertilization, the use of young seedlings, etc. is achieved.

VII Photosensitivity

Most of the local varieties in Malaya are characterized by the high sensitivity to the daylength, which has made the double crop difficult.

The daylength in Malaya ranges from 11 hrs. 45 min. to 12 hrs. 15 min. It seemed that the young panicle differentiation would be suppressed, if the daylength exceeds 12 hrs. a little. In this connection, many ecological tests were given. One example is shown in Table 3. In this experiment, sowing was made every month continuously for three years from 1961 to 1964. The change at the head sprouting and growth and the yield were measured. The table has disclosed that all the varieties sown in Jan.-Feb. are latest in head sprouting and maturation, and those sown in Sept.-Oct. are earliest therein. From this fact, it is conceivable that the sowing period of the single or double crop area in the main season in Malaya is so designed that the number of growing days may be shortest, and vice versa in the off season of the double crop area.

In the meantime, the table has disclosed that the non-photosensitive variety B.M.5 is constant in the number of its growing days, wherever it may be sown throughout the year.

VIII Resistance to the Blast Disease

In Malaya, the blast disease has not so far been made so much of. With the recent increase in the application of fertilizer, however, outbreak of blast disease has been noticed in years, when the weather was unfavorable. The most dangerous stage is the nursery period in the main season when there are many rainy and cloudy days. With the diffusion of the varieties of higher fertilizer response in recent days, meanwhile, the fertilizer application would increase to bring out the damage of blast disease.

Nursery test on the blast disease has disclosed that most of the local varieties in Malaya are susceptible to blast disease, but only a few varieties of them are highly resistant thereto. Of the latter are the Suban Intan 117, Mayang Ebos 80, and Cadung Ket. The varieties of slightly higher resistance are the Radin Kuning, Siam 26, Mayan Pasir, Achen Puteh, Pandang Trengganu, Siam 48, Morak Sepilai, Mayan Segumpel, etc.

In the meantime, it has been revealed that

Table 4 Introduced varieties with high blast resistance (1964)

Katakatara Da 2	Pakistan
Dular	Pakistan
Zenith	U.S.A.
Sigadis	Indonesia
Ta Poo Choo	Taiwan
Pah Leuad 29-8-1	Thailand
Leuang Yai 34	Thailand
Te Tep	Indonesia
Tadukan	Philippines
Chokoto	Taiwan
Kanto 51	Japan
Yakeiko	Taiwan
Chianung 289	Taiwan
Murangakayan	Ceylon
Ran Tulasi	India
Kanto 53	Japan
Peta	Philippines
Reminad str. 3	Philippines
Milbuen	Philippines
Taichung 181	Taiwan
Chianung 2	Taiwan
Kaoshung	Taiwan
CP 321/hd	U.S.A.
K 10B-281	(From IRRI)
CO 25	India
FK 170	Philippines
2216/57/1/64	(From IRRI)
M/302	Ceylon
H-4	Ceylon
H-5	Ceylon
FB-86	Philippines

there are a considerable number of the varieties of high resistance among the varieties introduced from overseas. Countries of their origin are Pakistan, U.S.A., Thailand, Formosa, the Philippines, Ceylon, India, etc. It has been additionally revealed that all the varieties for the double crop are susceptible to blast disease. In this connection, mating has since 1964 been started to introduce the genes resistant to blast disease. Meanwhile, the nursery test has been given throughout the year to conduct the line selection. The problem then is that the selection of the hybrids of the parent resistant varieties is very difficult because these varieties are inferior in yield, economy, shape and quality. In this connection, back crossing seems effective.

Blast nursery test given in the Bukit Merah Experiment Station has disclosed that the introduced varieties in Table 4 are extremely high in resistance to blast disease.

IX Ecological Experiment

In order to observe the ecological characteristics of Malayan local varieties, growth analysis was given to selected Malayan early, medium and late maturing varieties, and to the Japanese and Taiwan varieties at different stages of sowing (refer to Table 5).

Movement of the growth period gives a change of daylength to the maturation of rice plants. A great change is observed in the maturation

Table 5 Seasonal changes of the growth stages

Date of sowing & transplanting	Varieties	Days from sowing to max. tiller.	Days from sowing to heading	Days from max. tiller. to heading	Days from max. filler. to Y.E.F.*	Maturation period (days)	Leaf order on main stem
10/Oct. 29/Oct.	Rikuu 132	56	59	3	−19	89	12
	Chanang 2	63	82	19	− 3	112	17
	Pebifun	63	86	23	1	116	17
	Radin Kling	63	84	21	− 1	114	17
	Siam 29	63	126	63	41	156	21
	Mayang Sa Batil	70	156	86	64	186	23
25/Nov. 9/Dec.	Rikuu 132	51	60	9	−13	90	
	Chanang 2	58	80	22	0	110	
	Pebifun	58	81	23	1	111	
	Radin Kling	58	78	20	− 2	108	
	Siam 29	72	146	74	52	176	
	Mayang Sa Batil	72	198+α	—	—	—	
15/Jan. 27/Jan.	Rikuu 132	50	56	6	−16	86	
	Chanang 2	64	82	18	− 4	112	
	Pebifun	57	83	26	4	113	
	Radin Kling	64	—	—	—	—	
	Siam 29	71	—	—	—	—	
	Mayang Sa Batil	71	—	—	—	—	
19/Mar. 6/Apr.	Rikuu 132	50	51	1	−21	81	
	Chanang 2	63	81	18	− 4	111	
	Pebifun	63	87	24	2	117	
	Radin Kling	63	—	—	—	—	
	Siam 29	71	—	—	—	—	

Note: * (1) Y.E.F. means young ear formation stage
(2) "—" indicates that heading time was not observed
(3) No records of leaf order are shown in the last 3 groups owing to damage by pests

period of the local varieties of high photosensitivity, while little change is found in the Taiwan variety of low photosensitivity or the Japanese variety whose heading is promoted at high temperature.

Seasonal change of growth is not much found in the number of days from the sowing to the max. tillering period, from the young ear forming to the heading period (22-23 days), and from the heading to the maturation period (30 days). From this fact, it is conceivable that the change of maturation period due to the seasonal change of growth is chiefly controlled by the young head differentiation period.

When we look at the relation between the length of the maturation period and the yield of varieties, the varieties of extremely short maturation period are low in yield, but those of too long maturation period are not necessarily high in yield, because there are many chances to meet bad environments in the process of growth. If the culture condition is completed in future, the economical and efficient number of growing days would be 120-150 days.

X Lodging Resistance

As in case of other countries in Southeast Asia, one of the most important improvements in the rice varieties in Malaya is to give them a high response to fertilizer and powerful culms. Many local varieties in Malaya are the panicle-type varieties of long culms (approx. 1.5-2.0 m. each) and long heads. In combination with the brittleness of their culms, they are so weak in resistance against lodging that fertilizer application is extremely limited.

As their intrinsic response to fertilizer is also on the low level, fertilization effect is low. In recent days, when the Engkatek (60-70 cm), a variety of very short culm was introduced from Sarawak, its lines have been made by means of pure line selection, compared and examined in the Telok Chengai Experiment Station. One of the objectives of breeding the Cuttack hybrid is also to introduce the high response to fertilizer and the strong and short culm property of the *Japonica* type. In future breeding, this must be an important objective of breeding. In this connection, the Taiwan varieties would become promising mates for crossing.

XI Prospects of Rice Breeding in Malaya

1. In order to increase the rice production in Malaya, the irrigation and drainage facilities must be completed in parallel with the improvement of rice varieties so that the double crop may be conducted as early as possible. Without the completion of such facilities, the improvement of varieties, growing and fertilization technique would be of no use.

2. In improving the varieties for the single crop areas, it is necessary to employ not only the present pure line selection system but also the crossing breed system to improve the fertilizer response of the conventional varieties as well as the effect of fertilizer. In this case, the short and strong culms of the varieties, increase of the ratio of effective tillering, and the improvement of resistance against the disease would be important. With the completion of irrigation and drain facilities, and the preparation of soil, more yield could be expected from the varieties of maturation period shorter than at present.

3. As for the quality of rice, the long narrow grains are usually appreciated highly in Malaya. If the people should come to eat the rice of shorter grains, it would be easier to enhance the breeding effect for the following reasons.

In order to obtain the varieties of long grains, the *Indica*-type varieties must be used as the parents above all. Most of these *Indica*-type varieties of long grains are so vigorous in growth and large in the absorption of fertilizer as to overgrow easily. More fertilizer would promote such a trend. Unexpectedly, however, the number of panicles would be small, and more application of fertilizer would often rather reduce the yield. The varieties of high efficiency, which could yield more highly when more fertilizer is applied, are mostly found among the *Japonica*-type varieties, or good *Indica*-type Taiwan varieties. At present in Malaya, however, these short-grain varieties do not suit the taste of the people.

As for the varieties of long narrow grains, however, the milling yield is too low, and the grain weight is too small to obtain the high production.

4. The rice crop will shortly be mechanized also in Malaya. The easy shattering of the present varieties must be gradually corrected to hardy shattering.

5. Seed farm system must be corrected, because the mixing of seeds would result in production decrease, especially in the double crop.

6. When the selection is made on the basis of the hybrid, *Japonica* × *Indica*, bulk plot would be prepared for the primary generation. As the *Indica*-type varieties are so vigorous in growth as to win the competition, the *Japonica*-type would easily die. It is, therefore, necessary to sort out the *Indica*-type in process of maturation.

7. In order to improve the selection efficiency, line selection must be primary, and the individual selection in the line must be secondary.

8. In relation to the pedigree following the medium-period generation (F5-F6), it is unnecessary that a large number of similar lines should remain, even though they are promising. It is more economical to discard them without hesitation, because only the best one would become the ultimate variety.

9. As the variety for the double crop must be non-photosensitive, it would come to nothing, unless the individual selection from the bulk plot is started in the off season. The late maturing variety for the off season must be deserted sooner or later. Meanwhile, severe selection is impossible in the main season.

10. Physiological and ecological character must be observed at the earlier stage of generation. Lodging examination is also necessary. When much fertilizer is applied, however, grains, more than 80-120 lbs/acre would be required.

11. In case the variety improvement is so advanced that the culm becomes short, and the growth habit becomes upright, the present standard growing method must be corrected. Closer planting would be required.

12. In relation to all the bred materials of various generations, blast disease must be checked in parallel.

13. It is necessary not only to positively introduce the varieties and hybrids from foreign countries but also to try various growing methods in various places so that they may display their characteristics. Above all, attention should be paid to the Taiwan varieties. In this case, no good result could be achieved, unless the growing method is carefully considered. In other words, their nuresery period should be reduced, close planting should be given and a great deal of fertilizer applied to them.

14. Breeding experts in Malaya must be trained as early as possible.

15. Breeding organization must be completed. In this connection, breeding center stations equal to the present Telok Chengai Experiment Station respectively shall be established in rice crop centers such as Provinces Kelantan, Kedah, Penang, Perah, and Malacca. Each station shall have a subordinate organization, in which the breeding program is independently worked out on advice from the Headquarters to conduct the hybridization and selection, and the promising lines are delivered to the representative districts in each province to check their adaptability. For this purpose, the staff of the Divisions II and III shall be invested with some authority, and be self-confident of their tasks. If such steps are taken, the prospects of rice breeding will be brighter, and achievement will be greater in future.

PADI SOILS AND FERTILIZER APPLICATION TRIALS IN MALAYA

Masanori MIYAKE*

I Japanese Colombo Plan Soil Chemists

In Aug. 1958, S. SATO[1], the first Japanese Colombo Plan soil chemist arrived at his post in Bukit Merah Padi Experiment Station, Province Wellesley, Malaya. When he observed the soil profile of the padi field of the station, he found that the root development of rice plant was restricted to within the thin tilled layer. On the basis of the soil analytical data of the Bukit Merah and Telok Chengai Padi Experiment Stations, which N. KAWADA, member of the Japan's preliminary survey team for the agricultural technique cooperation based upon the Colombo Plan carried back, he found that the soil of the above station was low in pH, and base saturation degree, had little exchangeable CaO, MgO contents and very little free iron and easily reducible manganese contents. In this connection, the objective of his tests was to correct the above disadvantages.

In the Bukit Merah Padi Experiment Station (B.M.) and the Bumbong Lima Padi Test Station (B.L.), he gave various fertilizer test including the 3-element experiment; slag (Ca-Silicate) application test, etc.

Based upon the observations and the test records, he has made the following recommendations:

1) The ploughing depth and the soil layer thickness should be increased. The conventional system, in which the soil was left too long along until the transplanting after the submergence, should be given up to utilize the soil drying effect of nitrogen.
2) Response to the nitrogen application is larger than that to other elements. The proper amount of nitrogen to be applied is 30-60 lbs./acre. A 2/3 portion of this should be mixed with the whole soil before the transplanting, while the 1/3 should be applied at the young ear formation stage.

Prior to S. SATO's return in Aug. 1960, M. NAGAI[2] arrived at his post in the B.M. in Jul. and took over Sato's work. He worked hard for the padi field soil survey, crop cutting test and the survey of farmers' culture method in Province Wellesley (P.W.). As a result of his efforts, he had success in completing a padi soil map of P.W., according to which he made the major 3-element experiments in 16 selected farmers' fields.

In the B.M. and B.L. stations, he laid stress upon the N application, and made various more detailed tests in relation to the application time, spacing and the depth of water.

He has pointed out the following points to be improved:

1) Recommendation for the fertilization quantity, which the Department of Agriculture has made, is a recommendation in terms of state or district, which is too vague to be applied to each farmer. It is, therefore, necessary to make a precise soil survey and recommend a proper fertilization in terms of soil.
2) As farmers make a habit of applying no compost to the padi fields, they generally burn the padi straw after the harvest. In this connection, it is desirable to establish a system of utilizing the padi straw for retaining the soil fertility, as the soil is short of organic matter and heavy.
3) In the off season, only Pebifun is usually grown, while many varieties are planted in the main season. Their growing duration is so different as to range from 140 to 180 days. Therefore their harvest time is not uniform, and the cessation of irrigation at a proper stage is difficult. Such a situation has impeded the proper maturation and decreased the efficiency of harvest work. In order to better the condition, it is necessary to recommend a variety of high fertilizer

* Soil Chemist,
Hokkaido National Agricultural Experiment Station.

responses for each area, and diffuse it among farmers.

4) As the soil is heavy, it becomes hard, when it is dried. As it cannot be easily ploughed, the tilled layer is liable to become shallow. In many cases, such a situation has resulted in a low yield of rice crop. In this connection, it is necessary to investigate the proper ploughing time, depth and method.
5) The incompletion of large and small paths in the padi fields has kept the farms from being mechanized, and made it difficult to transport the fertilizer and farm products. It is, therefore, necessary to complete the field paths.

In Mar. 1962, K. SUGIMOTO (Agronomist)[3] arrived at his post in the B.M. and succeeded M. NAGAI's fertilizer experiments. NAGAI returned home in July 1962. On his suggestion that it would be desirable for the soil chemist to make his researches in the well-equipped laboratory of the Department in Kuala Lumpur, because the B.M. station was not provided with electricity* and water or chemical analysis facilities, M. MIYAKE[4] arrived of his post in Kuala Lumpur in Nov. 1962. In the laboratory of Soil Science Division, he has chemically analyzed the soil and plant samples of the fertilizer tests, which the agronomists in the P.W. had given, and interpreted and criticized the test record on the basis on analyses.

In the meantime, he observed the rice crop in a farmer's field on the outskirts of Kuala Lumpur, and made researches in the relation between the N in the soil, and the growth of plant. He returned home in Mar. 1965. His crecommendations are as follows:

1) Though the rice culture technique of the individual farmer in Malaya is low in yield, it would be reasonable under his social and natural environment at present. Even if only the fertilization is improved in this culture system, great increase in yield could not be expected. In order to use the fertilizer more efficiently, it is necessary to improve the rice variety, irrigation and drain facilities, etc. besides the culture technique proper.
2) Fertilizer test records are dependent on the seasonal, soil and other rice culture conditions. In order to draw a general conclusion from these test records, it is necessary not only to give a large number of tests, but also to make observation on the soil and plants during the rice growth to check the reason for their change.
3) As the Department of Agriculture naturally cannot make so large a number of tests as to include all the conditions, individual farmers would have to decide how much fertilizer should be applied, or how to apply the fertilizer. In this connection, stress must be laid upon the training of farmers of various technical levels by means of various methods.
4) Though importance has so far been attached to the nitrogen (N) in researches, phosphate (P) should also be studied more than before. In the padi field of the experiment station, to which phosphate had been applied, the effect of this element cannot be easily determined, because it continues for a long time. In some farmer's field, to which no fertilizer had been applied for a long time however, soil of very little phosphate content would be often found.
5) Recommendation of fertilization for farmers cannot be directly introuduced from the soil survey or soil chemical analyses. But their records are a foundation for fertilizer test. without these data, the fertilizer tests would have only a limited value. In starting the fertilizer trials, therefore, the soil of selected farms should be surveyed, and the classiffication of the previously established soil type or soil series should be given, if possible.

II Geology

It was during the older Palaeozoic era, when the deposit to the Southeast Asian geosyclinal sea was started. At present in Pulau Langkawi and other places, these deposits are found as quartzite, shales, and lime stone. Quartzites, shales, and limestone, which had deposited at the Carboniferous, Permian and, Triassic periods, have formed the Foothills of the main ranges, and made up the larger part of the sedimentary rocks in

* Electric appliance, pH meter, etc. could be operated as occasion demands, when the generator was driven by the oil engine.

Malaya. The limestone has formed the hills rising over the alluvial plain, which have caves producing the bat guano. Thus it has given a unique landscape to the plains in Malaya. As this limestone does not break and re-deposit unlike other rocks, but dissolves away, it has little importance as the parent rock of soil. It is known that there was volcanic activity in the shallow sea at the Permian period. The ejecta interbedded on the sedimentary rocks is called the "Pahang volcanic rocks". As the soil originating from these rocks is fertile, it is important from the viewpoint of agriculture. Most of these rocks are, however, covered with thick jungle. At the Jurassic period, when the granite was intruded, and the older sedimentary formations were powerfully folded, the prototype of the Malay Penninsula was formed for the first time. Due to the later truncation, the core granite is exposed over almost half of the country. The sediments from the later Jurassic to the early Cretaceous period have been also made known. As for the tertiary rocks, shales and sandstones with thin bands of soft coal and lignite are found in several places, but their area is small. Shallow water deposits of the Pleistoscene (older Alluvium) remain as the dissected terraces and platforms 20-230 feets above the sea level.

III Padi Soil in Malaya

In his "Soil Map of Malay", 1962[5], W.P. PANTON has classified the Malayan soil into the following 11 categories:

1) Lithosols and shallow latosols on steep mountainous and hilly land considered unsuitable for extensive agricultural development.
2) Red and Yellow latosols and red and yellow podzolic soils on gently to strongly sloping land, mostly of average fertility, derived from acid igneous rocks.
3) Red and yellow latosols and red and yellow podzolic soils on gently to strongly sloping land of variable fertility derived from a variety of sedimentary rocks.
4) Red and yellow latosols and red and yellow podzolic soils on flat, gently sloping and strongly sloping land, mostly of below average to average fertility developed over raised terraces and platforms of older alluvium and sub-recent alluvium.
5) Reddish brown latosols on gently to strongly sloping land, mostly of above average fertility, derived from basic and intermediate igneous rocks.
6) Laterite soils on gently to strongly sloping land, mostly of average to below average fertility.
7) Low humic gley soils, being moderately and poorly drained soils developed over coastal plains and in the valleys and flood plains of the larger rivers, of very variable fertility.
8) Poorly drained esturaine and coastal soils (azonal) mostly tidal, of limited suitability for agricultural development.
9) Freely drained coarse textured grey brown podzols of below average fertility, developed over recently accumulated coast deposits with associated swamps.
10) Organic soils, principally peats, with some mucks, developed over mineral alluvial soils in poorly drained situations of limited suitability for agricultural development.
11) Disturbed land, chiefly tin tailings, of limited suitability for agriculture.

As disclosed in the above, this classification has made much of geological condition, i.e., parent rock of soil. In Malaya where there was no volcanic activity during the tertiary and quaternary periods, unlike in the Japan, the Philippine or Sunda Islands, most of the soil has originated from the acid igeous rocks (granite and granodiorite), sedimentary rocks (quartzite, shales, phyllites and conglomerates), and the unconsolidated sand and clay deposits. With the hot and wet tropical rainforest climate, such a gelogical condition means that the Malayan soil lacks the nutrients for plants and shows acidity. In this connection, it would be reasonable that the rubber tree, for which better physical conditions as opposed to chemical conditions are required than the chemical fertility of soil, has been chosen as the major crop in such a country.

C.W. ARNOTT[6] has summarized a large number of analyses of soil treated in the laboratory of the Department of Agriculture, and reported that the pH, easily soluble P, 1/2N acetic acid extractable K, total N, etc. are lower than the standards used in New Zealand. In spite of such lower soil inherent fertility, however, the fast decomposition of the soil components to the available forms and the rapid circulation of nutrients, soil→plant→soil, in hot and humid tropical zones make it possible to maintain higher productivity than that in the case of the nutrient level in temperate regions.

Most of the padi fields in Malaya are distributed on the low humic gley soils of PANTON. In Tables, Nos. 1 and 2, analyses of the surface soils of 21 padi fields on the west coast of Malaya are shown. What is remarkable in the particle-size distribution is that every soil is high in clay content. In Kedah and Perlis plain, heavy clay soils are solidified to form deep cracks in the dry season. Until the submergence for a considerably long time in the rainy season, fields cannot be tilled. The water supply in the padi growing season mostly relies upon the rainfall. If the fields are hit by drought, therefore, water runs short, even when the river water is utilized for irrigation. Under such a condition, only the soils, whose vertical permeability could be almost reckoned as zero, are used for the padi fields. This is one of the reasons for the large clay content in the soil of padi fields. With the difficulty of tilling, this has also resulted in the small thickness of the top soil. The pH ranges from 4.5 to 6. The pH of the Pulau Gadong soil is as low as 3.5, because it contains much sulfuric acid as shown in Table 2. Such a soil is found on an ill-irrigated lowland on the coastal plain, which had been a swamp forest of Gelam (*Melaleuca leucadendron*) before the reclamation. It is called "Gelam soil"[7]. In the rainy season, it yields as much as the general soil. When the water runs short, the pH of the field water becomes lower than 3, and the rice plants die.

Table 1 Physical and chemical analysis of the soil

Place name	Percentages on fine soil: Clay	Silt	Fine sand	Coarse sand	Texture	pH (H_2O)	Moist. %	Loss on ignition %	Total C %	Total N %	C/N	Easily sol. P ppm
1. Kuala Perlis	59	28	14	Tr.	HC	5.5	5.0	7.6	1.14	0.13	8.8	195
2. Sena	77	16	8	2	HC	5.8	2.8	9.6	1.02	0.14	7.3	86
3. Simpang Ampat	67	20	8	Tr.	HC	6.0	3.9	14.3	2.77	0.41	6.8	58
4. Langgar	54	33	8	Tr.	HC	5.8	1.7	9.0	1.80	0.25	7.2	345
5. Telok Chengai	69	18	9	Tr.	HC	4.8	4.0	10.2	1.52	0.21	7.2	55
6. Kuala Kedah	59	22	22	Tr.	HC	4.7	3.0	9.3	1.70	0.24	7.1	105
7. Sungei Limau	54	29	14	Tr.	HC	5.0	3.3	12.1	2.77	0.34	8.1	77
8. Guar Chempedak	54	21	21	3	HC	4.5	3.0	13.6	3.48	0.28	12.4	283
9. Padan Buloh	26	12	23	43	SC	5.3	0.9	5.4	1.92	0.22	8.7	79
10. Bukit Merah	36	23	40	5	LiC	4.9	1.7	6.4	1.39	0.16	8.7	77
11. Kp. Buleh Dua	65	24	6	Tr.	HC	4.8	3.6	17.3	4.23	0.54	7.8	176
12. Titi Serong	51	24	23	Tr.	HC	5.1	3.6	22.3	7.27	0.80	9.1	120
13. Briah	59	26	14	Nil	HC	5.0	3.7	18.3	5.11	0.61	8.4	170
14. Pantai	48	23	25	2	HC	5.3	1.6	12.5	2.39	0.25	9.6	43
15. Jelebu	53	14	21	7	HC	5.5	2.6	15.3	3.36	0.41	8.2	75
16. Ampang Tinggi	46	19	35	3	HC	5.6	1.1	8.0	0.71	0.10	7.1	62
17. Ampang Tinggi	48	15	23	10	HC	6.9	2.0	13.1	3.59	0.35	10.3	142
18. Pulau Gadong	26	33	36	Tr.	LiC	5.2	0.9	6.1	1.81	0.12	15.1	103
19. Kendong	32	33	32	9	LiC	6.0	0.8	8.0	1.54	0.20	7.7	33
20. Pulau Gadong	44	19	38	Nil	LiC	3.5	1.9	10.2	2.73	0.20	13.7	20
21. Tanjong Karang	75	14	4	2	HC	5.4	4.2	14.7	3.09	0.34	9.1	185

1-3: Perlis, 4-8: Kedah, 9-11: Province Wellesley, 12-13: Perak, 14-17: Negri Sembilan, 19-20: Malacca, 21: Selangor. No. 9 soil contains gravel 3% on original soil. Texture: International Scheme.

As shown in the Table, this soil contains no soluble Mn, and shows Mn defficiency at the pot experiment. The high conductivity of the Kuala Perlis and Kuala Kedah soils comes from the effect of seawater, as these soils are those of the padi fields near the coast. They contains much chloride. The Padan Buloh soil has a lot of sand fraction, and the lowest cation-exchange capacity, but is solidified due to a small content of clay, when it is dried. The Simpang Ampat, Titi Serong, and Tanjong Karang soils are different from one another in properties, though their C.E.C. is more than 40 m.e. The Titi Serong, which is wet even in the dry season, has an organic surface soil of deposits of non-decomposed weeds and rice plant remains, and low in grain yield. The Simpang Ampat soil is low in soluble iron, gives out a sulfide smell at the incubation, and is not high in yield. The Tanjong Karang soil shows the highest yield of all the padi soils in Malaya.

The total-N of these soils is 0.1-0.8%. The NH_4-N content under the field conditions is 1-7mg/100g., approx. 1/100 of the above. When the soils are incubated after drying, NH_4-N, 5-50 mg/100g is produced. (Table 2)

The schematic-reconnaissance soil survey program, which is under way at present, is expected to be expected to be completed in 1967. According to this program, the soils useful for agriculture in Malaya will be classified into the stages of soil series. As its completion is urgent for land utilization and planning, not only the Malayan staff but also U.S. Peace Corps members, Canadian and New Zealander Colombo Plan soil surveyors have participated in this program. Especially, in reference to the survey of padi field, A.R. MacWalter[8] has made a report upon the survey on the Perlis and Kedah coastal plains. Though his ultimate report is not made public, a soil map and the explanation are made available. In addition, M. Nagai has also made

Table 2 Chemical analysis of the soil

	Conductivity μmhos/cm	Sulphate SO_4%	Chloride as NaCl%	Milli equivalent per 100g soil oven dry basis					mg/100g oven dry basis		
				C.E.C.	K	Ca	Na	Mg	NH_4-N air-dried soil after incubation	Morgan-soluble after incubation Fe	Mn
1	1,430	0.091	0.241	27.2	1.19	3.66	7.43	10.74	14.9	542	2.8
2	122	Nil	Nil	25.0	0.16	10.99	0.26	2.28	5.7	393	4.5
3	500	0.059	0.029	41.9	0.23	6.90	1.65	16.68	15.3	78	4.5
4	84	Nil	Nil	17.8	0.07	2.11	0.11	1.94	14.7	140	2.4
5	480	0.074	0.015	32.1	0.26	5.08	0.56	9.37	11.6	330	2.2
6	1,670	0.133	0.244	27.1	1.13	2.59	6.35	12.03	10.6	373	1.2
7	150	Nil	Nil	31.4	0.13	4.05	0.35	5.89	7.6	151	4.5
8	185	0.012	0.006	33.8	0.13	0.77	0.11	0.72	7.0	596	0.9
9	36	Nil	Nil	6.9	<0.01	0.47	<0.01	0.29	7.9	49	0.1
10	67	Nil	Nil	12.9	0.03	1.25	0.04	0.62	9.5	276	2.1
11	400	0.059	0.012	35.9	0.16	11.38	0.07	3.98	10.0	88	1.7
12	670	0.053	0.049	41.4	0.26	5.46	1.21	9.62	27.9	319	3.3
13	150	Nil	Nil	34.0	0.23	2.59	0.04	1.99	56.8	271	1.8
14	84	Nil	Nil	13.8	0.16	1.38	0.17	0.74	25.9	129	3.4
15	240	0.005	0.015	17.4	0.13	1.55	0.04	0.99	48.1	199	2.7
16	50	Nil	Nil	9.5	0.18	0.99	0.04	0.87	11.9	240	5.2
17	630	0.016	0.099	18.5	0.12	4.57	1.04	2.32	43.5	160	4.4
18	400	0.056	0.020	12.5	0.03	0.34	0.35	0.58	16.0	183	0
19	310	0.007	0.046	7.8	0.03	0.43	0.31	0.58	30.0	100	5.6
20	2,850	0.593	0.070	20.7	0.13	1.03	1.56	0.65	8.3	252	2.5
21	500	0.060	0.023	42.2	0.99	8.10	0.82	15.18	11.3	319	18.1

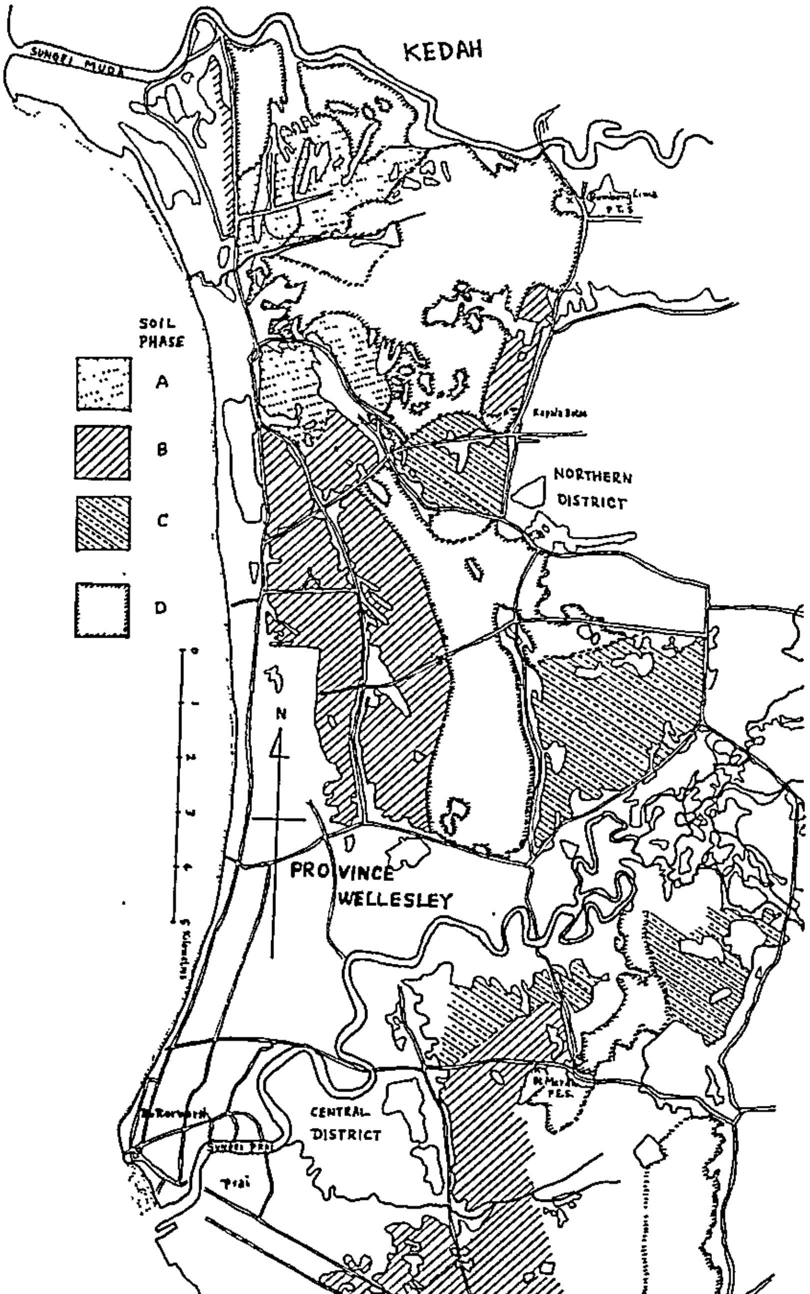


Fig. 1 *Soil map of Province Wellesley*

a report on the padi field soil in Province Wellesley, which will be introduced hereunder. In Jan. and Feb. 1965, K. KAWAGUCHI, et al., Kyoto University, made a profile examination and analysis of the soils of major padi fields throughout Malaya.

IV Padi Soil in Province Wellesley Classified by M. NAGAI

M. NAGAI has made a soil survey of 82 padi fields in the double cropping area in P.W., investigated the real status of rice culture of each farmer, made a crop cutting test to check the yield in various places, and worked out a soil map of P.W. His established soil phases are the following four (Fig. 1):

Soil phase A; It is characterized by a sand layer, less than 50cm below the ground surface. As its surface soil is generally clayey, there are few cases of excessive drainage. It is distributed around the rivers and the "permatang"*. Its area is small. Yellowish brown iron mottling is rich in the lower part of the 2nd layer. The yield is generally low.

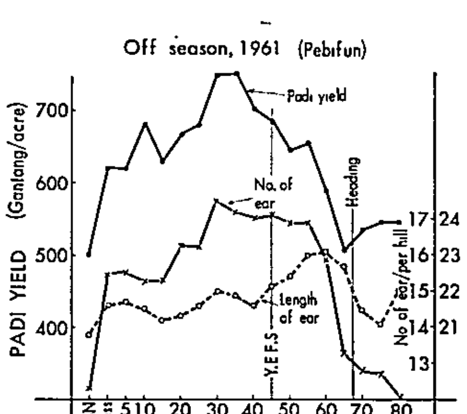


Fig. 2-a *Experiments on time of nitrogen application for the off-season crop, 1961*

Soil phase B; It is distributed along the west coast, and located in somewhat lower places. The underground water level is high. Top soil is soft, deep, wet, rich in organic matters and dark gray. This soil phase is found in the padi fields of high yield, which are, however, uncertain in yield and often damaged by flood.

Soil phase C; It is located in the highest places, shows brown or yellowish brown, and is well drained. Subsoil is rich in iron mottling. Some parts would be damaged by drought or their yield would decrease due to the tardiness of culture work based upon the water shortage. Yield is generally low.

Soil phase D: This soil area is located in the middle of the double cropping area, adjacent to the above B area. As the area is largest, and the soil condition is best, the mechanized cultivation work is most prevalent. Though its yield is lower than that of the above B, more yield can be expected from the improvement of culture technique. Table 3 shows the profile of soils in typical points and some analyses.

V Experiments on the Three Major Elements given in Province Wellesley

M. NAGAI has made trial of three major elements in 15 selected farmers' fields in P.W. The average grain yield for each District is shown in Table 4. The effect of nitrogen was observed without exception. (In relation to the Central District in the off-season, the record was irregular.) The effect of phosphate and potash varied with the place. They were effective in some places, but ineffective in others, whether or not the phosphate was little or not applied, its effect was observed. As for the potash, its effect was observed in the padi field belonging to the soil phase A, or in fileds excessively drained. Though S. SATO made a report upon the remarkable effect of potash, his test was made in the

* Permatang: Malayan term; Sand ridge area which has grown from an offshore bar. This area runs in several rows almost parallel with the coast. As this area is well drained, and good well water is obtained, it has become a site for residences.

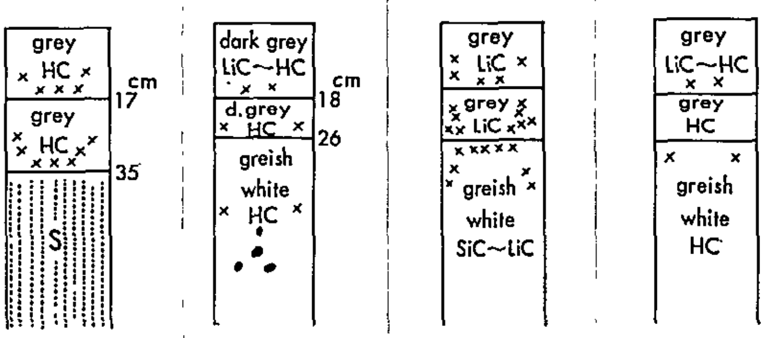
Table 3 Four soil phases in Province Wellesley

Soil phase	A	B	C	D
Padi yield gantang/acre	300—400	500—	300—400	400—500

Soil profile

× × iron mottlings

. plant residues



		A Top soil	A Sub soil	B Top soil	B Sub soil	C Top soil	C Sub soil	D Top soil	D Sub soil
Depth (cm)		0~17	17~35	0~18	18~26	0~16	16~28	0~19	19~30
Percentages	Clay	48	51	42	44	44	40	44	47
	Silt	23	24	21	17	25	21	17	16
	Fine Sand	15	11	21	20	14	12	15	15
	Coarse Sand	11	12	12	16	22	32	20	22
	Gravel	—	—	—	—	—	7.6	—	—
pH		5.0	4.9	4.4	4.5	4.7	4.4	4.8	4.6
Moisture %		3.5	3.9	8.5	3.4	2.2	2.5	6.8	2.7
Loss on ign. %		7.2	6.6	11.0	9.2	7.4	5.6	8.8	8.6
Total-C %		0.92	0.40	3.32	2.60	1.76	0.59	2.02	1.89
Total-N %		0.14	0.11	0.34	0.26	0.32	0.09	0.14	0.13
C/N		6.57	3.64	9.77	10.00	5.50	6.56	14.43	14.54
C.E.C. m.e.		15.82	15.65	21.37	20.35	12.14	10.34	14.36	14.71
Ex. K m.e.		0.02	0.05	0.20	0.19	0.05	0.05	0.04	0.04
Ex. Ca m.e.		4.70	3.67	1.10	0.93	0.64	0.47	1.52	1.23
Ex. Mg m.e.		1.69	1.28	1.36	1.73	0.54	0.45	0.74	0.78
Ex. Na m.e.		0.09	0.09	0.35	0.35	0.05	0.05	0.05	0.05
Total Base m.e.		6.50	5.09	3.01	3.20	1.28	1.02	2.35	2.10

Table 4 Results of three major elements' trials

	Main season				Off season			
	Northern district		Central district		Northern district		Central district	
	Grain yield	Index	Grain yield	Index	Grain yield	Index	Grain yield	Index
—F	485	100	404	100	465	100	519	100
—N	496	102	425	105	509	109	556	107
—P	543	112	450	114	519	112	542	104
—K	560	116	480	119	552	119	547	105
NPK	582	121	489	121	555	119	553	107

N: main season 30 lbs./acre, off season 60 lbs./acre (Amm. Sulphate)
P_2O_5: 60 lbs./acre, (Christmas Island Rock Phosphate) K_2O: 30 lbs./acre. (Potassium chloride)
Grain yield: gantang/acre

excessively drained field of Bumbong Lima Padi Test Station.

From the above, it is conceivable that in the main season, the proper application quantity for the soil phase A and B area is 30 lbs. N/acre, and that for soil phase, C and D, 60 lbs. N/acre, while that in the off-season is 30 lbs. N/acre.

VI Experiments on the Time of Nitrogen Application

M. Nagai has tried experiments in Bumbong Lima P.T.S. to find at which growth stage the N should be applied (Fig. 2).

Off-season, 1961: When the N (ammonium sulfate), 60 lbs./acre was applied at intervals of 5 days and compared with the base dressing, the highest yield was obtained in a field where the N was applied 30-35 days after the transplanting. This period corresponded to the effective tillering stage, and the increase in the number of ears due to the additional N application resulted in the high yield. When the N was applied earlier than the above time, the number of stems greatly increased, but many of them bore little fruit. As the number of ears did not increase, yield was low.

Main season, 1961-1962: When the N, 30 lbs./acre was applied at intervals of one week, the highest yield was observed in the padi field where it was applied 4-9 weeks after the transplanting. When the N was applied 4-5 weeks thereafter, the number of ears was found to be most. When the N was applied at the young ear formation stage, the ear length (probably one ear weight) was large. The ear weight chiefly controlled the yield. It can be attributed to the difference of varietal character that the number of heads has a large share in the yield in the off-season, and the weight of ear in the main season.

In addition to the above, M. Nagai has made an experiment on the split application of nitrogen, by using the variety, Radin China 4 in the Bukit Merah Padi Experiment Station (in the main season of 1961-1962). From this experiment, he has concluded that the yield can be ascertained, when the N is applied between the 40th day after the transplanting, and the young ear formation period.

When the spacing × nitrogen level test was given in B.M. (in the main season of 1961-1962), a rice variety, Radin China 4, was employed.

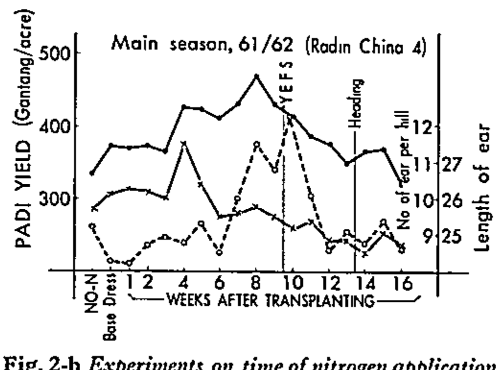


Fig. 2-b *Experiments on time of nitrogen application for the main season crop, 1961/62* (Bumbong Lima P.T.S.)

The max. yield for the single N (30 lbs./acre) level was observed in the 10" × 10" (inches) plot, and that for the double N level in the 14" × 14" plot. When a comparison was made between the treatments, 3 and 10 plants per hill in the spacing of 14" × 14", no great difference was found. From this fact, it was concluded that no high yield could be expected from any space larger than the 14" × 14".

Using rice variety, Pebifun, the effect of the water depth 2,4 and 8 inches, was tested. It was found that the growth at the primary stage was best, the number of stems was large and the yield was high, when the water depth was 2".

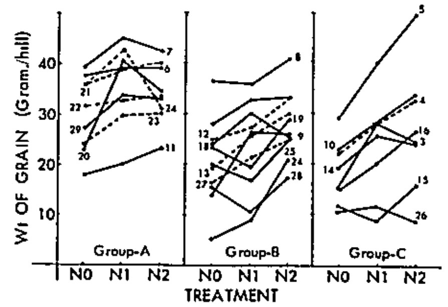


Fig. 3 *Yield results of nitrogen application trials*

VII Nitrogen Application Trials in the Farmer's Fields in Province Wellesley

Chiefly on the basis of his observations of soil profile, as mentioned above, M. NAGAI has classified the padi field soil in P.W. into 4 types: soil phase A,B,C and D. From the viewpoint of soil fertility, he has later classified it into 3 sorts· Group A, B and C, Group A almost corresponds to Soil Phase D in average yield, and Group C to Soil Phase A and C in low yield. In reference to the nitrogen trials, which Agronomist North had given to the farmers' fields in P.W., M. MIYAKE has collected and analyzed the soil of various experimental sites, and divided it according to the above classification:

1) Group A soil is high in clay, organic matter, cation-exchange capacity and easily soluble phosphorous and potassium. It can be more easily identified than other Group B and C soils.
2) Quantity of the NH_4-N, which is formed, when the air dry soil is incubated, correlates to (i) total N% of the soil, (ii) quantity of the NH_4-N, which is formed, when the wet soil is incubated, (iii) Moisture content at the sampling of the soil, furthermore, to (iv) the amount of N absorbed by rice plant grown in this soil, and (v) available SiO_2 content of the soil.
3) In Fig. 3, the yield results of the nitrogen application trials, each line shows the yield in each experimental site. On average, the yield is high in Group A, and B and C come next. As for the A and C soils, high response to a single dose of nitrogen (30 lbs./acre) was observed. In B soil, a high response to a double dose (60 lbs./acre) was observed. In some Group A soil, the yiled was found to drop, when a double dose of nitrogen was given. In the Group C soil, the response was generally high. This seems to have shown that the soil inherent fertility is low.
4) Available silica in each soil has been determined by means of acetate buffer extraction. The value was found to correlate with the SiO_2 percentage of stem and leaf at harvest time.

VIII Soil Nitrogen and Plant Growth (Pot Experiment)

In order to investigate the change of fertilizer nitrogen in soil, and the soil nitrogen during the rice cropping period, and its effect upon the growth and yield of rice plants, pot experiment has been given in the padi cage in Kuala Lumpur. The soils used are the following 5 sorts: Simpang Ampat (Perlis), Kuala Kedah, Sungei Limau (Kedah), Tanong Karang (Selangor)- marine deposits, and Langger (Kedah)-flood deposit on the levee. Each pot of the soils were divided into two groups: N added (Urea, 0.6gN/6Kg soil per pot) and that left untreated.

Seedlings of the Pebifun variety were transplanted. Experiment results can be summarized

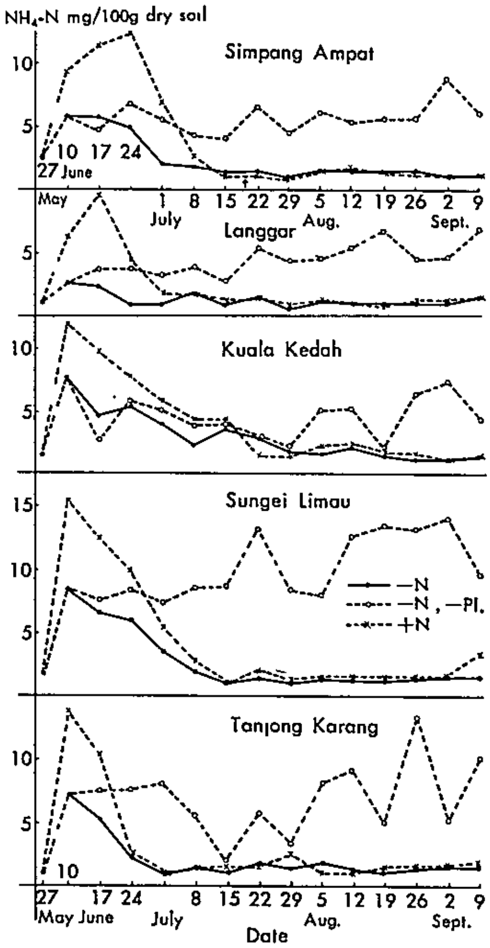


Fig. 4 *Ammonium nitrogen in milligrams per* 100g *dry soil*

as follows:

1) When the nitrogen was applied to any soil, the height, the number of stems and the dry weight of rice plant increased. But the data of maximum tillering stage or the growth type shown in the curves of increase in the plant height and the number of stems is intrinsic to the soil. When so much N as in this experiment was applied, no change was observed.
2) Of the factors which would affect the growth at the intitial stage, the electric conductivity of the field water (which depends upon the salt content of the soil) was the most important one. As for the Kuala Kedah soil, seedlings stopped their growth, and reached higher than 7000 μmhos/cm. When the salt was diluted by rainfall or renewed irrigation water, and the conductivity became lower than 3000 μmhos/cm, the growth began to recover. As the urea application increased the salt concentration, it had an adverse effect upon the growth at the primary stage.
3) NO_3-N content of the soil disappeared within two weeks after the submergence. NH_4-N (Fig. 4), which has a high concentration at the primary stage, decreases its concentration, when it is absorbed into the rice plants. After a definite period, the concentration remains low at an almost constant value. As shown in the Figure, the length of period from the initial stage to this low level stage is dependent upon the N application, and the type of soil. The above lapse of time is short in a soil in which the growth of rice plants is good at the primary stage (e.g. Tanjong Karang), while it is long in a soil in which the growth is bad (e.g. Kuala Kedah). In non-cropping pots, change of the NH_4-N is so small that the initial high standard can be maintained
4) Between the NH_4-N concentration in the soil a certain period, and the N content (%) in the plant one week thereafter, the following correlation was found:

   $r=0.84$

   regression line; $Y=2.28X-1.14$

   where

   $X=\log N$mg./100g. soil

Y=N% in the plant

The above discloses that the N content (%) in the rice plant grown in the soil of high NH_4-N concentration is also high.

5) The inverse proportion that the NH_4-N concentration in the soil reduces, when the N absorbed into the plant increases quantitatively was also observed. In other words, the soil controls the rice plant, while the plant has an effect upon the soil. As previously mentioned, the date of maximum tillering stage did not change with the N application. The NH_4-N concentration in the soil during this period was approx. 1-2 mg./100g. At a concentration lower than that, tillering would stop.

IX Rice Growth in Gombak

In order to observe the growth of rice plants under the normal farming condition, an experimental plot was laid out in a farmer's field at Gombak, Kuala Lumpur District, Selangor. In this connection, the locally recommended variety, Radin Kuning was grown without fertilization to make a leaf-by-leaf analysis and trace the change of soil components. The obtained experimental records can be summarized as follows:

1) It took 178 days from the sowing to the maturing stage. The plant height reached no less than 2 m. Plants, which had been lodged by squall' in the latter half of the maturing stage, were supported by bamboo rails until they ripened. The yield was 3.36 tons/acre on a straw basis, and 1.13 tons /acre on a grain basis. On the other hand, the same long-term variety was grown in the near-by farms. As these farmers transplanted the undernourished seedlings in little padi-fields to the depth of more than 10 cm by means of a transplanting tool, "Kuku Kambing" to control the growth at the primary stage, they suffered from little lodging. From this fact, it is conceivable that the conventional method of farmers is most suitable and reasonable for the character of the variety, climate, soil, water and other environmental conditions.

2) It was mentioned in the previous paragraph

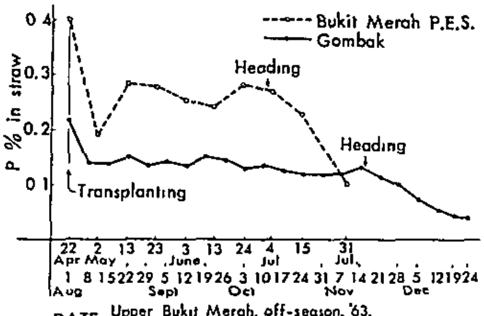


Fig. 5 *A comparison of phosphorus content of rice straw grown in Gombak and Bukit Merah*

that on the semi-logarithmic graph, there is a linear relation between the NH_4-N concentration in the soil, and the N content (%). When the correlation in the first half of the growth was checked in this test, not a semilogarithmic but a linear relation was observed, the correlation factor is as high as r=0.95. In the latter half of the growth, when the absorbed N translocate from the lower leaves to the upper leaves, there would be less direct relation between the soil N and the plant N.

3) Compared with the rice plants in the Bukit Merah P.E.S., it was found that the P content (%) in stem and leave of Gombak rice was very low throughout the whole growth period (Fig. 5), and the soil was short of P. In this connection, it is necessary to investigate the significance of phosphate in the nutrition of rice plants in tropical zones.

4) According to the following three points: leaf-age development, N accumulation in the leaf blade and sheath, and the nitrogen content (%) in the leaf blade at its maximum accumulation, 24 leaves, which had emerged on the main culms until the heading stage, have been classified into the following 4 groups (Fig. 6):

Group I: Leaves which begin their growth on the nursery

(a) 1/0-3/0;

Leaves developed and active in the

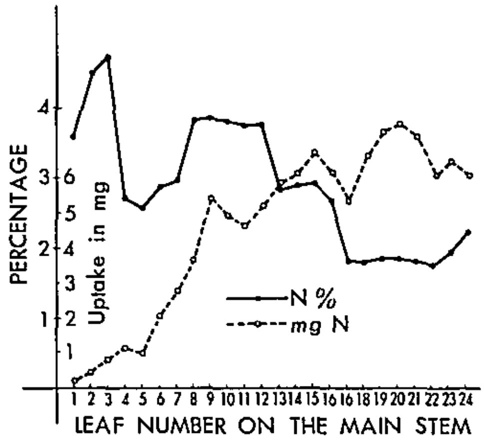


Fig. 6 *The percentage of nitrogen in the leafblade at its maximum accumulation*

nursery. Their N percentage is high and their dry weight is small.

(b) 4/0-7/0;
Leaves active at the seedling establishing stage, N percentage is low, and their blade weight is larger than their sheath weight.

Group II: Leaf blade is almost equal to the leaf-sheath in weight.

(a) 8/0-12/0;
Leaves accompanied by effective tillers, N percentage is medium.

(b) 13/0-16/0;
Leaves which are considered as being correspond to the uneffective tillers, N percentage is low.

Group III: Leaf sheath weight is larger than the blade weight. Carbon nutrition stage is indicated.

17/0-21/0;
N (percentage) is lowest, while the N content is highest. Leaves developed from the elongated stem. They are active at the young ear formation stage.

Group IV: 22/0-24/0;
The N percentage is a little higher than that of the above groups. Leaves are active during the maturing stage.

5) When the rice plants in Gombak, Malaya were compared with those in Kotoni, Hokkaido, Japan in their growth, the N percentage of each leaf of the former was far lower than that of the latter. This would be one of the reasons for the inefficiency of grain production of rice plants in the tropics (Fig. 7).

6) In Malaya and Japan, the maturing period is almost the same. During this period, the number of leaves on each stem keeping its activity is also almost the same. When the whole number of leaves is larger, therefore, the ratio of leaves useful for the maturation, and the ratio of grains to the stem decrease. This would be an important factor for the inefficiency of grain production of rice plants in Malaya.

7) When the changing process of the NH_4-N concentration in the soil of non-fertilized padi fields was traced throughout approx. one year, the NH_4-N was on a low level in a fallow season, but changed with the rainfall. When irrigation is started, the NH_4-N con-

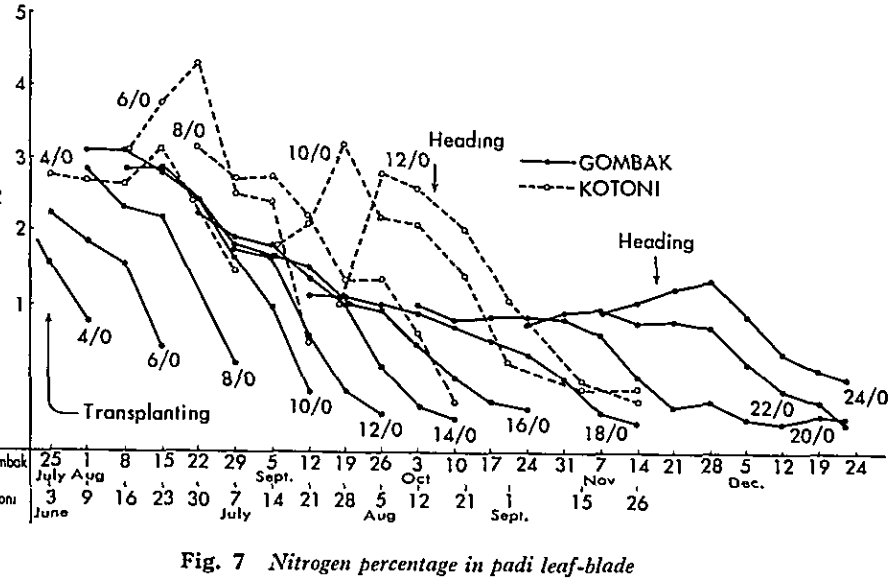


Fig. 7 *Nitrogen percentage in padi leaf-blade*

tent momentarily increases, and is then absorbed into the rice plants, and decreases. Nitrogen, which is released, when the soil is incubated after air drying, i.e. the "effect soil drying" nitrogen increases, when watering is started. In relation to the retention of nitrogeneous fertility of the soil, rainfall during the fallow period, or submergence for a long time before the transplanting seems to be of a considerable significance.

X Silicic Fertilizer and Nitrogen Application

K. Sugimoto, Agronomist, and Chee Sek Pan, Agronomist North gave several nitrogen application tests including the furnace-slag applied plots in Province Wellesley. When their harvested plants were analyzed, and their records were examined, the following conclusion was obtained:

1) In Province Wellesley, there are many padi fields, which show a considerable response to the application of N, 30-60 lbs./acre.
2) Effect of the top dressed N is higher than that of the basic N in many cases.
3) When the silicic fertilizer (furnace slag) is applied in addition to the N, its effect is not always remarkable, but is advantageous for the grain yield in many cases. Independent of its effect, the stage application increases the absorption of silica (SiO_2) and magnesium (Mg) of rice plants, but has no effect upon the absorption of calcium (Ca).

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RICE PESTS AND THEIR CONTROL

Eiji KAWASE*

I General Aspect of Rice Pest Control Viewed *from the Point of View of* Technical Cooperation

Pest control in Malaya has been long studied by Englishmen very hard. In 1930, CORBETT made public the life history of four species of *Leptocorisa*. In 1931, MILLER described the larvae of *Pentatomidae* and *Coreidae*. In 1932, CORBETT worked out a diagram of insect pests of coconuts. But their works mostly related to taxonomical study. In 1932, PAGDEN made public 16 varieties of parasitic plants of *Chilotraea* other than those of rice plants, and recorded the vicissitudes of the stem-borer by laying kerosene light traps in the Kurian area. In 1933, CORBETT, together with PAGDEN worked out a list of literature of insects. In 1934, PAGDEN studied the parasitic bees of the rice crop pests, recorded 5 sorts of egg parasitic bees of *Tryporyza*, and made a fundamental study of pest control. Later in 1956 and 1957, WAYATT tackled the stem-borer control task on a full scale, and launched insecticide tests and the survey of stem-borers in the Kurian area.

Of the rice crop areas in Malaya, the Kurian area is said to have long been most seriously damaged by stem-borers. In some districts, the rate of damaged stems was reportedly as high as 100%. This area is a wet field zone where such *Indica*-type long-term varieties of no less than 200-day growth as the Machang, Padi Hitam, etc. are cultivated, and the plant height is often as high as 1.5-2 m. Even in the off-season of the single crop a year, the high-cut second rice plants are not dried. As the plants are high-cut, or only their heads are nipped at harvest time, stem-borers are not lacking in food throughout the year. Thus this area is very favorable for the stem-borers to live. On the other hand, this area is a zone often hit by the Penyakit Merah, which became common recently. Damage of field rats is also more serious than that of stem-borers. In addition, this area has many problems including diseases such as blast disease, leaf spot, white withering, etc. Unlike the double cropping areas such as Kedah, P. Wellesley, etc., the rice crop has been continued, the pests and diseases being controlled. Before the author et al. started the stem-borer control test, there were British academic achievements of a high level, but no administrative pest control was yet put into practice. There was a large gap between the fundamental researches and the practice of farmers. In such a situation as that mentioned above, the author et al. carried agricultural chemicals and control appliances, and made stem-borer and other pests control tests in the Kurian area. Accordingly, their works have attracted special attention of the public.

II Development of Technical Cooperation

On the request of the Malayan Government, H. ISHIKURA made a preliminary survey of stem-borers in Malaya. On the basis of this survey's records three experts, KOYAMA (Aug. 1958-Jul. 1959), KIMURA (June 1960-Jul. 1962), and KAWASE (Jul. 1960-Jul. 1962) have been dispatched to Malaya during 4 years to investigate the control of stem-borers.

The author et al. took over the tasks of their predecessors in the Titi Serong Padi Experiment Station. KIMURA took over the collection of data on the number of various killed pests by means of light traps, the mode of the life of *Chilotraea*, and the chemical tests. The author took over the carried control appliances, and the tasks of the pest control by chemicals of farms in Province Perak, chemical tests for the stem-borers, etc. All of their achievements for four years will be summarized hereafter. On the basis of these records, S. MATHUSHIMA has agreed with the

* Entomologist,
Ishikawa Prefectural Agricultural Experiment Station

Malayan government authorities that the damage of field rats and Penyakit Merah is serious. This completion of the study of stem-borer control has become the first step of the conversion of study into researches on field rats and Penyakit Merah.

When they had established the stem-borer control technique, the author et al. were consulted about the tropical crop including not only the rice but also the fruits, vegetables, palms, etc., and controlled the pests abnormally breaking out in the Province, Kedah, Perak, Selangor, Johore, Perlis, etc., by using the control appliances. In consequence, the Titi Serong Padi Experiment Station gave an impression of a pest control center in Malaya. In addition to the Titi Serong Station, a pest laboratory has been newly started in the Parit Buntar Agriculture Office. The staff of 20 persons (at the peak of the work) including the author, 1 Agricultural Assistant, 2 Junior Agricultral Assistants and laborers has carried out the stem-borer control work.

III Fruits of Investigations

1. Records of the light traps for the prediction of insect outbreakes

In 1932, PAGDEN made and laid light traps of Kerosene lamps in the Kurian area. WAYATT, the author, et al. recorded the number of killed stem-borers and major pests by means of light traps. In the Kurian area, kerosene light traps were laid at Titi, Serong, Simpang Tiga, Kuala Kurau and Silinsing, while electric light traps were laid at Simpang Tiga (which had electricity) to be compared with the kerosene light trap. In the Bukit Merah P.E.S., too, kerosene light trap was laid.

Though the kerosene lamp light seems to be brighter than the electric light, the electric light trap can catch more pests than the kerosene, and the lighting time of the kerosene is shorter than the electric. The number of killed pests increases at sunset, and decreases after 10:00 p.m. until daybreak. Because of its capacity, the kerosene light trap is operated between sunset and 10-11p.m. But it is very useful in a place where electricity is not available.

In relation to the *Tryporyza* as well as the *Chilotrae*, unlike Japan, more females were trapped. The season when the trapping rate of female was high is Sept.-Oct. 1960, and Aug. 1961-Jan. 1962, when both species were in their prime. The high trapping rate of males was in May-Jul. in 1961.

The month when the largest number of *Tryporyza*'s were killed in 1959-1962 in the Kurian area was November in Titi Serong and Simpang Tiga, and January in Bukit Merah, Silinsing and Kuara Kulau. As for the *Chilotraea*, it was Jan. in Titi Serong, Jan.-Mar. in Simpang Tiga, Jan. in Bukit Merah, Mar. 1961, and Jan. 1962 in Silingsing and Mar. in Kuala Kurau. As for the *Sesamia*, *Cnaphalocrosis*, etc., the season varied. On a quantitative basis, the number of killed *Tryporyza*'s is in the order Titi Serong, Simpang Tiga, Kuala Kurau, Silinsing, and Bukit Merah. The number in Bukit. Merah is one-tenth of that in Titi Serong. As for *Chilotraea*, it is in the order Simpang Tiga, Silinsing, Kuala Kurau and Bukit Merah. As above, the number of killed *Chilotraea*'s in Bukit Merah was one-tenth of that in Simpang Tiga.

When the annual change in Titi Serong and Simpang Tiga was observed, *Tryporyza* was found most in 1962 and 1960, and less in 1961 and 1959. As for the *Chilotraea* in Titi Serong, its number decreased in order 1960, 1959, 1962 and 1961. In Simpang Tiga, it was most numerous in 1962, and averaged less than that in other years. If the number of trapped pests for a long period is recorded, the number of various trapped species in each year and place can be statistically estimated. It is, therefore, very convenient for trapping stem-borers. At the first stage, the connection between the sampling of farms and the number of trapped pests is required.

It is said that less pests fly down into the light trap, when the moon is at its full. When the record of trapped pests is illustrated in terms of a total for 2 and 7 days, the effect of a full moon comes out. If a total value for 5 days or the mean value for 5 days is utilized, or the non-measured value is supplemented, the judgement on pest control can be obtained.

2. Stem-borers

The stem-borer in Malaya (Photo. 1) is called the "Ulat botant". Stem-borers, which do serious damage to the rice crop, are of two species: *Chilotraea* and *Tryporyza*. In addition, there

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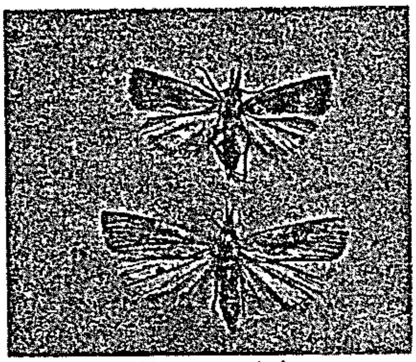

Chilotraea polychrysa

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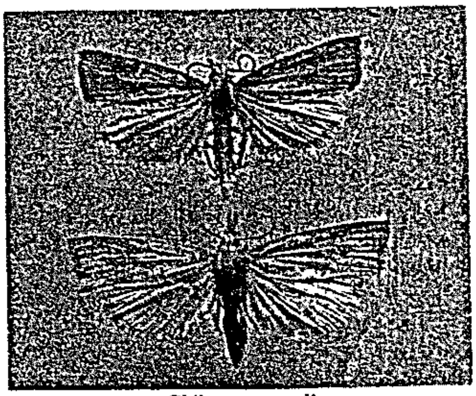

Chilo suppressalis

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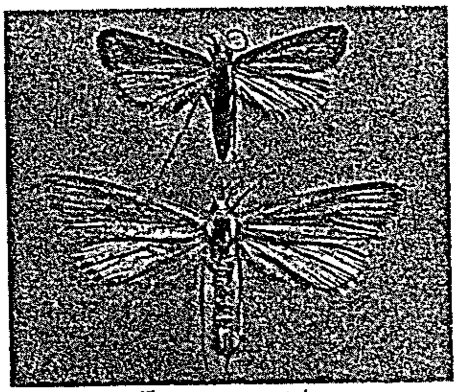

Tryporyza incertulas

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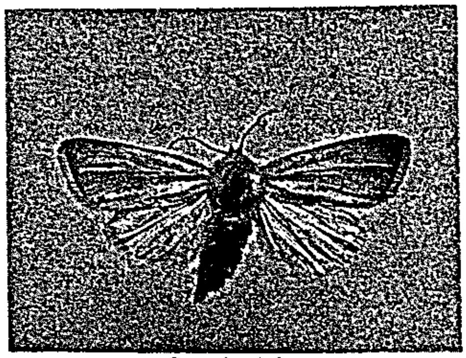

Sesamia inferens

Photo 1 (Phot. by HATTORI)

are the *Tryporyza dodatellus* WALKER, *Borolia venalba*, etc., which had flown into the light traps and been continuously surveyed by the author et al. But they are unknown in many parts.

Chilo suppressalis WALK. is widely distributed in Hawaii, the Philippines, India, China, Malaya and Japan. Though the rice plants in Japan are seriously damaged by it, its damage to the rice plant is less in southern areas, and least in Malaya. In Jan. and Feb. a very small number of these species flew into the light trap in Titi Serong. In some years, the number of these killed species is larger than that of *Chilotraea* between Jan. and Apr. in the Parit Statu P.T.S. Its prime is in Feb.

Chilotraea polychrysa MEYR. is distributed in Malaya and Thailand, and seems to have been distributed over considerably wider areas. In relation to its mode of life etc., however, there are many unknown points. In Malaya, its damage is often greater than that of *Tryporyza*.

Tryporyza incertalas WALK. is distributed throughout Japan, Formosa, China, Thailand, Malaya, Burma, Ceylon, India, the Philippines, Sumatra, Java, Borneo, etc. and does serious damage to the rice crop. Recently in Japan, it has not only occured in restricted areas, but also its damage is more serious in the southern areas. Though it has so far been universally known as the *Schoenobius*, it has recently been termed the "*Tryporyza*" by COMMON.

Sesamia inferens WALK. is distributed throughout India, Southeast Asia, China, and the Philippines. In the Kurian area, it is in the prime in Jan.-Feb., the harvest season of the rice crop, but its number is small.

3. Pests which damage rice plants

In the Division of Entomology, Kuala Lumpur, insect pests, which had been considered as harmful to the rice crop, have been sent to the British Museum, the identified ones carded, and the egg, larva, pupa and the distinction between the females and males primary-colored on the cards, which are preserved. In 1962, there were 158 sorts of lists of paddy pests, in which their scientific term and common name are stated. In this connection, further efforts are expected to write them in Malay. If these data are issued including a list of insect pests to the rice crop, it would be a gueat gride in determining the pests to the rice in Southeast Asia.

Insect pests, which broke out most frequently during my stay in Malaya, were the *Nymphula*, *Oxya*, *Leptocorisa*, and *Scotinophora* for the late maturing variety of rice, and the *Nephotettix*, *Sogata*, and *Nilaparvata* for the Taiwan-variety. Throughout the rice crop areas on the west coast, the damage of the rice black maggot, *Cnaphalocrosis*, which is very similar to the *Hyderllia* breaking out in Japan, damaging the leaves of rice plants.

As for the damage of *Nilaparuata lugnes* STAL, a great outbreak of approx. 1,000 acres occured on 24 Nov. 1960 in Perlis close to the northern part of Thailand on the west coast of Malaya. A large occurrence had been recorded there in the past, too. The recent detection and control at early stages have borne fruit, and the importance of the control organization has been recognized. Withering of the rice plants was as large as 30 yards diameter, and the rice plants yellowed and decayed. The plant height after the heading was 150 cm., the portion from the N-1 leaf to the N-2 leaf became green, and the following 6 leaves yellowed and decayed. The rate of decay of a single plant was 85.4%. Of the area, 1,000 acres, the 68% was damaged. When the scooping was given 50 times, 1,746 insects were caught in the withered field, and 220 insects in the adjacent field.

Nilaparvata, *Nephotettix*, and *Sogata* were small in number. In this connection, the State Agricultural Officer (S.A.O.) said that BHC and Dieldrin were effective in controlling these pests and that the fog machine was effective. In Johore, a large outbreak of *Sogata* was found locally. In Johore, the damage of *Cnaphalocrosis*, rice white withering and field rats were also found.

Damage of the *Nymphula depunctalis* GUER. was found every year in the Silinsing P.T.S. in the Kurian area. It was reportedly the 3rd occurrence, when the damage was found on 22 Sept. during the 3rd seedling period. As for the damage, the epidermis of leaves is eaten up in striped patterns. The eaten portion is like that of *Oxya*, but can be easily cut. Many larvae make the cut and make the dead leaves into the rolls, where they live. In the daytime, they swim on the water surface, and eat the rice leaves at night. The species in Borneo and Java are more powerful than the conventional species in Malay. Damage of the Radin Che Ali, Radin Serai, Chemah, etc. was serious.

Scotinophora has usually broken out in Bukit Gantang and Kuala Kangsa, Perak. During the seedling period, the number per 3.3m² was 300. In the padi field, the max. number per plant was 22. Of 100 plants, insects were parasitic on 91 plants. There was a total of 685 insects at the rate of 7.5 per plant. There are three species: *S. bispinosa*, *S. cinerea*, and *S. coarctata*.

In addition, there was a large occurrence of *Oxya* in the Formosan-rice crop area in Bukit Gantang, which did serious damage to the seedlings. At the nursery and primary stages of the padi fields, a large number of leaves were eaten by *Orthoptera*. The *Nephotettix* has recently been classified into the *N. cincticeps*, *N. impicticeps*, and *N. apicalis*. Many of them fly into the light traps. Their damage is little to the late maturing varieties, but serious on the hills. In the stricken field of Formosan rice varieties in Bukit Gantang, 111-1,225 insects were trapped, when 50-time sweepings were given, and the Sevin Dipterex was found effective.

Leptocorisa is also large in number in the padi field area adjacent to the jungle. In Bukit Gantang, 103-136 insects were trapped, when 50-time sweepings were given. They grow into imagos in the weeds of the jungle, fly to the padi fields immediately after the head sprouting period, and eat the panicles. The heads then turn black-brown and bear no fruit. Sevin Dipterex was very efficacious.

4. Life of the *Chilotraea*

As no detailed record of the life of *Chilotraea polychrysa* MEYER was made available, KOYAMA has made a study of the mode of life of this species, and disclosed the following points:

The female imago of this species bears 4 egg lumps on the back of a rice plant leaf over 3 nights.

As one egg lump has 73 grains on the average, the female imago bears 300 grain eggs. The egg period is 5 days, and the hatching begins at 9,00-10,00 a.m. The larva passes generally 6 instars. Some larva becomes a pupa at the end of 5th instar, while the other pass 4-6 instars. Three days are required for the larval period during 1st to 4th instar, 4 days in 5th, 5 days in 6th for the male, while 5 days in 5th and 7-10 days in 6th for the female. Larval period is 24-26 days, and the pupal period is 6 days long. One generation is approx. 1 month. As there are 11-12 generations during one year, eggs, larvae, pupae and moths can be found throughout the year.

In the off-season when no rice crop is given, larvae repeat their generation by eating the living stems of the rice stubbles and the regenerated second buds. There are few larvae in the dried and withered rice stubbles, while many larvae and pupae in the living rice stubbles. They repeat their generation in the corn growing naturally. In the Menderong and Rumput Miyak, weeds of the *Cyperaceae*, larvae could be bred (Table 1).

Larva younger than the 3-aged eats the rice plant in the leaf sheath. When it is over 4-aged, it makes its way to the lower portion of rice stem, sometimes the stem inside and center below the water surface, ripened larva sneaks into the base of stems and cut the nodes. In case of the Seraup 50 one week after its efflorescence, 80% of the larvae aged 6 were found in the stems, and 16% in the leaf sheaths. As for the larvae aged 3, 17% of them were in the stems, and 83% in the sheaths. When the vertical distribution of the position of the larvae living at this period was observed, the portion less than 17 inches above the base of stem was found, and the larvae of 2-6 inches in size were found to account for 60% of the total. The fact that the larvaes of old age smuggled themselves into the inside, especially the lower portion of stems has made the chemical pest control more difficult.

5. Chemical control of the *Chilotraea*

In relation to a new egg lump one day old the killing effect of Dieldrin is 97%, and that of BHC-Dipterex 50%. In relation to the eggs 2 days after their birth, the hatching rate reduces by only 10-20%, and no egg killing efficacy can be expected. As for the prevention effect against the eating damage of larvae, the BHC emulsion, 0.037% was efficacious for 4 days, Dipterex, 0.07% for 1 day and Dieldrin, 0.05% for 3 days.

BHC-Dipterex is not so efficacious against the larvae, which make their way into the culms after the beginning of the growth of the internode. As the culm wall of the rice plants is thick, and is surrounded by double or triple thick leaf sheath to prevent the infiltration of insecticide into the leaf sheath, the larvae cutting into the culm are generally older ones. Before the larvae get into the hard rice culms, i.e. before they eat

Table 1 Result of *Chilotraea* larvae breeding for plants

Name of test plants	No. of egg-mass	No. of hatch in larvae	No. of living lavrae				No. of pupation	No. of adultation	% of adultation per larvae
			5 day	10 day	15 day	20 day			
Rice plant (*Oryza sativa L.*)	14	1604	1064	169	473	310	91	60	5.6
Menderong (*Scirupus grossus L.*)	16	1236	208	68	50	32	14	11	0.9
Rumput Miyak (*Panicum distachyum L.*)	8	507	74	15	3	2	1	1	0.5
Rumput Pahit (*Paspalum conjugatum L.*)	5	420	11	1	1	0	0	0	0 0
Jagong (*Zea Mays L.*)	19	1455	691	546	438	374	226	168	11.6
Tebu (*Saccharum officinarum L.*)	5	965	181	69	46	19	9	8	0.8

the leaf sheaths and are aged 4, chemicals should be applied. It should be, used, if possible, before the culms are formed. In applying chemicals, stress should be laid upon the prevention of seriously damaged stems (chiefly withered stems) during the young head formation period. Proper application time would be usually 1 month before the heads begin to sprout or 45-50 days before the head sprouting time of 50% of a unit paddy field.

6. Survey of the real status in the North Kurian area

Damage of the *Chilotraea-Tryporyza* in this area is as follows: When the larvae is aged more than 4, it eats the rice stem. During the tillering stage, stems are withered. During the flowering stage, heads remain immature. During the maturing stage, more fruits are not borne.

In making a survey of the real status of stem-borers, 44 points in a region, 53 sq. mile in the North Kurian area were selected.

The rate of immature head during the harvest period was as low as 0.4-2.4% in 1961. When the heads affected by Neck rot were then found, and the rate of affected heads was checked, the rate was 75.7% in 1962. The varieties in the Kurian area had resistance to Neck rot. The unripened heads damaged by the Neck rot was 20% less than the non-damaged heads. Though the rice seedlings are transplanted in the padi fields in late August in the Kurian area, they are only locally damaged in Sept.-Oct., i.e., 1-2 months after the transplantation. The rate of damaged stems is 0.9%, 0.6-3.6%, and 2.9-11.4% in Sept., Oct., and Dec. At the harvest stage, damage increases, and the above rate reaches 55.6-99.3%. In the coastal areas, Sungei Bakau, Tanjong Piandan and Kuala Kurau, the density is especially high so that some plants are withered.

At the primary stage, the damage of stem-borers is less in the fields where the water is supplied from the canal and the transplantation is given early. In the fields where there are a large number of stems, many damaged stems are found. Water depth of the fields in the Kurian area was 4.8 inches on 6 Sept., 6.3 inches on 5 Oct., 4.4 inches on 8 Nov., 1.0 inch on 4 Dec. and 0.8 inch on 12 Dec. On 6 Sept. when the whole area was not yet irrigated, only the fields ranging from Sungei Limau near the canal to Kuala Kurau, from Kuala Kurau to Bagan Serai and from Bagan Serai to Simpang Tiga were watered. The author et al. have made no test of B.H.C. grains and oil. They could be sufficiently used, if the water depth during the control period from Nov. to Dec. is as much as 4.8 inches.

As for the damage of larvae, the *Tryporyza* begins to eat the rice plant in Sept., *Chilotraea* in Oct. and *Sesamia* in Dec. The prime of *Tryporyza* larvae is in Dec. and that of *Chilotraea* in Jan.-Feb. After the harvest, their number increases. At the primary stage of damage, the death rate from the *Tryporyza* as well as the *Chilotraea* is as high as 20%. With the growth of rice plants, it decreases. As for the *Tryporyza*, however, it increases a little after the head sprouting (Table 2).

At the harvest period when the damaged stems were extracted to check the stems, into which stem-borers had entered, it was found that the stems eaten by only the *Tryporyza* accounted for 12.1% of the total, those by only the *Chilotraea* 32.4%, those by *Tryporyza* and *Chilotraea* 5.2%

Table 2 Number of stem-borer in Kurian area

Time of survey	*Tryporyza*			*Chilotraea*			*Sesamia*		
	No.	Larva of dead %	Pupa of dead %	No.	Larva of dead %	Pupa of dead %	No.	Larva of dead %	Pupa of dead %
6 Sept.—15. Sept.	15	20.0	6.7						
5. Oct.—11. Oct.	45	17.8	0	5	20.0	20.0			
8. Nov.—16 Nov.	116	1 72	5.2	24	0	0			
4. Dec.—18 Dec.	390	4.4	0.5	48	8.4	0	5		
12 Jan.— 6 Feb.	106	2.8	0.9	352	3.4	0	15		
16 Jan.—27. Feb.	216	5.1	0.9	1565	1.5	0.2	203	2.0	0

and those by *Tryporyza*, *Chilotraea* and *Sesamia* 2.9%. The stems, into which no stem-borer had entered, accounted for 46.8%, and the non-damaged sound stems 0.6%.

In the Kurian area, the plants are cut at as high a level as 70cm., and their stubbles sprout second heads. When the density of stem-borers living in stubbles was checked in Feb.-Mar., the density for the stems of stubbles accounted for 62.7% of the total, that of the non-headed new stems 28.1% and that of the headed ones 9.1%. Each stubble was found to have a total of 4.2 pests including 3.7 *Chilotraea*, 0.1 *Tryporyza* and 0.4 *Sesamia*. Per stem, there were 0.15 pests for the aged stem of stubble, 0.26 for the new stem, and 0.02 for the head-sprouting stem. From this fact, it is conceivable that the stem-borers repeat their generation even in the off-season.

The density of stem-borers inclusive of *Chilotraea*, *Tryporyza* and *Sesamia*, in the off-season in the Kurian area was 114,914 at maximum, and 3,339 at minimum. This is closely related to the number of rice plants set out in the padi fields of the Kurian area, which is 20,000-25,000 on the average, 36,009 at maximum and 6,195 at minimum. When the number of plants set out in the padi field increases, the density of stem-borers per acre increases. The max. yield in the Kurian area in 1962 was 896 gantang, while the min. was 33 gantang in some districts. The number of rice plants for the yield of 896 gantang was 22,409 and the density of stem-borers was 84,030, while that for the yield of 33 gantang was 9,922, and the density of stem-borers 3,271. In the padi field where the max. density of stem-borers was 114,914 and the number of rice plants was 21,683, the yield of 720 gantang was secured without any pest control. In the fields of high yield, therefore, the number of rice plants is large, and the density of pests is high. In this connection, there remain many problems, which shall be settled in future researches. The Seraup 50, which had been bred in the Titi Serong P.E.S. is a variety resistant to the stem-borers, and has occupied 80% of the padi fields in this area.

7. Damage of the stem-borers

On the basis of the survey records of Mr. TAN (A.A), (assistant to the author in the Kurian district in 1961) which had been submitted to Mr. UNTH, entomologist, the damage of stem-borers was 9.7-40.5%, and 20.5% on average, and the yield decrease per acre was 94.5 gantang. Likewise, the damage of field rats was generally 11.0-56.1%, and 31.1% on average, while the yield decrease per acre was 163.9 gantang. In this survey, the padi fields were classified into three grades: 1st-3rd, and then the seriously stem-borer-damaged district was compared with the less damaged district in yield.

When the calculation was made from the yield test made by the author et al., i.e. 7 regressive straight line formulas of significance, the yield increase per 10% of the rate of damaged stems was 21.8-38.9 gantang. According to WYATT, the yield increase per 10% of the rate of damaged stems is generally 93.4 gantang, and 55.0 on the average. Though both tests are different from each other in method, they seem to almost agree with each other in yield increase value.

8 Proper period for the pest control

When farm tests were given to decide the proper period for pest control, by using the Rogor 40, B-4895 Dieldrex, a very interesting record was obtained as shown in the Fig. 1. Judging from the light traps, the spraying period was decided in combination of the thrice, twice and non-controlled fields. As disclosed in Figure 1 the yield can be secured, when the spray is given three times. When the peak of *Tryporyza* damage at the primary stage (10.Oct.) falls on the peak of *Chilotraea* damage at the primary stage (12. Jan.), the effect of twice spray is the same as that of thrice spray (Fig. 2). When the economical effect is aimed in the one-time spray, spray should be given in the prime of *Tryporyza* at the beginning of Dec. But the yield then is lower than that for the twice spray. In relation to the spray period, the above agrees with the records of WYATT. As two species of stem-borers eat the rice plants together, the selection of chemicals and the proper period for the application come into question every time.

9. Chemical control

When the relation between the chemical dusting and spraying quantity and the death of pests is observed from the test records of

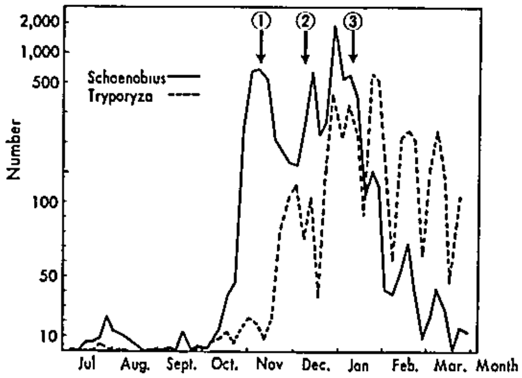

Fig. 1 *Rise and fall of ste-borer*

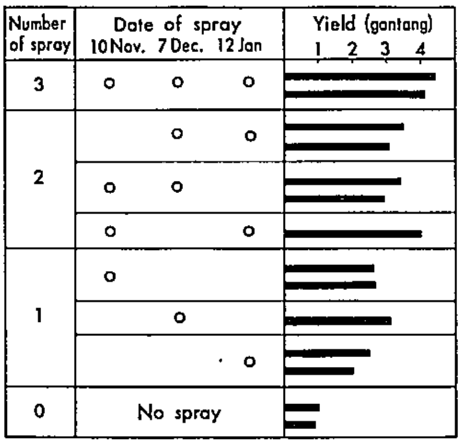

Fig. 2 *Yield in gantang*
Insecticide : .Rogo-40
Place : Simpang P.T.S.
Daet : 1962

chemical agents, the shorter Formosan-varieties are naturally differnt from the longer Indian-varieties, approx. 2m, in the application quantity of chemicals. In case of the Formosan-varieties, like the Japanese varieties, it would be enough, if the dust is applied at the rate of 12-16 kg per acre, or the liquid at the rate of 400-600 *l* per acre. Toward December when the long-term variety of rice becomes 1-1.5 m high, and the phosphate agent is sprayed on the stem-borers living in the stems at the rate of 72 *l* per 10 × 10 yard, however, the killing effect of 100% is achieved. When it is sprayed at the rate of 54 *l*, the killing effect is reduced to 76%-93%. When the stem becomes thicker and the plant grows higher, a killing effect of 100% cannot be expected, even if the agent is sprayed at the rate of 76 *l* per acre, because the spray area becomes larger with the growth of plants, and the plant culms become too hard for the chemical to permeate easily. Considering these points, such long-term rice varieties as the Seraup 50, Machang Mayang, Kelantan Padi Hitam, Machang Bunga Padi Bays, Radin Kling, Seri Raja, etc. should be sprayed with chemical, approx. 800-1,000 *l* per acre.

As for the chloride chemicals such as the BHC, Gammexane, Dieldrin, etc. the prevention effect against the pest eating is high, extremely stabilized in the application at high temperature, and can prevent the yield decrease as compared with the organic phosphate, though these chemicals cannot totally kill the stem-borers living in the stems. When the stem-borers in the stems are killed by means of application of chemicals, the rice plants can immediately recover their health so that their green becomes dark, and their stems and leaves grow well. Consequently, they would often become a target for a following attack of stem-borers. In some case when the chemical is applied, the yield would often decrease.

10. Cost for the chemical application

In investigating the actual cost for one application of chemicals per acre, four sorts of machines including the Kubota power duster and Maruyama power sprayer driven by a 2.5 h.p. engine respectively, Maruyama knapsack hand-operated sprayer, and the Kyoritsu knapsack hand duster have been used. The investigation has disclosed the following facts: As for the cost of chemicals, dust is higher. Power duster is inexpensive in labor, while the knacksap hand-operated spray is expensive from that point of views. When the fuel and maintenance costs were added, the knapsack hand-operated sprayer cost $18, highest of all, and the knapsack hand-operated duster S11.6. The yield for the non-application is 424.8 gallon per acre, that for one application 445.8 gallon per acre and that for two applications

509.3 gallon per acre. Therefore, the yield increase for one application is 21 gallon, and that for two applications is 84.5 gallon. If it is assumed that one gallon costs 62 cents, the approximate income for one application becomes S13, and that for two applications S52 (Table 3). If the cost of insecticide and other miscellaneous expenses are higher, no economic effect is achieved in some case when one application is ineffective. If two operations increase the yield, an income increase of S16 can be expected, even when the knapsack hand sprayer is used.

IV Prospects of the Pest Control

In Malaya, a large number of researchers have so far made a study of the control of stem-borers in the Kurian area. In the rice crop areas other than the Kurian area, it has also been disclosed that a considerable number of stem-borers occured. If the fertilization work is further promoted, control of the stem-borers not only for the late maturing varieties but also for the Formosan-varieties will gain importance. In kedah, Tanjong Karang, etc., there was a great outbreak of not only the stem-borers but also the *Nephotettix*, black maggot, etc., when the single crop was replaced by the double, or the newly reclaimed fields were planted with the Formosan-varieties.

The insecticide test has disclosed that the BHC, Gammexane, Rogor, etc. are harmless to fish and very efficacious in stem-borer control.

In relation to the proper control period, the utilization of light traps would be very effective. As two species of stem-borers repeat 11 generations throughout the year, it is very difficult to expect a perfect control effect from one application of insecticide. As the period from late Nov. to late Dec. is a period when pest control is most effective, however, more investigation is required for the proper control period. Such control appliances as the knapsack power duster, etc., which have been imported from Japan and Europe, are too heavy to be used by farmers for a long time. Farmers have a preference for such light applicances as the hand duster, etc. It is also desired that various kinds of agricultural chemicals, which have been authorized in Japan, should be accepted as soon as possible (at present only limited sorts are sold on the market), and that more pest control experts should be engaged in the control work.

Table 3 Cost of chemical application per acre

Name of appliarce		Maruyama power sprayer	Maruyama knacksap-hand sprayer	Kyoritsu knacksap-hand sprayer	Kubota knacksap power duster
	Place	Bagan serai	Kuala Kurau	Bagan Sarai	Simpang Limau
	Date	5, Nov. '59	9. Sep. '59	14, Des. '59	17. Oct '59
	Test acre	9	0.6	0.5	1.5
	Insecticide	Dipterex E.	Dipterex E	BHC, D.	BHC, D
Cost per Acre	Labour cost (Member×Time)	4×1h 2$ *	1×18h 9$	1×1h 0.6$	1×0.5h 0.3$
	Cost of insecticide	8$	8$	10$	10$
	Fuel for power engine	0.5$	—	—	0.33$
	Maintenance of applicater	2$	1$	1$	1.5$
	Total	12.5$	18$	11.6$	12.13$

* 1$ (Singapole $)≒118 yen

PADDY NEMATODE OF MALAYA

—RICE-ROOT NEMATODE—

Yoshiaki KUNII*

I Introduction

As the researches in plant nematode have been started in Europe or U.S.A. where upland farming is chiefly conducted, the study of the nematology of paddy farming is behind that of the nematology of upland farming. The survey and study of plant nematode in Japan has also developed in relation to the promotion of upland farms. In reference to the nematode of upland plants, a large number of works have been published. In relation to the nematode of paddy plant, i.e. rice plant, however, many problems remain unsettled to be further studied in future.
These problems must be investigated as a subject common to the paddy field areas in Southeast Asia.

The author, a Colombo Plan expert was in office for one year from May 1963 at the Division of Entomology, Department of Agriculture, Ministry of Agriculture and Cooperatives, Kuala Lumpur, Malaya, to survey not only the distribution of rice-root nematode in the paddy field areas of Malaya but also the relation between the Penyakit Merah (Red disease) of rice plant and the nematode.

The author hereby expresses hearty thanks to Director JAMIL of the Department of Agriculture, members of the research division, especially Mr. AHMAD YUNUS, Senior Entomologist and Messrs. LIEW and KOH, active assistants of the author, who cooperated with the author in the survey work.

II History of the Study of Rice-root Nematode

Rice-root nematode was recorded for the first time by van BREDA de HAAN (1902) in relation to the rice plant in Java. It was about 60 years ago. It was made public as a nematode theory on the "Mentek" disease of rice plant, which had been discussed in Java. But this theory was rejected by VALETON (1909) and van der ELST (1912) for the reason that there was neither perfect evidence nor statement.
VALETON said that the nematode could be detected from the Mentek-attacked rice plant as well as the healthy rice plant. In his reports made for 13 years from 1935 to 1948, furthermore, KUILMAN assumed a negative attitude towards the nematode theory on the relation between the rice-root nematode and the Mentek. Thus the nematode theory on Mentek made public by van BREDA de HAAN (1902) seems to have been shelved for the present.

Since the advent of J. van der VECHT and BERGMAN (1952 and 1953), however, the researches on the paddy nematode by Dutch scholars in Java have reached a climax.
They have studied the inoculation of rice-root nematode into the rice plants, made an ecological observation and drawn the following conclusions:

1) When the growth factor of rice plants is very bad, and their recovery is reduced, damage is extremely serious, if the roots of rice plants are infested with rice-root nameatode of high population density. (Mentek appears.)
2) Appearance of Mentek has a close relation to the quality of soil. Especially the alluvial heavy clay is subject to its damage. Thereafter in 1960, KOJIMA et al. (1962), Colombo Plan experts, who had made a survey of rice plants in Indonesia, also reported that the appearance of Mentek is closely related to the quality of the soil.

Rice-root nematode, which had termed the *Tylenchus oryzae* by van BREDA de HAAN (1902) is listed in terms of the *Tylenchus apapillatus*, which IMAMURA (1931) had extracted from the

* Zoo Physiologist,
National Agricultural Experiment station

Komaba paddy field, Tokyo, Japan. It has since then been named the *Anguillulina oryzae* (v. B. de HAAN) GOODEY (1936), *Rotylenchus oryzae* (v.B.de HAAN) FILIPJEV & SCHUURMANS STEKHOVEN (1941), *Rotylenclus apapillatus* (IMAMURA) FILIPJEV & SCHUURMANS STEKHOVEN (1941), and *Radpholus oryzae* (v.B. de HAAN) THORNE (1949) respectively. When ICHINOHE (1959) identified the nematode, which GEMMA & SHIBUYA (1959) had extracted from the rice plants in Akiochi paddy, Yamagata Prefecture, Japan, with the *Radopholus oryzae*, the researches on the rice-root nematode in Japan renewed their start about 30 years after IMAMURA's discovery. KAWASHIMA (1963) and many other nematode researchers have obtained ecological and control data of rice-root nematode. On the other hand, its scientific name was changed into *Hirschmannia oryzae* by LUC & B. GOODEY (1962), and recently (1964) the *Hirschmanniella oryzae*.

III Geographical Distribution of the Rice-root Nematode

According to the specimens collected in Java, Bali, Sumatra, Thailand, and the Philippines, THORNE (1961) has identified the geographical distribution of rice-root nematode in these areas, and pointed out that there is a difference among the collection areas in the body length of the nematode. HASHIOKA (1963) observed the rice-root nematode in his study of rice plant pests in Thailand. CHANTANAO (1962) reported the confirmation of the nematode throughout the paddy areas in Thailand.

In Thailand at the neck of the Malay Peninsula, the distribution of nematode is in this district. In Malaya, however, no records of rice-root nematode is to be found. JOHNSTON (1958) stated in his report entitled "Rice Plant Pests" that he extracted this nematode from the rice plants of the Penyakit Merah (Red disease), and that he extracted it from healthy rice plants.

In 1963-1964 when the author made a survey of the paddy areas on the west coast of the Malay Peninsula, chiefly the Penyakit-Merah-stricken areas in the Kurian district, Province Perak, he identified the rice-root nematode from all specimens (rice roots and the soil around them) (1964). This was also the case with the Trengganu district on the east coast. Considering the wide distribution of the nematode in Thailand, which CHANTANAO had pointed out, it is probable that these areas geographically continue into Thailand.

IV Damage of the Rice-root Nematode

1. Population density and the type of outbreak of nematode

In the first place, BERMANN funnel was used to extract the nematode from the rice roots. Rice roots, which had been split into pieces, approx. 1cm. size, were wrapped in cotton cloth, and immersed in water. The length of immersion was 3-5 hrs. In Japan, it is generally immersed for 48 hrs. In Malaya, where the fixed temperature is always approx. 30°C, the maximum limit was set at 5 hrs.

The population density of the nematode thus extracted showed extremely high values. Without exception, 300-500 individuals of nematode were counted from the extracted rice roots per 10g of fresh root. The repeated survey has disclosed that there was no significant difference in number between the nematode extracted from the rice roots, which seemed to be affected by the Penyakit Merah, and the nematode extracted from the near-by healthy roots.

In relation to the type of outbreak of the rice-root nematode, it is understood in Japan that the nematode migrates from the old to the new rice roots immediately at the transplantation in May and July. Its population density in root becomes so high in August and September, and would often show a rate of 3,000 individuals per 10g of fresh root. But there seem to be two types: In one type, the population density suddenly decreases after the harvest period, while it gently decreases over winter in the other. The population density of the nematode in the soil around the rice roots was investigated, when the nematode was extracted by means of sieving method. In this case, too, a considerable number (100-1,000 individuals per 100g of fresh soil) of nematodes were detected. This seems to be worthy of note in comparison with the fact that only a small number of rice-root nematodes are extracted from the soil in Japan.

One reason why the type of outbreak in Malaya is normal and little change is observed in the density is probably that the rice plants do not wilt immediately after their reaping, as they are chopped at the harvest time, and subsequently the rice plant roots do not decay for a time long enough to be active as hosts of the nematode.

2. Experiment of inoculation

As means of the damage analysis of nematode, nema-free river sand and vapor-sterilized soil were sampled. The rice-root namatode extracted from the rice root was incoulated. Inoculation experiment was given, by transplanting young Seraup 50. The first small-scale experiment (inoculation for 50-250 individuals) disclosed that approx. 6% of the inoculated larvae was infected. In a pot, approx. one out of fifty thousand 1,000-2,500 individuals of the nematode were inoculated. As a result of the above experiment, however, there was found no significant difference between the inoculation and non-inoculation areas in the plant length, number of tillers, discoloration etc.

3 Experiment on the nematode

When the nematicide experiment was given to the rice-root nematode in the soil by means of organic phosphorous compound (EN 18-133) and halogen compound (DBCP), both agent showed a high nematicidal effect.

When a young plant (Seroup 50, seedling period: 2 months) was dipped in a 1,000-fold solution of the DBCP emulsion (75%), transplanted into a pot charged with soil containing the rice-root nematode, and checked 130 days thereafter, there was observed to distinct difference between the DBCP-treated area, and the non-treated area in the number of the nematode extracted from the rice root. In relation to the weight of rice root, however, it weighed 133g per hill in the treated area, 23% more than 108 g in the non-treated area. The above point must be further investigated. The difference in the population density of infected larvae at the early stage of rice plant would cause a difference in the root development. In this connection, the secondary effect of chemicals should be taken into consideration.

4. Nematicidal test in the field

After the demonstration of the preliminary tests mentioned in items 1-3, nematicide was applied to the field in the Simpang Tiga P.T.S. in the Kurian area. In a field, 10m. sq., DBCP emulsion and granule were respectively applied at the rate of 24g/plot and 200g/plot (treatment date: 19 Jun., transplantation date: 26 Sept.).

As for the number of nematode extracted from the rice root, the number in 25 days after the transplantation in the DBCP granule treated area was less than half of that in the non-treated area, whereas there seemed to be no difference between the emulsion treated area and the non-treated area. According to the second survey in 140 days after the transplantation, however, the number of nematodes extracted from the rice root became over three times as many as that of the first survey, and no significant difference was observed between the nematicide treated area and the non-treated area. In reference to the plant length and the number of tillers, there was no distinct difference between both areas at the first as well as the second survey.

The above experiments had many defects in the field management etc. If a general conclusion is drawn from the above, the relation between the infection of rice-root nematode and the change in growth of rice plant is indistinct. According to the observations of the nematode inoculation test as well as the nematicide pot and field tests, the growth of the rice plant is a little better in the nematode-free or low population density area, which showed a little higher values in relation to the plant length and the number of tillers. Discoloration of leaves is a symptom of disease the most difficult to identify

V The Future Problems

The author can conclude as follows: Rice-root nematode is widely distributed over the paddy field areas in the Malay Peninsula. The rice and water plant roots are infected with the nematode, which is active in disturbing or exciting the metabolic function of the hosts. On the other hand, the cross of its environmental factors (physical, chemical and biological) has formed a more complicated situation.

Penyakit Merah is just one of these problems. Unless a system is considered to clarify the realities, all work will be splintered and inefficienf

In connection with the above, researchers in the rice-root nematode should be engaged in the investigation work of Penyakit Merah in close collaboration with the research workers on the rice plant, host of the nematode, those of soil, environment of the nematode, those of the pests disturbing the growth of rice plants, etc.

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CONTROL OF THE FIELD RATS

Masami Mochizuki*

I Introduction

According to the Colombo Plan, the author was dispatched to Malaya to give guidance to the field rat control technique. During his term of office from Nov. 1962 to Nov. 1964, he made a survey of the actual status of field rat control in Malay to orient the technical cooperation, worked out and put into practice a guidance program, reported to the Malayan government the technical data made available from the guidance, and requested the steps to be taken in future. Outline of this cooperation and its prospects are as follows:

At present in Malaya, raticide is used for controlling the field rats. In making this Rodenticide, zinc phosphate is mixed with various baits at the weight ratio of 2 : 100. Cyanogas is very seldom used. In the rice crop areas, the Rodenticide, which is kept in the custody of the agricultural office of the district, is delivered to farmers free of charge. By mixing it with the baits, Agric. field officers make poisoned bait and then leave at the farmer's disposal. As bait, boiled padi is generally used. There is no experiment and research organ for the control of field rats. In the Department of Agriculture, there are a few only officers of some experience in rat control work in the Insect Division attached to the Research Branch of Department of Agriculture. There is also no consistent policy nor experiment station for conducting research into the control of field rats.

Such being the case, there is a great danger that the technical cooperation will become self-righteous and its course will be distorted, if it is oriented under the present condition alone. We must remember the achievements of European, especially British experts about the species and life of field rats and their control, which cannot be neglected. Those past data shall be summarized and studied hereunder: The species of the field rats living throughout Malaya are 25-26, and most of them belong to the *Rattus*. Forest and trees in the fields are little damaged, while the rice-cropping areas and the oil palm estates are seriously damaged (Photo 1) Padi fields are said to be chiefly damaged by the *Rattus argentiventer*, and the oil palm estates by the *Rattus jalorensis*. The major field rats in Malaya are of almost medium size (length of the head and body, approx. 100-200 mm), and large in number. The mode of life of most field rats with reference to their control is unknown in many points.

In controlling the rats, many rattraps including the conventional type (Photo 2) and the European-made guillotine-type were used before but are not used at all now. As for the Rodenticide, some kinds of vegetable components produced on the site, arsenicals, other chemicals and even the virus were used. At present, however, zinc phosphate is generally used. This zinc phosphate agent seems to have been imported from England, where progress had been made in its researches, by a British firm in post-war days, and diffused among farmers. In recent days, however, some firms are active in importing coumarin and other chemicals.

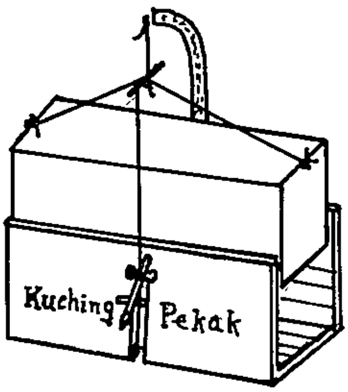
Under the guidance of British experts, meanwhile, practical field rat control was given chiefly to the padi fields and the nearby palm plantations in Province Wellesley (1927), Krian area, Perak (1924-1925), Malacca (1929), etc. on a wide scale, especially to exterminate the field rats in the padi fields before the harvest. As a result of this control, a large number of rats were caught (purchased at the rate of 1 cent per tail of the rat). In the Krian area, the rat damage of the rice plants could be reportedly reduced from approx. 6% to 1%, though the estimating method for the damage is unknown. In this control work, various kinds of traps, Rodenticides and batis

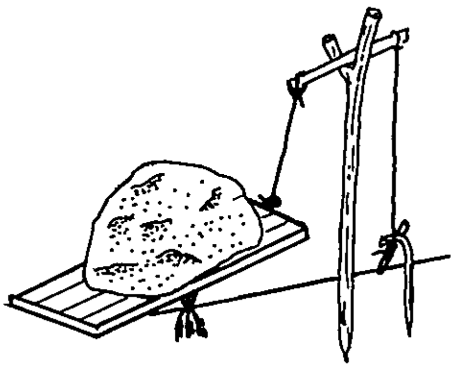
* Entomologist,
Toyama Prefectural Agricultural Experiment Station.

↖ Photo 1. Damage of the padi plants during the latter period of gthe growth. All padi plants except those around the padi field were so seriously damaged (Tanjong Karang)

← Photo 2. Rattrap of conventional type (Data from the Etimology Division, Departm ent of Agriculture)

↓ Photo. 3 A species of typical field rat (*Rattus argentiventer*)





Perangkop Timpa

were used. In addition as this control work ranged over a long time there were many difficulties in practice, so that perfect control could not be achieved. It is, therefore, necessary to examine the simplification of control method and the shortening of control period to reduce the damage of rice plants growing in the paddy fields.

The Malayan Government has requested the author to serve in the Insect Division, Research Branch of the Department of Agriculture, work out and consult about the control program, and if necessary, go to the fields. Thus the Government had an enthusiam for our technical cooperation in establishing a step to protect the rice crop against the damage of field rats. In connection with the above, the author has to cooperate in establishing a fundamental, effective and simple control system for only the rats living in the paddy fields. For this purpose, an experiment room, appliances and personnel were secured at minimum cost. Directions were then given to all the officials in charge throughout the tests ranging from the fundamental to the applied so that they might master the objective and method of each test as well as the correlation among various tests. The Tanjong Karang rice experiment station (S.W.R.S.) was selected as a point where major guidance was to be given, while the Parit Buntar's rice crop pest experiment field and the Pulau Gadong rice experiment station were chosen to examine the regional problems. Of the staff of the Insect Division, three officials were trained in the Tanjong Karang Padi experiment station (S.W.R.S.) for about one month, and then stationed in the above three places respectively. Data were collected every month, a direction program was worked out arrangements were made, and the author went to the site for guidance, as occasion demanded (Fig. 1).

As a result of such steps, the trained officials became selfconfident and eager about the exhibition of rat control to farmers, and attracted the attention of farmers in the Tanjong Karang district. An arrival at his post, the author requested the establishment of a laboratory in the Tanjong Karang experiment station (S.W. R.S.), which is said to have been recently completed. In this laboratory, the officials, who had been instructed by the author, are reportedly scheduled to give control tests continuously. Data submitted to the Malayan Government are those up to the rat control test for the double crop at the return of the author. As only a few tests were given, however, there would be many points in the above data, which must be corrected.

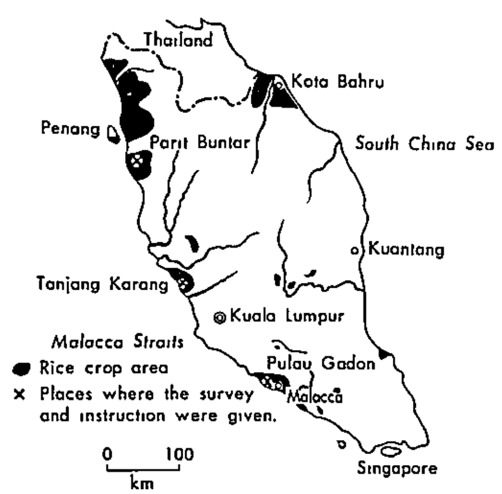


Fig. 1 *Map showing the areas where the survey and the instruction were given*

II Species and Distribution of Field Rats

It was said that the rats infesting the paddy field areas were mostly the *Rattus argentiventer* (English name: Rice field rat, Malay name: Tikus Sawah, Chinese name: 田鼠). According to our survey, all the rats infesting the paddy fields belong to the *Rattus* family. In addition to the *R. argentiventer*, the *R.r. diardii* (English name: Malaysian House-rat, Malay name: Tikus rumah, Chinese name: 家鼠), *R. jalorensis* (English name: Malaysian Wood-rat, Malay name: Tikus belukar, Chinese name: 林鼠), *R. exulence* (English name: Little House-rat, Malay name: Tikus rumah kechil, Chinese name: 小家鼠), *R. annandalei* (English name: Singapore rat, Malay name: Tikus Singapura, Chinese name: 新加坡鼠)

Table 1 Outer characterestics of the rat species in the padi fields

Characteristics / Species	Mammae formula	HBL	TL	T/HBL	HFL	EL
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1 *R. argentiventer*	3+3=12	14.80	14.40	95.50	3.28	1.91
		±2.46	±1.60	±6.60	±0.12	±0.42
2 *R. jalorensis*	2+3=10	17.37	15.22	90.70	3.91	2.28
		±2.56	±1.41	±4.63	±0.44	±0.18
3 *R.* sp. (unidentified)	3+2=10	15.75	14.72	92.40	3.64	1.96
		±0.98	±1.40	±5.16	±0.28	±0.14
4 *R. exulens*	2+2= 8	13.86	12.86	95.67	2.50	2.36
		±2.40	±1.85	±5.45	±0.93	±0.30
5 *R r. diardii*	2+3=10	16.20	18.33	113.00	3.43	1.99
		±2.22	±2.22	±7.81	±0.36	±0.12

Table 2 Color of rat species in the padi fields

Name of Species	Dorsal color	Ventral color	Tail color
R. argentiventer	Dark brown	White	Grey
R. jaolorensis	Dark brown, brown, etc.	Whitish grey, white, etc.	Grey
Rattus sp.	Dark brown, brown, etc.	White, Whitish grey, etc.	Black
R. exulens	Dark brown, brown, etc.	White, grey, yellowish brown, etc.	Grey and black
R.r. diardii	Dark brown, yellowish brown, etc.	White, brownish white, greyish white.	Grey

and the *Rattus sp.* (non-stated) were observed (Table 1, 2 and Photo. 3). Their prevailing species varies with the regions. In the Malacca area, the *R.r. diardii* was prevalent, in the Tg. Karang area the *R. argentiventer* and *R.r. diardii*, and in the Kurian area the *R. jalorensis* (Table 3). Considering these facts, it would be necessary to investigate the species and the actual status of field rats over all other major rice crop areas.

III Ecological Adaptation

When the change of the number of *R. argentiventer* living in the paddy fields of the single crop area throughout the year was checked, the high density of the living rats was observed in May-Jul. after the harvest and in Oct-.Nov. at the growing stage of rice plants. Density was especially high in May and Jun. (Fig. 2), when approx. 20 heads of young and adult rats were found per 3.3 acres. In Apr. approx. 8 heads of young rats were found living. From this fact, it is conceivable that the period immediately after the harvest is most favorable for rat breeding in this area.

Though more than 90% of the paddy fields in Malaya yield a single crop a year, double crop is also being introduced increasingly. When the single cropping area was compared with the double cropping area in the change in the number of field rats, the number of those living in the double crop area was very small, while those in the single crop area is far larger, and the rats were found to be well grown (Fig. 3). From the survey records and observations in the paddy field alone, therefore, it is conceivable that the introduction of the double crop system has given an environment unfavorable for the rats living after the harvest of the 1st-period rice crop. In this connection, it is important prior to rat control not only to equip the paddy fields with complete watering facilities for the double crop, but also to make a full survey of the ecological adaptation of field rats, which would be found in relation to the watering, etc. in the season.

Most of the rat nests are temporary for the

Table 3 Reference of the rats in the padi fields

1. Tail length/head and body length
   105.19∼120.81.........*Rattus rattus diardii*
   88.90∼102.10........ (2)
2. Head and body length
   14.81∼19.93 cm ......*R. jalorensis*
   12.34∼17.26 or less...(3)
3. Ear length
   2.06∼2.66 cm. ......*R. exulans*
   1.82∼2.10 ... .(4)
4. Number and type of mammae
   3+3=12 ....*R. argentiventer*
   3+2=10 . ...*Rattus* sp.
   (species not stated)

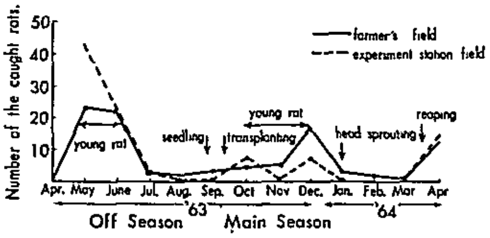


Fig. 2 *Development of the number of rats caught in the single crop area* (Tanjong Karang)

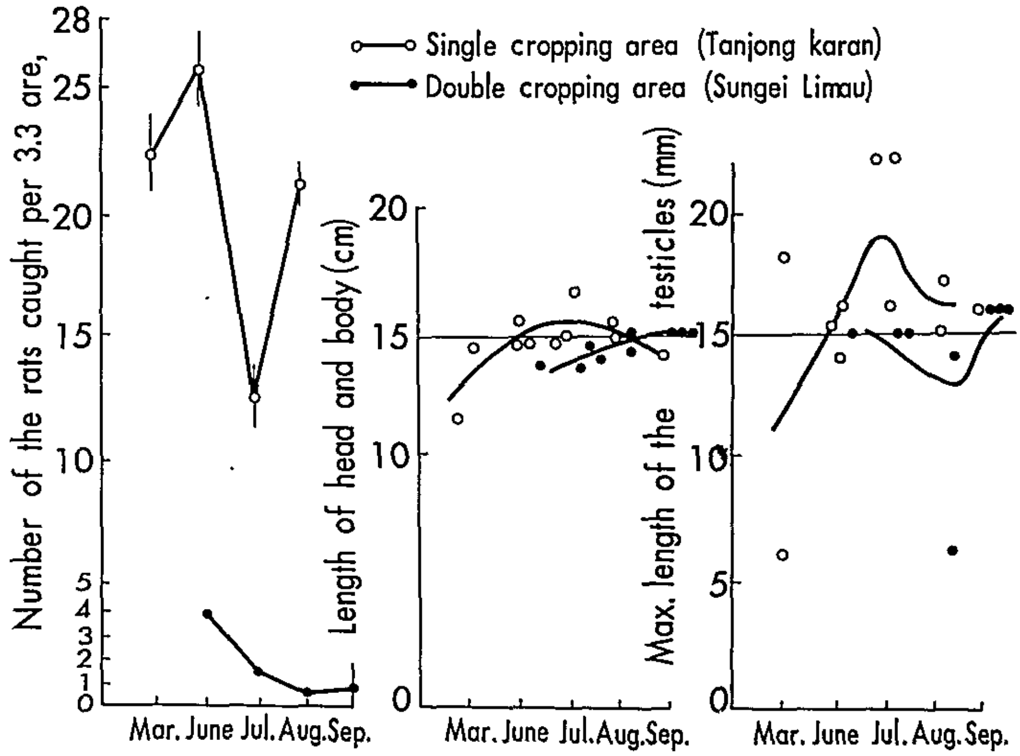


Fig. 3 *Number and growth of the rats living in the single and double crop area*

Table 4 Species of the field rats classified in terms of regions

Regions	R.r. *diardii*	*R. exulens*	*R. argentiventer*	*R. jalorensis*	*R.* sp.	*R. annandalei*	Total	Places where the rats were caught
Malacca	17	6	0	0	0	0	23	Outdoors and indoors
Tanjong Karang	63*	4	151	4	1	1	224	Mostly outdoors
Kurian	3	3	3	65	17	0	91	Outdoors

Note: * shows the number of rats mostly caught indoors

probable reason that the rats are sensitive to the environment, and very movable. According to the visual observations of the movement of rats out of and into the paddy fields, the *R. argentiventer* has a marked leaning of movement from the weed area to the paddy fields. Though the *R.r. diardii* appears at the maturing stage of rice plants, it tends not to move to the paddy field but rather move indoors. Though the *R. jalorensis* likes to move to the paddy fields during the period from the sowing to the harvest, it also likes to go to the bushes. The *Rattus* sp. is a little less than the *R. jalorensis* in its leaning towards the paddy fields, and more towards the forests. These activities of field rats should be more studied.

IV Damage and Eating Habit

As compared with other species, the *R. argentiventer* in paddy fields feeds more on grass, and eats the padi seed, 9g. per day. It eats from about 2:00 p.m. to 8:00a.m. in the next morning, and is especially active from 6:00p.m. to 10:00p.m. As for the mode of damage, more damage is found in the breaking than in the eating. In the nurseries, damage is observed, when the rats pick up the germinating padi and eat the albumen. This habit is similar to the habit of digging out the roots of Lalang imperata (*Imperata cylindrica*) and other Graminare weeds, i.e. the starch-reserve section. In Aug.-Sept. when the seedlings are bred in the nurseries of the 1st-period crop, most of the grass is withered, and therefore the damage concentrates upon the nurseries remarkably. When the seedlings enter the weaning period, or the surroundings are supplied with water, the damage seems to cease. During the nursery period of the 2nd-period rice crop, when there remain many heads and stubbles in the fields after the harvest, concentrative damage to the nurseries is little. At the beginning of the growth in padi fields, rats eat the stems of no chlorophyll content, especially in the weed-grown hills or the nurseries long left alone. But such damage is generally slight.

During the internode growing period, when the node of the vegetative point appears on the water level, rats eat the core, i.e. the growing point portion preferably. This portion agrees with the eaten portion above the ground found in the Lalang. But the young heads are not eaten. During the period from the milky stage to the maturing stage, rats cut the 1st internode above the stem, and eat the albumen portion of panicles. Damage done to the node of vegetation point of stems during the internode growing period is often most serious at the head sprouting stage. It seems to be because the rice plants during the head sprouting period are food most suitable for the field rats. During such a period, concentrative damage is observed in paddy fields. It is, therefore, necessary to consider such a crop system as could prevent the above damage of field rats. Though the yield decrease due to rat damage is estimated at 13.0% on average, it closely relates the total number of rat-stricken stems during the period from the head sprouting stage to the harvest time (Fig. 4). When the above total number is large, the damage during the head sprouting period seems to be serious. When the damage before the head sprouting period is early and serious, damage during the head sprouting period seems to be serious (Fig. 5). In the seriouly stricken areas, a control method must be established on the basis of the number of living field rats and the development of damage. The period immediately before the head sprouting

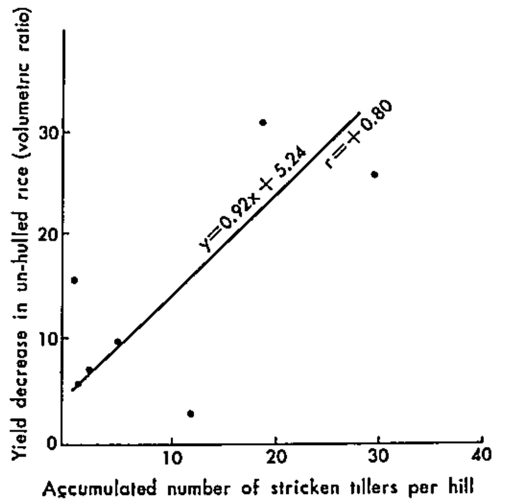


Fig. 4 *Relation between the damaged tiller and the yield decrease* (in the Kurian area)

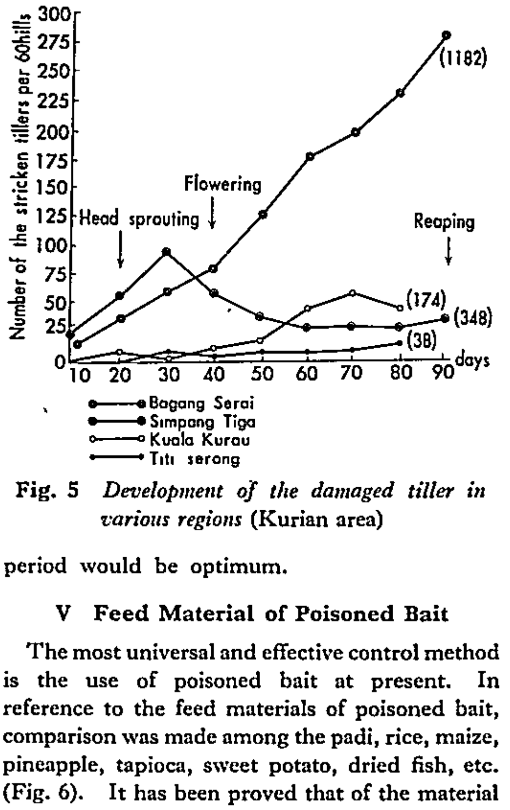


Fig. 5 *Development of the damaged tiller in various regions* (Kurian area)

period would be optimum.

V Feed Material of Poisoned Bait

The most universal and effective control method is the use of poisoned bait at present. In reference to the feed materials of poisoned bait, comparison was made among the padi, rice, maize, pineapple, tapioca, sweet potato, dried fish, etc. (Fig. 6). It has been proved that of the material samples, tapioca is most to the taste of rats. But it takes much time to make poisoned bait of tapioca. At present, unhulled rice is generally used as the feed material of poisoned bait. Like the hulled rice, the unhulled rice is inferior to the tapioca in the quantity eaten by rats. As its taste is good, however, it cannot be given up as a feed material of poisoned bait. As the unhulled rice has chaff, much time is required for the process of making poisoned bait. Because the poisoned bait of hulled rice can be made easily, the practical use of poisoned bait of hulled rice should be investigated for the present. Fruits of maize, etc. would be better to make rats satisfied with the poisoned baits. In consideration of such a condition, the bait materials should be investigaed.

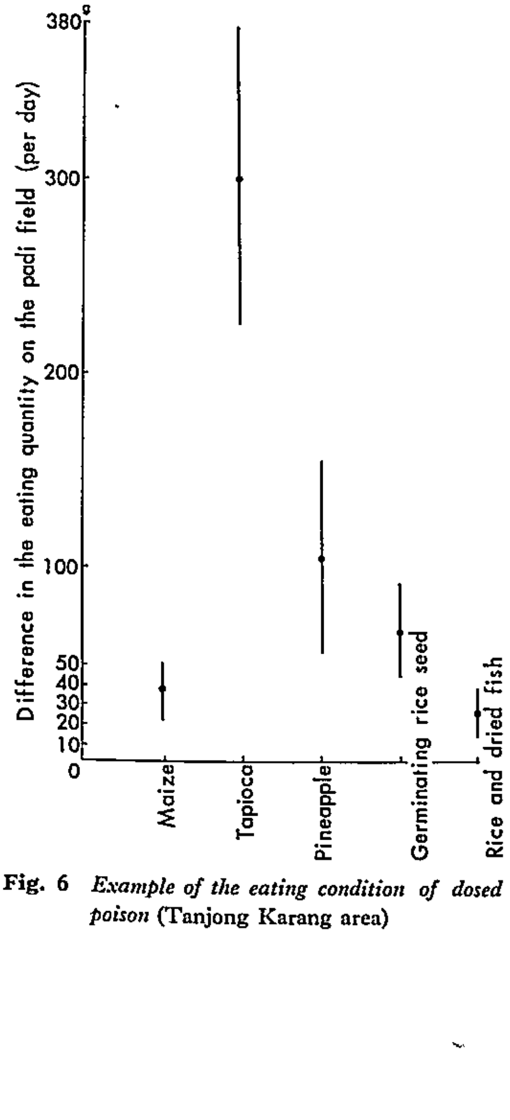


Fig. 6 *Example of the eating condition of dosed poison* (Tanjong Karang area)

Table 5 Characteristics of two species of field rats

Species of the rat	Number of days from the dosing of poison to the start of eating	Eating quantity (g)/weight (100g)*	Min. lethal dose (mg)/weight (100g)
R. argentiventer	1.33±0.49	0.26±0.52	13～ 18
R. jalorensis	1.12±0.88	1.26±0.75	255～355

Note: In preparing the poison, raticide of monofluor acetate was mixed into the hulled rice.
* shows an eating quantity for the first day when a rat of powerful resistance was dosed.

VI Rodenticide and Poisioned Bait

In connection with the material of poisoned bait, the Rodenticides including one sort of the zinc phosphide currently used in Malaya, three sorts of coumarin, one sort of thallium, and one sort of monofluor acetate were sampled. Their specified standard quantity or less was applied to, or absorbed into the rice, and then fresh poison was used to investigate the eating quantity. It has been then proved that the eating quantity is large for one sort of coumarin, thallium and monofluor acetate, and small for one sort of zinc phosphide and two sorts of coumarin. It comes from the effect of the distaste of rats in their choice of food. When the same sort of Rodenticide was sampled to investigate the killing effect, the effect seemed to be considerably dependent upon the species of rats, though it might be dependent upon the difference in the killing period, the weight of rats, etc. (Table 5) The corruptibility of poison greatly affects the Rodenticidal effect. From this point of view, one sort of the zinc phosphide and monofluor acetate each was used to make the poisoned rice of small component of Rodenticide. The test has disclosed that the eating quantity of poison was lowest on the 4th-5th day, because their effect began in approx. 5 days after they were made (Fig. 7). When the weather is relatively fair, therefore, the Rodenticidal effect could be expected for 3-4 days after dosing, but the reduction of damage cannot be expected during the period when the poison is eaten by rats. In 1-2 days after placing the poison, most of the field rats begin to eat the poisoned bait. But even the biggest eating quantity per head for the first time was 2g. (daily) per 100g. of the weight of the rat (Table 5). From this viewpoint, it is necessary that the rat should take the lethal dose at the first time (within one day).

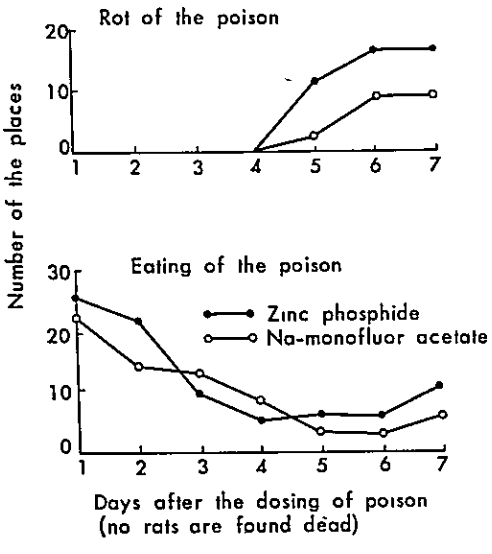


Fig. 7 *Rot and eating condition of poison* (in Tanjong Karang area)

VII Practice of the Rat Control

On the basis of the above test records, *R. argentiventer* rats were controlled once during the head sprouting period of double crop in a paddy field, approx. 1.8 ha. As for the Rodenticide, one sort of powerful and less distasteful monofluor acetate was used. In consideration of the resistance and size of rats, etc., it was absorbed into the rice at the ratio of 1 : 10. In consequence, no damage was observed during the period from 4th to 6th day after the dosing of poison, and no rat seemed to remain alive. After the above period, however, damage increased in each survey point for the probable reason that the rats invaded from outside. It is, therefore, desirable not to increase the frequency of control, but rather to grasp the invasion extent of rats, and expand the control area so that the control may be given in such a state, where no invading individual is found. In controlling the rats in the nurseries, a preli minary test was given in the upland rice nursery of the single crop area. When the poison is laid around the nursery, however, it is more effective to lay more dosing points than in the case of the paddy field.

VIII Summary of the Above

As mentioned above, efforts have been made to establish a proper step for the control of field rats in Malaya, by limiting the researches to those or rats living in paddy fields. In order to achieve the control effect, many points of research seem to remain unsettled. At the current stage, however, the following steps would be feasible:

In controlling the *R. argentiventer*, stress should be laid upon the single crop area. As for control during the most important paddy field period, priority should be given to an area, which is frequently infested at the early stage. As for the control period, the head sprouting period is optimum. In relation to the zinc phosphide used in Malaya at present, approx. 3g should be mixed into the rice (100g strictly) and then applied uniformly. Poison should be dosed in the afternoon of a fine day immediately before the rats become active. Poison should be laid on the hills at intervals of approx. 3m at the dose of approx. 20g per point. A wider control area is more effective. Control should not be given to a small area, and zinc phosphide should not be used continuously. In the case of a nursery, much poison should be laid around the nursery immediately before the buds of the seedlings come out.

In close relation to various agricultural facilities or farming techniques, the ecological adaptation of field rats not only in the paddy fields should be energetically examined to reduce the density of living rats and prevent concentrative damage.

In areas, where rat control is required, a wholesale control program for the wide area should be worked out, and put into practice completely. In such a case, a completely mechanized system including the use of helicopter, etc. and its practical use should be taken into consideration. On the other hand, it is also important to improve the raticides which are said to be most effective, to remove the danger to men, livestock and natural enemies. In this connection, it is most important to pay attention to the recent development of new raticides, and examine the practical use of new raticides, which are said to be least noxious to men and livestock and extremely effective in killing the field rats.

As for the prospects of rat control viewed from a technical point, survey and tests are naturally required. As these works have been reportedly continued by the staff, who cooperated with us, the Malayan government has felt more interest in the rat control than before. We should not be, therefore, reluctant to cooperate with Malaya in rat control work. As a matter of fact, rat control in a single crop area infested with field rats is an urgent need. At present, however, most of the farmers have no will to put rat control into practice for themselves. Control should be generally conducted by the farmers themselves. As the first step, a small number of districts should be chosen, and the rat control model should be demonstrated under the sponsorship of an organization of farmers in the districts to diffuse rat control techniques among farmers. In the meantime, efforts should be made to ensure that the control may be mainly by the organization of farmers. The fact that more farmers' unions have recently been organized in Malaya would be a step towards the possibility that the rat control will be conducted by the organizations of farmers in future.

PROBLEMS OF TECHNICAL COOPERATION

Following the introductory statement made by Mr. TAKAMURA, chief of the International Cooperation Section of the Ministry of Agriculture and Forestry, the meeting discussed various problems of technical cooperation in agriculture. As a basis of the discussion questionnaires had been distributed to all participants. The following points, according to the questionnaire, seemed to reflect the general concensus of opinion:

1) Technical cooperation should be carried out with integrated and well-planned programs for considerably long periods, rather than scattered and sporadic assistance being given.
2) Expert services can be provided more effectively on a group basis consisting of several specialists on related fields.
3) The provision of expert services might well be combined with a fellowship program for technicians of the recipient country where the expert is assigned.

It was agreed that technical cooperation could be more effective in the countries where lack of techniques constitutes a major obstacle to agricultural development. If other factors than technical are the main obstacles, technical cooperation could not be very effective. This was endorsed by the successful achievements of technical cooperation in Malaya, as reported at this Symposium, where political and social conditions were favorable.

The experts who had served in Malaya stressed the importance of a carefully planned program. The technical cooperation program, according to their opinion, should be started first by sending one or two experts with broad knowledge of agriculture whose task would be to work out the program to be followed by a group of experts on related fields.

In order to solve the technical problems common to the countries in Southeast Asia, the establishment of an agriculture reasearch centre was proposed by many participants. Such a center, if established, would also provide a place for training research workers and technicians to be assigned with technical cooperation in the countries of the region.

With respect to a training program for trainees from developing countries, the meeting noted that various problems and difficulties experienced in early years had gradually bear solved. Yet there still remain some problems to which consideration should be given, such as the problem of an academic degree for foreign trainees under the technical cooperation program. There was an opinion, though it was not unanimous, that one of the agriculture faculties of the universities in Japan should be opened solely for foreign trainees.

The Symposium finally discussed the specific question as to whether the technical cooperation in Malaya for rice improvement, which has produced such outstanding results as were reported at this meeting, should be further continued or be terminated by handing it over to the Malayan technicians. The experts who had served in Malaya considered that the program should be continued. During the period of their services, these experts had not trained their successors sufficiently. They also suggested that the program should include the provision of a fellowship for the Malayan technicians who would be the successors of the Japanese experts now working in Malaya.

Among the specialists to be provided to Malaya for rice improvement, that of a rice breeder was considered as of first priority. Since, however, breeding work requires a long span of time, some other methods for quicker results might well be included in the program. The prevention of stem-borer was considered as one of the most effective methods of increasing rice production.

At the closing of the Symposium, all participants highly appreciated the usefulness of this kind of joint study.