A NOTE ON RICE VARIETIES OF JAPONICA TYPE FOUND IN NORTHERN THAILAND[1]

HIKO-ICHI OKA[2] and WEN-TSAI CHANG[3]

(Received May 23, 1963)

It has been generally thought that rice varieties (*Oryza sativa* L.) of the Japonica type are distributed in Japan, Korea and Northern China (c. f. Nagai, 1959, pp. 133–141). It is also known that the so-called Bulu type grown in Indonesia has similar characters as the Japonicas (Wagenaar *et al.*, 1952). Observing the pattern of character association and F_1 sterility relationships, the senior writer has formerly concluded that rice varieties of Asian countries can be divided into two major groups corresponding to the two types, Indica and Japonica, and called them in accordance with their geographical distribution "Continental" and "Insular" groups, respectively; the Insular or Japonica group was divided further into Tropical and Temperate sub-groups (Oka, 1958). Thus, Japonica varieties in Asia were found to be distributed mainly in the islands of Western Pacific, ranging all the way from Indonesia to Japan, and in certain parts of the continent, viz., China and Korea. Whether the Japonica type occurs in India and Indochinese penninsula was questionable.

In the report of their scientific mission to Sikkim, Kihara and Nakao (1960) state, on the basis of phenol reaction test, that "most of the rice varieties in Sikkim belong to Indica and nearly one-tenth belong to Japonica". They found that in the major variety of Sikkim, Addey, plants with positive and negative reactions were mixed, and considered that "the rice in Sikkim is nothing else but a mixture of Japonica and Indica", whose partial seed sterility might be due to natural hybridization between the two types. However, it is almost beyond question that the two types cannot be classified by a single criterion without taking the pattern of character association into consideration.

Sikkim is located on the old caravan route connecting India and Tibet, and "Addey" is the name of the person who helped to introduce foreign varieties to Sikkim. Therefore, if truly Japonica varieties were found in Sikkim,

(1) Contribution from National Institute of Genetics, Japan, no. 476. The writers wish to express their sincere thanks to the Rockefeller Foundation for the financial support (RF57080) which enabled them to make this study.

(2) Member, National Institute of Genetics, Misima, Japan.
(3) Associate Professor, College of Agriculture, Chung-Hsing University, Taichung.

we could not assert that they were originated in the Himalayan mountains. There is actually a Japonica-like variety in Kashimir which is called "China".

The senior writer had a chance to visit Thailand from November to December of 1958, and has collected a number of seed samples from wild and cultivated rice populations. The plants from the seeds were observed in the experimental field of the College of Agriculture, Chung-Hsing University, Taichung, Taiwan. Some of them, obtained from Chiengrai Changwad (the northernmost prefecture of Thailand) showed Japonica-like features; they mostly belonged to the collection made by the Phan Rice Seed Station from the upland fields in Chiengrai prefecture. They are grown by the native people in their "shifted" farms; first, trees are cut down at the beginning of the dry season, and after being dried, are burnt to ashes. At the advent of the rainy season, holes are made with a pointed stick and a few grains are dropped in each hole which is closed by the planters' foot. The harvest is done by cutting with a small sickle and the grain is threshed by beating the sheaves against the side of a big basket or on a mat.

Those varieties were investigated regarding several characters which distinguish the Indica and Japonica types, i.e., phenol reaction (Ph), potassium chlorate resistance (K), low temperature resistance (Lt), apiculus hair length (Hr), etc. For the methods to take measurements of these characters, the reader may refer to Oka and Chang (1962).

Most strains from northern Thailand had glutinous endosperm. Eighteen out of thirty-three strains from Chiengrai prefecture showed negative phenol reaction, while those from the valley of Chiengmai and other plain regions had positive reaction. Data for the other three characters (K, Lt, Hr) are given in Table 1, together with the data for the control varieties of Indica and Japonica types obtained from various Asian countries, which had been used by the senior writer for studies on the differentiation of rice varieties (c.f. Oka, 1958). The data in the table show the varieties from Chiengrai prefecture varied in a wide range in each of the three characters; some of them showed high resistances to potassium chlorate and low temperatures and long apiculus hairs, in the same manner as the Japonica varieties used as the controls. Further, as shown in Table 1c, two strains had glabrous glumes; this is a trait found in the Tropical-Insular (Japonica) group, and is known to be distributed in the Philippines, Hai-Nan Island, Taiwan (mountain region) and Japan (some upland varieties).

The mode of association of these characters was investigated using a discriminant formula, $X=-K+0.75\ Lt-0.22\ Hr+0.86\ Ph$, which was formerly used by the writers (Oka and Chang, 1962) for classifying Indica and Japonica types. Distributions of the discriminant score found in northern Thailand and control variety-groups are given in Table 2. The table shows that the varieties from

Table 1. *Distributions of measurements of characters among rice varieties of northern Thailand and control varieties.*

a) *Potassium chlorate resistance (Conc. of $KClO_3$ solution, in log.)*

Group	-1.33	-1.67	-2.00	-2.33	-2.67	-3.00	-3.33	-3.67	No. of strains
Northern Thailand,									
Mountain region		2	3	4	7	8	6	2	32
Valleys						5	8	3	16
Control varieties,									
Continental (Indica)	1		6	7	4	1	8	46	73
Insular (Japonica), Tropical	33	15							48
Insular (Japonica), Temperate	6	19							25

b) *Degree of damage to seedlings treated at 1°C (Index no.)*

Group	0	0.2	0.4	0.6	0.8	1.0	No. of strains
Northern Thailand,							
Mountain region	4	8	3	1		1	17
Valleys		1	2	6	7	2	18
Control varieties,							
Continental (Indica)		3	7	26	20	1	57
Insular (Japonica), Tropical	13	15	6	3	2		39
Insular (Japonica), Temperate	14	3	1	1			19

c) *Apiculus hair length (mm)*

Group	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	No. of strains
Northern Thailand,										
Mountain region	2		9	5	3	8	5	1		33
Valleys			1	8	12					21
Control varieties,										
Continental (Indica)			26	24	4					54
Insular (Japonica), Tropical	6		1	2	5	7	10	1	2	34
Insular (Japonica), Temperate				3	4	5	2	3	1	18

the northern mountainous region of Thailand are mostly of the Japonica type, while those from the valley and plain region of the same locality are typical Indicas. Another intersting fact derived from the table might be that the mountainous varieties have larger scores than the typical Japonicas, and appear to be to some extent near the Indica type.

Table 2. *Distribution of discriminant scores for classifying Indica and Japonica types.*

Group	1.0	2.0	3.0	4.0	5.0	6.0	7.0	No. of strains
Northern Thailand, Mountain region	1	2	10	2	2			17
Northan Thailand, Valleys					1	11	1	13
Control varieties	27	16 (Japonica)	9	2	16	26 (Indica)	9	105

Further, those strains were crossed with five test-strains of *O. sativa* in order to observe their F_1 sterility relationships. Distributions of the F_1 pollen fertility are given in Table 3. The strains from Chiengrai prefecture tended to show higher F_1 fertility with the test-strains of Japonica type than with those of Indica type. The scores given by a discriminant formula which maximized the difference between Indica and Japonica types by combining F_1 pollen fertilities with these five test-strains (Y=1.0(108)+0.18(414)−0.12(521)−0.58(563) −0.62(647); used by Oka and Chang, 1962), were computed for each strain. Distributions of the discriminant scores are shown in Table 4. The table indicates that the mountainous strains are intermediate between the Indica and Japonica types in F_1 sterility relationship, while the ranges of the two types overlap.

Table 3. *F_1 pollen fertilities of strains from Chiengrai prefecture of Thailand with five test-strains.*

Test-strain	% of good pollen						No. of strains
	90	80	70	60	50	40	
108 (Indica; Taiwan)	2	3	6	2			13
414 (Indica; India)	2	4	4	1		1	12
521 (Japonica; Japan)	3	5	3	2			13
563 (Japonica; Japan)	5	5	3	1			14
647 (Japonica; Celebes)	6	4	2	2	1		15

Table 4. *Distribution of discriminant scores for Indica-Japonica classification, combining F_1 pollen fertilities with the five test-strains given in Table 3.*

Group	(Indica)				(Japonica)				No. of strains
	70	50	30	10	-10	-30	-50	-70	
Mountain varieties of Thailand				3	4	3			10
Control varieties,									
Continental (Indica)	3	3	15	16	8	3			48
Insular (Japonica)				4	17	15	8	9	53

The writers (Oka and Chang, 1962) have investigated rice strains collected from the Jeypore Tract, Orissa, India, which showed a continuous array of intergrades between wild and cultivated forms. In this material, a number of Japonica-like plants were found among those approaching cultivated forms, suggesting that the Indica-Japonica differentiation might be advanced when the plants approach cultivated forms. The Jeypore Tract is believed to have been isolated from the civilization of the outer world for unnumerable years. It was then inferred that the Indica and Japonica types are monophyletic and the differentiation might have taken place with the evolution of wild plants toward cultivated ones, possibly due to a differential response of genotypes to some environmental factors involved in cultivated conditions.

Along this line of thinking, it may be said that in the varieties grown in northern Thailand, the Indica-Japonica differentiation is still under way. Wild populations of *O. perennis,* the supposed progenitor of *O. sativa,* are found in the valleys of northern Thailand. The cultivated varieties under consideration however showed no traits of wild forms, e.g., premature grain shedding and strong dormancy of seeds. Unlike the materials from the Jeypore Tract, the northern Thailand materials did not show a continuous array connecting wild and cultivated forms, except for some hybrid swarms (c.f. Oka and Chang, 1961). This suggests that in the present, there is no particular condition which favors intermediates between wild and cultivated forms. It is therefore difficult to determine whether these varieties have been introduced from other countries, or have been created in the present area.

Northern Thailand is distant from the trade route connecting India and China, and there is no trace of recent introduction of foreign varieties. The varieties grown in this area (northern and north-eastern Thailand, Laos, and some adjacent part of Burma) are mostly glutinous; glutinous rice is the people's staple food. The supposed wild progenitor, *O. perennis,* is essentially non-glutinous. The cultivated varieties in this area may then be regarded as forming a particular group. It is noticeable that here Japonica-like varieties are grown on the hills (500 m–1,000 m above the sea level) and Indicas in valleys. The same pattern of distribution is also known from Kuang-hsi Province of China, though in this case non-glutinous varieties are concerned (Yü, 1944).

We may then assume that in some place in India, Burma or Thailand, a primitive cultivated form might have arisen due to an evolutionary force as postulated by Hinata and Oka (1962); this process might have been possible in any country if certain necessary conditions had been provided. Those initial plants, carrying a large variability and a latent tendency to differentiation into Indica and Japonica types, might have been spread over the area under consideration, and gradually differentiated into Indica and Japonica types in response

to different modes of selection under hill and valley conditions. It is possible that the glutinous type was selected by the people living in this area after the plants had assumed the cultivated type.

Summary

Rice varieties obtained from northern Thailand were investigated regarding the pattern of character association and F_1 sterility relationship. Those from the mountainous region (mostly glutinous) appeared to be intermediate between Indica and Japonica types, being close to the Japonica. Those of the valley and plain region (also mostly glutinous) were of Indica type. It was inferred that the Indica-Japonica differentiation might have taken place in the course of dispersion into habitats with different modes of selection.

泰國北部所發現日本型稻的簡報

岡彥一 張文財

研究泰國北部稻的各種形質組合以及品種間的第一代雜種不稔性之結果，發現來自山區的品種（大部分爲糯稻）多屬於印度型與日本型的中間型，但是比較接近日本型，而來自山谷與平原地區的品種（亦是大部分爲糯稻）則全部屬於印度型。由此可以推測印度—日本型稻的分化可能是受不同環境淘汰的結果。（摘要）

Literature Cited

HINATA, K., and H. I. OKA. Some considerations on the evolutionary dynamics of cultivated rice. Jap. Jour. Genet. **37**: 329-342, 1962.

KIHARA, H., and S. NAKAO. The rice plant in Sikkim. Seiken Ziho, Report of Kihara Inst. Biol. Res. **11**: 46-54, 1960.

NAGAI, I. Japonica rice, its breeding and culture. Yokendo, Tokyo, 1959.

OKA, H. I. Intervarietal variation and classification of cultivated rice. Ind. Jour. Genet. & Pl. Breed. **18**: 79-89, 1958.

OKA, H. I., and W. T. CHANG. Hybrid swarms between wild and cultivated rice species, *Oryza perennis* and *O. sativa*. Evolution **15**: 418-430, 1961.

OKA, H. I., and W. T. CHANG. Rice varieties intermediate between wild and cultivated forms and the origin of the Japonica type. Bot. Bull. Acad. Sinica **3**(1): 109-131, 1962.

Wagenaar, G. A. W., J. CH. von SCHOUWENBURG, and H. SIREGAR. Semi-sterility of rice hybrids in Indonesia in relation to the Indica-Japonica problem. Balai Besar Penjelidikaw Pertanian (Bongor) **127**: 1-21, 1952.

YÜ, I. C. Keng rice in the south-western provinces. (In Chinese) Nung Bao, Central Agr. Exp. Inst., Chung-King, China **9**(25-80): 266-270, 1944.