Breeding Non-Seasonal Short Duration Rice Varieties in Southern Japan

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In southern Japan like in the other regions of the country rice is grown only once a year from April to November and before or after rice culture, wheat or barley is generally adopted in rotation system. In this cropping system, there is little hope on the development of scale, especially with reference to yield income in an agricultural management because it can be said that the land area per family in the agricultural population where rice cultivation can be done is considerably small for yielding enough income according to statistics which reveal that around 80 percent of families possess no arable land more than one hectare.

For alleviating this stagnation in agriculture, it is absolutely necessary to raise the income derived from the limited land area by means of recombination of some profitable commercial crops in rotation in an agricultural programme. For this purpose, a crop rotation system should be changed from the present ones in which rice culture plays a predominant part to the newly proposed rotation system, in which some crops such as forage crops, vegetables and others can play considerably an important role together with rice plant from the viewpoint of increment of income in agricultural management.

The breeding programme for non-seasonal short duration rice variety in southern Japan is devised in response to the agricultural requirement mentioned above. In this programme the rice varieties require some new features; namely, the developed varieties should have a yield of 4 tons per hectare in unhulled grain within 100 to 110 days from planting to harvesting, even though its rice culture is initiated in early spring (March) or in beginning of August. Through the success of this programme, an income in agriculture will sharply increase in the newly devised rotation system in which the paddy field is made available to vegetable or other crops after harvesting rice in August, or, in other case, available also to some kinds of valuable crops before rice culture in August.

Features of non-seasonal short duration variety

IRRI has indicated that rice varieties of early maturity and insensitivity to photoperiod can play an important role in agriculture in

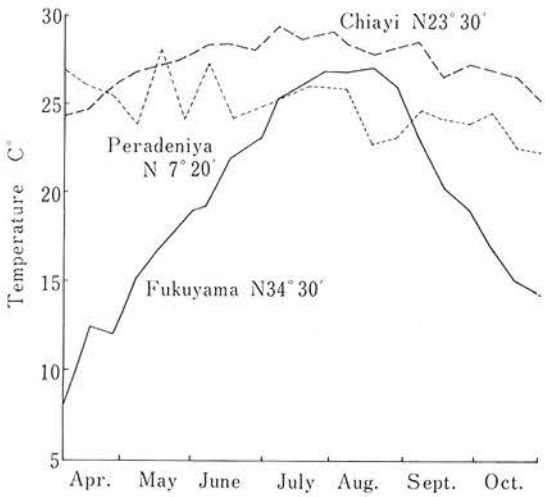

Fig. 1. Temperature in the different latitudes.

low latitudes, if two or three crops per year are to become a reality.[1] IRRI has already released the promising variety IR 8 in this direction.

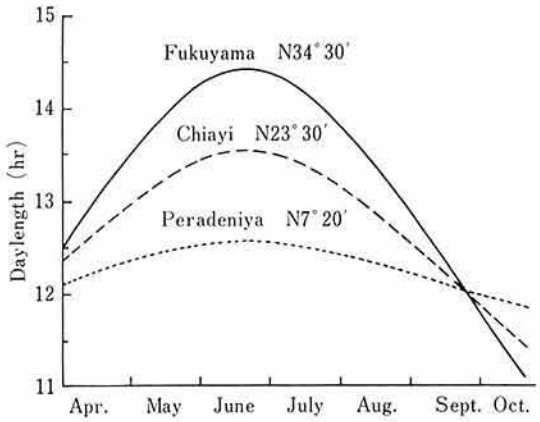

Fig. 2. Daylength in the different latitudes.

Climatic condition in southern Japan is much different with that in latitudes; temperature and daylength in southern Japan being more variable than in low latitudes as shown in Fig. 1 and 2.[5] In this sense, therefore, the objective varieties, non-seasonal short duration ones in southern Japan, may require different heading characteristics from those varieties with similar object in low latitudes.

Heading character of rice plant can be generally explained by a basic vegetative growth (B.V.G.) and photoperiod sensitivity. Further nature of photoperiod sensitivity is controlled by critical daylength of the optimum region (C.D.O.) and degree of retardation of heading caused by super-optimum photoperiod (D.R.H.).[3]

As the first step of this breeding programme, it was necessary to investigate the interaction between genotype for heading characters and seeding time among Japanese rice varieties. A total of 150 varieties including those cultivated both in Japan and Taiwan were tested in the experimental design containing seven kinds of seeding time from April to August and six kinds of daylength, i.e., 10, 12, 13, 14, 15 hours and natural daylength at every seeding time.

From the results obtained it was concluded that the Japanese rice varieties can be classified into five groups,[4] Hokkaido, Tōhoku, Hokuriku, south region and the Ponlai groups, in terms of heading characteristics as shown in Fig. 3. The varieties of the Hokkaido group arrived at heading day with much short duration from seeding, showing 1,200~1,300°C in accumulated temperature (A.T.) from seeding to heading and much less than 4 tons per hectare in grain yield.

The varieties of the Hokuriku group, when they are seeded in July or August, need many days until heading by means of large B.V.G. of 1,600°C in A.T. and show no sufficient production because of damage by low temperature in autumn.

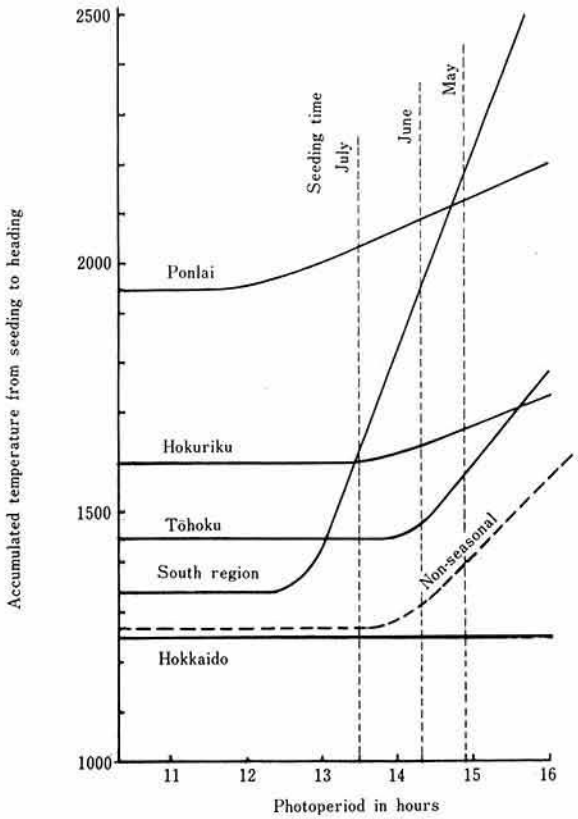

Fig. 3. Varietal difference of photoperiod response and relation between seeding time and accumulated temperature.

The Tōhoku group varieties tend to retard in heading when seeded in April and in August because of 1,400~1,500°C in A.T. and their medium photo-sensitivity.

The south region varieties, having B.V.G. of 1,300°C to 1,400°C in A.T. and high photo-sensitivity, need a very long duration when seeded in April or May.

The Taiwan japonica varieties of the Ponlai group, even though photo-sensitivity is small, require a very long duration from seeding to heading because of more than 1,800°C in A.T.. In these present varieties identified there are no varieties that have heading characters acquired as a non-seasonal short duration variety.

Judging from all of the results in the experiment mentioned above, it is estimated that the varieties regarded as non-seasonal short duration one, as shown in Fig. 3, should have B.V.G. of 1,300~1,400°C like the Hokkaido group, C.D.O. of 14 hours similar to the Tōhoku group and intermediate value of D.R.H.. The ideal variety with the necessary features for non-seasonal short duration one when seeded in April or May is considered to be able to have a sufficient amount of growth for yield resulting from the somewhat larger and shorter growth duration than that of the Hokkaido group and Tōhoku Hokuriku group, respectively.

Even when seeded in July or August, the ideal variety can reach to heading before the middle of September without damage due to low temperature in the ripening period because photo-sensitivity is taken off by the fact that C.D.O. of 14 hours is shorter than natural daylength and the B.V.G. only affects the magnitude of duration from seeding to heading day. In this case it may be safe to say that the nature of photo-sensitivity can serve as a security valve for getting high yield.

Breeding programme and the newly developed varieties

In the breeding programme, it was planned to recombine the necessary heading characters from the Hokkaido group which has small B.V.G. with the Tōhoku group which has intermediate degree of D.R.H. and 14 hours of C.D.O.. As crossing parents two selections were chosen at the first step of the breeding scheme. One of them, R-151, which was the mutant of the recommended variety Koshihikari by ^{60}Co, had almost the same value of B.V.G. with that of the Hokkaido group, and had the neutral photoperiod nature besides the good grain quality.

The other parent, which came from the cross of (Fukei 71 × Fukei 67) × Koshihikari × Koshihikari, had photo-sensitivity of the Tōhoku group, resistance to lodging introduced from Fukei 71 of the mutant of Fujiminori by ^{60}Co, resistance to blast disease due to the resistance gene *Pi-z*[2] in the U.S. variety Zenith through Fukei 67, and both good grain quality and seed dormancy from Koshihikari.

After crossing between the breeding materials, a green-house which is equipped with an automatically controlled apparatus for day-length treatment, was used for accelerating generations five times in one and half years, with the aim of raising a proportion of homozygotes in a hybrid population. From F_6, selection works were practiced to the hybrid population on the characters including heading day, plant height, grain quality, resistance to some kinds of diseases and yield.

In this selection scheme three kinds of cultivating conditions where the breeding materials were transplanted in April, May and August were applied for selecting strains having medium photo-sensitivity under the long day-length in the summer season and for selecting strains having small B.V.G. under the short daylength in autumn.

In F_9 generation, two strains which were named Chugoku 57 and 58 were released. These two varieties developed in this breeding programme provide the desirable heading characters, which consist of much the same B.V.G. with the Hokkaido group being 1,300°C in A.T. and the same photo-sensitivity with the Tohoku group being 14 hours in C.D.O. and medium degree of D.R.H..

Table 1. Characters of Chugoku 57 and 58 seeded at different times

Seeding date	Trans-planting date	Varieties	Heading date	Maturing date	Growing period in paddy	Culm length cm	Number of ears per m²	Grain[1] yield kg/ha
Apr. 7	Apr. 28	Chugoku 57	July 15	Aug. 14	107	78	550	6050
		Chugoku 58	July 16	Aug. 15	108	67	614	5180
May 8	May 23	Chugoku 57	July 24	Aug. 27	96	84	525	4660
		Chugoku 58	July 28	Aug. 28	97	74	658	4210
July 26	Aug. 6	Chugoku 57	Sept. 19	Nov. 4	90	70	336	3890

1) grain yield in unhulled grain

Besides both of the varieties, as necessary features available to a general rice culture, have resistance to blast disease due to *Pi-z* gene from Zenith, seed dormancy and good grain quality as in Koshihikari, but they are easy to lodge because, since there is a close relation between yield and rapid growth during short term, selection works were practiced for vigorous growth.

On the production when planted in April, as shown in Table 1, both of the varieties showed more than 5 tons per hectare in grain yield with growing duration of 108 days, seven days longer than that of the Hokkaido variety Nanei and seven days shorter than that of the Tōhoku variety Reimei. When planted in the beginning of August, Chugoku 57 yielded around 4 tons per hectare in grain yield with 90 days. In this case, heading date of Chugoku 57 was 19th in September, whereas the control headed on 23th September after the latest date accepted for getting fairly good yield, resulting in low yield and low grain quality through low temperature damage.

Instructions on the non-seasonal short duration rice varieties

Both varieties, Chugoku 57 and 58, are available to rice culture with the aim of short duration culture only in southern Japan. In a low latitude zone, both of them can not yield well because photo-sensitivity of varieties is removed under natural daylength shorter than 14 hours of C.D.O., with the result that varieties arrive at heading day with rather small B.V.G..[5] Further, both varieties show a tendency of premature heading observed during a long nursery period.

In the culture of these newly developed varieties, it is strongly recommended to apply a transplanting machine for young seedling which has been used in a practical rice culture in Japan of late for escaping from a premature heading and for labour saving.

Besides, it is advisable that the whole amount of fertilizer required for the plant growth until harvesting is applied all at one time at the initiation of culture in order to promote the vigorous growth in a short period. These varieties will contribute substantially to promote a multiformity in agriculture management in southern Japan.

References

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