A Method for Maximizing Rice Yield on the Basis of V-Shaped Rice Cultivation Theory (II)

By SEIZO MATSUSHIMA

Chief, Division of Statistics and Agronomy, Department of Physics and Statistics, National Institute of Agricultural Sciences

The main points in practising V-shaped rice cultivation can be summarized as in Fig. 4.

As seen in Fig. 4, the whole growth period of rice is divided into three growth periods, viz. early, middle and late growth period. The early growth period is from germination time up to 69 in leaf number index[1] which roughly corresponds to 43 days before heading. The middle growth period is from 69 up to 92 in leaf-number index which roughly corresponds to 43 to 20 or 18 days before heading. The late

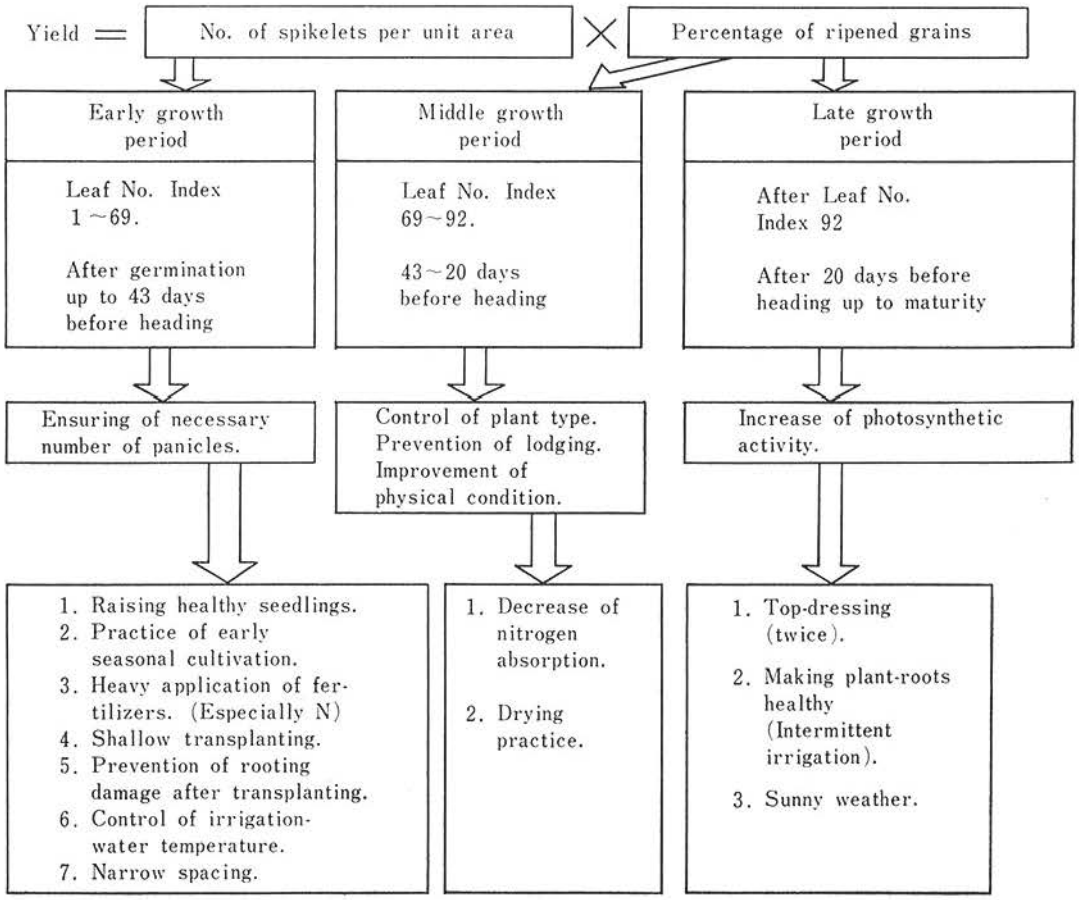

Fig. 4. Schematic representation on points in practice of V-shaped rice cultivation.

growth period is from 92 in leaf-number index up to maturity.

As mentioned above, the yield of rice is represented by the product of the number of spikelets per unit area and the percentage of ripened grains and therefore the two components must be increased for augmenting the yield. Now, the increase in the number of spikelets per unit area is the biggest problem in the early growth period, while the raise in percentage of ripened grains is the biggest one in the middle and late growth period, as shown in Fig. 4.

Practices in the early growth period

In the early growth period one must ensure the necessary number of spikelets by obtaining the necessary number of panicles per unit area as early as possible. For the purpose, one must increase the number of tillers as early as possible by using seven methods described in the following: For ensuring the necessary number of panicles by the end of the early growth period, one must obtain the necessary number of tillers which have three or more green leaves by the time of 43 days before heading, because the tillers which have less than three green leaves at the end of the early growth period will die away in many cases.

Raising healthy seedlings: The definition of healthy seedlings and the ways of raising them have been written in the author's book "Crop Science in Rice" (p. 47~54). Thereafter, he has further found the following facts: So long as the seedling age is nearly identical, the longer the seedlings have spent in a nursery bed, the larger they are in the dry weight, in the percentage of dry weight to the fresh weight, in the percentage as well as in the amount of carbohydrates, in C-N ratio and consequently the better in rooting. For controlling the rapid growth of seedlings, both the cool temperature[9] in early spring and the low water content[7] in soil can effectively be used.

Practice of early seasonal cultivation: It serves to lengthen the vegetative growth period and consequently to increase the number of tillers[1]. Thereafter, the author has further discovered that the cool temperature at the bases of culms of seedlings in early season is quite effective to promote tillering, and therefore the importance of early seasonal cultivation has come to be much more evaluated than before[6], [8].

Heavy application of fertilizer in particular nitrogen: Since nitrogen defficiency in the soil causes poor tillering, one must apply nitrogen to the soil as much as possible in the early growth period, but the extent of the amount of nitrogen to be applied should be limited so as not to be effective in the middle growth period.

Shallow transplanting: When the rice seedlings are transplanted shallowly in the soil, the growth points of the seedlings are placed shallower in the soil than those of deeply transplanted ones, so the growth points of shallowly transplanted seedlings are surely subjected to higher temperature during daytime and lower temperature during nighttime than those of deeply transplanted ones, which causes better tillering[4], [6], [8].

Prevention of rooting damage after transplanting: As to this point, refer to the author's book "Crop Science in Rice" (p. 57~58). Thereafter, the author has further studied the following facts: For preventing the rooting damage it is advisable that (1) short, thick and stiff seedlings should be used, and (2) seedlings which possess a large amount of roots should be used. Such seedlings are apt to be obtained by the following procedure: Set up an upland nursery bed in a paddy field without puddling and make the bed wet only at germination time, and thereafter raise the seedlings without submerging them at all but water very seldomly to an extent not to wither them, and on pulling up seedlings for the first time submerge them deeply.

Control of irrigation-water temperature: One of the most influential factors on the growth of rice is the temperature around the

growth points of rice plants[5), 6)]. During the vegetative growth period the growth points are generally in water, so the control of water temperature is quite necessary for a desirable growth. In the rooting period high water temperatures (31~37°C) during the day and the night are suitable for rooting of seedlings[4), 10)], while in the tillering period high water temperatures (31~36°C) during the day and relatively low water temperatures (15~20°C) during the night promote tillering[4), 6)]. As to the methods for controlling water temperature, see the author's book "Crop Science in Rice" (p. 58~60).

Narrow spacing: Narrow spacing of transplanted hills increases the number of panicles per unit area especially in sparingly fertilized paddy fields or in low fertility fields. Narrow spacing needs more labour than ordinary spacing does, but recently useful transplanting machines have been invented and they have come to make it possible to save labour.

Practices in the middle growth period

In the middle growth period one must control the plant type, must prevent the plant from lodging and must improve the physical condition of the plant. If one can succeed in decreasing the absorption of nitrogen by the plant during the middle growth period, one will surely be able to obtain good plant types, prevent the plant from lodging, make the plant accumulate much starch in culms and sheaths and consequently to make the plant more resistive to diseases, and as a result of which one will definitely be able to increase the percentage of ripened grains.

By using the methods mentioned in the last paragraph of this paper in the previous number, one can considerably decrease the absorption of nitrogen in this period as one likes. Another method to decrease the nitrogen absorption, which can be used just in the middle growth period, is to drain and to dry up the surface of the paddy soil. This drying practice, in particular an intensive drying practice, serves to decrease the absorption of nitrogen, but when it rains it sometime is useless. The drying practice, therefore, is best used as a supplementary means for decreasing the nitrogen absorption.

Furthermore, in Chiba Prefecture the Agricultural Experiment Station has reported another method which recommends farmers to conduct inter-tillage just after having applied PCP at the beginning of the middle growth period for decreasing nitrogen absorption by the plant.

Anyway, the biggest problem in the middle growth period is how to decrease the absorption of nitrogen, and this point is closely connected with the success of V-shaped rice cultivation. Here, many questions arise as to the extent of decreasing the nitrogen absorption because of the following facts being generally recognized: Namely, the more the nitrogen absorption is decreased in the middle growth period, the better the plant type is formed and the more the plant becomes resistive to lodging and consequently the more the percentage of ripened grains is increased, while the more the number of spikelets per unit area is decreased.

The answer to the questions, therefore, is as follows; in case of the number of spikelets per unit area being sufficient or the safety-first rice cultivation being intended, the nitrogen supply should heavily be reduced, while in case of the number of spikelets per unit area being insufficient or the safety-first rice cultivation being little worth consideration, the nitrogen supply should lightly be reduced.

However heavily the nitrogen supply may be reduced, though the number of spikelets will be reduced, the percentage of ripened grains will never be decreased, if only the rice plant will not be subjected to unfavourable conditions in the late growth period.

Practices in the late growth period

In the late growth period the biggest problem is how to increase the photosynthetic efficiency of the rice plant. The first necessity

for the purpose is to top-dress with nitrogen as soon as the middle growth period is over. This top-dressing can be considered as a top-dressing at the spikelet initiation stage, but the former is later than the latter by 5 to 7 days.

The photosynthetic efficiency is greatly increased by this top-dressing, resulting in a reduction in the number of degenerated spikelets[1] and in an increase in the amount of accumulated carbohydrates in the plant without corrupting the plant type[2]. Furthermore, again another top-dressing with nitrogen should be done at full heading time. This top-dressing serves also to increase the photosynthetic efficiency and consequently to promote development of caryopses[1].

The second necessity for increasing the photosynthetic efficiency is to increase the vitality of roots. For the purpose one of the most important things to do is water management. The vitality of roots can definitely be increased by the intermitted irrigration, which supplies oxygen into the soil and prevents roots from the damage of abnormal reduction of the soil.

The third necessity for increasing the photosynthetic efficiency is to subject the rice plant to sunny weather. Critical growth periods for the lack of sunlight are for 15 days just before heading and for 25 days just after heading, as shown in the author's book (p. 228). The rice plant, therefore, must be subjected to sunny weather during these periods.

To make the weather fine at will is impossible, but the following procedure is useful to make the plant subject to fine weather during the critical growth periods: Using a long-term record on sunshine hours observed in the nearest weather station, one can draw the figure as shown in Fig. 5. From Fig. 5, one can decide with ease which calendar period is most sunny in the critical growth period and consequently which calendar time is most suitable for heading of rice plants.

Once the most suitable heading date has been decided, referring to the data in the nearest Agricultural Experiment Station, one

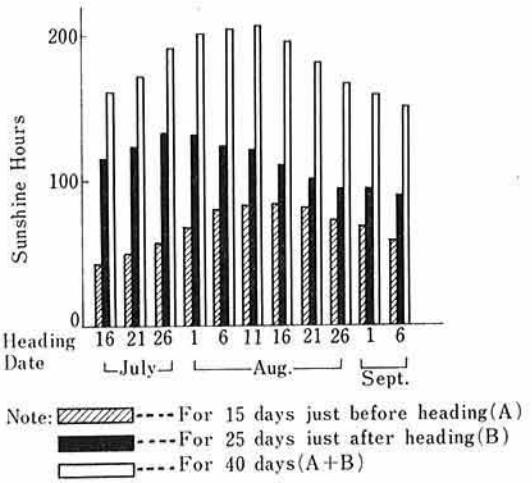

Fig. 5. Sunshine hours centering around various heading dates at Konosu Agricultural Experiment Station.

can further decide the most suitable variety, sowing date and transplanting date so as to make the rice plant head at the most suitable date. Without favourable weather conditions in the late growth period, high yields will never be obtained, even if the ideal rice plant has been raised.

Actual results of the V-shaped rice cultivation method conducted by farmers

Only four years have passed since the theory of V-shaped rice cultivation was made public to farmers in Japan, but nowadays it seems to have spread far and wide all over Japan. In 1968, maximizing yield contests on rice cultivation were held in 40 prefectures in Japan and the first prize in 16 prefectures, the second prize in 21 prefectures, the third prize in 16 prefectures, the fourth prize in 14 prefectures and the fifth prize in 16 prefectures were won by using the V-shaped rice cultivation method.

Moreover, it has been made clear that 42 per cent of farmers who won prizes from the first to the fifth have utilized V-shaped rice cultivation and they have been distributed

from Hokkaido in which the northernmost limit of rice cultivation exists to Kagoshima Prefecture which is the southernmost one in Japan. In 1967, a farmer, Mr. Y. Taniguchi, who lives at Furukawa-machi in Gifu Prefecture, yielded 9.6 tons of brown rice per hectare by using the method (Fig. 6).

Fig. 6. Rice plants at maturity raised by V-shaped rice cultivation at Taniguchi's paddy field. (Furukawa-machi, Gifu Prefecture)

Furthermore, the V-shaped rice cultivation method has already been introduced abroad. For instance, the Agricultural Experiment Station in Zenranando in Korea examined the method and proved it to be of great use in increasing yield. As the result the Agricultural Experiment Station started to encourage farmers to practise the V-shaped rice cultivation method. In 1968, the personal first prize as well as the group first prize in the maximizing yield contest were won by farmers who practised the method, which created a big sensation among farmers in the prefecture. In 1969, for encouraging farmers to conduct V-shaped rice cultivation, 1,790 pilot-farms en masse, which covers 26,000 hectares in area, were set up by being subsidized by the prefectural and national government.

In Taiwan some farmers in Unrinken started to practise the V-shaped rice cultivation method under the guidance of Mr. H. Lim who had studied in the author's laboratory for six months, and in 1967 a farmer, Mr. C. Heu, produced the highest yield (9.26 tons per hectare of pady rice) in Taiwan.

A noteworthy instance in Cambodia was reported in a symposium concerning the rice cultivation method in the world, which was held on January 26, 1968 at Tokyo University. Some Japanese experts (Dr. T. Hirano and others) yielded 8.52 tons per hectare of brown rice in Cambodia (near Battambang) by using the variety IRRI 8 under the V-shaped rice cultivation method which yield was told to be the highest record in all the tropical countries.

From these results the V-shaped rice cultivation method has been proved to be adaptable to a very wide area from Hokkaido in which the northernmost limit of rice cultivation exists to Cambodia which is situated near the equator.

References

4) Matsushima, S. and Tsunoda, K.: Analysis of Developmental Factors Determining Yield and Its Application to Yield Prediction and Culture Improvement in Lowland Rice. 49. Proc. Crop Sci. Soc. Japan 27 (2), 1959.

5) ———, Tanaka, T. and Hoshino, T.: Ditto. 70, 71. Proc. Crop Sci. Soc. Japan 33 (1~2), 1964.

6) ———, ——— and ———: Ditto. 75. Proc. Crop Sci. Soc. Japan 34 (4), 1966.

7) ——— and Hoshino, T.: A New Method for Raising Healthy Rice Seedlings. Nogyo oyobi Engei. 44 (4) (in Japanese), 1969.

8) Tanaka, T., Matsushima, S. and Tomita, T.: Ditto. 84. Proc. Crop Sci. Soc. Japan 37 (2), 1968.

9) Hoshino, T., Matsushima, S., Tomita, T. and Kikuchi, T.: Ditto 88. Proc. Crop Sci. Soc. Japan 38 (2), 1969.

10) ———, ———, ——— and Sadakane, A.: Ditto 89. Proc. Crop Sci. Soc. Japan 38 (2), 1969.