Promotion of Emergence and Establishment of Rice Seedlings by Using Calcium Peroxide-Coated Seeds in Direct Sowing on Flooded Paddy Fields

By YASUO OTA

Department of Physiology and Genetics, National Institute of Agricultural Sciences
(Yatabe, Ibaraki, 305 Japan)

Although direct sowing culture of rice on flooded paddy fields is difficult to get uniform stands comparable to transplanting culture, it is expected to become more popular if a technique to stabilize the emergence and establishment of seedlings is made available, because it is a labour saving method.

For the purpose of promoting the germination of rice seeds under flooded condition, therefore, many studies have been carried out so far, but no trial has been made to improve the emergence and establishment of seedlings by supplying oxygen to seeds.

The method presented in this paper is to supply oxygen to sown seeds by utilizing calcium peroxide which releases oxygen slowly in flooded soil and improves the emergence and establishment of seedlings in direct sowing on flooded paddy fields[1,3,4,6,9]. Conventional method of direct sowing of rice has several defects; low germination rate and poor root growth due to lack of oxygen; uneven growth of seedlings due to staggered germination, liability to lodge (direct-sown rice forms adventitious roots on soil surface which have not sufficient strength to support mature plants), and difficulty of weed control as compared with transplanted rice. The use of calcium peroxide for coating seeds was found very effective in promoting emergence and establishment of rice seedlings in direct sowing under flooded conditions.

In addition, it was also found that, when seeds were coated with the mixture of calcium peroxide and 3-hydroxy-5-methyl isoxazole (a growth regulator effective to promote the growth and physiological activity of roots), the emergence and early growth of seedlings were further improved.[2]

Method of coating rice seeds with calcium peroxide

Calcium peroxide (CaO_2) is itself stable at room temperatures. However, it decomposes slowly in humid soil and generates oxygen in the reaction to form calcium hydroxide. In the soil, calcium hydroxide may eventually combine with atmospheric carbon dioxide to form calcium carbonate[8].

$$CaO_2 + H_2O \rightarrow Ca(OH)_2 + O$$
$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

Calcium peroxide when coated on to rice seeds is liable to peel off during the process of sowing. Various seed-coating methods have, therefore, been tried using gum-arabic, gelatin, and polyvinyl alcohol. Each of these methods was unsatisfactory because calcium peroxide was not evenly coated on rice seeds, and the drying took a long time.

Significant progress was made in coating method for calcium peroxide by Mitsuishi and Nakamura (1977) who succeeded in improving adhesiveness of calcium peroxide to seeds by adding gypsum[7]. This method paved the way for the commercial use of calcium peroxide known in market as Calper G dust*.

Calper G dust is composed of:

CaO_2	more than 35%
$CaSO_4 \cdot 1/2\, H_2O$ (gypsum)	more than 25%
Other materials	less than 40%

Coating of rice seeds with Calper G dust by the use of coating machine

In practice, wet seeds are placed in the rotary pan of coating machine. The equal amount of Calper G dust is gradually mixed with rice seeds and is rolled to stick Calper G dust to the seeds. Occasionally water is sprayed to moisten the seeds. The quantity of water to be sprayed is critical. When sprayed less, the coating is not enough in quantity. When sprayed much, Calper G dust becomes sticky and seeds lump together, wasting much of the Calper G dust.

The rotary pan, 90 cm in diameter, is made of iron plate with the edge of about 20 cm in height (Plate 1). This pan is set on a stand with the inclination of 50 degree, and connected to a motor which rotates the pan at a rate of 20–25 rpm. A spray nozzle for water supply is arranged separately. In this pan, coating for about 10 kg in dry weight of rice seeds can be done in 15 min. For a large amount of seeds a concrete mixer can be used with good result.

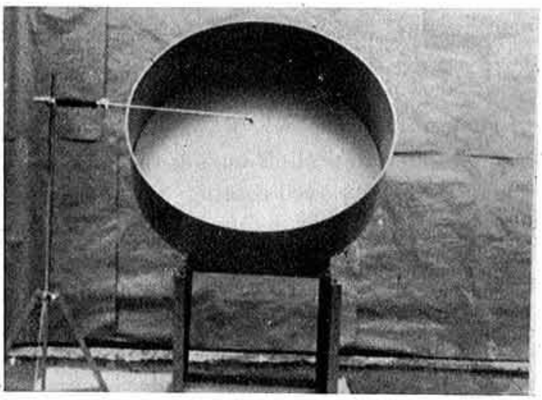

Plate 1. Coating machine (Rotary pan with a separate attachment for water spray)

* Produced by Hodogaya Chemical Co. Ltd., 4-2, Toranomon, 1-chome, Minato-ku, Tokyo 105, Japan.

Procedures of the seed coating are as follows:

At first, the seeds to be used are selected by specific gravity: seeds are placed into salt water (Sp. Gr. at 20°C; 1.10–1.13) and good seeds which sink in the salt water are used.

The selected seeds are immersed in water of about 15°C for 4 days until they absorb enough water for sprouting.

The wet seeds just before sprouting are dried for a while at windy place without direct sunshine.

Then, they are placed in the rotary pan (Plate 1). A lot of seeds, 10 kg in dry weight, is most suitable for each coating operation.

Rotate the pan at the rate of 20–25 rpm. Spray water on to the surface of seeds just to moisten them well. Pour slowly about 2 kg of Calper G dust into the rotating pan (Plate 2),

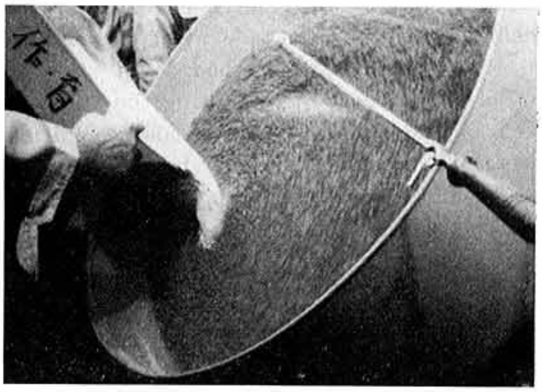

Plate 2. The preliminary application for ground-coating of Calper G dust

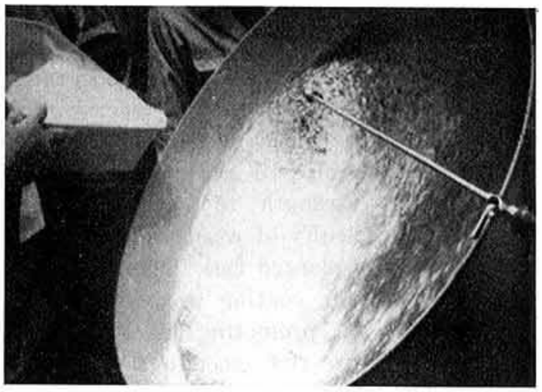

Plate 3. Appearance of rice seeds after the ground-coating

and keep rotating for further 1–2 min without spraying water (Plate 3). This enables to give uniform ground-coating.

After the ground-coating is made uniformly on the surface of seeds, rest of the Calper G dust was feeded slowly into the pan together with water spray, while the pan is always kept rotating.

Feeding of Calper G dust and water spray may be continued until whole quantity of Calper G dust is properly coated. When coated rice seeds begin to stick each other, spray of water should be stopped temporarily and a small quantity of Calper G dust be added. When whole quantity of Calper G dust is poured, stop water spray and continue rotating the pan for additional 2–3 min. (Plate 4).

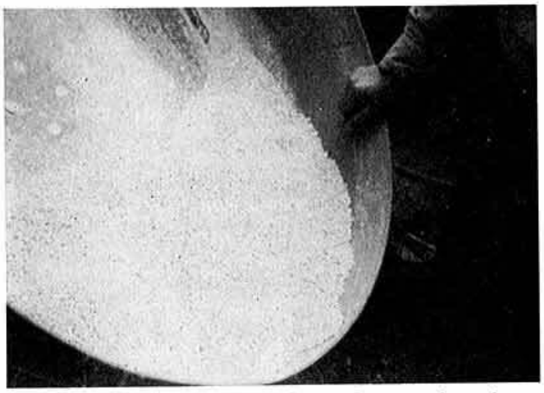

Plate 4. Rice seeds when the coating is finished

At last, the coated rice seeds were taken out of the pan for drying by wind in the shade for about 30 min.

The total quantity of water to be sprayed for the coating would be 20% of the quantity of Calper G dust used. When the quantity of water is too small Calper G dust will adhere to internal surface of the pan, creating a trouble to remove it off.

When a large quantity of Calper G dust is poured into the pan at one time, Calper G dust forms small lumps by itself without dressing seeds. It is therefore essential to supply it little by little.

In general the following calculation may be applicable.

Weight of dry seeds (paddy)	10 kg
Water absorbed by dry seeds during 4 days of immersion	2 kg
Calper G dust to be used	10 kg
Water consumed during coating operation	2 kg

After the coated seeds are dried for 30 min by wind, their color changes from milky white to pure white. The white colored coated seeds can be used for seeding, even for mechanical seeding, as they generally possess enough strength to endure the load.

When the sowing of the coated seeds is expected to delay, it is recommended to store them in a mesh-bag at a dry and windy place in the shade. They can be used for sowing within a period of two months. However, the coated seeds stored in bags without mesh, or under an enclosed condition at moderate temperature, will germinate in the bags.

Effect of Calper G dust coating on seedling emergence

Rice seeds can germinate in flooded paddy soil where oxygen supply is limited. Subsequent growth, however, may be highly impaired unless oxygen supply is adequate.

The oxygen concentration required for organ development is 2 ppm for appearance of radicle, 4 ppm for root elongation, more than 5 ppm for active root elongation and 5–6 ppm for growth of the first leaf.

Effect of different coating ratios of Calper G dust on seedling emergence was determined with the treated seeds covered with 2 cm soil and 2 cm water depth at 25°C (Table 1). It is clearly shown that Calper G dust coating is very effective in promoting seedling emergence, and the coating ratio of 100% gives the greatest effect.

Combined use of Calper G and Tachigaren dust for better seedling emergence

Even though the seedling emergence is improved by the use of Calper G dust in the direct sowing at low temperature, the growth

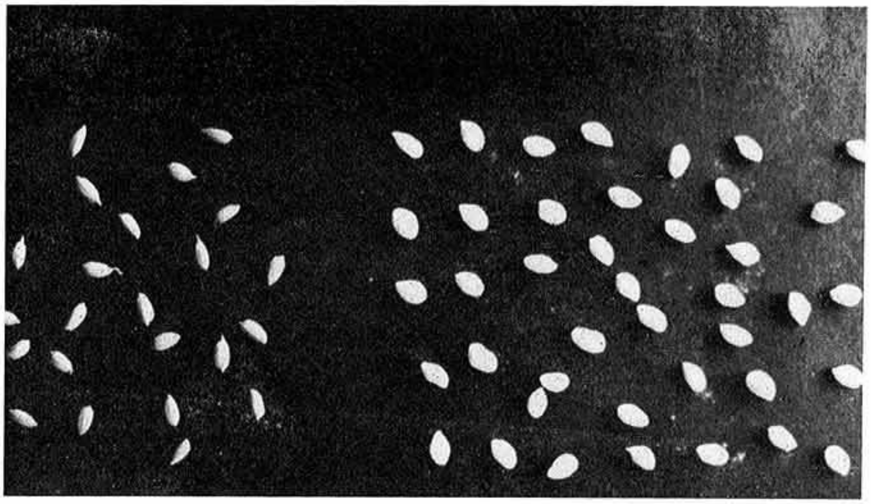

Plate 5. Dry rice seeds (left) and coated rice seeds (right)

Table 1. Coating ratio of Calper G dust and seedling growth[5)]

Seedling growth	Coating ratio (%) 0	25	50	75	100
Shoot-emergence (%)	36	57	74	76	77
1st leaf emergence (%)	7	26	41	59	73
Plant height (cm)	2.0	3.9	7.8	10.1	11.4
Dry weight (mg/plant)	10	20	40	50	60

Note: Measurement was made 11 days after sowing.

$$\text{Coating ratio} = \frac{\text{Weight of Calper G dust}}{\text{Weight of dry seeds}} \times 100\ (\%)$$

Table 2. Effect of seed coating with the mixture of Tachigaren dust and Calper G dust on growth of rice seedlings

Temperature	Plant parts	Growth in mg of fresh weigh and % in parentheses) Non-treatment	Calper G	Mixture of Calper G and Tachigaren dust***
L.T.*	Top	53 (100)	76 (143)	82 (153)
	Root	30 (100)	43 (146)	59 (199)
M.T.**	Top	60 (100)	83 (138)	93 (155)
	Root	28 (100)	53 (189)	66 (239)

Note: * Temperature adjusted 18°C in day time and 13°C in night time. Measurement was taken 30 days after sowing.

** Temperature kept at 32°–34°C for 3 days after sowing, then lowered gradually 25°C to 16°C at night time in the 4th to 7th day, and kept at 18°C in day time and 13°C in night time after the 8th day. Measurement was made 20 days after sowing.

*** Tachigaren was used at the rate of 3% of the dry seed weight.

Table 3. Grain yields and their components

Variety	No. of panicles/m²	No. of spikelets/ panicle	Percentage of ripened grains	Weight of 1000 grains (g)	Kernel yield ton/ha
Koshihikari	312	76.5	89.4	21.2	4.51
Milyang 23	324	132.0	73.6	22.6	7.12

Note: Seeds were coated with mixture of Calper G and Tachigaren. Date of sowing: 23th of May in 1979. Seeding rate was 5 kg/10 a. Application of fertilizer for Koshihikari; 5 kg of N/10 a as basal 7 kg of N/10 a as top dressing splitted three times. Application of fertilizer for Milyang 23; 10 kg of N/10 a as basal, 10 kg of N/10 a as top dressing splitted two times. Weed control by Sanbird applied one day after sowing.

of young leaves and roots is often retarded by low temperature, sometimes causing seedling rot infection. In such cases the use of the mixture of Calper G dust and Tachigaren was found to be very effective in promoting the early growth of seedlings (Table 2). This effect of the combined use of Tachigaren with Calper G dust has been proved useful not only at low temperature but also at high temperatures.

Field trials of direct sowing culture by the use of coated seeds

For the direct sowing on flooded paddy field, the sowing has to be done at the time when the mean temperature of 5 consecutive days reached 14–15°C or higher, and at the seeding rate of 4 to 6 kg of seeds per 10 a. The seeding depth is critical for seedling emeregence of Calper G coated seeds: 1–2 cm is ideal and should not exceed 3 cm. Sanbird (pyrazolate) of granule type is applied soon after to 5 days after sowing for weed control.

Table 3 shows the result of a field trial conducted at the Central Agricultural Experiment Station, Konosu, Saitama in 1979. Yields of Koshihikari (japonica var.) and Milyan 23 (japonica × indica var.) were fairly high as compared with mechanical transplanting culture.

Large scale field trials of this method have been practised in Japan: 19 ha in 1977, 37 ha in 1978, 40 ha in 1979, and 75 ha in 1980. Grain yields of these trials averaged 4 to 5 tons of dry brown rice/ha, which is similar to the yields of mechanical transplanting culture.

References

1) Kurokawa, T.: Effect of seed coating with calcium peroxide on seedling stand in the mechanized direct-sowing rice culture on the paddy field. *Rept. Tohoku Br. Crop Sci. Soc. Japan*, 17, 42–43 (1976) [In Japanese].
2) Ogawa, M. & Ota, Y.: Combined use of Calper and Tachigaren to improve seedling emergence under submerged condition. *Agr. & Hort.*, 48, 1297–1304 (1973) [In Japanese].
3) Ota, Y. & Nakayama, M.: Effect of seed coating with calcium peroxide on germination under submerged condition in rice plant. *Proc. Crop Sci. Soc. Japan*, 39, 535–536 (1970) [In Japanese with English summary].
4) Ota, Y. & Nakayama, M.: Utilization of calcium peroxide for agriculture as an oxygen generation agent. *Agr. & Hort.*, 46, 869–872 (1971) [In Japanese].
5) Ota, Y., Nakamura, Y. & Imamura, S.: The utilization of oxygen generating agent calcium peroxide in direct sown paddy rice. *Proc. 7th Asian-Pacific Weed Sci. Soc. Conf.*, 267–270 (1979).
6) Mitsuishi, S.: Study on the direct underground sowing in the submerging field of rice. *Special Bull. Ishikawa Pref. College Agr.*, 4, 1–59 (1975) [In Japanese with English summary].
7) Mitsuishi, S. & Nakamura, Y.: Studies on

direct sowing into flooded soils. I. Method of calcium peroxide coating. *Proc. Crop Sci. Soc. Japan*, **46** (Suppl. No. 1), 35–36 (1977) [In Japanese].

8) Yamada, N.: Calcium peroxide as an oxygen supplier for crop plants. *Proc. Crop Sci. Soc. Japan*, **21**, 65–66 (1951) [In Japanese with English summary].

9) Yoshida, S. & Rivera, C. T.: Effect of calcium peroxide on seedling emergence of IR 36 from puddled soil at different temperatures. *Int. Rice Res. Newsl.*, **3**, 17–18 (1978).

(Received for publication, April 16, 1981)