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Calcium peroxide as a seed coating material for padi rice

III. Glasshouse trials

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Summary Glasshouse trials indicate the optimum coating for rice seed as 35% (w/w) on seed weight of 60% calcium peroxide. Coatings in excess of this show no improvement and a 20% (w/w) coating gives comparable results to pregerminated seed.

As compared with untreated or pregerminated seeds an optimum seed coating of calcium peroxide increases the number of seedlings emerging through the water layer when rice seed is sown on the soil surface of waterlogged soil or at a depth of 1 cm below the soil surface.

The coating is applicable to a wide range of rice growing temperatures and not influenced by soil type.

Introduction

The indication by Japanese workers[6,7] that coating rice seed (*Oryza sativa* L) with calcium peroxide aids germination under production conditions such as are encountered in the Far East, and, comments from American sources[4,5,9,10,11] that such a coating may be applicable in the U.S. have indicated the possible global use in the padi.

Laboratory studies have indicated that a) calcium peroxide maintains oxidized conditions around a rice seed[1,2], b) no problem is encountered if seed is stored coated under 'normal' conditions[2], and c) sufficient oxygen is supplied by a seed coating of 35% (w/w) on seed weight of 60% calcium peroxide to enable the seed to establish[1,2].

However, when subjected to a large volume of soil with its commensal microflora and temperature variation the seed coating must continue to perform satisfactorily. Large scale environmentally controlled glasshouse trials provide an insight into the coating technique performance over a wide range of conditions.

Comparisons are made with pregerminated, and untreated seed.

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Materials and methods

Seed preparation

Seed of *Oryza sativa* L var. indica cv. Labelle was coated with 60% calcium peroxide[2] at levels approximating to 20%, 35%, 50% and 80% (w/w) on seed weight. Available oxygen was determined chemically[2]. Soaked seed was immersed in water for 24 h at 25°C and drained for 24 h at 25°C in the coating optimization experiment and immersed for 24 h at 15°C and partially dried for 6 h at 30°C in the subsequent experiments. Data is given in table 1.

Environmental conditions

Growing media Containers (surface area 1120 cm^2) were filled to a depth of 23 cm with puddled soil, either a heavy clay (pH [in water] 6.7) or a silty sand (pH [in water] 7.5). Seed was sown either at 1 cm depth in the soil or just below the soil surface. Flooding was to a depth of 7.5 cm and temperature was controlled as required. Each treatment was replicated twice, or thrice, 300 seeds in total being sown for each treatment. Containers were fully randomized and allowed to equilibrate.

Environmental control Glasshouse temperature was controlled automatically. Air temperature was held constant to within 2°C for the lower and 5°C for the higher required temperature. Soil and water temperature was monitored using thermocouples. Soil temperature was measured at a 1 cm depth in the soil and water temperature at a 4 cm depth in the water.

a) *Optimization experiment.* Air temperature was controlled at 35°C for 12 h (day) and 18°C for 12 h (at night). The air temperature took approximately 3 h to cool from 35°C to 18°C, and 1 h to rise from 18°C to 35°C.

b) *30°/20°C.* Air temperature was controlled at 30°C for 16 h and 20°C for 8 h. The air temperature took approximately 1 h to cool from 30°C to 20°C, and 0.5 h to rise from 20°C to 30°C.

c) *25°/15°C.* Air temperature was controlled on a diurnal cycle of 25°C for 16 h and 15°C for 8 h. Thermometer readings showed that the soil temperature ranged between 16°C and 21°C.

Monitoring a) *Water level.* The level was kept at 7.5 cm throughout the experiment, moisture lost by evaporation was replaced with water of the same temperature.

Table 1. Moisture content and available oxygen data for the seed used

Treatment	% Moisture content	% w/w Available oxygen (expressed as O_2)
Optimization		
Uncoated	11.5	–
Soaked	n.d.	–
20% w/w coating	11.6	1.7
35% w/w coating	11.6	2.6
50% w/w coating	12.7	3.7
80% w/w coating	12.4	4.4
30°C/20°C (day/night)		
Uncoated	8.6	–
Soaked	14.3	–
35% w/w coating	8.4	2.4
25°C/15°C (day/night)		
Uncoated	9.7	–
Soaked	10.5	–
35% w/w coating	6.5	2.9

n.d. = not determined

b) *Emergence*. The number of seedlings emerging through the water layer was counted at regular intervals. There was no statistical difference ($P < 0.05$) between emergence in replicates in any of the experiments.

c) *Harvesting*. After full emergence the plants were harvested from the 'buckets', the roots washed until clean and dried on paper to remove excess water. Plant fresh weight (on a total weight per 'bucket' basis) was determined and the plants were dried in a forced air draught at 60–70°C for 3 days, and weighed.

Results and discussion

Optimization of coating level

A coating[1] of 35% (w/w) on seed weight of 60% calcium peroxide provides approximately 1000 μg oxygen which has permitted normal establishment of rice seed when sown in unfavourable conditions.

Seed may be drilled into the soil or broadcast onto the soil surface and a layer of soil settle over it. Following the observation that calcium peroxide releases its oxygen more rapidly in water than in soil of the same pH[2] it was necessary to ascertain that the seed coating was sufficient to cover eventualities that may be normally encountered.

Optimization trials were carried out using seed coating levels of 20%, 35%, 50% and 80% (w/w) on seed weight of 60% calcium peroxide together with presoaked and untreated seed. Seed coating data are given in Table 1 and emergence data in Figure 1.

Table 2 shows the final plant numbers established. The results demonstrate the advantages of treating seed (either coating or by pregerminating) over no treatment. They also show that, for plant numbers established on surface sowing, a 20% (w/w) coating gave similar results to pregerminated seed but higher levels of coating (35%, 50% and 80% (w/w)) gave significantly better results than pregerminated seed.

Consideration of 1 cm sowing depths highlights the advantage of a 35% (w/w) coating. A 35% (w/w) coating produces significantly more plants than uncoated, pregerminated, and 50% (w/w) coated seed and there was some indication that it resulted in more emergence than 20% (w/w) and 80% (w/w) coatings.

A 35% (w/w) coating was not statistically inferior to any other treatment when both sowing techniques were considered and is optimum.

Efficiency of a calcium peroxide seed coating over a temperature range

Worldwide, rice is grown over a wide range of temperatures in many different soil types and under many different climatic conditions. If temperatures are low at seeding time (e.g. 18°C) then rate of germination and initial growth are reduced and poor stands can result. Work at IRRI[3,8] suggests that for the variety IR36 a non-dried calcium peroxide/

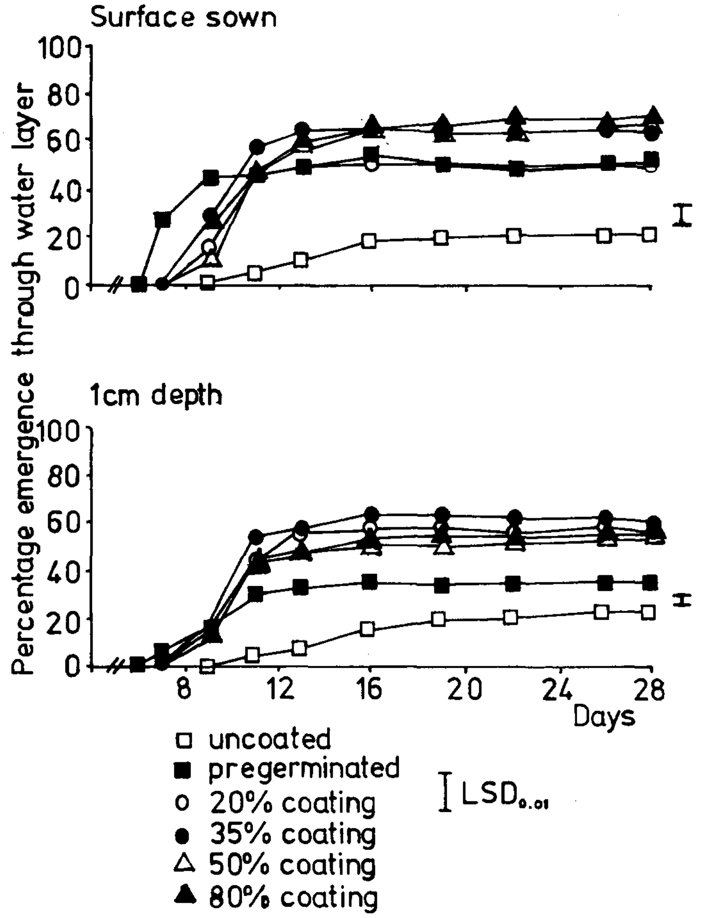

Fig. 1. Percentage emergence of Labelle rice through water layer for coating optimization.

calcium sulphate coating increases the rate of seedling emergence (*cf.* uncoated seed) at temperatures ranging from 26°/18°C to 35°/27°C (day and night). A seed coating of calcium peroxide must perform satisfactorily under any condition encountered in the field whether it be soil type or fluctuation in temperature.

Table 2. Final plant numbers established as a function of seed treatment in surface sown Labelle seed and Labelle seed sown at 1 cm depth

Sowing depth	Seed treatment						
	Uncoated	Pregerminated	CaO_2				
			20%	35%	50%	80%	
Surface	65a	152b	143b	187c	191c	206c	LSD 21.4 CV 11%
1 cm	70a	99b	165d	175d	157c	163cd	LSD 15.2 CV 9%

Glasshouse experiments were conducted in clay and silt soils and at temperature regimes of 30°C for 16 h/20°C for 8 h and 25°C for 16 h/15°C for 8 h using rice coated to 35% (w/w) on seed weight with 60% calcium peroxide and compared with pregerminated and untreated seed.

In rice sown at 30°/20°C shoots began to emerge through a water layer (7.5 cm) 8 days after sowing and emergence increased little after 20 days (Fig. 2). Table 3 shows the final plant numbers established at 28 days.

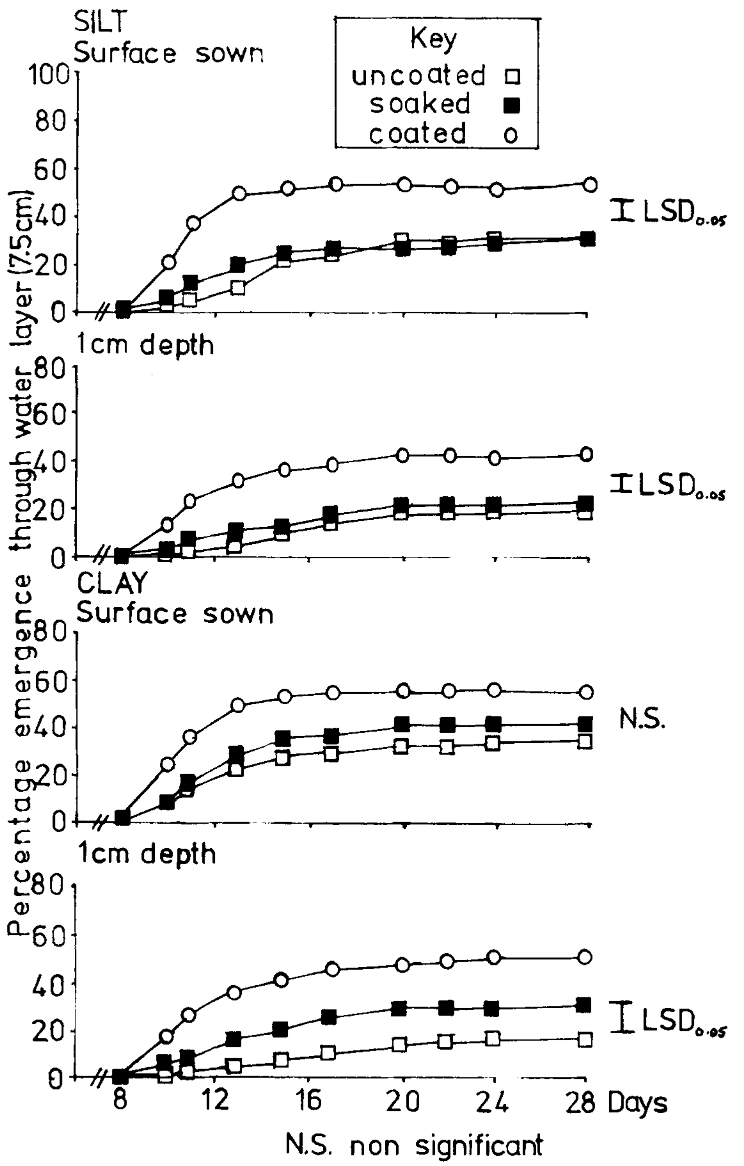

Fig. 2. Percentage emergence of Labelle rice through water layer for temperature range 30°/20°C.

Table 3. Final plant number established after 28 days at 30/20°C as a function of seed treatment

Sowing depth	Seed treatment			LSD 0.05	CV
	Uncoated	Pregerminated	35% (w/w) coating		
Surface					
Silt	97 a	95 a	162 b	23	9%
Clay	110 a	129 a	168 a	ns	24%
1 cm					
Silt	61 a	69 a	132 b	17	9%
Clay	52 a	96 b	159 c	36	16%

There are significant benefits over untreated and pregerminated seed for the 35% (w/w) seed treatment for surface sown in silt and 1 cm sowings in both silt and clay. There is a strong trend that a 35% (w/w) seed treatment increases the number of plants emerging compared to the pregerminated seed for surface sowing in clay where a 30% increase was obtained. Larger differences between coated and non coated seed occur when sown at a 1 cm depth in a more anaerobic environment.

The coating increased the weights of individual plants. Pooling all results of average plant weights gives values of 550 mg, 651 mg and 738 mg for control, pregerminated and 35% (w/w) treatment respectively. All these values are significantly different.

Rice grown under cooler conditions (25°/15°C) was slow to germinate, the first seeds emerging from the water 18 days after sowing (Fig. 3). Table 4 shows the final plant numbers established at 40 days. The results demonstrate the benefits of a 35% (w/w) coating over pregerminated or uncoated seed irrespective of soil type or sowing depth. Increases in plant numbers for a 35% (w/w) coating over pregerminated seed range from 85–88% for seed sown at a 1 cm depth.

The results in total show that the average plant fresh weights were

Table 4. Final plant numbers established after 40 days at 25°/15°C as a function of seed treatment

Sowing depth	Seed treatment			LSD		CV
	Uncoated	Pregerminated	35% CaO_2	0.05	0.01	
Surface						
Silt	117 a	145 a	188 c	11	18	9%
Clay	95 a	96 a	174 b	18	NS	19%
1 cm						
Silt	94 a	96 a	180 b	10	16	10%
Clay	55 a	82 a	152 c	15	25	21%

Values in rows followed by a different letter are statistically significantly different ($P < 0.05$) for surface sown in clay and ($P < 0.01$) for the other three systems according to Duncan's Multirange Test.

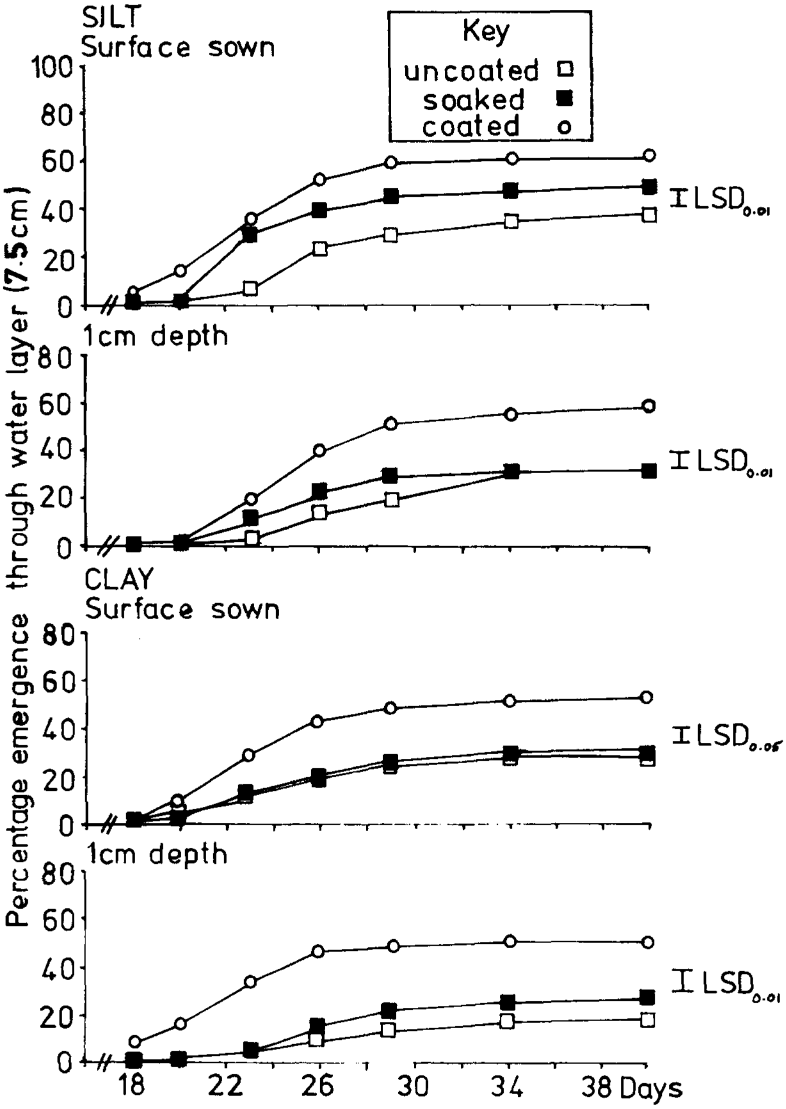

Fig. 3. Percentage emergence of Labelle rice through water layer for temperature range 25°/15°C.

250 mg, 312 mg and 353 mg for coated, pregerminated and 35% (w/w) treatment respectively. These weights are significantly different.

The low temperature glass house trial shows that a coating of 35% (w/w) on seed weight of 60% calcium peroxide increases the number of plants established under all conditions of sowing and also produces increases in average plant weight established per plot at the specific date of harvest.

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