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Unique Procedures for Germinating 'Super Dwarf' Rice

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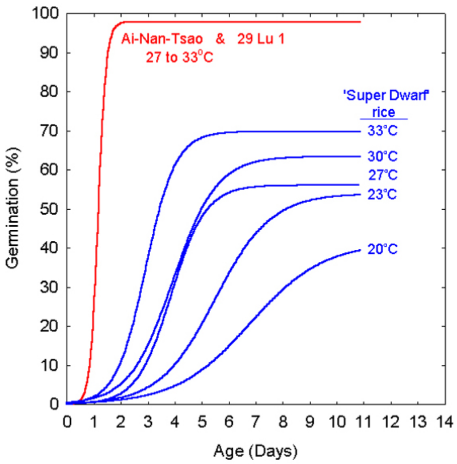
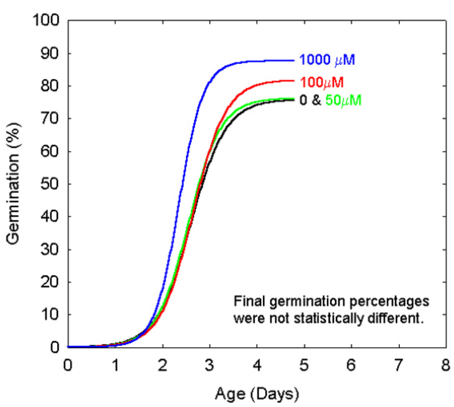
INTRODUCTION **Rice (*Oryza sativa* L.) is an important crop for advanced life support, but the height of even full-dwarf cultivars (80-cm tall) has made them difficult to use in controlled environments. We identified a rice mutant that lacks 3ß-hydroxylase, the enzyme responsible for conversion of gibberellic acid 20 (GA_{20}) to GA_1 (Murai et al., 1990; Honda et al., 1996). GA_1 is the active form of GA in most plants, so this rice variety is extremely short (20-cm tall). 'Super Dwarf' rice has a higher harvest index (50%) and similar yield to the commonly used rice cultivars 'Ai-Nan-Tsao' and '29-Lu-1' and its parent line 'Shiokari' (Kinoshita and Shinbashi, 1982). Uniform stand establishment is critical with small research plots. It is therefore important to determine procedures for optimum germination**



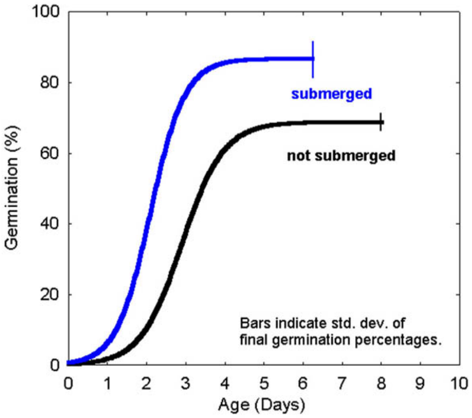
GERMINATION TEMPERATURE

'Super Dwarf' rice is more sensitive to germination temperature than dwarf cultivars Ai-Nan-Tsao and 29-Lu-1. Increasing the temperature up to 33 °C improved germination, but was still below other dwarf cultivars. Increasing temperatures above 33 °C did not further improve germination.



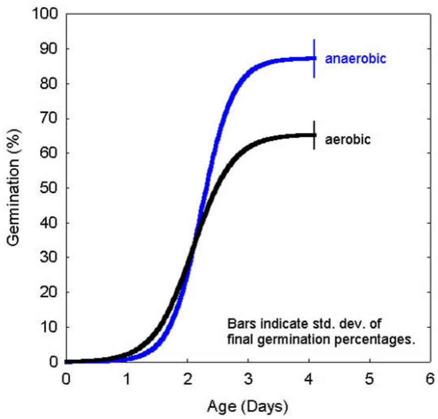
GA APPLICATION

GA activates alpha-amylase, an enzyme that catalyzes the breakdown of starch into sugar (Ritchie and Gilroy, 1998). Applying GA to GA-deficient 'Super Dwarf' improved germination some, but resulted in tall plants.



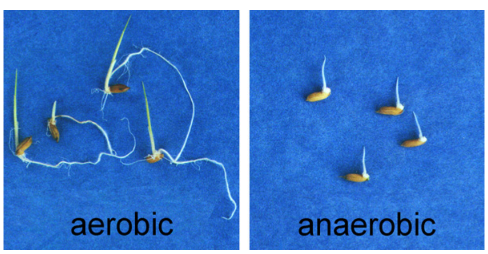
SUBMERGED GERMINATION

Inadvertently, we submerged seeds under 3 cm of water at 33 °C. Surprisingly, this produced the highest germination percentages of all previous treatments.



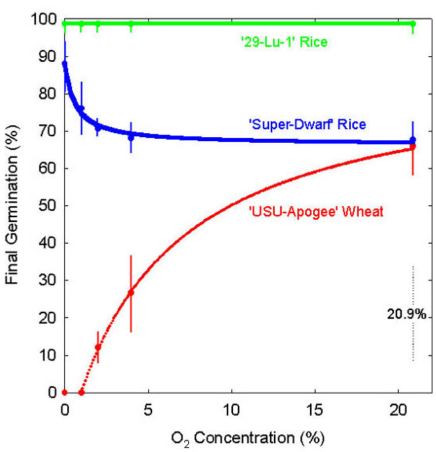
ANAEROBIC VS. AEROBIC (GRAPH)

Further tests indicated that the improved germination percentages could be repeated in an anaerobic environment created by N_2 gas flushed continuously over the wet seeds. The improved germination was probably due to fermentation products breaking dormancy (Cohn et al., 1987).



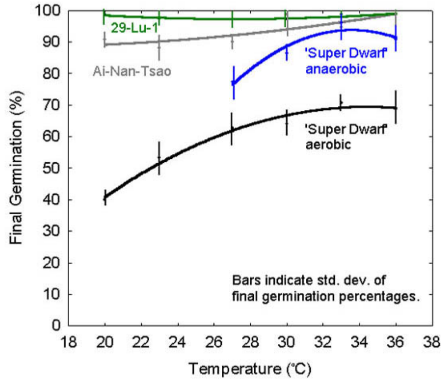
ANAEROBIC VS. AEROBIC (PICTURE)

Anaerobic seedlings initially have a different morphology than aerobic seedlings, but revert to normal morphology upon exposure to oxygen. The shoot elongates until it is above the water. Oxygen then moves through the shoot, from the air, to the seed and root growth begins.



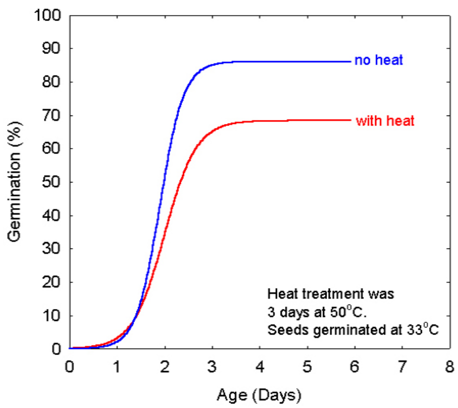
O_2 CONCENTRATION

'Super Dwarf' rice germination is significantly reduced even at 1% O_2, which appears to be unique to this cultivar. Like most other cereals, wheat does not germinate in anoxia or extreme hypoxia (1% O_2).



OPTIMUM TEMPERATURES & ANAEROBIC CONDITIONS

The temperature optimum is the same for aerobic and anaerobic conditions, but anaerobic conditions result in approximately 20% more germination.



HEAT TREATMENT TO BREAK DORMANCY

It would be convenient to treat whole seed lots in such a way as to break dormancy without requiring unusual cultural conditions. The International Rice Research Institute uses a heat treatment of dry seed for three days at 50 °C prior to germination as a standard treatment with 'japonica' rice varieties to break dormancy (Jones, 1926). 'Super Dwarf' is a 'japonica' variety. Surprisingly, this treatment decreased germination of 'Super Dwarf' by 20% in our studies.

CONCLUSION **Submerging seeds under water at 33 °C creates the anaerobic conditions necessary to achieve 95% germination of 'Super Dwarf' rice. This method is superior to other methods including application of GA to seeds, elevating temperatures alone, or heat treating the seeds before imbibition. While the morphology of anaerobically germinated seeds differs from aerobically germinated seeds, anaerobic seedlings will quickly revert to the normal morphology upon exposure to normoxic conditions with no apparent effects. This high germination percentage is necessary for even stand establishment, good radiation capture, and higher yields.**

REFERENCES

Cohn, M. A., Chiles, L. A., Hughes, J. A., Boullion, K. J. 1987. Seed dormancy in red rice VI. Monocarboxylic acids: an new class of pH dependent germination stimulants. *Plant Physiol*. 84:716-719.

Honda, I., Sudo, K., Iwasaki, S., Yanagisawa, T., Yamaguchi, I., Kato, H., Ikeda, R., Hirasawa, H., Takahashi, N. 1996. Characterization of endogenous gibberellins in dwarf rice mutants. *Biosci., Biotech, and Biochem*. 60:2073-2075.

Jones, J. W. 1926. Germination of rice seed as affected by temperature, fungicides, and age. *J. Am Soc. Agron*. 18:576-592.

Kinoshita, T. and Shinbashi, N. 1982. Identification of dwarf genes and their character expression in the isogenic background. *Japan. J. Breed*. 32:219-231.

Murai, M., Shinbashi, N., Kusutani, A., Hirose, S., Takamure, I., Kinoshita, T. 1990. Identification of dwarf genes in rice lines, Yukara dwarf and Fukai 71, and its responses to environmental factors. *Japan. J. Breed*. 40:33-45.

Ritchie, S. and Gilroy, S. 1998. Gibberellins: regulating genes and germination. *New Phytologist*. 140:363-383.