PROJECT NO. RM-4

**ANNUAL REPORT**

COMPREHENSIVE RESEARCH ON RICE

January 1, 1987 - December 31, 1987

**PROJECT TITLE:** Production and Quality of Rice Seed

**PROJECT LEADER AND PRINCIPAL UC INVESTIGATORS:**


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**OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION TO ACCOMPLISH OBJECTIVES:**

Objective I: Evaluate seed vigor tests and develop simple and reliable testing procedures to measure seed vigor.

A. A seed bank containing the major current rice cultivars was collected to provide seed lots with a range of vigor levels.
B. Experiments were conducted at Davis to identify the conditions required for specific vigor tests. Percentage germination, mean time to germination, slant board seedling growth, and several variations of the accelerated aging test were evaluated as indicators of seed vigor.

Objective II: Determine the influence of seed maturity, seed moisture content at harvest, and drying and storage conditions on the development and maintenance of seed vigor.

A. Field plots of M201 and L202 rice cultivars in the Richvale area were harvested at moisture contents ranging from 26% to 15%. Seeds were threshed, dried, cleaned, and stored under both optimal and adverse conditions.
B. Seed vigor and storability as related to seed moisture content at harvest are currently being evaluated at Davis.

Objective III: Investigate the potential for incorporation of seed vigor enhancement techniques into current seed handling and planting operations.

A. Preliminary experiments have been conducted at Davis to determine the osmotic potentials required to prevent germination of rice seed.

## SUMMARY OF 1987 RESEARCH (MAJOR ACCOMPLISHMENTS) BY OBJECTIVE:

### OBJECTIVE I

In order to investigate factors influencing seed quality, it is necessary to have a method of measuring seed quality. The standard germination test determines seed viability under optimal conditions, but is often a poor predictor of field emergence performance under stressful conditions. While seed lots with poor germination percentages will generally also be of low vigor, seed lots with high viability according to the standard germination test can vary widely in vigor. Thus, additional tests are required to distinguish among lots with acceptable viability according to their physiological vigor.

Developing such tests has two components: first, to identify tests which can be readily performed in the laboratory and which will separate lots according to some criterion and, second, to determine whether the results of the laboratory tests predict the performance of the same seed lots in the field. We are now nearing completion of the first phase of this overall goal. We have collected a bank of seed lots and have compared them in a number of tests.

1) A standard germination test was conducted at 20°C (68°F) on a slanted blotter paper substrate in the dark for 14 days. The official seed testing rules call for alternating 20°-30°C temperatures, but we have chosen the lower temperature to add a slight stress to this test. Seedlings were scored as normal or abnormal according to Association of Official Seed Analysts rules.

2) The mean time to germination ($T_{50}$) was determined by daily germination counts of seeds placed on blotter paper in petri dishes at 20°C in the dark. Germinated seed (coleoptile >2mm) were removed at each count. The $T_{50}$ was calculated as $T_{50} = \Sigma N_i T_i / \Sigma N_i$, where $N_i$ is the number of newly germinated seeds at time $T_i$. The time values were log-transformed for the calculation to give normal distributions around the mean time.

3) Seedling lengths were measured after germination and growth for 14 days in the dark at 20°C on slanted blotter paper. This test was based on that reported by Jones and Peterson (1976) and Peterson et al. (1978) to be a good predictor of field emergence among various rice genotypes.

4) A number of variations of an accelerated aging (AA) test were screened. This test is based on the principle that as seeds deteriorate, vigor first declines, followed by loss of viability. By placing seeds in extremely adverse conditions of high temperature and high moisture content, aging equivalent to several years of normal storage can be induced to occur within a few days or even hours. Several temperature and duration combinations were tested using the "box" method. In this method, seeds are suspended on a wire mesh screen over water in a closed plastic sandwich box. The boxes with seeds are incubated at a given temperature for various durations, then germinated in a standard test and scored for coleoptile emergence. The high humidity in the box raises the seed moisture content and leads to rapid seed aging at the high temperature employed. A variation of this test, called "controlled deterioration", first hydrates the seed to a given moisture content, then ages them in sealed vials. We also tried a very short-term treatment of soaking seeds in water at 50°C (122°F) for six hours.

What is anticipated by these tests is that seeds with lower vigor will lose viability more rapidly under these adverse conditions than will seeds of high vigor.

An example of the effects of various aging durations and temperatures on germination is shown in Table 1. It can be seen that even

Table 1: Effects of accelerated aging by the "box" method on germination of rice seed.

| Cultivar | Lot # | Control (before aging) | Aged 43°C (110°F) 24 hr | 48 hr | 72 hr | Aged 50°C (122°F) 24 hr | 48 hr | 72 hr |
|---|---|---|---|---|---|---|---|---|
| | | | % Germination | | | | | |
| S201 | 3 | 94 | 96 | 97 | 72 | 77 | 15 | 0 |
| | 2 | 94 | 96 | 98 | 65 | 66 | 5 | 0 |
| M102 | 13 | 90 | 98 | 97 | 84 | 88 | 49 | 0 |
| M201 | 18 | 99 | 96 | 95 | 88 | 93 | 80 | 0 |
| | 19 | 97 | 98 | 98 | 90 | 95 | 50 | 0 |
| | 4 | 97 | 98 | 98 | 90 | 94 | 85 | 17 |
| | 26 | 91 | 97 | 90 | 84 | 58 | 1 | 0 |
| L202 | 22 | 95 | 97 | 92 | 82 | 70 | 46 | 0 |
| | 23 | 91 | 92 | 90 | 54 | 79 | 8 | 0 |
| | 27 | 94 | 98 | 98 | 73 | 45 | 0 | 0 |

short durations under these extreme conditions can reduce viability markedly. The usefulness of the AA test is that it can bring out differences among lots which differ little on the standard germination test. Comparing, for example, lots 19 and 4 of M201 in Table 1, the initial germination was identical, but as the aging conditions became more severe, lot 4 maintained the higher viability. A similar condition can be seen between lots 22 and 27 of L202. Germination after aging should give a better ranking of seed lots for vigor levels than does germination before aging. The advantage of this test is that it is simple and can fit easily into routine seed testing procedures. However, it must still be shown that the aging test does predict field performance.

A summary of the various seed quality tests we have conducted is shown in Table 2. All of the seed lots we collected were of good quality, leading to relatively little variation in the rate of germination or seedling growth indices. The aging tests generally identified the lowest quality lots, but the germination after aging was not always correlated with the

Table 2. Germination and seedling growth characteristics of rice cultivars and seed lots.

| Cultivar | Lot | Germ. (%) | 1/log $T_{50}$[1] (1/log hrs) | Length[2] (mm) | AA box[3] (%) | AA vial[4] (%) | AA soaked[5] (%) |
|---|---|---|---|---|---|---|---|
| S201 | 3 | 93 | 0.500 | 67 | 68 | 77 | 48 |
| | 2 | 93 | 0.508 | 60 | 53 | 55 | 41 |
| M102 | 12 | 94 | 0.502 | 80 | | | |
| | 13 | 90 | 0.521 | 80 | | | |
| M201 | 25 | 98 | 0.514 | 67 | 69 | 90 | 80 |
| | 6 | 96 | 0.501 | 66 | 74 | 85 | 78 |
| | 20 | 96 | 0.500 | 65 | 80 | 93 | 79 |
| | 18 | 96 | 0.495 | 62 | 88 | 94 | 56 |
| | 19 | 95 | 0.509 | 66 | 91 | 92 | 84 |
| | 14 | 94 | 0.504 | 62 | 77 | 94 | 80 |
| | 4 | 93 | 0.498 | 66 | 89 | 91 | 87 |
| | 5 | 93 | 0.504 | 63 | 87 | 94 | 87 |
| | 7 | 92 | 0.500 | 78 | 64 | 92 | 75 |
| | 26 | 87 | 0.478 | 56 | 51 | 45 | 58 |
| M202 | 10 | 93 | 0.518 | 71 | | | |
| | 11 | 92 | 0.511 | 65 | | | |
| | 9 | 90 | 0.506 | 59 | | | |
| | 8 | 89 | 0.518 | 62 | | | |
| M401 | 16 | 93 | 0.505 | 70 | | | |
| | 15 | 91 | 0.525 | 66 | | | |
| L202 | 24 | 96 | 0.522 | 81 | 65 | 81 | 72 |
| | 22 | 95 | 0.520 | 71 | | | |
| | 23 | 91 | 0.518 | 76 | 78 | 77 | 69 |
| | 21 | 91 | 0.517 | 72 | 61 | 76 | 64 |
| | 27 | 91 | 0.508 | 55 | 49 | 49 | 46 |
| Calpearl | 17 | 94 | 0.529 | 79 | | | |

[1]This term expresses the rate of germination; higher values indicate more rapid germination.
[2]Seedling lengths from the slant board test.
[3]Germination percentage after aging for 48 hrs at 50°C in 100% RH.
[4]Germination percentage after aging for 24 hrs at 50°C in sealed vials, 20% seed moisture content.
[5]Germination percentage after aging for 6 hrs at 50°C submerged in water.

initial germination percentage. When field emergence tests are conducted in the spring, we will be able to evaluate whether the AA tests were useful in ranking seed lot quality. We are now storing seed lots under less than optimal conditions in order to induce natural deterioration and bring out greater variation in vigor among them.

For cultivar M201, sufficient lots were available to do initial correlation studies among the various quality parameters. As shown in Table 3, some significant correlations were evident. Surprisingly, all correlations with seedling length were negative, indicating an inverse correlation of seedling length with other quality parameters. This may be due to the rather long duration of the test, making it more of an "exhaustion" test, rather than indicating the speed of germination and growth. For the future, we will shorten the duration of the test to determine whether this provides the expected relationship with seed quality.

Table 3: Correlation coefficients for comparisons among seed quality parameters for ten seed lots of cultivar M201.

| Parameter | Rate | Length | AA box | AA vial | AA soaked |
|---|---|---|---|---|---|
| Germination | 0.73* | -0.49 | 0.62 | 0.93** | 0.65* |
| Rate | | -0.42 | 0.60 | 0.77** | 0.70* |
| Length | | | -0.60 | -0.50 | -0.69* |
| AA box | | | | 0.74* | 0.46 |
| AA vial | | | | | 0.56 |

*,**Correlation significant at the 5% and 1% levels, respectively.

Another factor is the relatively small range of values available in the growth test (Table 2), which could lead to unreliable correlations due to random error in the measurements. Among the AA tests, the "box" test had the poorest correlations with other vigor parameters, while the "vial" test had the best. Results from field emergence trials need to be evaluated before a firm decision can be made regarding which test, or tests, will give the best indication of field performance potential.

OBJECTIVE II

The relationships between seed maturity, seed moisture content at harvest and seed quality are being studied in cultivars M201 and L202. Field plots (ramdomized complete block design, 5 replications) were established in grower fields in the Richvale area. Plots were harvested and threshed and samples were taken for moisture content determinations. Moisture content was measured by an oven method (130°C for 6 hrs), which was found to give identical results to the recommended two-stage procedure with grinding. The lots were dried with forced air to approximately 14% moisture content and stored at 30% RH and 10°C (50°F) to allow the seed moisture to equilibrate in all lots. Subsamples of the seed will also be stored at 30°C (86°F) to cause more rapid deterioration and determine any long-term effects of seed maturity on storage life.

The sampling dates and seed moisture contents for the two cultivars are shown in Figure 1. We have concentrated on the range of moisture contents over which rice is normally harvested. A better distribution of samples was obtained for M201 than for L202, due to the rapid-drying characteristics of the latter. However, we should be able to test the earlier findings of Oelke et al. (1969) that seed vigor and quality continued to increase as seed moisture content declined to very low levels. We will be doing the laboratory testing on these seed lots in the upcoming months and will do field emergence trials in the spring. As some variation in moisture content occurred among replicates at each sampling date due to the time of day when each was harvested, we should also be able to establish whether it is seed maturity or moisture content, per se, which is the more critical factor for seed quality.

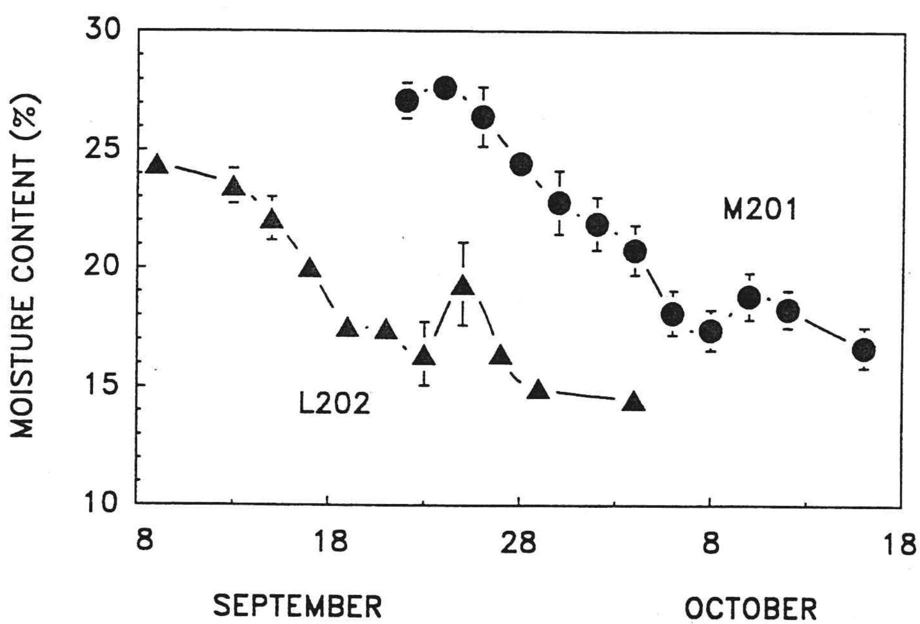


Figure 1: Seed moisture content at harvest at different harvest dates for M201 and L202 cultivars. The error bars indicate the standard error of the mean of five replicates, when they exceed the size of the symbol.

OBJECTIVE III

The intent of this objective was to determine the feasibility of incorporating seed enhancement techniques, such as seed priming, into current rice seed handling procedures. The principle of seed priming is to osmotically restrict germination to allow all seeds to reach the same stage, then release the inhibition, giving rapid and uniform germination. Since rice seed is soaked before planting, these procedures could be incorporated into the soaking period. Another potential use of this procedure would be to block germination in soaked seeds if bad weather prevents planting on schedule.

As a preliminary study to evaluate these possibilities, the sensitivity of rice seed germination to osmotic potential was determined (Figure 2). Increasing the osmotic strength (concentration) of mannitol in the germination medium successively delayed and prevented germination. Much less osmoticum is needed to delay germination as compared to completely inhibiting it. These studies have established the ranges of osmotic potentials that will be needed to manipulate rice seed germination. Germination in osmoticum may also prove useful as a vigor test. These studies are of lower priority than those in Objectives I and II, and have received less attention thus far. We will resume work on these aspects after the spring emergence trials are completed.

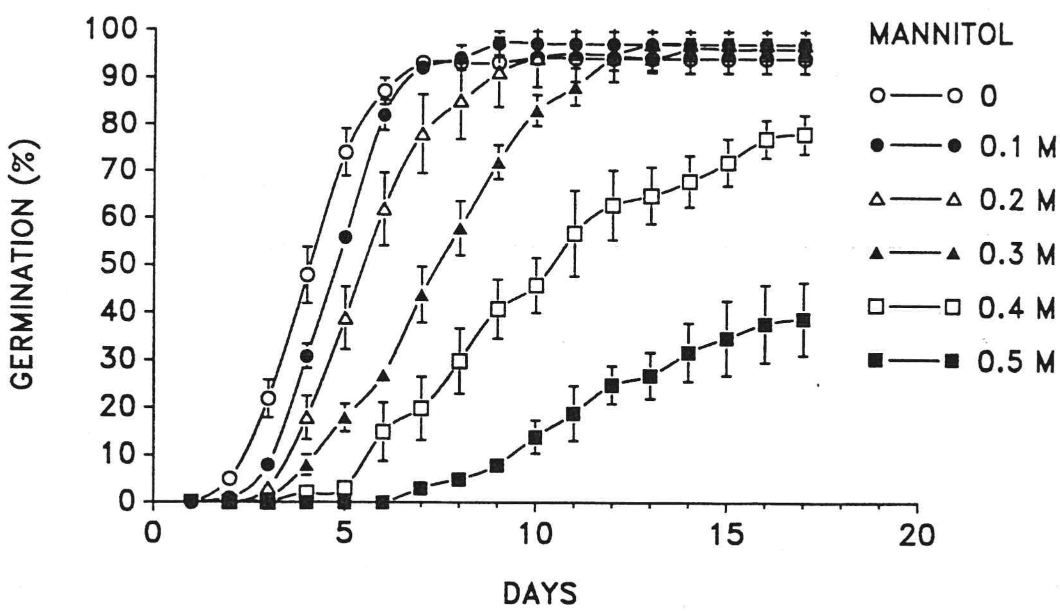


Figure 2: Time course of germination of M201 seed at 20°C in various concentrations of mannitol. The values are in molar units and correspond approximately to 0, -0.24, -0.48, -0.72, -0.96, and -1.2 MPa osmotic potential.

## PUBLICATIONS OR REPORTS

None.

## CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

Studies were initiated to develop vigor tests for current rice cultivars, and use them to determine the relationship between seed maturity (moisture content) and seed quality. A seed bank has been collected to provide seed lots of varying vigor for these studies. A number of tests, including germination, rate of germination, seedling length, and accelerated aging tests are being evaluated for their application to rice. Samples of M201 and L202 seed have been harvested at a range of moisture contents and are currently being evaluated by the vigor tests mentioned above. Field emergence trials are planned for the spring for comparison with the vigor test results. Preliminary studies have been initiated to determine the feasibility of manipulating germination by osmotic solutions to delay germination or improve the rate and synchrony of emergence.

## REFERENCES CITED:

Jones, D. B. and M. L. Peterson. 1976. Rice seedling vigor at suboptimal temperatures. Crop Sci. 16:102-105.

Oelke, E. A., R. B. Ball, C. M. Wick, and M. D. Miller. 1969. Influence of grain moisture at harvest in seed yield, quality and seedling vigor of rice. Crop Sci. 9:144-147.

Peterson, M. L., D. B. Jones and J. N. Rutger. 1978. Cool temperature screening of rice lines for seedling vigor. Il Riso 27:269-274.