PROJECT NO. RM-4

ANNUAL REPORT

COMPREHENSIVE RESEARCH ON RICE

January 1, 1988 - December 31, 1988

PROJECT TITLE: Production and Quality of Rice Seed

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OBJECTIVES AND EXPERIMENTS CONDUCTED BY LOCATION TO ACCOMPLISH OBJECTIVES:

Objective 1. Evaluate the accelerated aging test as as vigor test for rice by comparison with other laboratory tests and field emergence trials.

A. Standard germination, seedling length, rate of germination, and accelerated aging tests were conducted on seed lots representing a range of vigor levels and cultivars.
B. Field emergence trials were conducted at Davis to determine how the laboratory tests related to the field results.

Objective 2. Determine the influence of seed maturity and seed moisture content at harvest on the development and maintenance of seed vigor.

A. Seeds of cultivars M-201 and L-202 from seed fields in Butte County were harvested over a range of moisture contents, dried and stored. The seed quality tests described under Objective 1 were conducted to evaluate the relationship between harvest moisture content and seed quality. Head rice percentages were also determined on the same samples.
B. The entire study described in (A) is being repeated in 1988-89 using cultivars M-202 and S-201.

SUMMARY OF 1988 RESEARCH (MAJOR ACCOMPLISHMENTS) BY OBJECTIVE:

OBJECTIVE 1

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 further tests may be required to distinguish among lots with acceptable viability according to their physiological vigor. We have identified several tests which have either been used as vigor tests for rice or hold promise for use as vigor tests. Field emergence trials were also conducted to determine how the various laboratory tests correlate with field performance. The following tests were conducted on 14 M-201 seedlots which differed in vigor, and on single seedlots of 10 cultivars.

(1) Standard germination tests were conducted at 20°C (68 °F) on slanted blotter paper in the dark for 14 days. Tests generally consisted of two replicates of 100 seeds each. Seedlings were scored as normal or abnormal according to Association of Official Seed Analysts Rules.

(2) Seedling lengths were measured after germination and growth for 14 days in the dark at 20°C (68 °F) on slanted blotter paper. Twenty seedlings from each of two replicates used for the standard germination test were measured.

(3) 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 (68 °F) in the dark. Germinated seeds (coleoptiles >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. Tests were on two replicates of 100 seeds each.

(4) The accelerated aging (AA) test consisted of placing seeds in vials, submerging in water, sealing, and incubating in a water bath at 45 °C (113 °F) for 20 hours. The seeds were then transferred to Petri dishes on moist blotters and scored for germination after 6 days at 20 °C (68 °F). Tests consisted of two or three replicates of 100 seeds each. Survival after AA has been correlated with seed vigor in a number of species.

(5) Field emergence trials were planted on May 20 at the U.C. Davis Rice Research Facility. Five replicates of 100 seeds each were soaked for 20 hours and planted in a randomized complete block design within wire cages. We attempted to maintain a water depth of 10 cm, but problems with the water supply resulted in variation from 0 to 12 cm during the emergence period, with a corresponding variation in water temperature from 18 to 30 °C (64 to 86 °F). The variation in water depth also prevented accurate determination of the rate of emergence. After 5 weeks, all seedlings within each cage were harvested and those over 10 cm in length were counted as emerged.

Vigor series

Seed lots for the vigor series tests were obtained from the Butte County Rice Growers and from our field harvests (see Objective 2). All lots were of M-201, and were from 1985, 1986 or 1987 harvests. Standard germination percentages of all lots were >90%, except for the single lot from 1985, which was 81%. The objective of the vigor tests was to see whether they could distinguish among these lots of high viability to detect which ones had the greatest potential for field emergence.

The results of the standard germination test and the AA test are shown in Figure 1. The standard test percentage was highly correlated with the field emergence percentage ($r^2 = 0.82$), as would be expected. However, since there was little variation in standard germination percentage for most of the seedlots, the range of values among seed lots might be insufficient to clearly distinguish the most vigorous lots. With the AA test, on the other hand, a wide range of germination values was obtained within the high range of field emergence percentages (Fig. 1). In this range (down to about 40% field emergence), the AA test was fairly well correlated with field emergence. However, it failed to predict accurately the emergence of the two lower-quality lots, leading to a quadratic relationship between

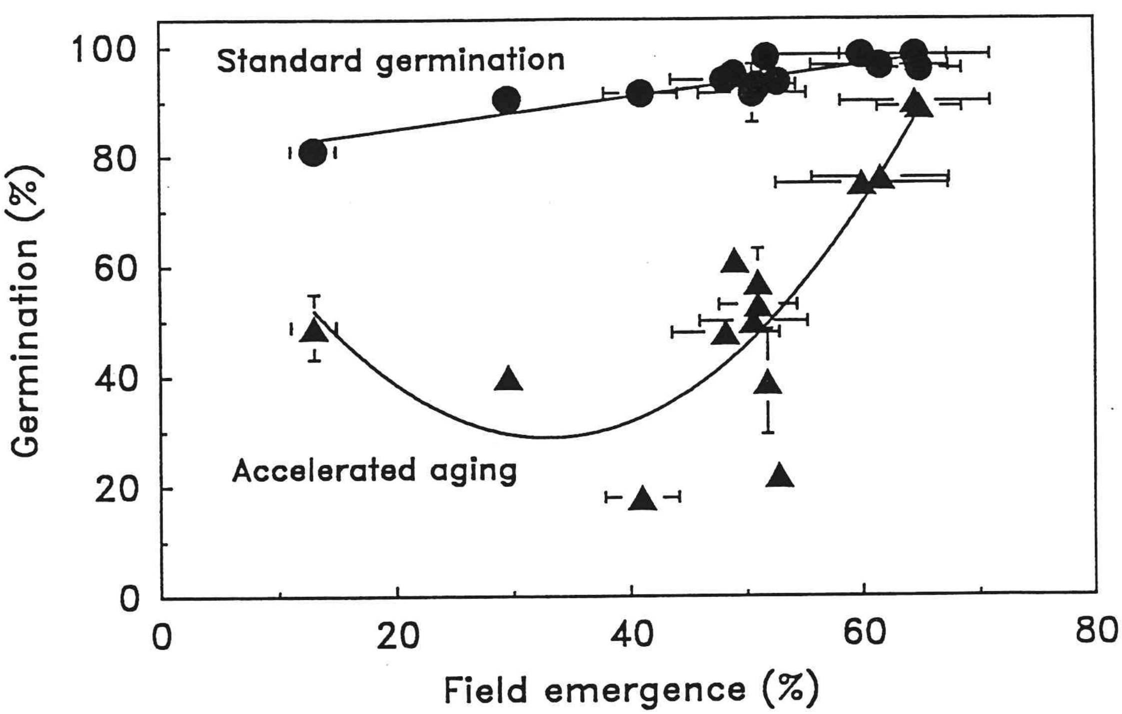

Figure 1. Standard germination test percentages and accelerated aging survival percentages plotted versus field emergence percentages for 14 seed lots of M-201. Standard errors are shown where they exceed the size of the symbols.

field emergence and AA test results ($r^2 = 0.72$). Seedling length and T_{50} exhibited little variation among the seed lots, and were therefore not highly correlated with field emergence (data not shown).

Cultivar series

This test was done to survey a range of current cultivars in each of the germination and vigor tests. Seed lots of 1987 Foundation Seed were obtained from the Rice Experiment Station, Biggs, California. The field emergence percentages of the cultivars tested are shown in Figure 2.

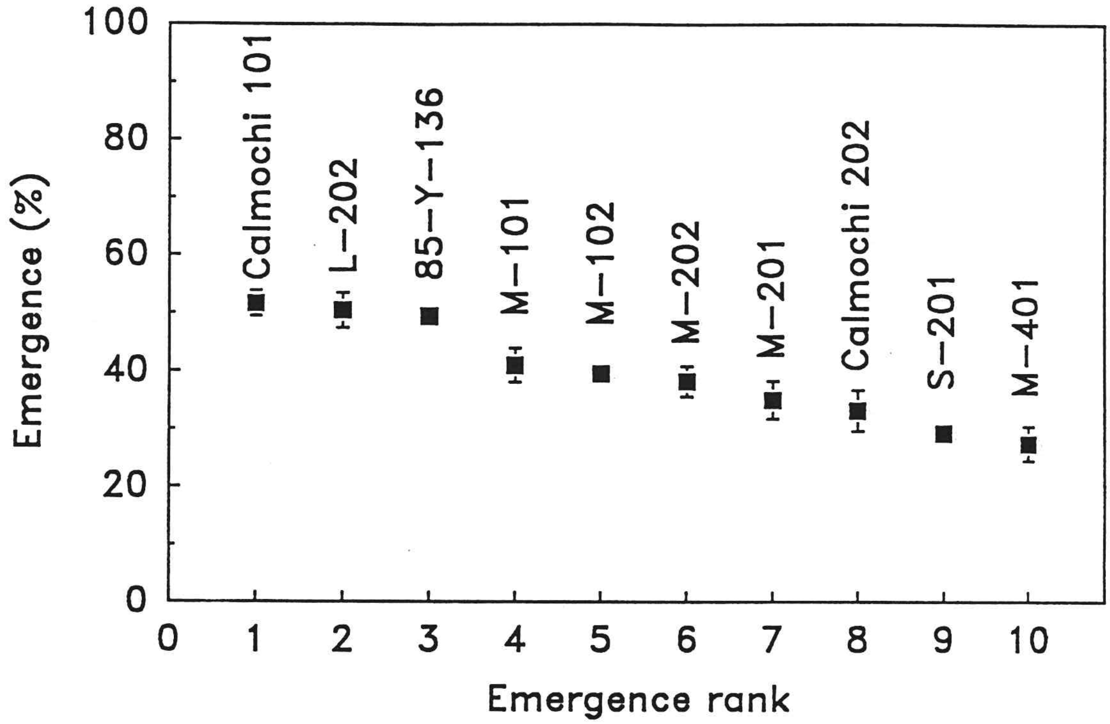

Figure 2. Field emergence percentages of ten cultivars of rice. Each cultivar is represented by a single 1987 Foundation Seed lot. Standard errors are shown where they exceed the size of the symbols.

Unlike the vigor series, where some of the vigor tests were highly correlated with field emergence, none of the laboratory tests was significantly correlated with the cultivar emergence values (Fig. 3). This may indicate that the variation in emergence was more dependent upon cultivar characteristics than it was upon seed vigor, per se.

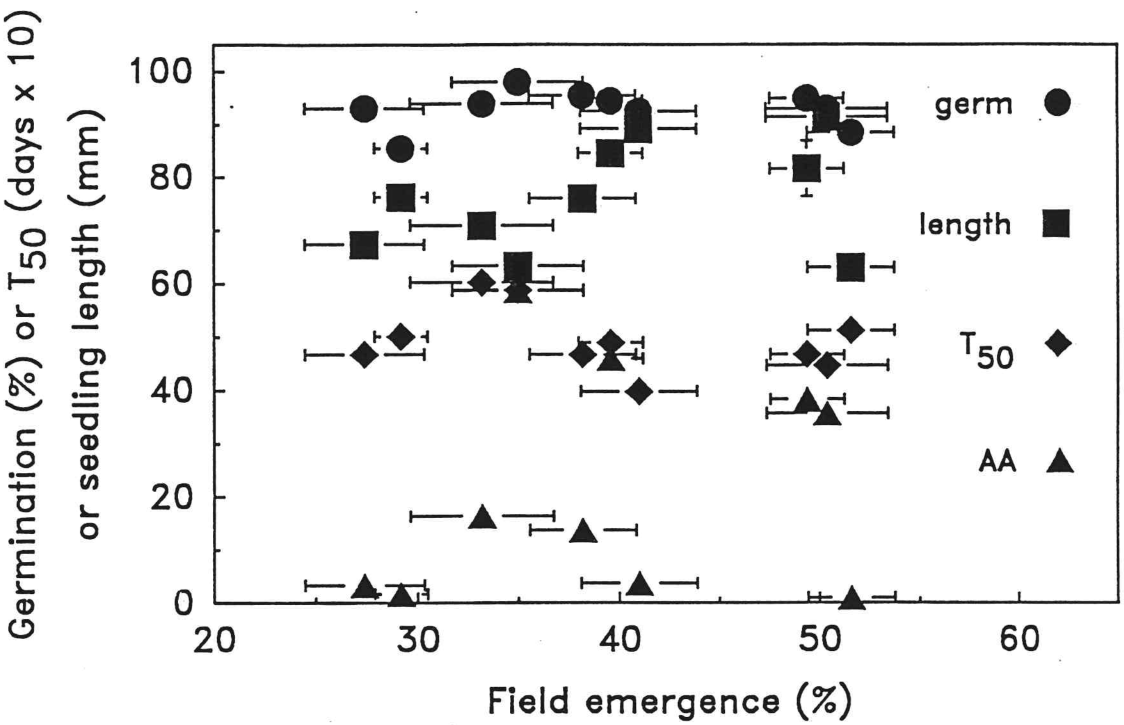

Figure 3. Results of seed vigor tests plotted versus field emergence percentage for single seed lots of 10 cultivars of rice. None of the tests correlated well with the emergence results, as can be seen by the scatter in the points. Standard errors are shown where they exceed the size of the symbols.

Conclusions

Based upon the results of the vigor series, the standard germination test was a good predictor of field emergence ranking among seed lots, if the range of germination percentages was large. Over a narrower range of high germination percentages, the AA test was able to identify the best lots, but it failed to correlate well over the entire range of seed quality. Once the germination percentage falls below 90%, a vigor test may not be needed. For lots with >90% germination, the AA test would provide additional information to discriminate among lots of similar standard germination percentages. The results of the cultivar series indicate that the vigor tests may need to be calibrated within each cultivar, since the cultivars differ in their inherent seedling vigor.

OBJECTIVE 2

The second objective was to determine the influence of seed moisture content at harvest on seed quality and vigor. Field plots (randomized complete block design, 5 replications) were established in grower fields in the Richvale area. Plots (50 ft^2 in 1987, 10 ft^2 in 1988) were harvested and threshed and samples were taken for moisture content. Moisture content was measured by an oven method (6 hours at 130 °C), which was found to give identical results to the recommended two-stage procedure with grinding. In 1988, moisture content measurements were made on the same samples using the Motomco moisture meter. The lots were forced-air dried

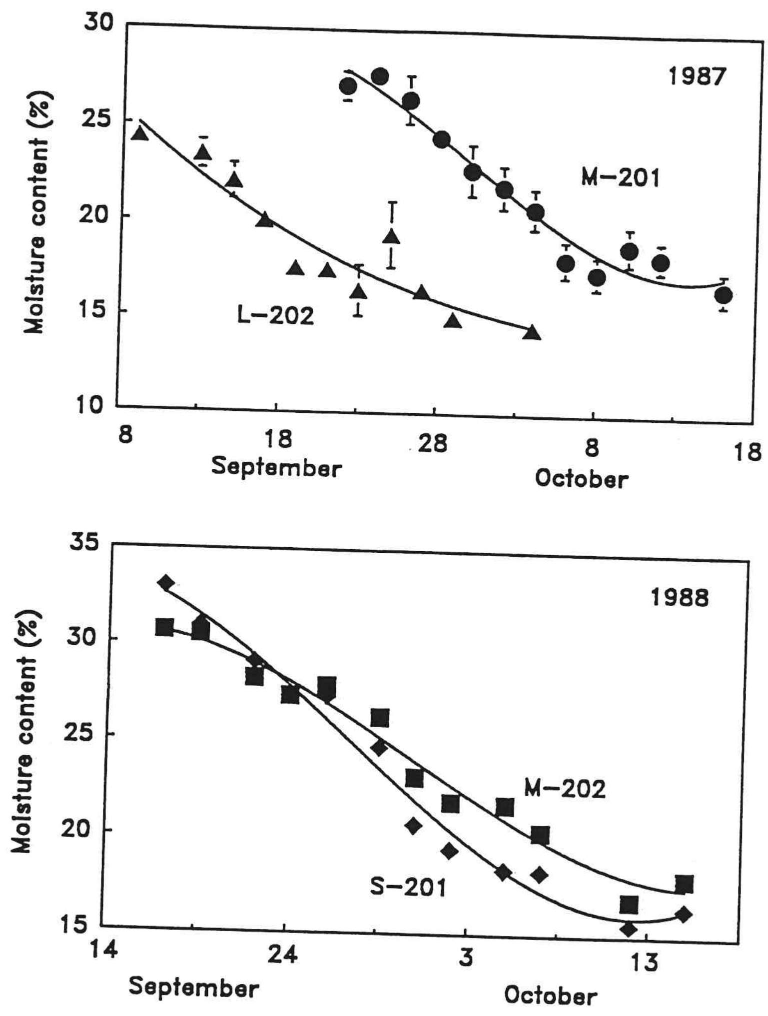

Figure 4. Harvest moisture contents as a function of harvest date for 1987 (top) and 1988 (bottom). Seed from these harvests were used to study the relationship between harvest moisture content and seed quality. Standard errors are shown where they exceed the size of the symbols.

without heat to approximately 14% moisture content and were stored at 30% RH and 10 °C to allow the seed moisture to equilibrate in all lots. Subsamples of the seed were also stored at 30 °C (86 °F) for three months to cause more rapid deterioration and indicate any long-term effects of seed maturity on storage life.

Harvest moisture content

Harvest moisture contents as functions of harvest date are shown for 1987 and 1988 (Fig. 4). In both years, the range of moisture contents spanned the entire range over which harvesting of rice seed could be expected. In 1988, the moisture contents obtained from the oven method were compared to those from the Motomco moisture meter (Fig.5). At the lowest and highest moisture contents, the agreement between the methods was quite good, but the oven measurements tended to give higher values for moisture content than did the Motomco at intermediate moisture contents. All data reported here are based on the oven technique. If necessary, the percentages can be adjusted according to Figure 5 to convert these to Motomco readings.

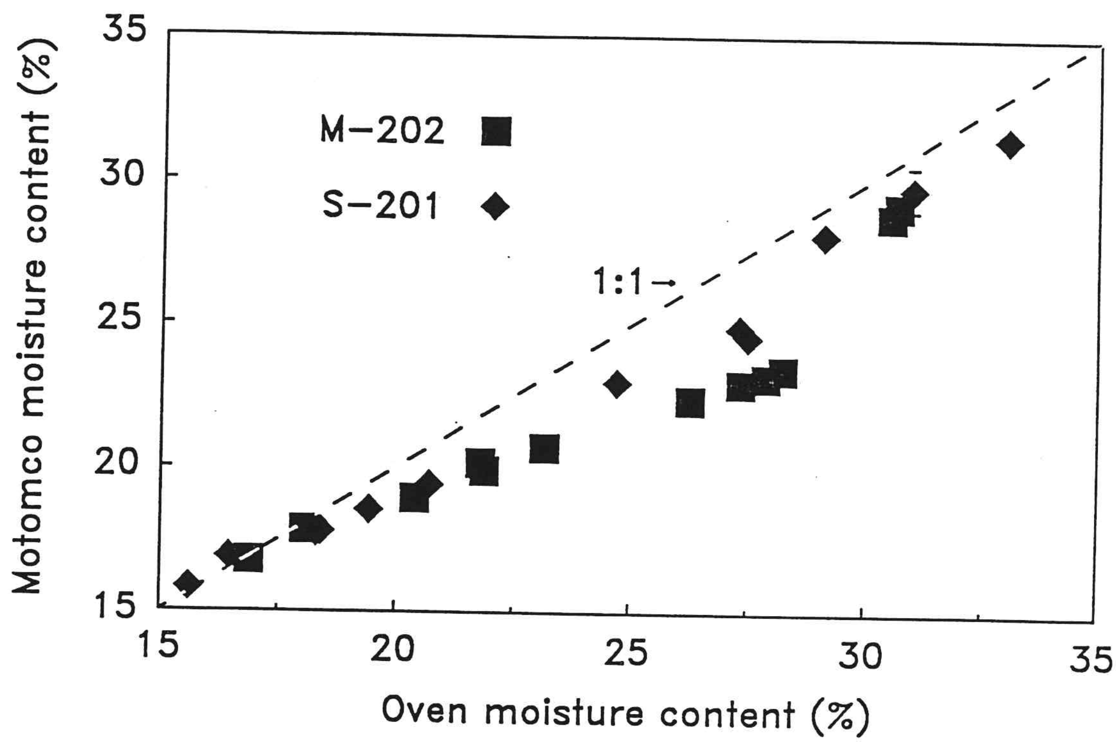

Figure 5. Comparison of seed moisture content readings based upon the oven method (6 hours at 130 °C) versus the Motomco moisture meter. The dashed line indicates the 1:1 line, where all the points would fall if the two methods agreed exactly. The deviation from the 1:1 line is due to somewhat higher readings from the oven method as compared to the Motomco.

Head rice percentage

Head rice percentages are known to decrease as the moisture content at harvest decreases. Our results confirmed this relationship, with L-202 being more sensitive than M-201 (Fig. 6). In both cultivars, however, little decline in head rice percentage was observed above 20% harvest moisture content.

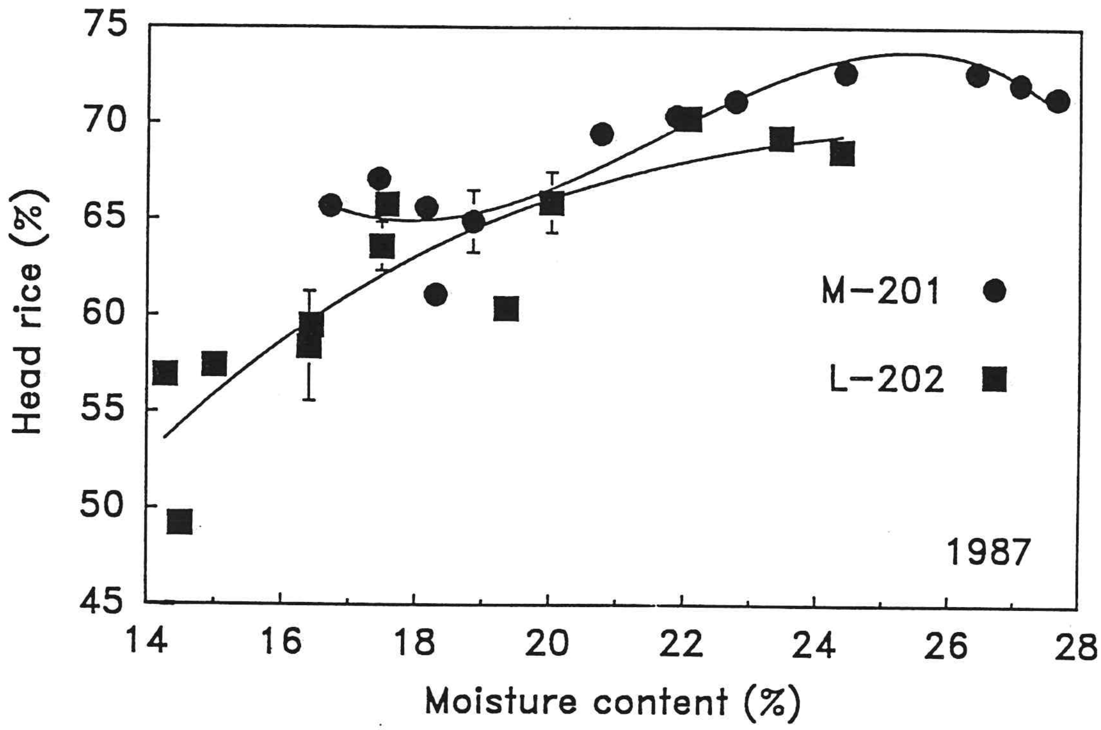

Figure 6. Head rice percentages as functions of harvest moisture content for M-201 and L-202. Standard errors are shown where they exceed the size of the symbols.

Seed vigor

Seeds harvested at the various moisture contents were subjected to the vigor tests described under Objective 1. An initial series of tests was done to determine whether there were significant block effects. None were detected, so composite samples were prepared using equal parts from each of the five field blocks. The seeds were then stored at 30 °C (86 °F) for 3 months to subject them to a uniform aging period, and they were retested. Few differences were detected before and after storage. The germination percentage increased slightly in M-201 lots harvested at high moisture content, and the seedling lengths increased by 10 to 15% for both

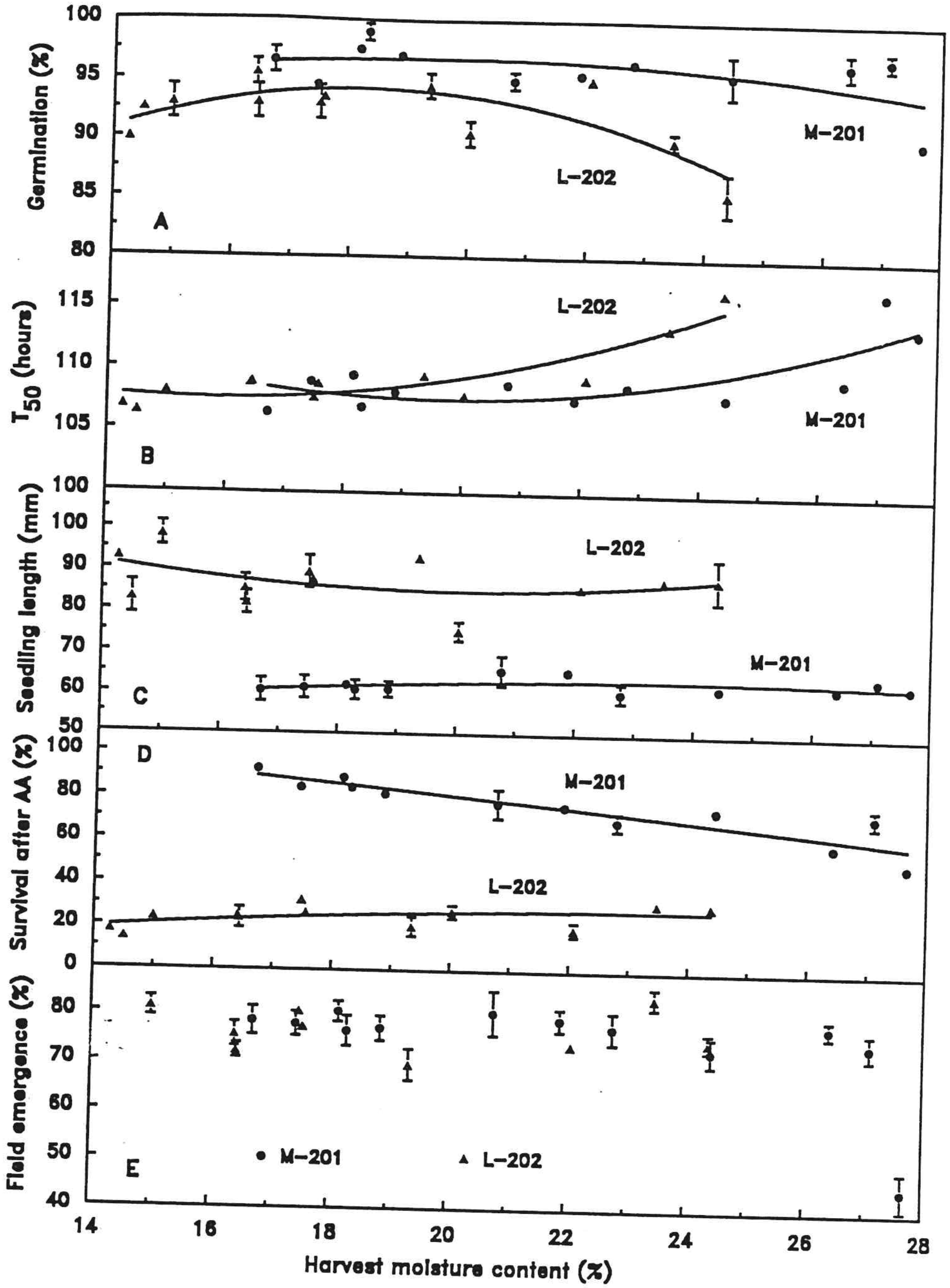

Figure 7. Seed vigor test results plotted versus harvest moisture content for M-201 and L-202. (A) Standard germination test. (B) Speed of germination (time to 50% germination at 20 °C). (C) Seedling length after 14 days at 20 °C. (D) Survival after accelerated aging for 20 hours at 45 °C. (E) Field emergence percentage. Standard errors are shown where they exceed the size of the symbols.

cultivars. The latter could be due to slight differences in the test temperature, rather than to an actual change in seed vigor, although a slight dormancy is sometimes evident in fresh rice seed. The remaining data shown will be on the stored seed.

Standard germination percentages decreased slightly for both cultivars at the highest harvest moisture contents, but were relatively unaffected below 27% for M-201 and 23% for L-202 (Fig. 7A). The rate of germination (T_{50}) exhibited a similar trend (Fig. 7B). Seedling lengths showed little variation with harvest moisture content for either cultivar (Fig. 7C). The cultivars had contrasting responses to AA, with the percent survival increasing with maturity for M-201, but decreasing for L-202 (Fig. 7D). L-202 was also much more sensitive to the aging conditions than was M-201. Field emergence percentages showed little variation with harvest moisture content, except for the highest moisture content of M-201 (Fig. 7E).

Conclusions

All of the tests except the AA test were fairly consistent with the field emergence trial, showing relatively little difference in seed vigor due to harvest moisture content below about 27% for M-201 and 22% for L-202. The AA test, which is related more to long-term storability and vigor under stress conditions, suggested that vigor continued to increase as moisture content decreased for M-201, but had an opposite trend for L-202. Taking all of the vigor results together with those for head rice, it appears that maximum seed quality has been achieved at moisture contents in the range of 22-24%. Further drying would yield only slight additional improvement in vigor, and increase the risk of mechanical damage during harvesting.

PUBLICATIONS OR REPORTS:

Bradford, KJ, ML Ransom, CM Wick. 1988. Relationship of harvest moisture content to rice seed germination and vigor. 22nd Rice Technical Working Group Meeting, June 26-29, 1988, University of California, Davis. (Abstract)

Bradford, KJ, ML Ransom, CM Wick. 1988. Relationship of harvest maturity to seed quality of rice (*Oryza sativa* L.). Agronomy Abstracts, p. 144.

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS:

The objectives of these studies were to develop methods of measuring rice seed vigor and apply them to determine the influence of harvest moisture content on rice seed quality. The seed vigor tests used, in addition to the standard germination test, were speed of germination, seedling length after 14 days, and accelerated aging (survival after submersion at 113 °F for 20 hours). Using seed lots of M-201 which varied in vigor, the standard germination test was actually the best predictor of field emergence percentages. However, among lots where germination exceeded 90%, the standard germination test was less effective in discriminating among lots which differed in field emergence performance. In this range of seed quality, the accelerated aging test provided an additional ranking which agreed fairly well with the field results. The speed of germination and seedling length tests showed relatively little variation among the seed lots and thus were not highly correlated with field emergence. When the same tests were applied to high-quality seed of a range of cultivars, none of the tests correlated well with field emergence. This may indicate that the differences in field performance were related more to cultivar characteristics than to seed physiological quality. Overall, the accelerated aging test appears to have promise as a supplement to the standard germination test. It should allow identification of seed lots which have high germination percentages, but relatively low vigor.

Studies to determine the influence of harvest moisture content on seed quality were completed for cultivars M-201 and L-202. As expected, head rice percentage decreased as moisture content fell below approximately 22% for both cultivars. Germination percentage reached a maximum at 27% for M-201 and at 22% for L-202. Further drying before harvest had little effect on germination or the other vigor parameters (seedling length, speed of germination). In the accelerated aging test, survival of M-201 seeds tended to increase as harvest moisture content decreased, while the opposite trend was observed with L-202. This suggested that delaying harvest might be advantageous for M-201, but not for L-202, if the seed are to be stored for a long time or planted under stressful conditions. Field emergence showed little variation due to harvest moisture content for either cultivar. An identical study is currently underway for cultivars M-202 and S-201. Based upon all of the data, including the head rice results, it appears that maximum seed quality has been achieved at moisture contents in the range of 22 to 24%. Further drying would yield only slight additional improvement in vigor, but with an increased risk of mechanical damage during harvesting.