

## DEVELOPMENT OF AUTOMATIC RICE CHECKER FOR MEASURING MOISTURE CONTENT AND MILLING YIELD

*F. Lu, T. Lin, Y. Lee, Y. Chen*

Department of Agricultural Machinery Engineering, National Taiwan University  
136 Chou-san Road, Taipei, Taiwan

**A b s t r a c t.** The development of an automatic rice checker for measuring rice quality, in terms of moisture content, bulk density, and milling yield, has been getting much attention. The machine corrects human subjective judgment in grading paddy that is purchased from rice growers by rice mills or farmers' associations in Taiwan.

The dimensions of the automatic rice checker, developed in 1992, are 1150 x 800 x 1966 mm. It consists of rice huller, moisture meter, weighing device, pneumatic sorter, air compressor, vertical conveying system with a bucket, actuator, and power screw, and microprocessor.

It takes about 1 min and 30 s to complete the whole process, including two replications of hulling. The data of moisture content, weight of paddy and brown rice, and milling yield (ratio of brown rice to paddy) are shown on the display panel and then transmitted to a PC through RS-232C for further data processing.

The automatic rice checker is designed for local farmers associations, to avoid human bias in inspecting and grading the dried paddy that is handed in by rice growers. After several tests, the rice checker has proved to be accurate and efficient. The manufacturing cost of the rice checker is about US\$ 5 000.

**K e y w o r d s:** automatic rice checker, moisture content, milling yield, rice

### INTRODUCTION

Accuracy in grading is necessary, because of a price differential between designated grades. In most paddy purchasing centers and rice markets the grain is inspected and tested to evaluate its quality and to grade the grain to different classes. In some rural areas, this inspection simply means that the

buyer picks up a handful of paddy, looks at it, blows through it to check for chaff, and feels or bites it to check for moisture. This subjective evaluation is not a sound basis for decision, and often leads to problems between seller and buyer. At the other extreme, international rice sales are based on clearly defined standards and grades determined by scientific methods and equipment. Between these extremes is a variety of individual testing equipment suitable for paddy and rice testing and grading laboratories [6].

Song [4] made an extensive report on methods of grading and testing rice quality for rice breeders. These indices for rice quality are milling quality, grain appearance, and cooking and eating quality. Webb [5] reviewed the criteria of rice quality in the United States and stated that some of the factors affecting the grade of rice, include grain type, chalkiness, and milling yields. Other significant factors involved in establishing rice grades include moisture, degree of milling, color, dockage (impurities), damaged grains, red rice, odors, and seed or grains of any plant other than rice. In evaluating rice quality, there are six grades in the U.S.A., four grades in Japan, and three grades in Taiwan.

For the rice milling industry, it is rather

important to know the potential milling yield of paddy before deciding to purchase grain from an individual rice grower. Lee [2] indicated that quantity and quality of potential milling output (head and broken rice yields) of a stock of paddy can be assessed before milling by visual and empirical examination of the paddy. This assessment calls for testing devices that simulate the results of the commercial milling process in the smallest space and in the shortest time.

Bauwin and Ryan [1] pointed out that the major problems in grading grain are accuracy (closeness with which the measurement approaches the true value) and precision (repeatability of the measurement) of values obtained for the various grading factors and for the grade designation. Accuracy and precision are affected mainly by the following sources of variation: type of sampling device, sampling procedure, grading factors such as machine-determined values and manual-determined values (human judgment), and sample homogeneity (inherent). The range of variation can be ascertained by repeating the analysis many times with the same sample.

The official inspection of grain by an authorized inspection agency is mandatory in Taiwan. All lots of grain that are offered for sale to the Food Bureau must be graded by an individual who is licensed by an official agency. In actually grading a lot of grain, a quantitative value for each of various specific factors such as moisture, test weight, heat damage, etc., is ascertained and, on the basis of these and other criteria, a grade is designated.

Official inspection personnel are defined as employees of governmental agencies or farmer's associations or other persons licensed to perform all of the official specified functions involved in rice inspection. After a lot has been sampled and graded, licensed or authorized personnel will issue grain-inspection certificates attesting to grades and other factors of the grain they inspect. This certificate is usually attached to the in-

voice and to other documents. The certificate conveys direct evidence of the official grade of the grain delivered. This practice is a protection to both the buyer and seller and tends to prevent controversy.

In Taiwan, to receive an inspector's license, the individual must pass a written and practical examination given by the Provincial Food Bureau. The large number of inspections are labor intensive and tedious, even when they are assisted by use of the individual equipment or instruments. It is deemed necessary to combine several pieces of testing equipment or instruments into one objective and accurate rice quality checking unit for handy operation of the rice quality evaluation. The development of an automatic rice checker for measuring rice quality, in terms of moisture content, bulk density, and milling yield, has been getting much attention. Such a machine corrects human subjective judgment and speeds the evaluating process in grading paddy.

The objective of this study was to develop an automatic rice checker for local farmers' associations to avoid human bias in inspecting and grading the dried paddy that is handed in by rice growers.

## MATERIALS AND METHODS

### Application of automatic rice checkers

In most paddy purchasing centers, rice drying centers, country elevators, and rice markets the grain is inspected and tested to evaluate its quality. In Taiwan, paddy can be sold to drying centers or farmers associations as fresh grain, immediately after mechanical harvesting, or as dried grain of moisture content below 13%. The harvested paddy should be dried from 23% to 13% moisture content in order to implement the quality evaluating process. Paddy grading specifications of the Provincial Food Bureau are listed as follows: moisture 13% or less, foreign materials 0.5% or less, other alien grains 6% or less, test weight for grade one 55.4 kg/hectoliter or more, test weight for grade two 53.2 kg/hectoliter or more [3].

Figure 1 shows a typical flow chart for modern rice drying and milling centers that incorporate an automatic rice checker and a data-managing system that exchanges information among rice mills, farmers' associations, and the Food Bureau in Taiwan. The rice automatic checker provides objective rice quality information for the grading process and sends the quality data to the computer center of the rice mill, the farmers associations and the Food Bureau for subsequent administration processing.

Grain can be tested for variety, size, shape, uniformity, damage, chalkiness, odor, and admixture of other grains and seeds. All these characteristics determine the quality of the sample and how the sample stands

against grades or standards. Despite the many scientific methods available for evaluating paddy and rice quality, some important characteristics must still be determined subjectively. For example, no practical inexpensive objective method or instrument exists for measuring odor, flavor, taste, and texture. Instruments for measuring color are expensive and cannot be used to test other factors such as damaged grains, which influence color [6].

It is a common, convenient, and acceptable practice between rice grower and buyer to judge rice quality by examining brown rice. If one is not considering chalkiness, flavor, and colored or damaged grain, there is a correlation between milling

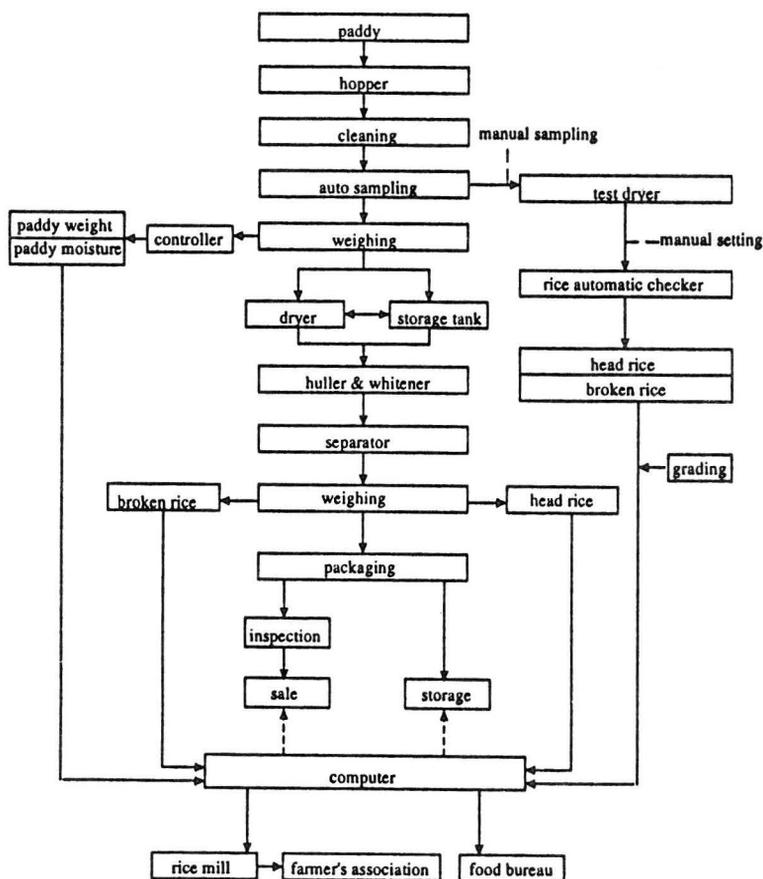


Fig. 1. Typical flow chart for a modern rice drying and milling center.

yield and other grain qualities. Rice flavor checkers and damaged grain checkers are available in Japan. In considering cost and efficiency, most of the automatic rice checkers used in Japan only measure the output of brown rice milled from a sample paddy of standard moisture content. Figure 2 shows the flow chart of an automatic rice checker made by the Japanese Satake Company. This kind of rice checker is suitable for the need of rice mills to determine milling yield in a short time.

### Design of the automatic rice checker

The automatic rice checker developed in this study aims to provide local farmers associations with a reliable, inexpensive, simple, easy, and time-saving tool to inspect and grade the dried paddy, in order to avoid human bias. The rice qualities inspected and

processed by the rice checker are moisture, test weight, and brown rice milling yield.

Figure 3 shows a flow chart of the rice checker. The equipment of the rice checker includes a digital scale for weighing, a digital conductance moisture meter for measuring moisture content, a vertical disk sheller for hulling, a blower for separating brown rice from husks, a PC-286 for data processing and displaying, and an air compressor and conveying system for transporting the rice sample from one part of the equipment to another. The conveying system consists of a hopper, vertical power screw table, air cylinder, sample bucket, and grain discharging tube. The paddy quality data can be transmitted to a remote computer through RS-232C for record keeping and invoice issuing and other managing treatment.

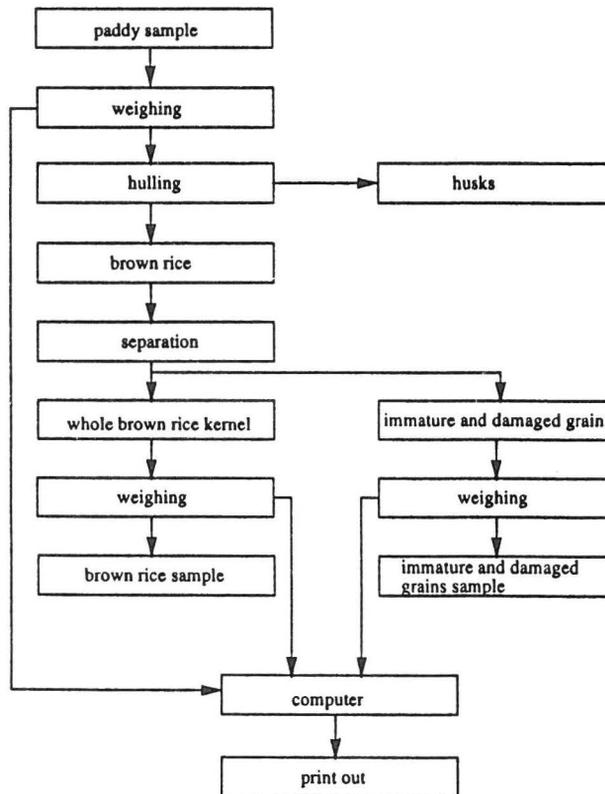


Fig. 2. Flow chart of a rice checker made by the Japanese Satake Company.

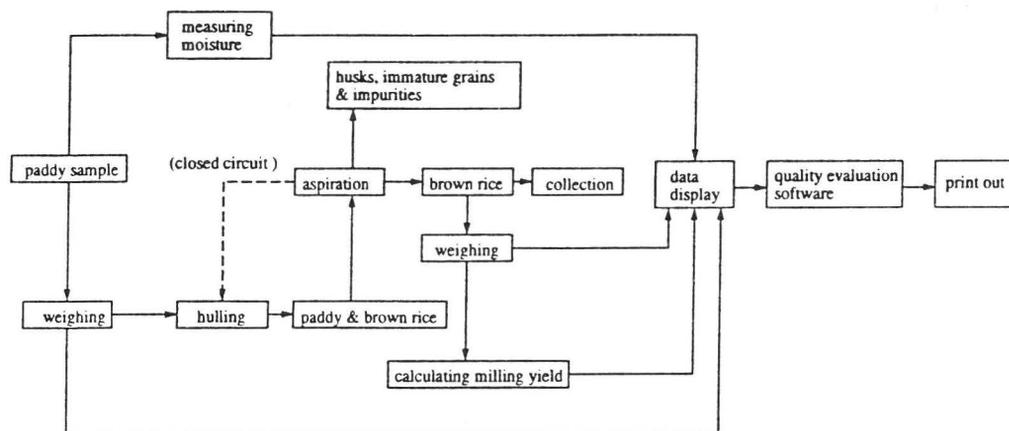


Fig. 3. Flow chart of the automatic rice checker.

The automatic rice checker measures 1150 x 800 x 1966 mm, as shown in Figs 4 and 5. A panel with push buttons for choosing the number of repetitions of closed-circuit hulling, automatic processing, manual processing, and independent specific functions of the checker is located in front of the checker.

#### RESULTS AND DISCUSSION

The automatic rice checker as shown in Figs 4 and 5 has been developed and tested successfully. It takes about 1 min and 30 s to complete the whole process, including two replications of closed-circuit hulling. The data of moisture content, weight of paddy and brown rice, and milling yield (ratio of brown rice to paddy) are shown on the displaying panel and then transmitted to a PC through RS-232C for further data processing.

A dried paddy sample of 100-300 g (of moisture content 10-16 %) is required for each quality evaluation. The operating sequence of the rice checker is illustrated by numbers in circles in Fig. 4 and is explained as follows:

1. The paddy sample is discharged into paddy inlet hopper.

2. About five to ten paddy kernels are collected by the moisture-sensing device. The sensor consists of a circular disk and a

pressing ram actuated by the cylinder. The moisture is determined when the paddy is pressed against the circular disk for 5 s. After measuring, a high-speed air jet blows the crushed paddy away from the circular disk.

3. The paddy from the inlet hopper drops to the holding bucket (at position 2) through the discharge tube. The bucket is actuated by another cylinder to move forward and backward.

4. The bucket (at position 1), which is filled with paddy, sits on top of the scale for weighing.

5. The bucket moves upward by means of the pushing force of the clockwise rotation of the power screw table and dumps the paddy into the inlet hopper of the huller.

6. The bucket moves downward to the discharge outlet of the huller by means of the pushing force of the counterclockwise rotation of the power screw table and picks up clean brown rice. The brown rice and husk fall through an air stream that permits the brown rice to drop through while the air picks up the immature grains and husks. If the hulling process is set for more than one time, the bucket will move upward and dump the brown rice into the huller for a second process of hulling. After the preset closed-circuit hulling is completed, the bucket moves backward and downward to the scale to

weigh the brown rice.

7. After the brown rice is weighed, the bucket moves upward again to bucket position 3 and dumps the brown rice into a hopper located below the blower. The brown rice is then discharged to the brown rice outlet for collection and visual or other inspections if necessary. After emptying the brown rice, the bucket moves backward and downward to a location above the scale and is ready to receive another new paddy sample for next run of the operation.

The accuracy and precision of measuring paddy moisture is shown in Fig. 6. The paddy moisture was around 14.5%. The measuring error was determined by testing

the sample with another calibrated digital conductance moisture meter. The moisture measuring errors were between 2% and 5% in test of ten samples. The error will be further decreased if the moisture measuring process is repeated more than two times instead of making only one measurement for each sample. The weighing precision of the paddy is quite acceptable, as shown in Fig. 7. The brown rice milling yield is around 80% for the same stock of paddy tested.

The automatic rice checker is designed for local farmers associations, to avoid human bias in inspecting and grading the dried paddy that is handed in by rice growers. After several tests, the rice checker has proved

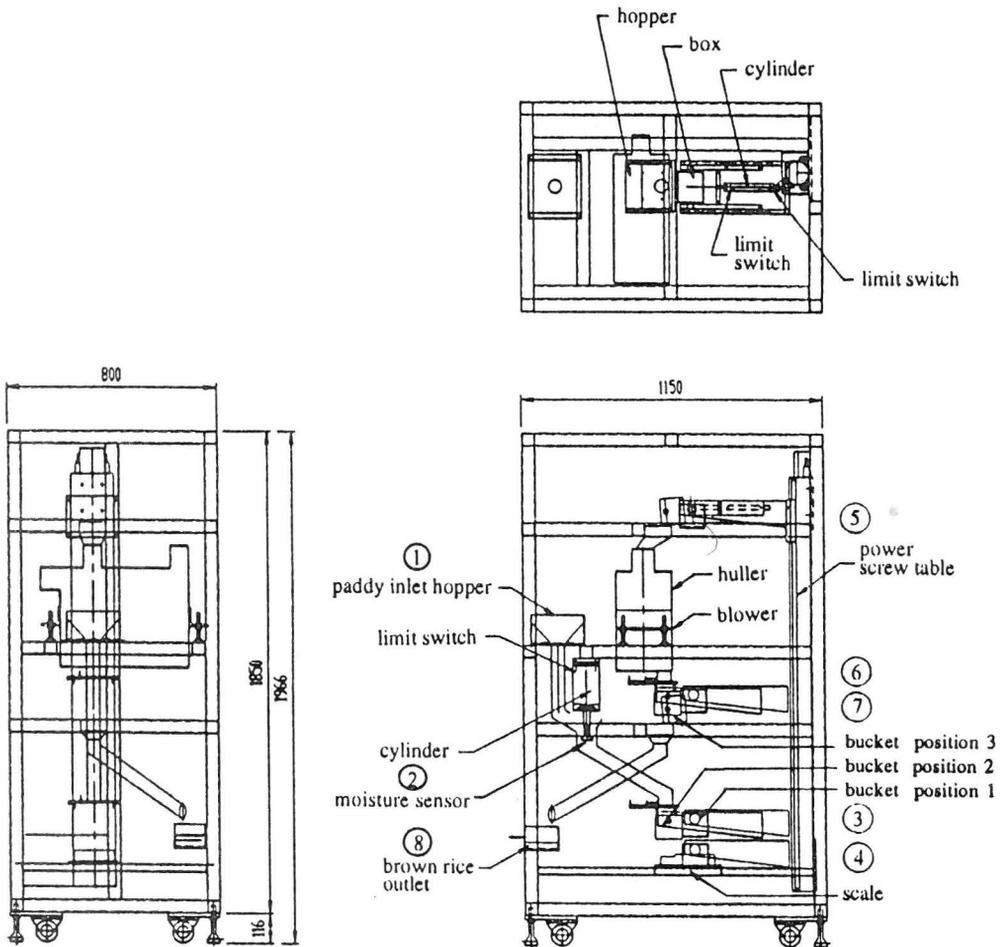


Fig. 4. Major dimensions of the automatic rice checker (mm).

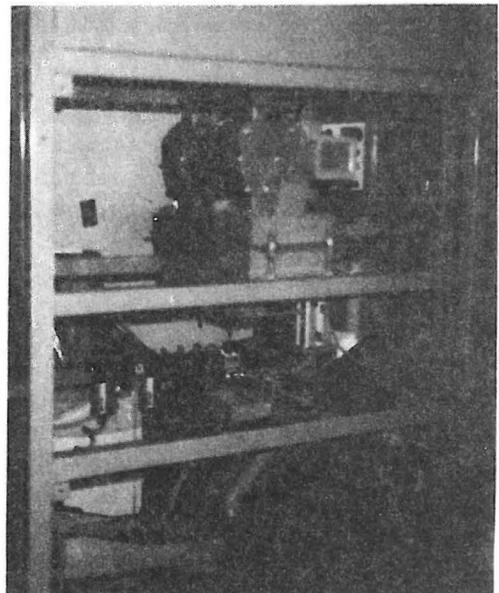
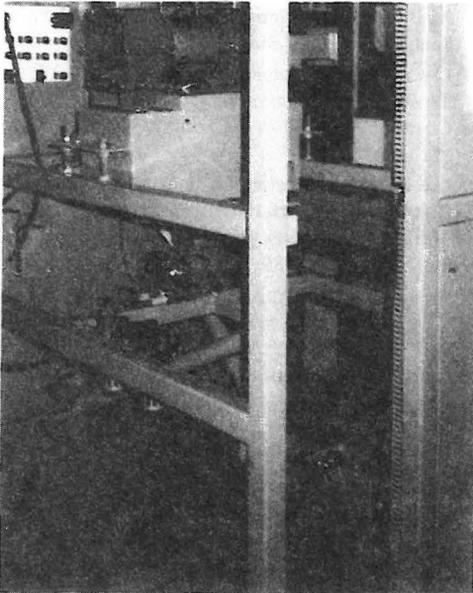
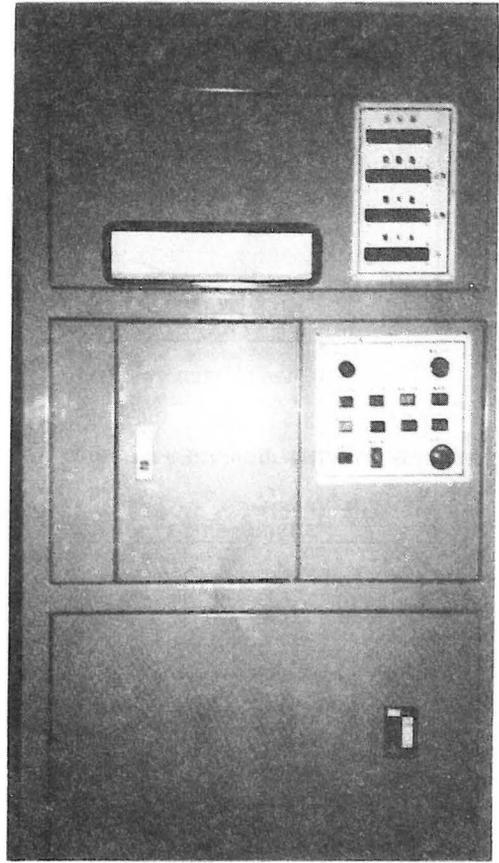
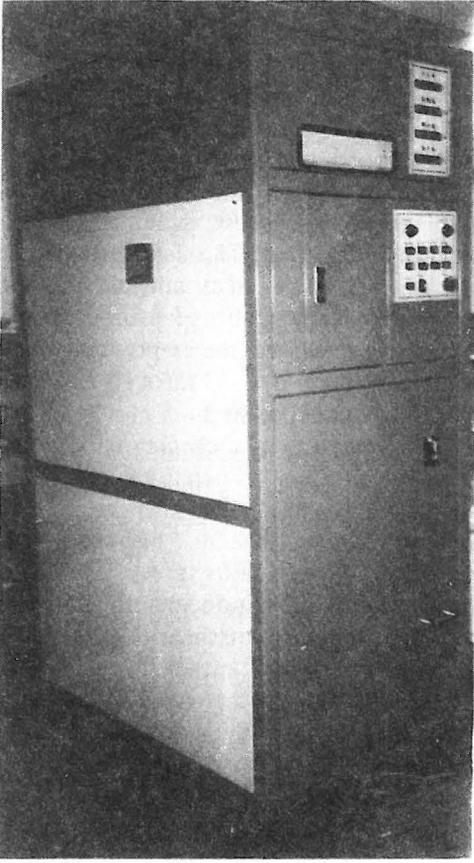


Fig. 5. The automatic rice checker.

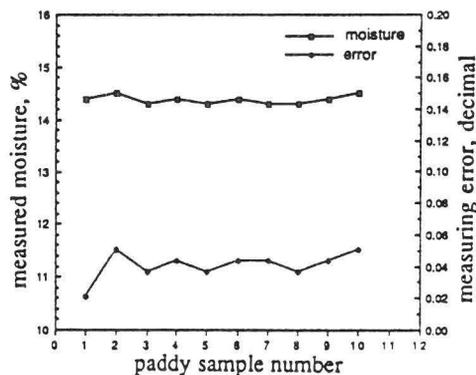


Fig. 6. Accuracy and precision of the moisture measurement of the automatic rice checker.

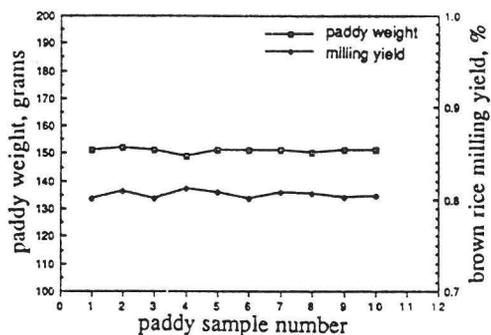


Fig. 7. Precision of the measurement of paddy weight and milling yield of the automatic rice checker.

to be accurate and efficient. The cost of the rice checker is intended to be less than US\$ 5 000; it is rather inexpensive in comparison with commercial automatic rice checkers available in the market.

### CONCLUSIONS

The development of an automatic rice checker for measuring rice quality, in terms of moisture content, bulk density, and milling yield, has been getting much attention. The machine corrects human subjective judgment in grading paddy that is purchased from rice growers by rice mills or farmers associations in Taiwan.

The dimensions of the automatic rice

checker, developed in 1992, are 1150 x 800 x 1966 mm. It consists of a rice huller, moisture meter, weighing device, pneumatic sorter, air compressor, vertical conveying system with a bucket, actuator, and power screw, and microprocessor.

It takes about 1 min and 30 s to complete the whole process, including two replications of hulling. The data of moisture content, weight of paddy and brown rice, and milling yield (ratio of brown rice to paddy) are shown on the display panel and then transmitted to a PC through RS-232C for further data processing.

The automatic rice checker is designed for local farmers associations, to avoid human bias in inspecting and grading the dried paddy that is handed in by rice growers. After several tests, the rice checker has proved to be accurate and efficient. The manufacturing cost of the rice checker is about US\$ 5 000; it is rather inexpensive in comparison with commercial automatic rice checkers available in the market.

### REFERENCES

1. **Bauwin G. R, Ryan H. L.**: Sampling, inspection, and grading of grain. In: *Storage of Cereal Grains and Their Products* (Ed. C.M. Christensen). The American Association of Cereal Chemists, Inc., St. Paul, Minnesota, U.S.A., 1974.
2. **Lee K. W.**: Management of the rice mill. In: *Post-harvest Preservation of Paddy/Rice Loss* (Ed. The Council of Agriculture). Executive Yuan, Republic of China, 1986.
3. **Lee K. W.**: The rice milling industry in Taiwan. In: *Post-harvest Preservation of Paddy/Rice Loss* (Ed. The Council of Agriculture). Executive Yuan, Republic of China, 1986.
4. **Shiun Song**: Grading and testing for rice quality. In: *Post-harvest Preservation of Paddy/Rice Loss* (Ed. The Council of Agriculture). Executive Yuan, Republic of China, 1986.
5. **Webb D. B.**: Criteria of rice quality in the United States. In: *Rice: Chemistry and Technology* (Ed. B.O. Juliano). The American Association of Cereal Chemists, Inc., St. Paul, Minnesota, U.S.A., 1985.
6. **Wimberly J. E.**: Technical Handbook for the Paddy Rice Postharvest Industry in Developing Countries. International Rice Research Institute, Los Banos, Laguna, Philippines, 1983.