NATIONAL INSTITUTE OF CROP SCIENCE (NICS)
Tsukuba, Ibaraki 305-8518, Japan.

Flour particle size selection for high flour yield lines of hexaploid wheats in CIMMYT ~ A collaboration work between the Japan International Research Center for Agricultural Sciences (JIRCAS) and CIMMYT wheat-breeding programs.

Hiro Nakamura (NICS, JIRCAS) and Richard Trethowan (University of Sydney, CIMMYT).

Introduction. In order to strengthen the international competitiveness of Japanese domestically produced common wheat, improving flour-milling quality is essential. Also necessary is developing a high-quality product that will satisfy the demands of domestic consumers in many developing countries. To achieve these goals, high flour milling and high-yielding wheat cultivars must be developed. Hiro Nakamura (JIRCAS, now at NICS) hoped to breed high flour-milling quality and high-yielding wheat cultivars at CIMMYT for many developing countries and proposed this wheat-breeding project to CIMMYT in 2005. Improving both the international competitiveness of common wheat grown in developing countries and its grain quality to satisfy the demands of local milling companies is important, but the most important aspect of wheat quality is grain hardness, which is related to flour yield.

In the U.S., the particle size parameters of wheat flour have been analyzed by laser-beam diffractometry since the late 1980s, and the American Association of Cereal Chemists (AACC) technical committee on quality tests for wheat and flour reported the results of a study to determine wheat flour particle size parameters using this method (Gaines 1985; McDonald 1994). Wu et al (1990) measured flour particle size distributions by sieving and air classification. Additionally, it was reported that detailed particle size distributions could be easily determined using laser light apparatus (Devaux et al 1998). Flour yield also has a major affect on the quality of wheat-based bread and noodle products in Japan (Yamashita 1994). A previous report showed that the particle size index of soft cultivars of common wheat was significantly associated with the flour yield obtained by milling (Yamazaki and Donelson 1983). The particle size of wheat flour is known to be related to the hardness of the wheat kernel, which is an important factor in determining the functionality of wheat-based food products (Obuchowski and Bushuk 1980). Therefore, determining the relationship between flour yield after milling and flour particle size distribution using the laser light-diffraction apparatus is important.

Wheat that is used to produce breads and/or noodle must meet certain minimum requirements in terms of flour yield and protein content. The Wheat Breeding Institute is making great efforts to improve protein quality as part of Japanese wheat-breeding programs (Nakamura 1999, 2000). Flour yield is the most important technical and economic factor in milling and has a major influence on grain marketing. Improving the flour yield of commercial wheat cultivars will, thus, be of great importance in wheat-breeding programs all over the world. In addition to its nutritional importance, flour hardness has a significant effect on food processing during the manufacture of breads, biscuits, breakfast cereals, pasta, and udon products. The aim of the current study was to identify lines in CIMMYT wheat-breeding program with high flour yield using the flour particle size and/or the flour particle size distribution as an index of flour yield; as done previously in Japanese wheat-breeding programs (Nakamura 2005, 2006).

JIRCAS-CIMMYT research in wheat breeding at CIMMYT (JIRCAS proposal in 2005).
The activities in this project are as follows:

Develop high flour-milling and high-yielding wheat lines through breeding.

1. Screen wheat germ plasm with high flour-milling quality using the flour particle size distribution method.
   1) Evaluate CIMMYT wheat germ plasm by applying the flour-milling quality evaluation method.
   2) Screen and identify gene pools for high flour-milling quality using the CIMMYT gene-bank collections.
2. Select improved wheat lines with high flour-milling quality and high-yield.
   3) Accumulate high flour-milling quality genes in CIMMYT high-yielding cultivars by crossing (higher-yielding wheat lines × high flour-milling quality wheat lines).
   4) Evaluate and select improved wheat lines with high flour-milling quality and high yield (higher-yielding wheat lines × high flour-milling quality wheat lines) under field conditions in Mexico.

Expected results.

1. Identify wheat germ plasm with high flour-milling quality.
2. Develop wheat lines with high flour-milling yield and high grain yield at CIMMYT.

Materials and Methods. In total, 154 lines and cultivars of hard and soft, CIMMYT hexaploid wheat were examined in this study. The 154 wheat lines and cultivars were used in crossing at CIMMYT by Richard Trethowan; wheat breeding leader for rain-fed environments. The samples were cultivated during the same growing season in a wheat-breeding field. The wheat samples were passed through a Brabender Quadrumat wheat flour laboratory mill under constant temperature. The Brabender Quadrumat laboratory milling procedures are standardized in the CIMMYT wheat-breeding programs. The resulting flour samples were subjected to wheat quality analysis. In Japan, an air classifier was used to separate the flour samples. A standard-range laser instrument was used to measure particles, ranging in diameter from 0.9 to 209.7 μm, suspended in gas using low-angle light scattering from a helium-neon laser. For the laser measurements, 2-g samples were separated from 50–100-g flour with a spinning riffler and placed in air-tight vials.

Results and Discussion. In the previous study, flour yield was associated with the median particle size (μm), and the hard wheat cultivars with flour particle size distribution pattern III with one peak had a greater flour yield than those showing patterns II and I (Nakamura 2006). Therefore, the flour particle size of 154 lines and cultivars of hexaploid wheat from CIMMYT was investigated in relation to the median flour particle size, and the flour particle-size distribution pattern (I–III) as determined by laser diffraction. Hard and soft wheat cultivars are known to differ in flour yield after milling. This study demonstrated that hard and soft wheat cultivars also differed in median flour particle size and flour particle-size distribution patterns based on the results of air classification. The hard wheat samples differed from the soft wheat samples in terms of the median flour particle size based on the air classification results. The hard and soft wheat cultivars also showed different flour particle size according to the air classification.

By using wheat flour particle size distribution measurement (median particle size, mainly), high flour-yielding materials were selected among the 154 wheat lines and cultivars. The results indicate that median particle size is widely distributed in CIMMYT hexaploid hard wheats (Fig. 1). In total, 24 lines and cultivars possessed a median particle size of more than 100 μm, which was associated with high flour-yield (Fig. 1). Considering wheat cultivation, disease resistance and other quality items such as bread-making quality, 12 lines were selected for crossing and selection in the CIMMYT wheat-breeding program to develop high yielding wheat with superior milling quality. The 12 parents were crossed with high yielding materials producing 65 combinations at CIMMYTs Ciudad Obregon wheat breeding station in Sonora in February 2006. The particle size distribution analysis method could be used to identify lines with high flour-yield in early generation testing, as has been revealed in a previous study (Nakamura 2005, 2006). In this study, we could simply and quickly identify wheat genetic resources with high flour milling yield in a systematic evaluation of CIMMYT materials and crosses to high grain yielding lines were subsequently made the CIMMYT shuttle breeding system, which allows two generations per year, by growing nurseries at Obregon in northwestern Mexico and at Toluca in central Mexico, will allow these materials to be rapidly developed (Braun et al. 1996, Trethowan et al. 2007, Ortiz et al. 2007).

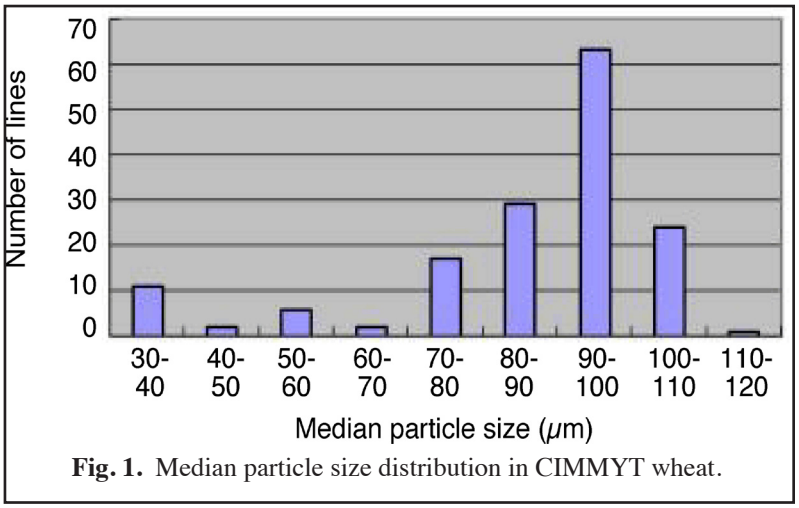

Fig. 1. Median particle size distribution in CIMMYT wheat.

Flour yield is a critical technical and economic factor in milling. The flour particle size distribution is another significant parameter that must be considered in the design, adjustment, and operation of a mill. In addition, particle size is an important indicator of the quality of high-ratio flour (Posner and Hibbs 1997). This new technique for the selection of cultivars suitable for bread production in the CIMMYT wheat breeding and quality evaluation program is easy to perform and does not require expensive equipment. The median flour particle size comprises a genotypic fingerprint that can be used for many purposes, including hard and/or soft wheat variety protection, registration, certification, and crossing, as well as functioning as a tool in wheat breeding. Although, the median flour particle size might not be the primary factors determining bread-making quality, they might be linked to other parameters that contribute to wheat quality and yield.

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Personnel.

Hiro Nakamura is now a senior scientist at National Institute of Crop Science in Japan since April 2007. Richard Trethowan is now a professor at University of Sydney in Australia since July 2007.