

(Format No. 3)

SUMMARY OF DOCTORAL THESIS

Name: **Md. Alamgir Hossain**

Title: MECHANISMS AND CAUSES OF POOR GRAIN FILLING IN WHEAT UNDER WESTERN JAPAN ENVIRONMENT

(西日本で栽培したコムギにおける登熟不良のしくみと原因の解明)

Summary: Grain filling is an important process, which determines the final grain weight, a major component of grain yield in wheat. The smaller grain weight as a result of poor grain filling, sometimes, become a major constraint for wheat production in Western Japan, which experiences much precipitation and hot humid summers. Three experiments were, therefore, conducted for this dissertation to elucidate the mechanisms and causes of poor grain filling in wheat grown in Western Japan.

In the first experiment, the grain filling mechanisms of two Japanese wheat cultivars, Daichinominori (Western Japanese cultivar) and Haruyutaka (Hokkaido cultivar), which differ in grain weight and yield in Western Japan, were examined over 3 seasons (2005/2006, 2006/2007 and 2007/2008). The experiment was conducted in both of their native areas, Yamaguchi of Western Japan and Hokkaido with a view to understand the mechanisms of poor grain filling in Haruyutaka under Western Japan environment. When grown in Western Japan, Haruyutaka had a lower grain yield due to smaller grains than Daichinominori and when grown in Hokkaido, Daichinominori had a lower grain yield due to smaller grains than Haruyutaka. The slower grain growth, especially, during the later period of grain filling was considered to be the major cause of smaller grain in both cultivars, but it was more pronounced in Haruyutaka grown in Western Japan. Average grain filling rate was higher in Daichinominori than in Haruyutaka in Western Japan while they possessed nearly similar rate in Hokkaido. Haruyutaka and Daichinominori ceased total dry mass production earlier when grown in the non-native area, Western Japan and Hokkaido, respectively, resulting in less supply of current assimilation products to grain growth. When grown in Western Japan, the amount of post-anthesis culm reserves, water-soluble carbohydrates (WSCs), was smaller in Haruyutaka than in Daichinominori, while they accumulated a similar amount of WSCs in Hokkaido. The pattern of remobilization of WSCs to the grains was similar in both areas. However, the grain-filling period was significantly shorter in the non-native area. These results suggested that in the non-native environment, the grain size is decreased due to slower grain growth, mainly due to less current assimilation, and shorter grain-filling period.

In the second experiment, the grain filling mechanism of abnormally early ripening (AER) wheat was investigated over 3 seasons (2004/2005, 2005/2006, and 2006/2007) in Western Japan. AER is a physiological disorder related to the production of smaller grains leading to lower grain yield that frequently occurs in wheat Western

Japan. We found a symptom of AER in a farmer's field in Yamaguchi of Western Japan, in 2004/2005, and examined its physiological mechanisms for two weeks until maturity. In the following two seasons, 2005/2006 and 2006/2007, the mechanisms throughout the grain filling period at another farmer's field, where the symptoms appeared in the preceding four seasons, were examined. The grain yield was lower in AER than in the normal because of smaller grain weight in 2004/2005. The grain weight and WSCs in culms were similar at the beginning of symptom, two weeks before maturity, then the grain weight increased and culm WSCs decreased more sharply in the normal than in the AER. So the grain weight was poorer and more culm WSCs remained unutilized at maturity in the AER. Another field showed the symptom of AER in both seasons. The spike dry weight and culm WSCs were the similar between the treatments from anthesis to milk ripe stage in 2005/2006, then they showed almost similar pattern in their change as in 2004/2005 until maturity. It was thought that the slower grain growth during the later phase might be due to limited current assimilation and poor remobilization of culm reserves to the grains in AER.

In the third experiment, grain filling in waterlogged wheat grown in Yamaguchi of Western Japan was investigated over 2 seasons (2008/2009 and 2009/2010) using wheat cultivars Daichinominori and Haruyutaka. The overwetting of the soil owing to the precipitation pattern in Western Japan was assumed to be a one of the causes for poor grain filling in AER wheat and in Hokkaido cultivar Haruyutaka grown in Western Japan; and therefore, this experiment was conducted. Pre-anthesis waterlogging for 2 weeks and post-anthesis waterlogging throughout the grain-filling period were imposed in the seasons, 2008/2009, and 2009/2010, respectively, for the study. Though pre-anthesis waterlogging slightly reduced grain weight, it had no significant effect on grain yield or grain filling irrespective of cultivars. Post-anthesis waterlogging severely reduced the grain yield by 44% and 36% in Haruyutaka and Daichinominori, respectively. The yield loss was attributable to the smaller grain weight that was a result of slower grain growth rate later in the shortened grain-filling period. Post-anthesis waterlogging induced sudden leaf senescence 1 and 2 weeks after anthesis in Haruyutaka and Daichinominori, respectively, and drastically reduced the photosynthesis and ultimately dry mass accumulation. It also depressed the remobilization of WSCs from culms to grains leaving more residual WSCs in the culms at harvest in both cultivars. The impacts of waterlogging on grain filling were severer in Haruyutaka than in Daichinominori. The results indicate that the reduced grain growth at later grain filling due to waterlogging was attributable to decreased current assimilation and poor remobilization of culm WSCs to grain similar to that in AER plants. The results also indicate that the poor grain filling in Haruyutaka under Western Japan environment in previous studies might be associated with over-wetting of the soil especially during grain filling period.

In conclusion, poor grain growth during the later part of grain filling with a shorter grain-filling period resulted in a smaller grain in Haruyutaka and AER plants in Western Japan. Fewer contributions of both current assimilation and culm WSCs to the grain growth led to a poor grain filling. Overwetting of the soil during grain filling might be one of the significant causes of poor grain filling in wheat in Western Japan.