PHYSIOLOGICAL ASPECTS OF THE RESPONSES OF GRAIN FILLING TO HIGH TEMPERATURE IN WHEAT

by

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Abstract

High temperature during grain filling is one of the major limitations for grain yield in many wheat growing areas. The effects of a sustained period of moderately high temperature on physiological and biochemical aspects of grain development were investigated in wheat cultivars grown under controlled environment conditions. The effect of variation in plant nutrition on the response of cultivars to high temperature was also studied. The plants were grown in pots in a growth cabinet set at 20/15°C. After anthesis, half of the pots were shifted to another growth cabinet set at 30/25°C and the rest of the plants were kept at 20/15°C as control. The supply of nitrogen to the grains was altered either by changing the level of nitrogen applied to the plants or by trimming of the ears.

There was a substantial reduction in individual grain weight ranging from 21 to 40% at the higher compared to the lower temperature. Genotype variation existed for both rate and duration of grain filling but the variation was small for the duration at high temperature. There was a small increase in the rate of grain filling in response to an increase in growth temperature. The small positive response of the rate of grain filling was not associated with the availability of sucrose in the grains. Nor was the differential response of the two cultivars in response to temperature associated with the changes in the level of sucrose or in the amounts of the precursor of starch synthesis, ADP-glucose, in the grains.

The affinity of soluble starch synthesis (SSS) for its substrate amylopectin, and the efficiency of the enzyme were decreased at high temperature *in vitro*. The differential

responses of the efficiency of SSS in Kavko and Lyallpur to an increase in temperature *in vitro* accounted to some extent for differences in the temperature sensitivity of grain filling. However, the most remarkable difference between the two cultivars *in vivo* was in the absolute values of the SSS efficiency as the values were greatest in the more tolerant cultivar Kavko. Compared to SSS the activity of granule bound starch synthase (GBSS) was less sensitive to high temperature. The activity of SSS was substantially lower at later stages of grain development but there was little developmental change in the activity of GBSS.

The variation in nitrogen supplied to the plants modified the response of the cultivars to temperature. Only at the standard level of nitrogen (which treatment included post anthesis nitrogen application) was the reduction in final grain weight at high temperature greater in Lyallpur than in Kavko; there was no difference between the two cultivars at low nitrogen. The effect of nitrogen on the differential responses of cultivars to temperature was due to its effect on starch weight and the effect was significant only for amylose but not for amylopectin. The difference between the two cultivars in terms of the rate of grain protein accumulation in response to temperature was also dependent on the level of nitrogen.

Trimming of the ears increased the weight of the remaining grains only in Lyallpur and not in Kavko. The increase in grain weight in the trimmed ears was associated with a simultaneous rise in the rate of grain filling. However, trimming did not significantly influence the response to high temperature. It seems that trimming does not alter the delivery of sucrose to the grains but instead appears to influence processes in the pathway of the conversion of sucrose to ADP-glucose. The efficiency of SSS was greater in the

trimmed than in the untrimmed ears but there was no straightforward relationship between grain filling rates and efficiency of SSS.

The composition of protein and starch were influenced by high temperature. The contribution of the HMW-glutenin was substantially higher at high temperature and also at the standard compared to the low level of nitrogen. However, the effect of the nitrogen level on the temperature response of HMW-glutenin was not big enough to be statistically significant. The grain amylose% was higher at high temperature only in Kavko. The increases in amylose% at high temperature were evident at low but not at the standard level of nitrogen.