Variation in the susceptibility of wheat to high temperature

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Wheat is a temperate cereal in which high temperatures during nearly all stages of growth can limit yield and make it a less competitive crop for warmer environments. High temperatures late in the development of the crop are not uncommon in the Australian wheat belt and the increasing use of wheat as an irrigated crop, when this is used to extend the normal growing season, or as an alternate summer crop, will increase the need for cultivars with a low sensitivity to high temperature. Genetic variation in the effect of temperature on yield is often difficult to isolate under field conditions, because of parallel variation in other environmental factors. For this reason a programme was initiated in the Canberra phytotron to examine the sensitivity to high temperature of a diverse range of cultivars.

Methods

Selected wheat cultivars were screened at three stages of development 1. Ear growth (flag leaf emerged to ear emerged) 2. Pollination (ear emerged to 4-6 days after anthesis) 3. Grain development (6 days after anthesis to maturity), and under three sets of temperature conditions (18/13?C, 24/19?C and 30/25?C - day/night). Plants (limited to single culms) were grown in 8 cm diameter tubular pots at 18/13?C until transferred to a specific temperature treatment and then subsequently returned to 18/13?C conditions until maturity. Crain dry weights and grain number per ear were determined at maturity.

Results and discussion

Over 40 lines tested to date include not only Australian bread wheats, but also English and Swedish cultivars and lines collected from more appropriate environments in Morrocco, Iran, Turkey and India, as well as several tetraploid durum wheats.

Galyansona (see table), which is grown widely in the hotter areas of India was no more stable, in relative terms, to high temperature than many of the other cultivars, but with a high grain weight per head under optimal conditions was still one of the best yielders at high temperature. Each result is the mean of 20 replicates ? se.

Temperature	Stage of development	Grains per head	Weight per grain (mg)	Grain weight per head (g)
18/13	All stages	67.6±1.0	43.0±0.4	2.903±0.04
30.25	Booting	50.6±1.8	45.0±0.4	2.272±0.08
30/25	Anthesis	69.8±1.0	42.1±0.4	2.934±0.05
30.25	Grain growth	62.3±1.4	32.5±0.6	2.025±0.06

An analysis of seven of the parental lines used in breeding Galyansona showed that they are all sensitive to high temperature during grain development and the overall depression of yield of 37% with the rise in temperature from 18/13 to 30/25?C was largely explained by a drop in 1000 grain weight. There is considerable variation in the effect of high temperature during ear development (booting) on yield in these parental lines with Timstein and Gabo being relatively stable and Brevor extremely sensitive. However the overall depression of yield per head with a rise in temperature from 18/13 to 30/25?C of 38% was similar to the reduction during grain development, but in this case the effect was largely explained by a drop in grain number. In two of the durum wheats tested grain number was insensitive to temperature during booting. In only one line (the bread wheat Halloran 757, collected from Afghanistan) was there stability to high temperature during grain development.

It would appear that improved cultivars for high temperature regions might be developed by combining the traits of high grain numbers and large grains with a greater degree of temperature stability and possibly hybrid vigour has a role to play in this area.