Solutions to haying-off in wheat

A.F. van Herwaarden and R.A. Richards
CSIRO Plant Industry, GPO Box 1600, Canberra, ACT 2601.

The aim of this trial was to test the growth and yield of reduced tillering wheats in the southern Mallee

Background

Wheat growers in southern Australia must supply sufficient, but not excessive, nitrogen to wheat crops to boost yield to the water-limited optimum and to profitably boost grain protein. The variability of rainfall, amount and distribution, results in highly variable responses to supplementary nitrogen fertiliser. Dryland cultivation of high-protein bread wheat and high-protein durum wheat carries a risk of over fertilisation, leading to haying-off and substantial economic loss. This additional risk stifles growers decision making with respect to supplementary nitrogen fertiliser.

Haying-off is the premature cessation of grain filling associated with post-anthesis drought. It follows vigorous vegetative growth stimulated by high soil nitrogen and typically results in low yield and pinched (shrivelled) grains. This pinched grain usually results in wheat loads not meeting silo receival standards due to high screenings and low hectolitre weight. Seasonal conditions in recent years has produced widespread haying-off with associated downgrading of crops due to high screenings. Haying-off is likely to be a continuing problem in southern Australia with current freely tillering cultivars.
Our research has confirmed that haying-off is associated with reduced post-anthesis growth in response to a lack of water supply. We found, however, that the amount of stem sugars present in high-nitrogen crops at anthesis was less than in low-nitrogen crops, despite there being more growth. The lack of these stem sugars, available for transfer to the grain, was most responsible for the yield reduction and pinched grain of the crops of high N-status.

In environments with inhospitable subsoils such as waterlogged duplex soils (Western Australia), high bulk density or impermeable layers (Eyre Peninsula, South Australia) and boron toxicity or sodicity (South Australia and Victoria) high levels of stem sugars may be of even greater importance when a lack of spring rainfall results in an abrupt end to the season due to the shallow depth of soil available to store water. This lack of soil water reduces post-anthesis growth and crops become more reliant on stem sugars to fill grain.

New wheats are now available which could improve yield stability at high nitrogen status and remove some of the risks and increase returns to growers trying to meet market demand for high protein wheat. These new wheat may resist haying-off by increasing storage of stem sugars. One of the ways this may be achieved is by reducing the amount of structural biomass produced by anthesis through reduced tillering. Several reduced tillering wheats are being compared to current varieties in field experiments managed to vary nitrogen status.

Method

Trial established at Birchip. Existing wheat varieties were compared to reduced tillering lines, in a situation of low and high N. Urea was predrilled on half of the plot area at 80 kg/ha (37 kg N/ha). Plots were sown on May 29 and the seeding rate was adjusted for each wheat line to establish similar plant densities. MM1 was drilled with the seed at 80 kg/ha (16 kg P, 8 kg N, 1.6 kg Zn).

The new lines used were:

974/949-3	selection from a cross between two reduced tillering wheats (from CIMMYT, Mexico). Flowering time is similar to Janz, and its yield is similar to other commercial varieties.
950	reduced tillering wheat from CIMMYT. Flowers earlier than Janz, and yielded higher than Janz in 1997 trials.
Janz/BKU hh#2	cross between Janz and a reduced tillering form of Banks. It flowers earlier than Janz and yielded higher than Janz in 1997 trials.

Results

The reduced tillering line 974/949-3 was badly affected by a problem known as stunting which, in some reduced tillering lines, results in a proportion of whole plants or tillers failing to elongate and produce grain. The high level of stunting can be inferred from the low spike density for this line (Table 3.6). It is uncertain whether the Janz/BKU line is a reduced tillering wheat or not since it produced as many spikes as the conventional cultivars in this environment.

At flowering there was a large response to nitrogen of about 1.5 t/ha for all wheats. The breeding lines except 974/949-3 had similar biomass to the cultivars at both levels of nitrogen. By maturity Frame appears to have produced the greatest biomass at both levels of nitrogen presumably due to its boron tolerance, and 974/949-3 the least biomass due to the high incidence of stunting. The other 4 wheats produced similar biomass to Frame with only 950 performing poorly at low nitrogen. The increase in spike density in response to additional nitrogen was similar for all wheats but spike density was lowest for 974/949-3 and 950. Grain yield was similar for all wheats except 974/949-3 in which other yield components could not compensate for the effect of stunting. The advantage of the breeding lines (excluding 974/949-3) appears to be in larger kernel size which should make them less prone to problems with high levels of screenings.

Table 3.6. Crop attributes measured at flowering and maturity on wheat lines fertilised with or without nitrogen.

Crop attribute	Wheat line					
	Frame	Goldmark	Silverstar	Janz/BKU	950	974/949-3[A]
	Flowering					
Biomass (t/ha) -N	3.72	3.14	3.37	3.30	2.86	2.58
+N	4.82	4.78	4.65	4.73	4.77	4.00
	Maturity					
Biomass (t/ha) -N	6.16	5.95	5.34	5.70	4.60	2.95
+N	7.94	7.35	7.54	7.20	7.45	4.87
Spikes (sp/m^2) -N	235	246	212	269	177	100
+N	273	280	279	312	250	149
Yield (t/ha) -N	2.26	2.42	2.32	2.32	1.84	1.14
+N	3.10	3.19	3.40	3.13	3.05	2.04
Kernel wt (mg) -N	42.3	35.7	35.0	41.5	42.9	35.2
+N	42.6	38.8	35.9	42.5	46.2	38.0

[A] This line badly affected by stunting prior to stem elongation.

This project "Solutions to haying-off" combines management and breeding strategies to tackle the problem of haying-off across southern Australia. The research participants form a multi-disciplinary team working across public research institutions and wheat industry groups. The project involves field based investigations including laboratory analyses of crop nitrogen and stem sugars and crop water use efficiency. Research is under way to evaluate and select wheats which contain higher levels of stem sugars than are currently found in Australian cultivars. Wheats which vary in their accumulation of stem sugars will be sown in 1999 to confirm that accumulation of these reserves is positively correlated with grain yield in dry environments or environments where sub-soil constraints to root growth results in the rapid onset of drought during grain filling.