Effect of waterlogging on the growth of barley

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Abstract

Waterlogging tolerance is one of the important breeding objectives in high rainfall areas. For this purpose, a project was set up for exchanging germplasm with China where barley has been selected for waterlogging for centuries. Experiments were conducted in both Australia and China to evaluate the effect of waterlogging on the growth of barley. Varieties showed different tolerance to waterlogging with some Chinese varieties showing much better tolerance than Franklin and Gairdner.

Key Words

Barley, waterlogging tolerance, germplasm

Introduction

Barley is relatively susceptible to waterlogging (Wang et al, 1996), and can suffer severe damage. Bandyopadhyay and Sen (1992) reported more than 50 per cent loss in yield after 2 days and 80% loss in yield after 3 days of a super-saturation treatment after six weeks normal growth in a coastal saline soil. In higher rainfall areas of south-eastern Australia, waterlogging is a major problem. Most barley growing areas of Western Australia can also suffer severe waterlogging in winter. Thus, bringing tolerance of waterlogging into barley varieties becomes a very important breeding objective. A project was set up to exchange waterlogging tolerant germplasm with China, where barley has been selected for this for centuries. The preliminary experiments reported here were designed to study the effect of waterlogging on plant survival and health, and to screen varieties for tolerance to waterlogging.

Materials and method

Ten selected varieties (Table 1) were sown in stainless steel tanks during the 2002 summer at Mt Pleasant laboratories in Launceston. Starting from the 3-leaf stage, all the varieties were waterlogged by immersing to the level of the soil surface for one week. The green leaf area was measured immediately after 7 days waterlogging. The same varieties were sown in another tank for un-waterlogged controls. More than 500 barley lines (mainly from China) were sown at Yangzhou University, China during the 2001/02 growing season. Two replications were waterlogged twice (in winter - 3-leaf stage and spring - stem elongation stage), with one replication as a control. Each waterlogging treatment lasted two weeks. A chlorophyll content meter (SPAD-502) was used to test 150 selected varieties (50 tolerant, 50 susceptible and 50 medium tolerant) immediately after waterlogging. The total number of green leaves remaining at anthesis was recorded. Scoring of leaf yellowness was also done after the second waterlogging treatment, as this caused the most significant damage to susceptible varieties.

Results and discussion

In the glasshouse, waterlogging was observed to cause chlorosis in all varieties. The total green leaf area was also reduced for all the varieties (Table 1). Waterlogging during the 3-leaf stage mainly affected the growth of the later formed fifth and sixth leaves. Survival of older leaves was also a useful discriminator between varieties subjected to water logging. For example, while the first leaf of Franklin and Gairdner was completely dead, that of Sunong 22 (SN22) still had 30% green leaf. The Japanese variety Naso Nijo (NN) was most susceptible, while both Franklin and Gairdner were more susceptible than Chinese varieties.

Table 1 The percentage of total leaf area that was green, in waterlogged treatment, glasshouse study*

Variety	ZND3	YUQS	ZP1	Franklin	NN	YU0133	SN22	YNP2	YYXT	Gairdner
1st leaf	21.1	28.2	1.7	0.0	0.0	4.2	29.1	0.0	17.4	0.0
2nd leaf	40.0	76.3	34.4	19.7	9.3	35.2	53.7	33.9	73.9	19.7
3rd leaf	61.0	85.4	74.8	56.8	36.5	64.2	75.8	72.2	82.4	60.1
4th leaf	73.4	91.3	86.6	83.4	68.4	79.0	78.9	88.9	92.5	85.4
5th leaf	84.9	94.0	89.2	95.0	82.5	91.9	92.6	94.7	100.0	94.4
6th leaf	89.9	99.8	97.9	/	98.6	98.4	98.8	100.0	100.0	/

/: Leaf not yet emerged at the time of measuring**.**
* All leaves were 100% green in all varieties in the control (non-waterlogged) treatment.

In the field trial carried out in China, a reduction in leaf greenness and green leaf area also occurred on most of the 500 varieties in response to waterlogging (data not shown). The number of remaining green leaves was reduced in most susceptible varieties (Table 2). Some Chinese landrace and bred varieties from the lower Yangtze River area showed much better tolerance to waterlogging treatment, while most of the Australian varieties were susceptible.

Table 2 Effect of waterlogging on the number of green leaves per plant in the field experiment in China

Variety	Y89187	AZS	916269	96AC19-14	Namoi	Schooner	Franklin	Harring-ton	Stirling
Waterlogged	3.45	3.64	3.91	2.72	3.06	1.55	1.29	2.01	1.95
Control	3.58	3.84	3.95	4.03	3.65	3.1	3.73	2.98	3.57
% of control	96.4	94.8	99.0	67.5	84.8	50.0	34.6	67.4	54.6
Score of tolerance	1	1	1	2.5	2.5	3.5	3.5	4.5	4.5

Score of tolerance: 1 = most tolerant and 5 = most susceptible. All the varieties were visually scored immediately after the second waterlogging.

The chlorophyll content (CC) was measured at the completion of each waterlogging interval. In general, there were no significant differences between waterlogged plants and the controls after the first waterlogging treatment in winter. This is because the temperature was very low and high rainfall occurred (controls were also affected) during the period of the first waterlogging. However the second (spring) waterlogging treatment had a much stronger effect on the CC, with reductions of 34.4% in Franklin.

Results of the glasshouse experiment showed that heading date of all the varieties was delayed by 3 to 5 days after early stage waterlogging. However, the field experiment showed that when waterlogged during the later stages of growth (stem elongation in spring), the heading date of most varieties was earlier than the controls. Hamachi et al (1988) reported that heading dates of barley varieties were scarcely affected by waterlogging, while the time to maturity was reduced by 11-14 days. The differences between experiments indicate that the effect of waterlogging on barley may depend on the barley growth stage and temperature when plants were waterlogged, but the differences are being investigated in further work in the glasshouse and field.

Conclusions

Waterlogging can cause severe damage to barley plants. The extent and severity largely depend on the time and plant growth stage when waterlogging treatments were applied. Differences between varieties were found, with some Chinese varieties showing much better tolerance. Crosses are being made between some of the more tolerant lines and Australian varieties. Doubled haploids will be produced for breeding and for screening molecular markers for waterlogging tolerance.

References

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