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SHORT RESEARCH NOTES

Genotypic differences in partial resistance to crown rot caused by *Fusarium pseudograminearum* in relation to an osmoregulation gene in wheat

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Abstract. Both crown rot and osmoregulation are expressed when wheat plants undergo water stress. A possible genetic linkage between high osmoregulation and partial resistance to crown rot was investigated by using lines that had been bred for high osmoregulation (*or* gene) from parents with low osmoregulation and varying crown rot resistances. Analysis of the incidence and severity of the disease showed no association with the presence or absence of the *or* gene.

Additional keywords: soilborne disease, wheat breeding.

Crown rot of wheat caused by *Fusarium pseudograminearum* is an important disease in many parts of the Australian wheat belt, particularly in New South Wales and Queensland and in other parts of the world (Cook and Papendick 1972; Burgess *et al*. 1975; Wildermuth *et al*. 1999). The growing trend towards conservation farming practices involving stubble retention has increased the focus on diseases such as crown rot that are carried over in residues. Crown rot symptoms develop when infection of the crown by *F. pseudograminearum* under moist conditions (Swan *et al*. 2000) is followed by dry spring conditions that lead to plant water stress (Liddell *et al*.1986). In the northern region of Australia, partial resistance to crown rot is recognised in the cultivars Sunco, Baxter and Lang.

Osmoregulation, a means by which plants adapt to water stress, is an intra-cellular response to a reduction in water potential (increase in water stress); it involves partial or full maintenance of cell hydration and turgor by an increase in solute content. Among different wheat genotypes, substantial differences exist in their ability to osmoregulate. At positive turgor, this ability is controlled by a single gene (*or*) on chromosome 7A (Morgan 1991). This response typically occurs at water potentials between 0 and –2 MPa, depending on unstressed osmotic potential levels. The effect on yield depends on the interaction between evaporative demand and soil water supply during the period of net positive growth of the crop. The effect on leaf water potentials can be substantial when evaporative demand greatly exceeds water supply (Morgan 2000). Yield improvement was demonstrated in a recent study by backcross breeding specifically for the *or* gene using three cultivars (Janz, Sunco and Cunningham) with varying levels of crown rot resistance (Morgan 2000). Sunco is partially resistant, Janz susceptible and Cunningham highly susceptible to this disease (Anon. 1993; Wildermuth and McNamara 1994).

Because crown rot is a disease which occurs in environments where water stress occurs during or after anthesis, it is important to determine if there is any association between crown rot resistance and osmoregulation. Although it is not clear if a direct interaction could occur in diseased tissue, there is a possibility of genetic linkage effects, and also of additive yield increases through higher osmoregulation and crown rot resistance. Our study examined the relationship between the effect of the *or* gene in three genetic backgrounds (including Sunco) and the incidence and severity of crown rot in wheat.

Three triple backcross lines, 88, Mulgara and 32 (Morgan 1999; 2000) with the allele conditioning high osmoregulation response and their respective recurrent parents, Janz (AUS 27690), Sunco (AUS 27691) and Cunningham (AUS 27692) with the allele conditioning a low osmoregulation response, were tested for their reaction to crown rot. The donor of the allele conditioning high osmoregulation was the cultivar Hartog. The recurrent parent cultivars are all related to the cultivar Cook, but show differences in resistance to crown rot (Wildermuth *et al*. 1999; Wallwork 2001). Hartog is susceptible to crown rot. To evaluate genotypic differences in incidence and severity of the disease, 6 g of seed of each genotype was sown in the

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Table 1. Incidence (I) and severity (S) in crown rot of three paired lines with low (L) and high (H) osmoregulation (O), grown in soil with and without inoculation by *Fusarium pseudograminearum* at Wellcamp (1999) and Malu (2000)

Cultivar/line	O	Wellcamp				Malu			
		Noninoculated		Inoculated		Noninoculated		Inoculated	
		I[A]	S[B]	I	S	I	S	I	S
Sunco	L	24.5	3.7	59.6bc[C]	13.9c	7.0	1.0	48.7	8.7
Mulgara	H	24.5	4.0	56.4c	13.3c	8.2	1.1	48.6	9.1
Janz	L	32.5	5.5	86.2a	24.8b	9.1	1.2	58.5	13.0
88	H	20.6	3.0	77.7ab	23.8b	5.6	0.8	74.0	15.6
Cunningham	L	17.5	3.0	79.8a	24.5b	5.3	0.7	66.0	13.7
32	H	22.1	3.8	84.5a	24.7b	5.8	0.8	58.8	12.5
		NS[D]	NS			NS	NS	NS	NS
Mean cultivars without *or* gene	L	24.8	4.0	75.2	21.0	7.2	1.0	57.7	11.8
Mean cultivars/lines with *or* gene	H	22.4	3.6	72.8	20.6	6.5	0.9	60.5	12.4

[A]Incidence is the percentage of tillers with symptoms of crown rot. [B]Severity is calculated from the extent of symptoms of crown rot vertically in tillers including presence or absence of dead heads. [C]Means followed by similar letters do not differ significantly $P < 0.05$. [D]Not significantly different.

field in single 3 m rows in three replicates with and without inoculum of *F. pseudograminearum* (Wildermuth and McNamara 1994).

The experiments were conducted at two black earth sites (Wellcamp and Malu) in southern Queensland. They were sown on 21 June 1999 and 23 June 2000, respectively. Incidence and severity of crown rot were assessed according to the technique of Wildermuth and McNamara (1994).

Leaf water potentials were measured using methods described previously (Morgan 1991), but with a longer equilibration time of 1 day to accommodate transportation. One flag leaf per replicate was sampled from the Wellcamp experiment on 2 October 1999. This was approximately 1 week before the appearance of whiteheads, and during the grain development period.

The experiments at Wellcamp and Malu were conducted in very different environmental conditions. At Wellcamp, moisture stress occurred after anthesis whereas the Malu site was subjected to considerable water stress for most of the growing period. Based on climate analysis for the nearby site of Dalby (Morgan 2000), the below average rainfall conditions at Malu (92.5 mm for May–October) would have favoured an osmoregulation yield response. Although the incidence and severity scores of the non-inoculated groups differed between the two sites, there was no significant difference between genotypes within the experiments at each site (Table 1). However, with inoculation, the cultivars showed significantly different reactions that were compatible with previous assessments. Sunco was the most resistant, with lowest values of both incidence and severity, whereas Janz and Cunningham were similar and more susceptible. The assessments of incidence and severity of the backcross derivatives were not significantly different from their respective recurrent parents, i.e. there was no difference between Mulgara and Sunco, 88 and Janz, 32 and Cunningham. Thus, the means for osmoregulation groupings were also not significantly different.

There were no significant differences in leaf water potentials between genotypes or osmoregulation groups in either the inoculated or uninoculated blocks (overall mean of –1.4 MPa). There was also no evidence of a possible inoculation effect (–1.3 and –1.4 MPa for uninoculated and inoculated, respectively). This suggests that the water potential decline expected with whitehead formation was rapid, i.e. during the week following these measurements.

The results show that resistance to crown rot is not affected by backcross breeding for the *or* gene in bread wheat. It suggests that genes in Sunco that affect the form of crown rot resistance found in this cultivar are not located near the *or* gene; i.e. in the more distal region (approximately 60 cM from the centromere) of the short arm of chromosome 7A (Morgan and Tan 1996).

Breeding for the *or* gene increases grain yield when evaporative demand exceeds water supply during the growing period (Morgan 2000) and, because there is no evidence of genetic linkage, grain yield can be improved without loss of crown rot resistance. This was illustrated in experiments in 1996/97 involving backcross-bred lines and recurrent parents (Morgan 2000), and in particular for the cultivar Mulgara. The Mulgara/Sunco response is closely correlated with the group response (Morgan 2000).

The breeding of Mulgara, which represents a more conservative backcross approach, has a possible negative aspect through genetic linkage between endosperm peroxidase activity and reduced dough strength at high protein levels (Morgan 1999). Also, the yield benefit clearly applies only to water-stressed environments and, when these are infrequent, the average yield gain over Sunco may not match that of more recently released cultivars selected by more conventional breeding methods and targeting a range of breeding objectives, but generally with lower crown rot resistances than Sunco.

Because both crown rot symptoms and osmoregulation are expressed most in the presence of water stress, the combination of high osmoregulation and the highest levels of crown rot resistance may provide an effective way of improving yield in situations favouring the development of the disease. Cultivars with this combination of characters are likely to be more popular in the more marginal areas as well as in crops sown into wheat stubble on short fallows. This practice is likely to increase with adoption of minimum tillage practices throughout the Australian wheatbelt (Wallwork 2001). Recent work suggests substantial potential for yield improvement through breeding for the *or* gene (Morgan 2000). Given a growing national incidence of crown rot infection through conservation farming practices, the combination of both available crown rot resistance and high osmoregulation should provide a useful means of yield improvement.

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