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SUMMARY – Understanding the genetics of economic traits is important for breeding durum wheat (*Triticum turgidum* L. var *durum*). We identified DNA markers linked to various traits for use in marker-assisted selection. A set of 155 doubled haploid lines from a biparental cross were evaluated for phenotypic traits and scored for microsatellite and DArT® markers. A genetic map was constructed using JoinMap® and QTL analyses were performed. QTL were identified as follows for traits and chromosomes: maturity 2A, 2B, 4B; height 4B; lodging 2A, 4B; leaf spot 2A, 1B, 2B; stem solidness 3B; sawfly cutting 3B; yield 2B, 3B; test weight 2A, 2B, 4B; 1000 kernel weight 1A, 2A, 2B, 4B, 6B; protein content 4A, 4B; grain pigment 2A, 4B, 6B, 7B; gluten index 2A ,1B; sedimentation volume 2A, 1B, 6B. The markers should be useful in sawfly cutting 3B programs for the characterization of parental germplasm and selection for these traits in breeding populations.

Introduction

This study was undertaken to improve understanding of the genetics of grain quality, pest resistance and agronomic traits of durum wheat (*T. turgidum* L. var. *durum*) and to identify DNA markers for cultivar development.

Materials and methods

The 155 doubled haploid lines from the cross of an inbred selection from Kyle*2/Biodur with Kofa were grown in replicated tests at three Saskatchewan locations over three years as described in Clarke *et al*. (2006). Maturity (Mat), plant height (Ht), lodging score (Ldg), leaf spot score (LSp), level of stem solidness (SS), percent sawfly cutting (SCt), grain yield (Yld), test weight (TWt), 1000-kernel weight (KWt), NIR protein concentration (Prt), NIR grain pigment concentration (Pg), gluten index (GI), and wheat sedimentation volume (SV) were measured on each entry in each replication and analysed as described in Clarke *et al*. (2006). The parents and population were scored for polymorphic microsatellite and DArT® markers. A genetic map spanning all 14 chromosomes was constructed using JoinMap®, and MQTL as described in Knox *et al*. (2004) and single marker (Knapp 2001) analyses were performed.

Results and discussion

A total of 101 microsatellite and 114 DArT® markers were mapped. The final map for QTL analysis consisted of 190 markers spanning greater than 1400 cM. All chromosomes were represented, with 6B and 7B having the greater coverage. With the exception of Ht, SS and SCt, multiple QTL were detected for each trait (Table 1). As with the QTL identified from our population (Table 1), Faris and Friesen (2005) reported 1B for LSp; Cook *et al*. (2004) 3BL for SS; Groos *et al.* (2003) 2B and 3B for Yld; Elouafi and Nachit (2004) 4BL, 6BS and 6BL for KWt; Prasad *et al.* (2003) 4A, Elouafi *et al*. (2003) 4BL and Blanco *et al*. (1996) 4BS for Prt; Cenci *et al*. (2004) 2A, Hessler *et al*. (2002) 4BS, Ammiraju *et al*. (2002) 6B and Elouafi *et al*. (2001) 7B for Pg; and Blanco *et al*. (1998) 1BS and Elouafi *et al*. (2000) 6B for gluten strength. The concordance of these chromosomes with our markers on the same chromosomes and their consistency across environments gives us confidence in their application in marker-assisted selection for improvement of durum wheat.

Table 1. Significant marker for simple interval mapping (SIM†, top line within cells) from MQTL and for single marker analysis (SMA††, bottom line within cells) for each trait for trials grown at Swift Current (SC), Regina (Rg) and Indian Head (IH) in 2000 to 2002

Trait	Chr†††	Marker Interval	2000	2001			2002		
			SC	SC	Rg	IH	SC	Rg	IH
Maturity	2A	*wmc114 – Barc10*	ns	* ,+ ,+ ,+	,+	ns	* ,+ ,+	o , ,+ ,+	,+ ,+
	2B	*Barc101 – gwm120*	o , ,+ ,+ ,+	,+ ,+	ns	,+	,+ ,+	,+	* ,+ ,+ ,+
	4B	*gwm495 – gwm165B*	* * ,+ ,+ ,+	ns	* ,+ ,+	ns	ns	ns	,+ ,+ ,+
Height	4B	*gwm251 – gwm165B*	* * * ,+ ,+ ,+	* * * ,+ ,+ ,+	* * * ,+ ,+ ,+	* * * ,+ ,+ ,+	* * * ,+ ,+ ,+	* * * ,+ ,+ ,+	* * * ,+ ,+ ,+
Lodging	2A	*gwm425 – Barc10*	nd	nd	* ,+ ,+ ,+	nd	nd	,+	nd
	4B	*gwm251 – gwm165B*	nd	nd	* * * ,+ ,+ ,+	nd	nd	* * * ,+ ,+ ,+	nd
Leaf spot	2A	*gwm114 – gwm425*	ns	nd	* * * ,+ ,+ ,+	,+ ,+	,+ ,+	* * * ,+ ,+ ,+	,+
	1B	*Barc119 – wmc49*	,+ ,+	nd	* * * ,+ ,+ ,+	,+	* ,+ ,+	,+	ns
	2B	*Barc101 - gwm120*	,+ ,+	nd	,+ ,+	* ,+ ,+ ,+	* ,+ ,+ ,+	o , ,+ ,+	* * * ,+ ,+ ,+
Solidness	3B	*gwm181 - gwm114*	* * * ,+ ,+ ,+	nd	nd	nd	nd	nd	nd
Cutting	3B	*gwm247 - gwm114*	nd	* * * ,+ ,+ ,+	nd	nd	* * * ,+ ,+ ,+	nd	nd
Yield	1A	*wmc95 - xgdm33*	ns	,+	* ,+ ,+ ,+	ns	,+	,+	,+
	2A	*wmc114 - gwm425*	o , ,+ ,+	,+	,+	,+ ,+	ns	,+ ,+	* ,+ ,+
	2B	*Barc101 - gwm120*	,+	* * ,+ ,+ ,+	ns	ns	,+ ,+	,+ ,+	* * ,+ ,+ ,+
	3B	*gwm181 - gwm114*	,+	* ,+ ,+ ,+	,+	,+ ,+	* * * ,+ ,+ ,+	ns	ns
Test Wt	1A	*wmc95 - gwm136*	,+ ,+	,+ ,+	,+	,+	,+	,+	o , ,+ ,+
	2A	*wmc114 - Barc10*	* * ,+ ,+ ,+	* * ,+ ,+ ,+	* ,+ ,+ ,+	,+ ,+ ,+	ns	,+	* ,+ ,+
	2B	*wmc332 - gwm120*	ns	* ,+ ,+ ,+	,+	ns	,+	,+	* ,+ ,+
	4B	*gwm251 - gwm165B*	* ,+ ,+ ,+	* ,+ ,+ ,+	,+ ,+	,+ ,+	* * ,+ ,+ ,+	* * ,+ ,+ ,+	,+ ,+ ,+
	4B	*Wmc8*	,+ ,+	,+	,+	,+ ,+	,+ ,+	,+ ,+	ns
Kernel Wt	1A	*Barc83 - wmc95*	,+ ,+	* * ,+ ,+ ,+	,+	ns	,+	,+	,+
	2A	*gwm339 - Barc10*	* * * ,+ ,+ ,+	o , ,+ ,+	,+ ,+	* * ,+ ,+ ,+	,+	* ,+ ,+	* * * ,+ ,+ ,+
	2B	*wmc175 - gwm120*	* ,+ ,+ ,+	* * * ,+ ,+ ,+	* ,+ ,+	,+ ,+	* * ,+ ,+ ,+	o , ,+ ,+	* * ,+ ,+ ,+
	4B	*gwm251 - gwm165B*	o , ,+ ,+ ,+	,+ ,+	,+	,+	,+ ,+	* ,+ ,+ ,+	,+ ,+ ,+
	6B	*Barc79 - gwm193*	* * ,+ ,+ ,+	* * ,+ ,+ ,+	,+	* ,+ ,+ ,+	,+ ,+	,+ ,+	,+ ,+
	?	*wmc786B*	* ,+ ,+ ,+	* ,+ ,+ ,+	ns	,+ ,+	,+	,+ ,+	,+
Protein	4A	*gwm165A - Barc206*	ns	* * ,+ ,+ ,+	,+	o , ,+ ,+ ,+	ns	ns	ns
	2B	*gwm47 - wmc332*	o , ,+ ,+	ns	,+ ,+	o , ,+ ,+	ns	,+	* ,+ ,+ ,+
	4B	*gwm251 - gwm165B*	ns	,+ ,+ ,+	o , ,+ ,+	* * * ,+ ,+ ,+	,+ ,+	* * * ,+ ,+ ,+	,+
	7B	*gwm537*	,+	,+ ,+	,+ ,+	,+ ,+	,+ ,+	,+ ,+	,+ ,+
Pigment	2A	*gwm339 - gwm425*	,+ ,+	* * ,+ ,+ ,+	,+	,+ ,+ ,+	* ,+ ,+ ,+	* * * ,+ ,+ ,+	* ,+ ,+ ,+
	4B	*gwm251 - gwm165B*	,+	* ,+ ,+ ,+	,+	ns	* * ,+ ,+ ,+	,+ ,+	* ,+ ,+ ,+
	6B	*Barc14 - Barc79*	* * * ,+ ,+ ,+	* * * ,+ ,+ ,+	* * ,+ ,+ ,+	* * ,+ ,+ ,+	* * * ,+ ,+ ,+	* ,+ ,+ ,+	,+ ,+
	7B	*wmc526 - wmc273*	* * ,+ ,+ ,+	* * ,+ ,+ ,+	* ,+ ,+ ,+	* * ,+ ,+ ,+	,+	,+ ,+	,+ ,+
	?	*wmc786B*	* * * ,+ ,+ ,+	* * ,+ ,+ ,+	* * ,+ ,+ ,+	* * ,+ ,+ ,+	* ,+ ,+ ,+	,+	,+
GI	2A	*wmc114 - gwm339*	,+ ,+	,+ ,+	* * ,+ ,+ ,+	,+	* ,+ ,+	,+	,+
	1B	*Barc119 - wmc49*	* * * ,+ ,+ ,+	* * * ,+ ,+ ,+	* * * ,+ ,+ ,+	* * * ,+ ,+ ,+	* * * ,+ ,+ ,+	* * * ,+ ,+ ,+	* * * ,+ ,+ ,+
SV	2A	*wmc114 - gwm339*	o , ,+ ,+	,+ ,+	* ,+ ,+ ,+	* * ,+ ,+ ,+	* ,+ ,+	,+	,+
	1B	*gwm413 - wmc49*	* * * ,+ ,+ ,+	* * * ,+ ,+ ,+	* * * ,+ ,+ ,+	* * * ,+ ,+ ,+	* * * ,+ ,+ ,+	* * * ,+ ,+ ,+	* * * ,+ ,+ ,+
	2B	*gwm120*	,+	,+	* ,+ ,+	,+ ,+	,+ ,+	,+	,+ ,+
	6B	*Barc14 - gwm193*	,+	,+	,+	ns	* ,+ ,+	,+	,+ ,+
	6B	*Barc79 - Barc178*	* ,+ ,+ ,+	,+ ,+	o , ,+ ,+	* * ,+ ,+ ,+	o , ,+ ,+	* * ,+ ,+ ,+	* ,+ ,+

†SIM: o (possible)≤0.10; *≤0.05; **≤0.01 and *** ≤0.001; ††SMA: *o*≤0.10; +≤0.05; ++≤0.01 and +++ ≤0.001; ns = not signif.; †††note overlapping loci; nd = no data.

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