

Mapping of QTLs for yield and quality traits in Indian durum wheat

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Introduction

Development of high yielding durum cultivars with better end use quality is the primary objective of durum wheat improvement programs. The main commercial and technological characteristics considered by millers and pasta makers are kernel properties like test weight, thousand kernel weight, vitreousness, milling yield, carotenoid content, quality as well as quantity of gluten and grain protein content while consumer is concerned about firmness of cooked pasta, cooking loss, stickiness and colour of pasta. The genetic basis of yield and quality components was, therefore, investigated in Indian durum wheat.

Material and Methods

Mapping population:

140 F_{2:7} RILs of PDW 233 (YAV'S'ITEN'S') × Bhalegaon 4 (Landrace)

Field trials:

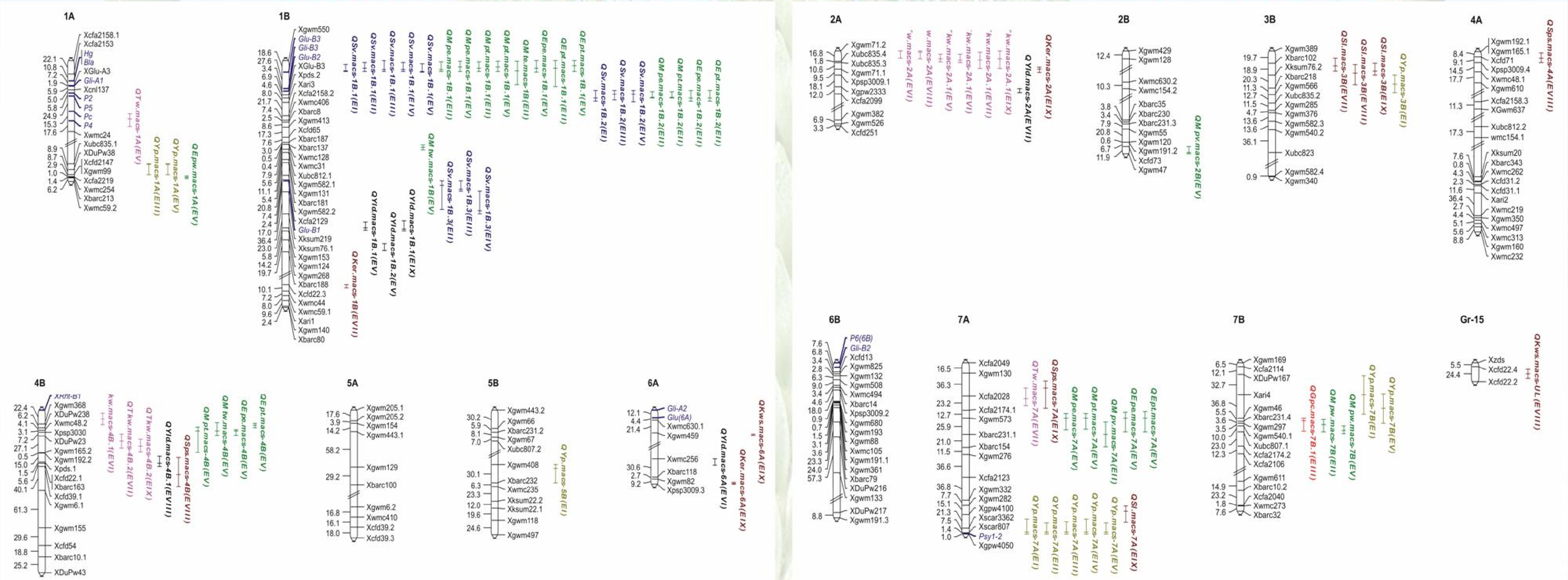
- Randomized Block Design with two replications each at three locations
- Pune (Peninsular Zone, 18° 31' N, 73° 55' E) [2001-02 (EI); 2002-03 (EIII); 2003-04 (EV); 2004-05 (EVI); 2005-06 (EVII) and 2006-07 with full irrigation (EVIII) and restricted irrigation (EIX) treatments]
- Indore (Central Zone, 22° 44' N, 75° 50' E) [2002-03 (EII)] and
- Karnal (North Zone, 29° 42' N, 77° 02' E) [2002-03 (EIV)].

Trait analysis:

- Grain Protein Content (GPC): Near-infrared spectroscopy with a Technicon 400 Infra-analyzer (Technicon Corp, NY).
- Gluten strength: Modified SDS-microsedimentation test (Dick and Quick, 1983).
- Yellow pigment content: The modified AACC method (Santra et al., 2003).
- Test weight: SINAR FP Auto 6080 moisture analyzer (Tecator, Sweden)
- Yield and yield components: Data of grain yield and yield components like spike length, spikelets per spike, kernels per spike, kernel weight per spike and thousand kernel weight recorded from the middle rows of each plot

Results

Main effect QTLs for yield and quality parameters detected on intraspecific framework map of PDW 233 × Bhalegaon 4.



Epistatic QTL interactions (Q×Q and Q×Q×E) detected for yield and quality traits

Trait / QTL _i	Marker interval _i	QTL _j	Marker interval _j	AA _{ij}	AAE
SDS-sedimentation volume (SV)					
QSV.macs-1A	P4 - Xwmc24	QSV.macs-7A	Xbarc154 - Xgwm276	-4.88 ^{****}	-
QSV.macs-5B	Xgwm118 - Xgwm497	QSV.macs-4A	Xgwm160 - Xwmc232	-2.78 ^{****}	-
QSV.macs-6A.1	Xbarc118 - Xgwm82	QSV.macs-1B.4	Xcfd22.3 - Xwmc44	1.18 ^{****}	1.04 ^{****} (AAEII)
QSV.macs-1B.4	Xcfd22.3 - Xwmc44	QSV.macs-6A.2	Gli-A2 - Xwmc630.1	-1.25 ^{****}	-
Midline peak energy (MPE)					
QMpe.macs-2A	Xgpw2333 - Xcfa2099	QMpe.macs-4A	Xwmc48.1 - Xpsp3009.4	-27.04 ^{****}	16.16 [*] (AAEII); -15.62 [*] (AAEV)
Midline peak time (MPT)					
QMpt.macs-2A	Xgpw2333 - Xcfa2099	QMpt.macs-4A	Xwmc48.1 - Xpsp3009.4	-0.57 ^{****}	0.35 [*] (AAEII); -0.34 [*] (AAEV)
Midline tail width (MTW)					
QMTw.macs-5B	Xwmc235 - Xksum22.2	QMTw.macs-3B	Xgwm566 - Xubc835.2	2.54 ^{****}	-
Envelope peak energy (EPE)					
QEpe.macs-2A	Xgpw2333 - Xcfa2099	QEpe.macs-4A	Xwmc48.1 - Xpsp3009.4	-18.88 ^{****}	-
Envelope peak time (EPT)					
QEpt.macs-2A	Xgpw2333 - Xcfa2099	QEpt.macs-4A	Xwmc48.1 - Xpsp3009.4	-0.39 ^{****}	-
Grain protein content (GPC)					
QGpc.macs-7B.2	Xgwm169 - Xcfa2114	QGpc.macs-4B	XRht-B1 - Xgwm368	0.25 ^{****}	-
Yellow pigment content (YPC)					
QYp.macs-7A.2	Xgwm573 - Xbarc231.1	QYp.macs-1B	Xcfd22.3 - Xwmc44	-0.54 ^{****}	-
Test Weight (TW)					
QTw.macs-7A.2	Xgpw4100 - Xgwm282	QTw.macs-3B	Xgwm389 - Xbarc102	0.60 ^{****}	0.31 [*] (AAEVI)
QTw.macs-4B	Xcfd54 - Xbarc10.1	QTw.macs-4A	Xwmc48.1 - Xgwm610	6.27 ^{****}	-
Thousand Kernel Weight (TKW)					
QTKw.macs-7A	Xcfa2028 - Xcfa2174.1	QTKw.macs-2A.2	Xgwm71.1 - Xpsp3009.1	-1.86 ^{****}	-
QTKw.macs-7A	Xcfa2028 - Xcfa2174.1	QTKw.macs-2A.1	Xgwm71.2 - Xubc835.4	0.58 [*]	0.91 [*] (AAEVI)
QTKw.macs-7B.1	Xgwm540.1 - Xubc807.1	QTKw.macs-6B	Xbarc79 - XDuPw216	5.17 ^{****}	-
QTKw.macs-7B.2	Xbarc10.2 - Xcfa2040	QTKw.macs-6B	Xgwm361 - Xbarc79	-1.15 ^{****}	-
Grain Yield					
QYld.macs-1B.3	Xbarc187-Xbarc137	QYld.macs-7A.1	Xscar807-Psy-A1	-178.2 ^{****}	608.9 ^{****} (AAEII); -334.5 ^{****} (AAEIII); 18.1 [*] (AAEIV); 330.1 ^{****} (AAEV)
QYld.macs-7A.2	Xgwm332-Xgpw4100	QYld.macs-4B.1	Xcfd22.1-Xbarc163	753.5 ^{****}	-
QYld.macs-7A.2	Xgwm282-Xscar3362	QYld.macs-4B.1	Xcfd39.1-Xgwm6.1	-881.1 ^{****}	-
QYld.macs-3B	Xbarc218-Xgwm566	QYld.macs-4B.2	Xcfd54-Xbarc10.1	1123.7 ^{****}	-
Spike Length					
QSI.macs-1B	Xgwm153-Xgwm124	QSI.macs-5A	Xcfd39.2-Xcfd39.3	62.70 ^{****}	-
Spikelets per Spike					
QSpS.macs-3B	Xgwm285-Xgwm376	QSpS.macs-4A.2	Xgwm160-Xwmc232	-0.34 ^{****}	-0.37 [*] (AAEII)
Kernels per Spike					
QKer.macs-1A	P4-Xwmc24	QKer.macs-4B	Xgwm6.1-Xgwm155	-6.53 ^{****}	-5.07 [*] (AAEII)

AA_{ij}: QTL × QTL epistatic interaction AAE: QTL × QTL × environment interaction *P < 0.05; **P < 0.01; ****P < 0.001

Important findings

- The map comprised 214 markers spanning a distance of 2357.9 cM with average marker density of 11.02 cM/marker.
- Five different QTLs associated with sedimentation volume were identified. Three of them were located in close vicinity of glutenin coding loci in chromosome 1B.
- Apart from glutenin coding loci, QTLs influencing mixing parameters and grain protein content were located in three other marker intervals Xwmc48.2 - Xpsp3030 (4B), Xgwm573 - Xbarc231.1 (7A) and Xgwm46 - Xbarc231.4 (7B).
- Total 26 main effect QTLs and 10 digenic epistatic interactions (Q × Q) for gluten strength were distributed over 11 chromosomes.
- The *Psy-A1* gene encoding *phytoene synthase*, the key enzyme in carotenoids biosynthesis pathway, was mapped at the centre of *QYp.macs-7A*, a major QTL for yellow pigment content.
- A *Psy-A1* gene specific marker targeting a microsatellite variation at 5' UTR region and two SCAR markers linked to the major QTL *QYp.macs-7A* were developed.
- A QTL flanked by Xgwm71.2 - Xubc835.4 on chromosome 2A has pleiotropic effect on test weight and thousand kernel weight.
- Grain yield was influenced by 5 main effect QTLs and 4 Q × Q interactions. A total of 10 main effect QTLs and 3 Q × Q interactions were identified for spike characters.

References

- Dick JW & Quick JS, 1983. Cereal Chemistry 60: 315-318.
- Santra M et al, 2003. Cereal Chemistry 80: 130-131.

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