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不同施氮期对小麦千粒重影响的 QTL 分析

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摘 要: 3 × 57 168 doubled haploid DH 2 12 323 QTL 40 QTL 2D 3A 4D 5B 6A 7D 2010 3 8 QTL 2010 13 QTL 2011 12 QTL 2011 7 QTL QTL 4.19%~23.14% 3 *Qtgw3A-2* *Qtgw5B* *Qtgw6A-1* *Qtgw7D-1* QTL QTL *Qtgw3A-2* *Qtgw4D* *Qtgw6A-1* *Qtgw7D-1* QTL QTL QTL QTL

关键词: ; ; ;
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QTL Mapping Analysis on the Effect of Various Nitrogen Supplying Dates on Thousand Grain Weight in Wheat

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Abstract: In this study, the QTLs/genes related to thousand grain weight were studied in twelve different environments for two years, using a doubled haploid (DH) population derived from a cross between two elite Chinese wheat cultivars Huapei3×Yumai57 for QTL mapping of thousand grain weight based on unconditional quantitative trait locus (QTL) analyses. A total of 40 unconditional QTLs were detected, including 8 QTL detected in Laiyang and 13 QTL detected in Taian in 2010, 12 QTL detected in Jiyuan and 7 QTL detected in Taian in 2011. Most QTLs detected in this study are located on chromosome 2D, 3A, 4D, 5B, 6A, and 7D. The phenotypic variance explained by single QTL varied from 4.19% to 23.14%. The effects were mostly contributed by the parent Huapei3. Of the QTLs, *Qtgw3A-2*, *Qtgw5B*, *Qtgw6A-1* and *Qtgw7D-1* were detected under three nitrogen supplying date, indicating that these QTL related to thousand grain weight were affected by nitrogen. *Qtgw3A-2*, *Qtgw4D*, *Qtgw6A-1* and *Qtgw7D-1* were detected at various experimental plots, suggesting that these QTL were expressed stably. Therefore, the number and the expression of QTLs have a great change under different nitrogen supplying dates, which suggest that the QTLs were specifically expressed in wheat under different nitrogen application stage. The findings in this study should be useful for topdressing nitrogen reasonably and manipulating the QTLs by marker assisted selection (MAS) and be potential in increasing grain yield and grain weight.

Keywords: Nitrogen supplying date ; wheat; thousand grain weight; QTL

[1]

[2,3]

/QTL

[4] QTL

[5] Dholakia [6] RIL 2 QTL 2D 2B QTL 3.5% 7.3% Varshney[7] QTL 1A 1D 2B 4B 5B 6B 7A 7D 8 1A 2B 7A QTL Kim [8] 5 QTL QTL 5.0%~12.2% Wang [9] RIL 21 QTL, 1A 1B 2A 2D 3A 3B

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3D 4A 4D 5A 5B 6D 7D Quarrie [10] QTL 1B 3D 4A 4B 4D 5A 5B 6B 7B QTL 12.1%~17.7% Zanetti [11] 226 RIL 8 QTL, 1B 2B 3B 5A 5B 7B Kumar [12] 3 QTLs 1A 2B 7A Hai [13] DH 2 QTL 2B 7B 12.7% 10.7% [14] RIL 1A 4B QTL Khalil [15] F2:3 QTL 4 6 QTL Anne[16] DH QTL 6 QTLs QTL/ 3 × 57 Doubled haploid DH QTL QTL QTL

1 材料与方法

1.1 材 料

3 57 168 DH 3 2006 57 2004

DH 21 323 284 SSR 37 EST-SSR 1 ISSR 1 HMW 2 485.7 cm 7.67 cm 24 [17]

1.2 田间试验

2009 2010 (S1,36.58'N,120.42'E) (S2,36.57'N,116.36'E) 2010 2011 (S3,35.5'N,112.38'E) (S4) 0~20 cm 17.58 g·kg^{-1} 23.46 mg·kg^{-1} 45.08 mg·kg^{-1} 153.5 mg·kg^{-1} 15.09 g·kg^{-1} 13.3 mg·kg^{-1} 68.6 mg·kg^{-1} 162.3 mg·kg^{-1} 13.7 g·kg^{-1} 67.97 mg·kg^{-1} 29.7 mg·kg^{-1} 137.7 mg·kg^{-1} T1 120 kg·hm^{-2} T2 120 kg·hm^{-2} T3 120 kg·hm^{-2} 120 kg·hm^{-2} 1 2 DH 3 1.0 m 2.2 cm×0.26 m

500 QTL

1.3 数据处理

SPSS 16.0 323 , (Inclusive composite interval mapping, ICIM)[18] QTL LOD 2.7 Step 1 cm

2 结果与分析

2.1 千粒重的表现型分析

1 DH

1.0 QTL

表 1 不同施氮期小麦亲本及 DH 群体的千粒重性状分布

Table 1 Distribution of thousand grain weight in parents and DH populations of wheat under different nitrogen supplying dates

Environment	Treatment	Parents		DH population					
		3 HP 3	57 YM 57	Mean	Max	Min	Standard deviation	Skewness	Kurtosis
2010Laiyang (S1)	T1	46.2	46.1	44.72	59.6	25.1	7.29	-0.16	-0.45
	T2	44.5	44.8	42.62	57.8	26.1	6.70	-0.07	-0.36
	T3	44.6	42.3	42.89	58.5	24.0	7.80	-0.18	-0.63
2010Taian (S2)	T1	48.4	44.7	46.24	61.6	24.9	6.52	-0.16	-0.07
	T2	52.6	45.7	46.83	58.3	30.5	5.84	-0.39	-0.11
	T3	51.4	47.4	45.75	60.4	27.3	6.84	-0.23	-0.44
2011Jiyuan (S3)	T1	42.9	44.1	44.14	58.2	30.6	5.30	-0.14	-0.17
	T2	40.8	44.2	43.64	55.2	29.7	5.79	-0.11	-0.59
	T3	45.5	44.2	45.08	58.3	26.8	5.79	-0.30	-0.10
2011Taian (S4)	T1	47.4	46.6	47.10	57.4	33.2	5.70	-0.29	-0.70
	T2	46.1	45.5	47.17	57.3	32.6	5.54	-0.29	-0.68
	T3	44.2	44.6	47.49	58.8	34.3	5.22	-0.33	-0.63

2.2 不同施氮期下小麦千粒重性状的 QTL 分析

2 40 QTL 2010 3 8 QTL 2010 13 QTL 2011 12 QTL 2011 7 QTL QTL 4.19%~23.14% (2 1

表 2 小麦千粒重性状 QTL 的效应

Table 2 Analysis of unconditional quantitative trait loci effects on thousand grain weight

Environment	QTL	Marker interval	Additive	LOD	H2(%)
2010Laiyang					
T1	*Qtgw3A-1*	Xcfa2193-Xgwm155	1.87	3.12	6.97
T1	*Qtgw6A-1*	Xgwm82-Xwmc553	2.38	5.29	11.20
T1	*Qtgw7D-1*	Xgwm676-Xgwm437	1.93	3.06	6.84
T2	*Qtgw2D-1*	Xwmc170.2-Xgwm539	1.54	3.02	5.40
T2	*Qtgw3A-2*	Xwmc264-Xcfa2193	1.73	3.82	6.92
T2	*Qtgw6A-1*	Xgwm82-Xwmc553	1.92	4.64	8.41
T3	*Qtgw4D*	Xwmc473-Xwmc331	1.98	3.80	6.67
T3	*Qtgw6A-1*	Xgwm82-Xwmc553	2.14	4.28	7.71
2010Taian					
T1	*Qtgw2D-2*	Xgwm261-Xwmc112	1.59	3.03	6.11
T1	*Qtgw3A-2*	Xwmc264-Xcfa2193	2.05	3.87	10.22
T1	*Qtgw6A-1*	Xgwm82-Xwmc553	1.55	2.84	5.80
T1	*Qtgw7D-1*	Xgwm676-Xgwm437	1.98	3.46	8.92
T2	*Qtgw2D-3*	Xcfd53-Xwmc18	1.36	2.99	5.52
T2	*Qtgw4D*	Xwmc473-Xwmc331	1.53	3.83	7.05
T2	*Qtgw6A-1*	Xgwm82-Xwmc553	1.56	3.86	7.21
T2	*Qtgw7D-1*	Xgwm676-Xgwm437	1.91	4.45	10.43
T3	*Qtgw2D-3*	Xcfd53-Xwmc18	1.57	3.05	5.27
T3	*Qtgw4D*	Xwmc473-Xwmc331	2.09	5.35	9.38
T3	*Qtgw5B*	Xgwm213-Xswes861.2	-1.69	3.31	5.70
T3	*Qtgw6A-2*	Xbarc1077-Xgwm82	1.67	3.28	5.96
T3	*Qtgw7D-1*	Xgwm676-Xgwm437	2.40	5.28	11.84
2011Jiyuan					
T1	*Qtgw3A-2*	Xwmc264-Xcfa2193	1.46	3.20	7.75
T1	*Qtgw5B*	Xgwm213-Xswes861.2	-1.26	2.83	5.27
T1	*Qtgw6A-1*	Xgwm82-Xwmc553	1.26	3.06	5.76
T2	*Qtgw3A-2*	Xwmc264-Xcfa2193	1.48	3.18	6.73
T2	*Qtgw4D*	Xwmc473-Xwmc331	1.51	4.31	7.10
T2	*Qtgw5B*	Xgwm213-Xswes861.2	-1.78	5.38	9.10
T3	*Qtgw3A-2*	Xwmc264-Xcfa2193	1.58	4.52	7.73
T3	*Qtgw4D*	Xwmc473-Xwmc331	1.51	4.66	7.05
T3	*Qtgw5B*	Xgwm213-Xswes861.2	-1.21	2.81	4.19
T3	*Qtgw6A-2*	Xbarc1077-Xgwm82	2.00	7.52	12.42
T3	*Qtgw7D-1*	Xgwm676-Xgwm437	1.75	5.01	8.89
T3	*Qtgw7D-2*	Xgdm67- Xwmc634	-1.48	4.33	6.83
2011Taian					
T1	*Qtgw2D-1*	Xwmc170.2-Xgwm539	1.58	3.64	7.82
T1	*Qtgw6A-1*	Xgwm82-Xwmc553	2.10	5.59	14.05
T2	*Qtgw2D-1*	Xwmc170.2-Xgwm539	1.36	2.78	6.14
T2	*Qtgw6A-1*	Xgwm82-Xwmc553	1.95	4.87	12.92
T3	*Qtgw2D-4*	Xwmc18-Xwmc170.2	-1.67	4.24	10.80
T3	*Qtgw2D-5*	Xgwm539-Xcfd168	2.47	9.72	23.14
T3	*Qtgw6A-1*	Xgwm82-Xwmc553	1.65	4.72	10.39

2010 T1 3 QTL 2 3A 6A 7D 6.84%~11.20% T2 3 QTL

5.40%~8.41% 3 T3 2 QTL
4D 6A
2010 T1 4 QTL 2D 3A 6A 7D
6.11% 10.22% 5.80% 8.92% 3
T2 4 QTL 5.52%~10.43% T3
5 QTL *Qtgw5B* 4 3
2011 T1 3 QTL
5.27%~7.75% T2 3 QTL 3A 4D 5B
6.73%~9.10% T3 6 QTL *Qtgw6A-2*
12.42% 3
2011 T1 2 QTL 2D 6A
3 T2 2 QTL
6.14% 12.92% T3 3 QTL *Qtgw2D-5*
23.14% 3

3 讨 论

3.1 不同施氮期下 QTL 表达的比较分析

QTL 34 3 6
57 3 QTL
T1 *Qtgw6A-1*
Qtgw3A-2 *Qtgw7D-1* T2 *Qtgw6A-1* *Qtgw3A-2* *Qtgw4D*
T3 *Qtgw4D* *Qtgw5B* *Qtgw6A-1* *Qtgw6A-2* *Qtgw7D-1*
QTL
QTL 2010
Qtgw6A-1 2010 2011 2011
Qtgw7D-1 *Qtgw3A-2* *Qtgw5B* *Qtgw6A-1* 2010 2011
2011 3 1 1 QTL QTL
Qtgw6A-1 *Qtgw3A-2* *Qtgw4D* *Qtgw7D-1* 3
Qtgw2D-1 *Qtgw5B* *Qtgw6A-2* 2 QTL
QTL

3.2 与前人研究的比较

40 QTL
QTLs 2D 8 QTL
Xgwm539 4 QTL [19] Huang [20] *Qtgw2D-2*
Qtgw2D-3 Groos [21] Ramya[22] *Qtgw4D* Xwmc473-Xwmc331
McCartney [23] [24] QTL 6A 11 QTL
Xgwm82 Jose [25] Huang [26] 7D *Qtgw7D-1*
Huang [20] Khalil [15] Börner [27] QTL *Qtgw7D-2*
[19]

3.3 千粒重的QTL与其它相关性状QTL的关系

QTL
McCartney [23] Mao [28] [29] *Qtgw2D-3* QTL
QTL[30] Xcfd53~Xwmc18
QTL[31] QTL[32] *Qtgw4D* Xwmc473-Xwmc331
McCartney [23] *Qtgw4D* QTL [24]
QTL *Qtgw7D-1* Xgwm676-Xgwm437 [29]

QTL [33] QTL *Qtgw7D-2* QTL[34] [19] QTL

3.4 施氮时期与 QTL

, , [35]

,

[36] [37] ,

[38] [39]

[40] ,

[1] 2D Xcfd53-Xwmc18 QTL 2010 *Qtgw2D-3* *Qtgw2D-3* T2 T3 T1 *Qtgw4D* McCartney [23] QTL *Qtgw4D* T2( ) T3( ) T3 *Qtgw6A-2* [41] QTL

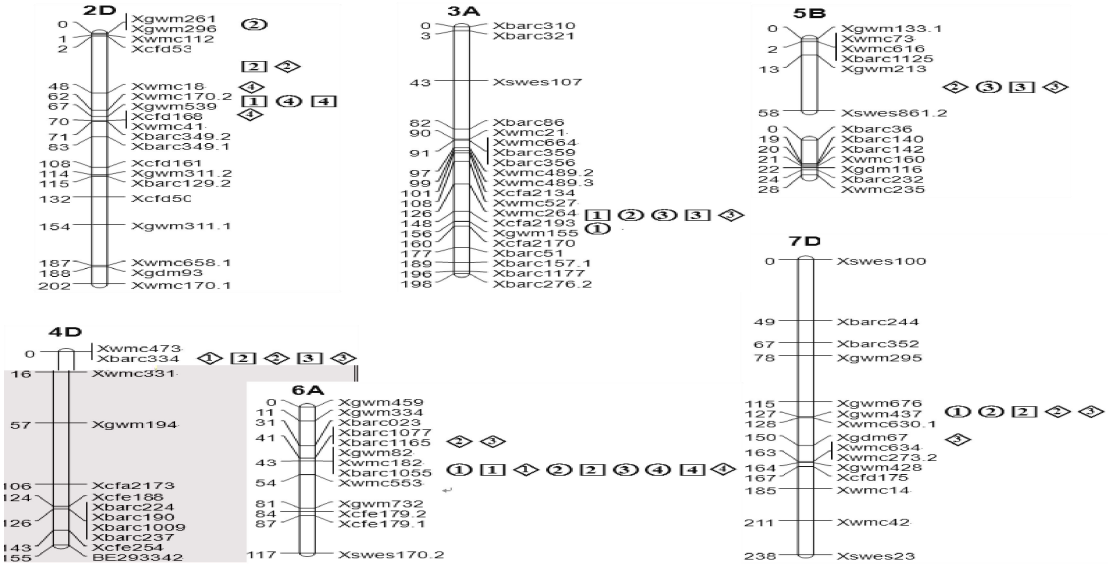

图 1 不同施氮期小麦千粒重的 QTL 定位图

Fig.1 The identification of QTL controlling thousand grain weight in wheat under different nitrogen supplying dates

○□◇分别表示 T1、T2、T3 施肥期的非条件 QTL Unconditional QTL detected under different nitrogen supplying dates

1/2/3/4 分别表示 S1/S2/S3/S4 的非条件 QTL Unconditional QTL detected under different nitrogen supplying dates

4 结 论

40 QTL 2D 3A 4D 5B 6A 7D QTL 4.19%~23.14% 3 *Qtgw3A-2* *Qtgw5B* *Qtgw6A-1* *Qtgw7D-1* QTL QTL *Qtgw6A-1* *Qtgw3A-2* *Qtgw4D* *Qtgw7D-1* 3 QTL

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