

( )

\*

( / / : // : )

)

(

/ QTL  
H  
H H H H

LOD QTL  
/ QTL  
QTL

QTL :

.(McDonald et al., 1995)

(ADF) (CP) (DMD)  
(NDF) (WSC) (CF)  
(ADL)

.(Smith, 1995)

.(Garcia et al., 2003)

.(Smith, 1995)

- 
1. Dry matter digestibility
  2. Crude protein
  3. Water-soluble carbohydrate
  4. Acid detergent fiber
  5. Crude fiber
  6. Neutral detergent fiber
  7. Acid detergent lignin
  8. Ash

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:

:

\*

|                                   |                    |               |   |
|-----------------------------------|--------------------|---------------|---|
|                                   | / /                | (ADF)         | (Buxton, 1996; Casler, 2001;                      |
| Abdel-Haleem et al.               |                    |               | McDonald et al., 1995)                            |
|                                   | QTL                | (1995)        |   |
|                                   | ADF QTL            | ( )           |   |
|                                   | H H H              |               | (Casler, 2001)                                    |
|                                   | / / /              | H             |   |
| CD0474C                           |                    | /             | (Casler, 2001)                                    |
|                                   | Nar7 bBE54A ABG460 |               |   |
|                                   | / / / /            | QTL           |   |
|                                   | QTL                |               | (QTL)   |
|                                   | QTL                |               |   |
|                                   | H H H H H H        |               | (MAS)   |
|                                   | / / / / /          |               |   |
| ABG156A                           |                    | /             |   |
| WG541 Adh6 ABG319A ABG316A MWG557 |                    |               |   |
|                                   | / / / / /          |               |   |
|                                   | QTL                | /             |   |
|                                   | H H                | DMD           | (Kleinhofs et al., 2001;                          |
|                                   | / /                | H H H         | Kleinhofs et al., 1993)                           |
|                                   | / / /              |               |   |
| ABG319B ABG495B ABG005 Hor5       |                    |               | QTL   |
|                                   | QTL                | BCD340E       |   |
|                                   | / / / / /          |               |   |
|                                   |                    |               | Abdel-Haleem et al., 2005; )                      |
|                                   |                    |               | Han et al. (Gibson et al., 1994; Han et al., 2003 |
|                                   |                    |               | (2003)  |
|                                   |                    | ADF           | (ADF)   |
|                                   |                    | QTL           |   |
|                                   |                    |               | QTL   |
|                                   |                    | H             |   |
|                                   |                    | (ADF ADF ADF) | QTL   |
|                                   |                    | / / /         |   |
| QTL ( )                           |                    | QTL           |   |
|                                   | Q×E                |               |   |
|                                   |                    |               |   |
|                                   | QTL                |               |   |
|                                   |                    | WG622         | H H   |
|                                   |                    | Hor2 AGA006   | (ADF) ABG313B                                     |

- 
1. Quantitative trait loci
  2. Marker- assisted selection

( )  
NIRS

(Roberts, 2004)

NIRS

QTL

(Roberts et al., 2004)

)

(

$$h^2 = [\sigma_g^2 / (\sigma_g^2 + \sigma_{ge}^2 / e + \sigma_e^2 / re)] / 2$$

$$h^2 = [1 - (MS_{G \times E} / MS_G)] / 2$$

$\sigma_g^2$  (Knapp et al., 1985; Therrien, 2003)

F<sub>1</sub>

$$\sigma_e^2 \quad \sigma_{ge}^2$$

$$\begin{matrix} e & r & \times \\ \times & & MS_{G \times E} \quad MS_G \end{matrix}$$

(1989) Hayes & Chen

(Hayes, 1992)

$$\begin{matrix} GG_N = W_{DH} - W_P & GG_P = B_{DH} - B_P \\ W_{DH} & B_{DH} \\ W_P & B_P \end{matrix}$$

$$GCV = (\sigma_g / \bar{x}) \times 100 \quad PCV = (\sigma_p / \bar{x}) \times 100$$

$\sigma_p$  (Johnson et al., 1955)

$$\bar{x} \quad \sigma_g$$

$$G_C = kh^2 \sigma_p$$

k (Johnson et al., 1955)

$$\sigma_p ( / )$$

5. Near infrared reflectance spectroscopy
6. Inframatic 8600
7. Perten

1. Steptoe (CI15229)
2. Morex (CI15773)
3. *Hordeum bulbosum*
4. Oregon State University Barley Breeding Programme

QTL LRS  $\geq$  /  $h^2$   
 .(

QTL QTL  
 (SAS Institute, 2008) / SAS  
 WinQTL QTL  
 QTL (Wang et al., 2007) /  
 (Corel Draw Graphics Suite X4, <http://barleygenomics.wsu.edu>  
 2008)

/ /

( ) (NABGMP)  
 .(Kleinhofs et al., 2001; Kleinhofs et al., 1993)

. (P  $\leq$  / )

QTL  
 (Hayes, 1992; Hayes & Iyambo, 1994;  
 Han & ) Peighambari et al., 2005)  
 (Chen et al., 1994) (Ullrich, 1994  
 (Buxton, 1996)

. (P > / )

×

QTL  
 QTL ( )  
 Zmapqtl  
 (CIM)  
 .(Jansen & Stam, 1994; Zeng, 1994)  
 / QTL LOD

(Abdel-Haleem et al., 2005; Bregitzer & Campbell, 2001;  
 (1994) Hayes & Iyambo .Peighambari et al., 2005)  
 (2005) Abdel-Haleem et al. (1994)Gibson et al.

×

QTL LOD  
 QTL  
 QTL  
 QTL  
 LOD

LOD  $\geq$  )

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6. Statistical Analysis System  
 7. Corel draw

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1. Stepwise  
 2. North American Barley Genome Mapping Project  
 3. Composite interval mapping  
 4. Cofactor  
 5. Forward-backward

(2001) Bregitzer & Campbell  
QTL

Abdel-Haleem et al. .

QTL (2005)

ADF

(2003) Han et al. .

( )

x

( $P > /$  )

x

/

/

/ /

( $P \leq /$  )

( $P \leq /$  )

.(Panes, 1957)

( )

CF NDF ADF)

(ADL

1. Transgressive segregation



ABG705 WG996 CDO474B KsuF2A  
*Qcp2Hs Qcp1Hs* QTL  
 H H H *Qcp6Hs* ( $DMD = \sqrt{ADF} - \sqrt{ADF} : R = /$ )  
 / /  
 (1988) Reid et al.  
 QTL (1988) Reid et al.  
 / / / ( $\%DigDM = \sqrt{ADF} - \sqrt{ADF}$ )  
 cMWG652A B15C His4A  
 H H H QTL QTL  
 / /  
 QTL  
*Qwsc5Hs Qwsc2Hsb Qwsc2Hsa* QTL / / QTL  
 / / /  
 ABG705 CDO474B ABG358  
 H H H QTL / / LOD  
 QTL LOD  
 / /  
 (*Qadf5Hs Qadf2Hs Qadf1Hsk*) QTL (Qadf2Hs) (Qwsc2Hsa)  
 / / / / / QTL  
 ABG705 CDO474B Pcr2  
 QTL *Qadf2Hs* QTL  
 / / *Qdmd1Hsk* QTL  
*Qcf1Hsk* QTL *Qdmd5Hs Qdmd2Hsk Qdmd2Hsz*  
*Qcf5Hs Qcf2Hszb Qcf2Hskb Qcf2Hsa Qcf1Hsz* / H H H H  
 / / /

( )

| ADL  | NDF  | CF   | ADF  | WSC  | CP   | DMD      |
|------|------|------|------|------|------|----------|
|      |      |      |      |      |      | / ** CP  |
|      |      |      |      |      | / ** | / ** WSC |
|      |      |      | / ** | / ** | / ** | / ** ADF |
|      |      | / ** | / ** | / ** | / ** | / ** CF  |
|      | / ** | / ** | / ** | / ** | / ** | / ** NDF |
| / ns | / *  | / ** | / *  | / ** | / ns | / ** ADL |
|      |      |      |      |      |      | / ** ASH |
|      |      |      |      | ns   |      | ** *     |
|      | ADF  |      |      | WSC  | CP   | DMD      |
|      |      | Ash  |      | ADL  |      | NDF      |
|      |      |      |      |      |      | CF       |





QTL

| R <sup>2</sup> |   | LOD |   | QTL <sup>a</sup> |   | QTL      |      |                 |     |
|----------------|---|-----|---|------------------|---|----------|------|-----------------|-----|
| /              | / | /   | / | /                | / | ksuF2A   | H( ) | <i>Qdmd1Hsk</i> | DMD |
| /              | / | /   | / | /                | / | CDO474B  | H( ) | <i>Qdmd2Hsz</i> |     |
| /              | / | /   | / | /                | / | WG996    | H( ) | <i>Qdmd2Hsk</i> |     |
| /              | / | /   | / | /                | / | ABG705   | H( ) | <i>Qdmd5Hs</i>  |     |
| /              | / | /   | / | /                | / | His4A    | H( ) | <i>Qcp1Hs</i>   | CP  |
| /              | / | /   | / | /                | / | B15C     | H( ) | <i>Qcp2Hs</i>   |     |
| /              | / | /   | / | /                | / | cMWG652a | H( ) | <i>Qcp6Hs</i>   |     |
| /              | / | /   | / | /                | / | ABG358   | H( ) | <i>Qwsc2Hsa</i> | WSC |
| /              | / | /   | / | /                | / | CDO474B  | H( ) | <i>Qwsc2Hsb</i> |     |
| /              | / | /   | / | /                | / | ABG705   | H( ) | <i>Qwsc5Hs</i>  |     |
| /              | / | /   | / | /                | / | Per2     | H( ) | <i>Qadf1Hsk</i> | ADF |
| /              | / | /   | / | /                | / | CDO474B  | H( ) | <i>Qadf2Hs</i>  |     |
| /              | / | /   | / | /                | / | ABG705   | H( ) | <i>Qadf5Hs</i>  |     |
| /              | / | /   | / | /                | / | ksuF2A   | H( ) | <i>Qcf1Hsk</i>  | CF  |
| /              | / | /   | / | /                | / | Per2     | H( ) | <i>Qcf1Hsz</i>  |     |
| /              | / | /   | / | /                | / | ABG358   | H( ) | <i>Qcf2Hsa</i>  |     |
| /              | / | /   | / | /                | / | MWG950   | H( ) | <i>Qcf2Hskb</i> |     |
| /              | / | /   | / | /                | / | CDO474B  | H( ) | <i>Qcf2Hszb</i> |     |
| /              | / | /   | / | /                | / | ABG705   | H( ) | <i>Qcf5Hs</i>   |     |
| /              | / | /   | / | /                | / | ABR337   | H( ) | <i>Qndf1Hs</i>  | NDF |
| /              | / | /   | / | /                | / | CDO474B  | H( ) | <i>Qndf2Hs</i>  |     |
| /              | / | /   | / | /                | / | ABG473   | H( ) | <i>Qndf5Hs</i>  |     |
| /              | / | /   | / | /                | / | ABR337   | H( ) | <i>Qadl1Hs</i>  | ADL |
| /              | / | /   | / | /                | / | B15C     | H( ) | <i>Qadl2Hs</i>  |     |
| /              | / | /   | / | /                | / | PSR167   | H( ) | <i>Qadl6Hs</i>  |     |
| /              | / | /   | / | /                | / | His4A    | H( ) | <i>Qash1Hsa</i> | ASH |
| /              | / | /   | / | /                | / | ABC257   | H( ) | <i>Qash1Hsb</i> |     |
| /              | / | /   | / | /                | / | ABG358   | H( ) | <i>Qash2Hs</i>  |     |

NDF

CF

ADF

WSC

CP

Ash

QTL

a

DMD

ADL

QTL (1999)

H

ABG705

QTL

CDO474B

QTL

H

QTL

*Qdmd5Hs* *Qadf2Hs* *Qdmd2Hsz*

QTL

*Qadf5Hs*

QTL

Orf et al. (1993) Mansur et al.

QTL

*Qash1Hsb* *Qndf5Hs* *Qcp6Hs* *Qadl6Hs*

1. Cluster gene

QTL

Q×E

QTL

(CF ADL NDF ADF)

QTL

QTL QTL QTL

*Qadf1Hsk Qndf2Hs Qcf2Hszb Qadf2Hs*

(2005) Peighambari et al. *Qcf5Hs Qadf5Hs Qadl1Hs Qndf1Hs Qcf1Hsz*

QTL

ADF (2003) Cardinal et al. QTL

NDF

NDF

ADF (Mertens, 1987)

(Reid et al., 1988)

(Ayoub et al., 2003; Zhu et al., 1999)

(Casler, 2001)

QTL

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1. Intake

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