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( / / : // : )

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(

/ 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

E-mail: ba\_siahsar@yahoo.com

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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)                                             |
|                                   | / / / / /          |               | QTL (Ayoub et al., 2003)                          |
| ABG156A                           |                    | /             |                                                   |
| WG541 Adh6 ABG319A ABG316A MWG557 |                    |               |                                                   |
|                                   | / / / / /          |               |                                                   |
|                                   | QTL                | /             |                                                   |
| H H                               |                    | DMD           | (Kleinhofs et al., 2001;                          |
| / /                               |                    | H H H         | Kleinhofs et al., 1993)                           |
|                                   | / / /              |               | QTL                                               |
| ABG319B ABG495B ABG005 Hor5       |                    |               |                                                   |
|                                   | 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>

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

$$e \quad r \quad \times$$

$$\times \quad MS_{G \times E} \quad MS_G$$

(1989) Hayes & Chen

(Hayes, 1992)

$$GG_N = W_{DH} - W_P \quad GG_P = B_{DH} - B_P$$

$$W_{DH} \quad B_{DH}$$

$$W_P \quad B_P$$

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

$\sigma_p$  (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  $\leq$  / )

(P  $\leq$  / ) (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.  
 .(Churchill & Doerage, 1994)

QTL LOD

×

QTL QTL

QTL QTL

LOD  $\geq$  )

6. Statistical Analysis System  
 7. Corel draw

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. .  
( )

×

( $P > /$  )

×

/

/

/ /

( $P \leq /$  )

( $P \leq /$  )

(Panes, 1957)

( )

CF NDF ADF)

(ADL

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1. Transgressive segregation

QTL

( )

( )

| ASH  | ADL  | NDF  | CF   | ADF  | WSC  | CP   | DMD  |
|------|------|------|------|------|------|------|------|
| / ** | / ** | / *  | / *  | / ns | / *  | / *  | / ns |
| /    | /    | /    | /    | /    | /    | /    | /    |
| / ** | / ** | / ** | / ** | / ** | / ** | / ** | / ** |
| / ** | / *  | / ns | / *  | / *  | / ns | / ** | / ns |
| /    | /    | /    | /    | /    | /    | /    | /    |
| /    | /    | /    | /    | /    | /    | /    | /    |
| /    | /    | /    | /    | /    | /    | /    | /    |
| /    | /    | /    | /    | /    | /    | /    | /    |
|      |      |      |      |      |      |      | (%)  |
|      |      |      |      |      |      |      | (%)  |

×

ns \*\* \*  
WSC CP DMD  
Ash ADL

( )

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

Stephoe(P<sub>1</sub>)  
Morex(P<sub>2</sub>)  
P<sub>1</sub>-P<sub>2</sub>  
 $\bar{x}_P = (P_1 + P_2)/2$   
WorstDHs  
BestDHs  
Range  
 $\bar{x}_{DHs}$   
SD<sub>DHs</sub>  
CV<sub>DHs</sub>  
 $\bar{x}_{DHs} - \bar{x}_P$   
GG<sub>N</sub>=W<sub>DH</sub>W<sub>P</sub>  
GG<sub>P</sub>=B<sub>DH</sub>B<sub>P</sub>  
GCV  
PCV  
GC<sub>5%</sub>  
H<sup>2</sup>

ns \*\* \*  
WSC CP DMD  
Ash ADL  
PCV B<sub>p</sub> B<sub>DH</sub> GG<sub>p</sub> GG<sub>N</sub>  
h<sup>2</sup> % GC<sub>5%</sub> GCV

(Knapp et al., 1985; Therrien, 2003)  $\{ h^2 = [\sigma_g^2 / (\sigma_g^2 + \sigma_{ge}^2 / e + \sigma_e^2 / re)] / 2 \}$   $h^2 = [1 - (MS_{G \times E} / MS_G)] / 2 \}$

ABG705 WG996 CDO474B KsuF2A  
*Qcp2Hs Qcp1Hs* QTL  
 H H H *Qcp6Hs* ( $DMD = \sqrt{196} - \sqrt{198} ADF : R = /$ )  
 / /

(1988) Reid et al.  
 (1988) Reid et al.  
 (%*DigDM* =  $\sqrt{196} - \sqrt{198} ADF$ )

QTL  
 / / /

cMWG652A B15C His4A  
 H H H QTL QTL  
 ×

/ /

QTL

*Qwsc5Hs Qwsc2Hsb Qwsc2Hsa* QTL  
 / / / QTL

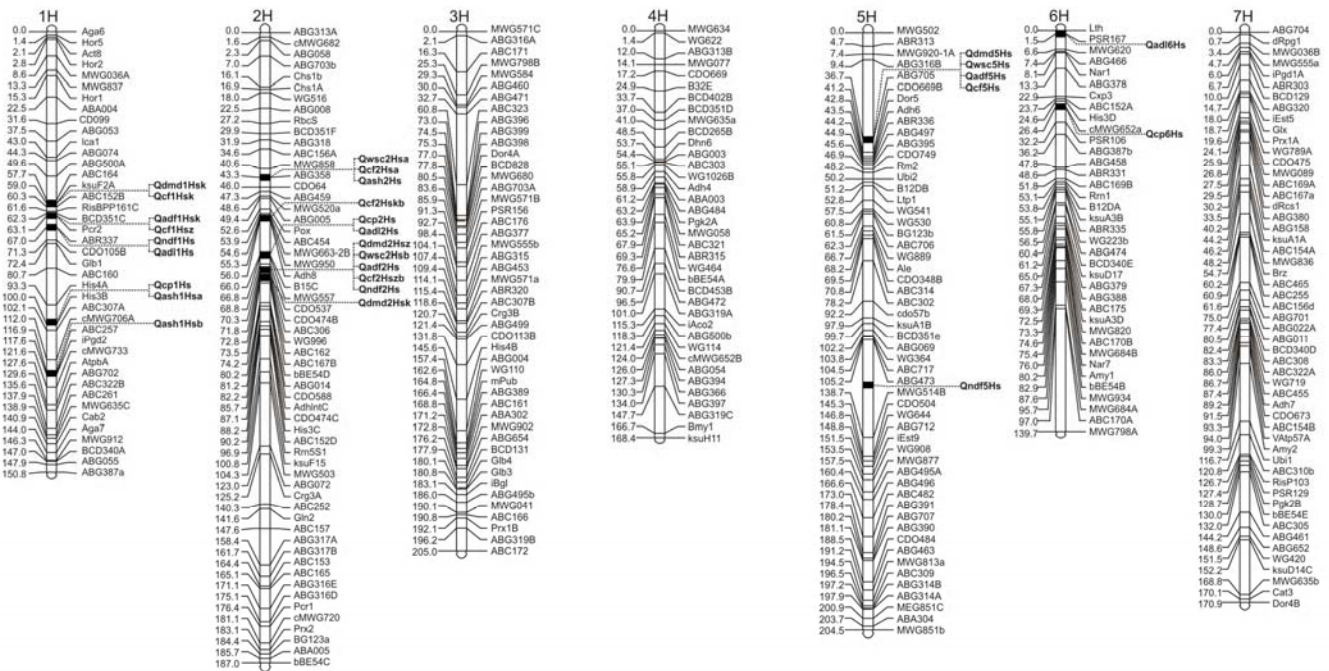
ABG705 CDO474B ABG358  
 H H H QTL  
 / / LOD  
 QTL LOD  
 (Qadf2Hs) (Qwsc2Hsa)

(*Qadf5Hs Qadf2Hs Qadf1Hsk*) QTL  
 / / / 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       |



|                 |                 |                 |                 |                |        |        |                  |                |                  |   |
|-----------------|-----------------|-----------------|-----------------|----------------|--------|--------|------------------|----------------|------------------|---|
|                 | ADF             |                 | WSC             |                | CP     |        | QTL              |                | DMD :            |   |
|                 |                 |                 | Ash             |                | ADL    |        | NDF              |                | CF               |   |
| QTL             |                 |                 |                 | /              |        |        | H                | H              | H                | H |
|                 | <i>Qash2Hs</i>  | <i>Qash1Hsb</i> | <i>Qash1Hsa</i> |                |        |        | /                | /              | /                | / |
| /               | H               | H               | H               |                | MWG950 | ABG358 | Pcr2             | ksuF2A         |                  |   |
| His4A           |                 |                 | /               | /              |        |        | ABG705           | CDO474B        |                  |   |
|                 |                 |                 | ABG358          | ABG257         |        |        | /                | /              |                  |   |
|                 |                 |                 | QTL             |                | QTL    |        |                  |                |                  |   |
| <i>Qcf1Hsk</i>  | <i>Qdmd1Hsk</i> | QTL             |                 |                |        |        | ( <i>Qndf5Hs</i> | <i>Qndf2Hs</i> | <i>Qndf1Hs</i> ) |   |
| <i>Qadl1Hs</i>  | <i>Qndf1Hs</i>  | <i>Qcf1Hsz</i>  | <i>Qadf1Hsk</i> | /              |        |        | H                | H              | H                |   |
| <i>Qcf2Hsa</i>  | <i>Qwsc2Hsa</i> | <i>Qash1Hsa</i> | <i>Qcp1Hs</i>   |                |        |        | /                | /              | /                |   |
| <i>Qdmd2Hsz</i> | <i>Qadl2Hs</i>  | <i>Qcp2Hs</i>   | <i>Qash2Hs</i>  |                |        |        | ABG473           | CDO474B        | ABR337           |   |
| <i>Qndf2Hs</i>  | <i>Qcf2Hszb</i> | <i>Qadf2Hs</i>  | <i>Qwsc2Hsb</i> |                |        |        |                  |                |                  |   |
|                 | <i>Qcf5Hs</i>   | <i>Qadf5Hs</i>  | <i>Qwsc5Hs</i>  | <i>Qdmd5Hs</i> |        |        | /                | /              |                  |   |
| Han & Ullrich   |                 |                 |                 |                | QTL    |        |                  |                |                  |   |
|                 |                 | QTL             | (1994)          |                |        |        |                  |                |                  |   |
|                 | QTL             |                 |                 | /              | /      |        | H                | H              | H                | / |
| H               |                 |                 |                 | B15C           | ABR337 |        |                  |                |                  | / |
|                 |                 | QTL             |                 | QTL            |        |        |                  |                | PSR167           |   |
|                 |                 |                 |                 |                |        |        | ( <i>Qadl6Hs</i> | <i>Qadl2Hs</i> | <i>Qadl1Hs</i> ) |   |
|                 |                 |                 |                 |                |        |        | /                | /              | /                |   |
|                 |                 |                 |                 |                | QTL    |        |                  |                |                  |   |
|                 |                 |                 |                 |                |        |        | /                | /              | /                |   |



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      QTL<sup>a</sup>      DMD      ADL

QTL (1999)

/      QTL

H      ABG705

QTL

CDO474B      /

QTL      H

QTL

*Qdmd5Hs*    *Qadf2Hs*    *Qdmd2Hsz*    *Qadl5Hs*  
 QTL      QTL  
*Qash1Hsb*    *Qndf5Hs*    *Qcp6Hs*    *Qadl6Hs*

QTL  
 Orf et al. (1993) Mansur et al.

1. Cluster gene

QTL

QTL  
 Q×E (CF ADL NDF ADF)  
 QTL QTL QTL  
 (2005) Peighambari et al. *Qadf1Hsk Qndf2Hs Qcf2Hszb Qadf2Hs*  
*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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