

Morphological and Physiological Traits

Note: Levy and Feldman {797} studied the inheritance of more than 20 morphological and biochemical traits in crosses of four *T. dicoccoides* lines and *T. durum*. Similarly, Kuspira *et al.* {744} studied 12 qualitative characters in *T. monococcum*. The symbols applied to the characters examined in these studies are not being reserved and listed in the Catalogue. However, both studies should serve as bases for future work.

1. Gross Morphology: Spike characteristics

Major hexaploid wheat types are categorized into groups with respect to three major gene pairs; viz. *Q*, *C* and *SI* {1038}.

1. Common wheat *Q c SI v*: vulgare group.
2. Club wheat *Q C SI v*: compactum group.
3. Shot wheat *Q c sI v*: sphaerococcum group.
4. Spelt wheat *q c SI v*: spelta group (including vavilovi).

The majority of hexaploid wheat stocks are already, or can be readily, classified into these groups.

Diploid wheat is assumed to be *q*. Durum and carthlicum groups have the genotype *Q c SI* {1049}.

1.1. Squarehead/spelt

Q{881}. [*k*{1550}]. 5AL{1293}. **v**: Common wheats. **CS**. **ma**: Complete linkage with cDNA clone PtAq22{0127}.

q{881}. [*K*{1550}]. **v**: Macha wheats; spelt wheats; *vavilovi* wheats. **s**: CS*8/White Spring Spelt 5A{1048}. **ma**: Cent - *Xrsq805(Emph)-5A* - 4.6cM - *Q* - 4.3cM - *Xpsr370-5A*{419}; *Q* was physically mapped in 5AL, fraction length 0.87, bracketed by deletions 5AL-7 and 5AL-23{446}; *Q* - 9.3cM - *Xpsr370-5A*{9903}.

The speltoid phenotype of at least some spelts may be caused by genes at other loci {0140}. Fine mapping of the 20cM region possessing *Q* and delimited by deletions 5AL -7 and -23 is reported in {0324}.

1.2. Club

C{1517}. Although gene *C* may be present in some forms of group *macha* {1447}, it is not universally present. Tsunewaki {1500} found that compact spike in one form was controlled by polygenes. [*Cd*{047}]]. 2D{1192}.2DL{1192,1517}. **i**: S-615*11/Elgin{1500}. **s**: CS*6/Poso 2D{1304}; CS*5/Red Egyptian 2D{1304}. **v**: Club wheats. **QTL**: Six QTLs for spike compactness were detected in Courtot/Chinese Spring but only 4 on chromosome arms 1AL, 2BS, 2DS and 4AS were consistent for at least two years {0114}.

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1.3. Sphaerococcum

The naturally-occurring sphaerococcum gene in chromosome 3D and various mutant alleles conferring a similar phenotype form a homoeologous series. The sphaerococcoid alleles are either recessive or incompletely dominant. All three mapped loci are closely linked to the

respective centromeres {0030}. The "a" alleles are allocated to Chinese Spring or "normal" wheats.

- s2**. Partially dominant{1286}. [*sp2*{1286}]. **v**: Sphaerococcoid wheats. "*Sphaerococcum simulator*" {1286}.
Sphaerococcum-like tetraploid wheats were reported{122,475,1282,1286}, but comparisons between them, or with *s2*, were not made. Whereas Schmidt & Johnson{1281} reported a single recessive controlling the sphaerococcum character in tetraploid wheat, Joppa{621} using the same stock found that two recessive genes were necessary to produce this phenotype.
- S-AI**{0029}. 3A{0056}. **v**: CS{0029}.
S-A1a{0029}. **v**: CS{0029}; common wheats{0029}.
S-A1b{0029}. [*S3*{0056}]. **v**: MS 1453{0056}. **ma**: *Xgwm2-3A(S)* - 5.1 cM - *S-AI* - 6.6 cM - *Xgwm720-3A(L)*{0030}.
- S-BI**{0029}. 3B{0030}. **v**: CS{0029}.
S-B1a{0029}. **v**: CS{0029}; common wheats{0029}.
S-B1b{0029}. [*S2*{0030}]. **v**: MSK 2452{0056}; MSK 2454{0056}. **ma**: *Xgwm685-3B(S)* - 4.2 cM - *S-BI* - 0.5 cM - *Xgwm566/Xgwm845/cent*{0030}.
- S-DI**{0029}. 3D{1292,0030}.3DS{1193,1194}.3DL{692}. **v**: CS{0029}.
S-D1a{0029}. **v**: CS{0029}; common wheats{0029}.
S-D1b{0029}. [*s1, spl*{1286}]. **i**: S-615*11/*T. sphaerococcum* var. *rotundatum*{1500}.
s: CS*7/*T. sphaerococcum rubiginosum* 3D{1304}. **v**: Sphaerococcum wheats{0029}.
S-D1c{0029}. [*S1*{0056}]. **v**: MS 3287{0056}. **ma**: *Xgdm72-3D(S)* - 8.0 cM - *S-DI* - 2.9 cM - *Xgwm456-3D/cent*{0030}.

1.4. Branched spike

Synonymns: branched head, four-rowed spike, supernumerary spikelet, tetrastichon spikelet.

- bh**{665}. 2A{665,9907}. **dv**: PI 349056{665}.
A chromosome 2B gene of minor effect was identified{9907} and an inhibitor was associated with chromosome 2D{9907}. In a monosomic analysis of the hexaploid line LYB with supernumerary spikelets, Peng *et al.* {9908} located recessive genes in chromosome 2A and 4A that promote the development of supernumerary spikelets and a gene in chromosome 2D that prevents their expression.

1.5. Elongated glume

Elongated glume is the phenotype associated with the polonicum group of tetraploid wheats. Expression in hexaploid wheat is much reduced compared with tetraploids. Matsumura {911} reported linkage of gene *P* and a gene for red coleoptiles implicating chromosomes 7A or 7B. A different gene was subsequently located in chromosome 7B {9990}.

- PI**. [*P*{911},*Eg*{922},*P-A^{pol}I*{0254},*P-A^{pet}I*{0254}]. 7AL{922,1547}.7A or 7B (based on linkage of 0.2 with a gene for red coleoptile){922}. **i**: Saratovskaya29*8//Novosibirskaya 67*2/*T. polonicum*{922}. **itv**: P-LD222 = LD222*11/*T. turgidum* var *polonicum*{1546,1547}. **tv**: *T. polonicum*{0254}; *T. petropavlovskiyi*{0254}. **ma**: *Xgwm260* - 7A(S) - 2.3cM - *PI* - 5.6cM - *Xgwm1083-7A(L)*{0254}; *Xgwm890* - 7A - 2.1cM - *PI*{0254}; *Xgwm260-7AS* - 2.3cM - *PI^{pol}* - 5.6cM - *Xgwm1083-7AL* {0254}; *Xgwm890-7AS* - 2.1cM - *PI^{pet}* {0254}.

Note: The loci determining elongated glumes in *T. turanicum* and *T. durum* conv. *falcatum* are not homoeologous to the *P* loci in the centromeric region of the group 7 chromosomes{0254}.

P2{9990}. 7BL{9990}. **ti**: LD222*7/*T. ispahanicum*{9990}. **tv**: *T. ispahanicum*{9990}. According to {0254} the loci of *T. polonicum*, *T. petropavlovsky* and *T. isphanicum* are allelic ('homoeoallelic') whereas other workers had claimed genes in the first two forms were not allelic. Wang et al {0254} however concluded that loci bearing alleles for elongated glumes in *T. turanicum* and *T. durum* conv. *falcatum* were not part of the above series.

1.6. Ear length

QEL.ocs-5A.1{0068}. 5AL{0068}. **v**: CS(*T. spelta* 5A)/CS(Cappelle-Desprez 5A) RI mapping population{9903}. **ma**: Associated with *Xbcd9-5A*{0068}.

2. Accumulation of Abscisic Acid

A QTL was mapped on 5AL between *Xpsr575-5A* {proximal} and *Xpsr426-5A* {distal} {1180}.

3. Alkylresocinols Content in Grain

Ar1{0281}. High alkylresocinols content is dominant {0281}. 5AL{0281}. **tv**: Langdon{0281}.

ar1{0281}. **tv**: Ardente{0281}; This cultivar has a low content compared to all tested durum and common wheats{0281}.

4. Aluminium Tolerance

Alt1{234}. **v**: ET3 = Carazinho/4* Egret{234}.

alt1{234}. **v**: ES3 = Carazinho/4* Egret{234}.

Alt2{848}. [**Alt_{BH}**{1213}]. 4DL{848}. **su**: *T. turgidum* cv. Langdon 4D(4B){848}. **ma**: *Alt2* was mapped to a 4 cM interval flanked by *Xpsr914* and *Xpsr1051*{848}; on a consensus 4B-4D map of *T. aestivum*; *Alt2* - 1.1 cM - *Xbcd1230-4D*{1213}. **v**: BH1146{1213,0115}; IAC-24{0115}; IAC-60{0115}; 13 induced mutants of Anahuac{0115}. **ma**: *Alt2* cosegregated with *Xbcd1230-4D* and fell within the interval *Xgdm125-4D* - 4.8cM - *Alt2* - 1.1cM - *Xpsr914-4D*{0248}.

5. Anthocyanin Pigmentation

5.1. Purple anthers.

A single, dominant factor was reported {1326}.

Pan1{921}. 7DS{921}. **v**: Ilyitchevka{921}; Mironovskaya 808{921}; Novosibirskaya 67{921}; Pyrothrix 28{921}; Saratovskaya 210{921}; Strela{921}; Ukrainka{921}. **tv**: *T. polonicum*{921}.

Pan2. 7AS{9959}. **tv**: *T. turgidum* ssp. *dicoccoides* acc. MG4343{9959}. **ma**: *Pan2* - 9.2 cM - *Rc1* - 12.2 cM - *Xutv1267-7A* (proximal){9959}.

5.2. Purple/Red auricles. Purple leaf base

For review see {1641}.

Melz and Thiele {983} described a "purple leaf base" phenotype where anthocyanin

pigmentation extended to the leaf base as well as auricles. Purple leaf base was expressed only when pigmentation occurred in the coleoptiles.

- Ra1**. [*Ra*{1645}]. 1D Gulyeeva{474}.(cited in{983}).2D{1645}. **v**: Kenya 58{1645}.
Ra2{983}. 4B{983}.
Ra3{983}. 6B{983}.
An5{983}. 5R{983}.

5.3. Red/purple coleoptiles.

There is an orthologous gene series on the short arms of homoeologous group 7. The 'a' alleles confer red coleoptiles.

- Rc-A1a**{0250}. [*Rc1*, *R*{401}]. 7A{769,1293}.7AS{0250}. **s**: CS*6/Hope 7A{1293}. **v**: Hope *Rc-B1*{1293}. **tv**: *T. turgidum* ssp. *dicoccoides* acc. MG4343{9959}. **ma**: *Pan2* - 9.2cM - *Rc1* - 12.2cM - *Xutv1267-7A*(proximal){9959}; *Rc-A1*(distal) - 11.9cM - *Xgwm913-7A*{0250}.
Rc-B1a. [*Rc2*, *R2*{401}]. 7B{742}.7BS{401,769,0250}. **s**: CS*6/Hope 7B{769}. **v**: Hope *Rc-A1*. **ma**: *Xgwm263-7B* - 26.1cM - *Rc-B1* - 11.0cM - *Xgwm1184-7B*{0250}.
Rc-D1a{0250}. [*Rc3*]. 7D{596}.7DS{1241,1444,0250}. **v**: Mironovskaya 808{1444}; Tetra Canthatch/*Ae. squarrosa* var. *strangulata* RL 5271, RL 5404{1240}; Tetra Canthatch/*Ae. squarrosa* var. *meyeri* RL 5289, RL 5406{1240}; Sears' *T. dicoccoides* /*Ae. Squarrosa* = Sears' Synthetic{596}. **ma**: *Rc-D1* (distal) - 3 cM - *Xpsr108-7D*{180}; *Xgwm44-7D* - 6.4cM - *Rc-D1* - 13.7cM - *Xgwm111-7D*{0250}.

Tahir & Tsunewaki{1453} reported that *T. spelta* var. *duhamelianum* carries genes promoting pigmentation on chromosomes 7A and 7D and genes suppressing pigmentation on 2A, 2B, 2D, 3B and 6A. Sutka{1444} reported a fourth factor in chromosome 6B and suppressors in 2A, 2B, 2D, 4B and 6A.

5.4. Purple/red culm/straw/stem.

Purple or red colour is dominant.

- Pc1**{743}. [*Pc*{743}]. 7B{743}.7BS{768}. **s**: CS*6/Hope 7B{743,768}. **itv**: LD222*11/CS (Hope 7B){1546}. **ma**: *Pc* (proximal) - 5.7 cM - *Xpsr490(Ss1)-7B*{110}².
Pc2{921}. 7DS{921}. **v**: Ilyitchevka{921}; Mironovskaya 808{921}; Novosibirskaya 67{921}; Pyrothrix 28{921}; Saratovskaya 210{921}; Strela{921}; Ukrainka{921}.

5.5. Purple grain/pericarp

Genes for purple pericarp have been transferred from tetraploid wheats to the hexaploid level {112,214,941,1138}. At the hexaploid level duplicate genes {112,941} and complementary genes {112,939,1138,438} were reported. At the tetraploid level, duplicate-gene {941} and single-gene {1327} inheritances were observed. Purple colour is dominant and may be affected by environment and genetic background. Complementary genes were located in chromosomes 3A and 7B {1138}. Possible pleiotropic relationships of genes affecting pigmentation of various tissues have not been studied in detail. *Pc2* and *Rc-B1a* may be the same gene {769}. Also, complementary genes involved in determination of purple pericarp could be related to culm colour {112}.

For review, see {1643}.

Complementary dominant genes.

- Pp1**{041}. 6A{041}. **i**: Saratovskaya 29*8/Purple {Australia} *Pp2*{040}.
Pp2{041}. 7A{041}. **tv**: *T. durum* Desf. subsp. *abyssinicum* Vav{040}.

Piech and Evans{1138} located complementary genes on chromosomes 3A and 7B.

6. Awnedness

hd b1 b2. Bearded or fully awned genotype

6.1. Dominant inhibitors

6.1.1. Hooded

Hd{1551}. 4AS{1195,1293}. **i**: S-615*11/CS{1500}. **v**: Chinese Spring *B2*{1293}. **ma**: *Xcdol387-4A* - 8.2cM - *Hd* - 7.2cM - *Xpsr163* - 4A{0047}.

was mapped as a QTL with a peak on Xfba78-4A in {0309}.

hd. **s**: CS*6/Hope 4A; CS*5/Thatcher 4A; CS*6/Timstein 4A.

6.1.2. Tipped 1

B1{1551}. 5AL{1293,0242}. **i**: S-615*11/Jones Fife{1500}. **v**: Timstein{741}; Redman{160}.

B1 was mapped as a QTL with a peak on Xwmc182-6B {0309}.

B1a{041}. **s**: Saratovskaya 29*8/Festiguay 5A{041}.

B1b{041}. **s**: Saratovskaya 29*8/Aurora 5A{041}.

B1c{041}. **s**: Saratovskaya 29*8/Mironskaya 808 5A{041}.

In a common genetic background, carriers of *B1a* have the shortest tip-awned phenotype; carriers of *B1b* and *B1c* have awns 2 to 3 times longer depending on environment. In F1 hybrids, differences between the substitution line combinations are significant. The postulation of *B1* in both CS and Courtot {0309} based on the phenotype of a CS deletion stock is not supported by genetic observations

6.1.3. Tipped 2

B2{1551}. 6BL{1293,1297}. **i**: S-615*11/CS{1500}. **v**: Chinese Spring *Hd*{1293}.

b2. **s**: CS*6/Hope 6B; CS*5/Thatcher 6B; CS*9/Timstein 6B.

6.1.4. Awnless

Genotypes *Hd B2* (e.g., Chinese Spring) and *B1 B2* (e.g., Federation) are awnless.

Presumably *Hd B1* is awnless. Watkins & Ellerton {1551} noted the probability of a third allele "*b1a*" leading to a half-awned condition, and in discussion they consider the possibility of a similar third allele at the *B2* locus. In view of more recent cytogenetic analyses, it seems that the half-awned condition could result from epistatic interactions between the alleles *B1* and/or *B2* and various promotor genes.

Although hooded, half-awned, tip-awned and awnless variants occur among tetraploid wheats, these are relatively infrequent. It has not been established with certainty that the above inhibitors are involved.

The inhibitor alleles have a pleiotropic effect on glume-beak shape {1348}. Acuminate beak is associated with full beardedness and occurs only in *b1 b2* types. *B2* reduces beak length producing an acute beak shape. *B1* reduces beak length producing an obtuse beak shape. In this effect *B1* is epistatic to *B2*.

6.2. Promotors

The effects of (recessive) awn-promoting genes were documented in a number of studies, mainly through monosomic and disomic F1 comparisons, and in tetraploids, whereas Heyne & Livers {549} provided genetic evidence of their effects. A series of "a" genes was documented, but the evidence supporting the existence of at least some of these was not well supported. Hence symbols for this gene series are not recognized.

6.3. Smooth awns

Smooth-awned tetraploid wheats were reported {016,045,690,1259} and genetic analyses {016,045,690} suggested a single recessive factor, with modifiers in most instances, relative to rough awns. The phenotype has not been reported in hexaploid wheats. No gene symbol is applied.

7. Basal Sterility in Speltoids

The presence of gene *Q* ensures the fertility of the first and subsequent florets in wheat spikelets {378}. In speltoids lacking *Q*, fertility of the second and subsequent florets is ensured by the dominant allele *Bs* (designated *A* in {378}) located on chromosome 5D {377}. In the presence of *Bs* the fertility of the first floret is under polygenic control.

In *bs bs* speltoids floret development is under polygenic control, and stocks with varying levels of basal fertility were isolated.

All group *vulgare* genotypes so far studied carry *Bs*.

The following stocks were described {378}:

	Genotype	Approx. sterile-base score
Group <i>vulgare</i>	---- <i>QQ Bs Bs</i>	0.00
Speltoids	StFF <i>qq Bs Bs</i>	0.00
	StF <i>qq Bs Bs</i>	0.08
	St1A <i>qq Bs Bs</i>	0.39
	St1 <i>qq Bs Bs</i>	0.96
	St2 <i>qq bs bs</i>	1.41

8. Blue Aleurone

The *Ba* allele in *T. monococcum* spp. *aegilopoides* acc. G3116 determines a half-blue seed phenotype and is different from the allele present in *Elytrigia pontica* that determines a solid blue phenotype {282}. They are treated as different genes.

For review see {1643}.

Ba1{643}. Derived from *Elytrigia pontica* (2n=70). [*Ba*{643}]. 4B[4BS-4e1₂]{643}. **tr**: UC66049B{594}.

Ba2. 4A^mL{282}³. **dv**: G3116{282}. **ma**: *Ba2* cosegregated with *Xcdo1387-4A*, *Xmwig677-4A* and *Xbcd1092-4A* {282}.

9. Brittle Rachis

Br1{9970}. 3DS{9970}. **v**: *T. aestivum* var. *tibetanum*{9970}.

Br2{0130}. 3A{0130}. **sutv**: LDN(DIC 3A){0130}.

Br3{0130}. *3B*{0130}. **svt**: LTN(DIC 3B){0130}.

Evidence for a homoeologous series extending to many related species is discussed in {0130}.

10. Boron Tolerance

Genes controlling tolerance to high concentrations of soil boron act additively.

Bo1{1111,1113}. *7B*{177}. **v2**: Halberd *Bo2Bo3*.

Bo2{1111,1113}. **v2**: (W1*MMC)/Warigal *Bo3*. Halberd *Bo1 Bo3*.

Bo3{1111,1113}. *4A*{0012}. **v2**: Warigal *Bo2*. Halberd *Bo1 Bo2*.

Very sensitive genotype: Kenya Farmer *bo1 bo2 bo3*.

11. Cadmium Uptake

11.1. Low cadmium uptake

Cdu1{963}. [*Cdu1*{1128}]. **dv**: Biodur{1128}; Hercules{1128}; Nile{1128}.

cdu1{963}. [*cdu1*{1128}]. **dv**: Kyle{1128}. **ma**: *Cdu1* - 4.6cM - OPC-20{1128}; *Cdu1* - 21.2 cM - UBC-180{1128}.

12. Chlorophyll Abnormalities

12.1. Virescent

VI. *3B*{122,1311,1294}. *3BS*{1423}. **v**: **CS**.

v1a. [*v*{1294}]. **i**: S-615*11/Neatby's Virescent{1500}. **s**: CS*9/Neatby's Virescent{1304}. **v**: Neatby's Virescent{1055}.

v1b. **i**: CS*/Hermsen's Virescent *v2b*{1304}. **v**: Hermsen's Virescent *v2b*{1311}.

V2. *3A*{1311,1545}. **v**: **CS**.

v2a. **v**: Viridis 508{1545}.

v2b. Expressed only when combined with *v2b* **i**: CS*/Hermsen's Virescent *v1a*{1304}. **v**: Hermsen's Virescent *v1a*{1311}.

v1b and *v2b* are expressed only when both are present. Corresponding normal alleles are designated *VI* {3B} and *V2* {3A} following Sears' {1295} demonstration of their effects on the expression of *v1a*.

12.2. Chlorina

Cn-A1. *7A*{1132}. *7AL*{1131,1304,1311}. **v**: **CS**.

cn-A1a. [*cn1a*]. **i**: Chlorina-1{1311}.

cn-A1b. [*cn1b*]. **i**: Cornell Wheat Selection 507aB-2B-21/6*CS{1133}.

cn-A1c. [*cn2*]. **i**: Chlorina-448. (CS background){1545}.

cn-A1d{665}. **dv**: CDd6{665,666}.

Cn-B1. *7BL*{1131}. **v**: Chinese Spring{1131}.

cn-B1a{665}. **dv**: CDd1{665,666}; CBC-CDd1{665}.

cn-B1b{665}. **dv**: CDd2{665,666}.

Cn-D1. [*Cn3*]. *7D*{1545}. *7DL*{1131}. **v**: Chinese Spring{1131}.

cn-D1a. [*cn-D1, cn3*]. **i**: Chlorina-214{1545}. **v**: CD3{1583}.

12.3. Striato-virescens

A mutant of this type was described {376} but has been lost.

13. Cleistogamous Flowering in Durums

Cleistogamy, a rare flowering habit in durum wheats, is controlled by a single recessive gene relative to chasmogamy {191}.

Cleistogamous genotypes *clcl*.tv: HI8332 {191}; WH880 {191}.

Chasmogamous genotypes *CICl*.tv: IWP5308 {191}; PWB34 {191}; WH872 {191}.

14. Copper Efficiency

Copper efficiency is a genetic attribute that enhances plant growth in copper deficient soil.

Ce{1276}. 4BL = T4BL.5RL{1276}. **v**: Cornell Selection 82a1-2-4-7{462}; Backcross derivatives of Cornell Selection to Oxley, Timgalen, Warigal{464}; Hairy necked Viking{1276}.

5BS = T5BS.5RL.**ad**:CS+5R{463}. **su**: CS 5R{5D}{463}. **v**: Sears' stock HN-2{464}; Backcross derivatives to Warigal and Timgalen{464}.

15. Corroded

co1. [*co*{1297}]. 6BS{1293}. **v**: Sears' corroded mutant.

co2. 6D{1570}. **v**: Kurrachee{1570}.

A gene(s) in chromosome 6A acts as an inhibitor of corroded {1039,1570}.

16. Crossability with Rye and *Hordeum* and *Aegilops* spp.

16.1. Common wheat

High crossability of some wheats, particularly those of Chinese origin, viz. Chinese 446 {790}, Chinese Spring {1216}, and TH 3929 {939}, with cereal rye, weed rye (*S. segetale* L.) {1646}, and other species, e.g., *Aegilops squarrosa* {691}, *Hordeum bulbosum* {1387,1397,1469} and *H. vulgare* {349,693}, is determined by additive recessive genes. The *kr* genes influence crossability with *H. vulgare*. Allele *kr1* is more potent in suppressing crossability than *Kr2* which is stronger in effect than *Kr3* {1387}. According to Zheng et al. {1649}, the effect of *Kr4* falls between *Kr1* and *Kr2*.

Kr1. 5B{1216}.5BL{762}.

kr2. 5A{1216}.5AL{1387}.

kr3. 5D.

kr4. 1A{1649}.

kr1 kr2. **v**: Chinese 446{790}; Chinese Spring{762,1216,1025}; Martonvarsari 9^{*}4/CS{1016}.

Kr1 kr2. **s**: CS^{*}6/Hope 5B{762,1216}. **v**: Blausamtiger Kolben{790}.

kr1 Kr2. **s**: CS^{*}6/Hope 5A{1216}.

Kr1 Kr2. **v**: Marquis{790}; Peragis{790}.

kr1 kr2 kr3 kr4. **v**: J-11{1649}.

Kr1 Kr2/Kr1 kr2. (heterogeneous). **v**: Martonvarsari 9{1016}.

Using the Chinese Spring/Cheyenne chromosome substitution series, Sasaki & Wada {1265} found significant differences in crossability for chromosome 5B, 7D, 1D and 4B. Differences between rye lines also occur {1265,1458}. Allelic variation in the potency of the dominant suppressor genes was reported {1385,343}. Evidence for allelic variation in dominant suppressors is reported in {1386}. Lists of wheat/rye crossabilities:{1383,1642,850,858}.

QTL: 65% of the variability in a Courtot/CS population was associated with *Xfba-367-5A(5AS)*, *Xwg583-5B(5BL)* and *Xtam51-7A{0134}*. Only the second QTL appears to coincide with known locations of *Kr* genes.

16.2. Tetraploid wheat

The Chinese tetraploid, Ailanmai, possesses recessive crossability genes on chromosomes 1A, 6A and 7A with the 6A gene being the least effective {0017}.

17. Dormancy (Seed)

Phs{9960}. Semi-dominant {9960}. 7D{9960}. **v:** Soleil{9960}. **ma:** Associated with *Xpsr1327-4A*{0346}.

QTL: Several QTL for falling number and alpha-amylase activity, two indicators for pre-harvest sprouting resistance, were identified in {0169}. The most significant were associated with *Xglk699-2A* and *Xsfr4(NBS)-2A*, *Xglk80-3A* and *Xpsr1054-3A*, *Xpsr1194-5A* and *Xpsr918-5A*, *Xpsr644-5A* and *Xpsr945-5A*, *Xpsr8(Cxp3)-6A* and *Xpsr563-6A*, and *Xpsr350-7B* and *Xbzh232(Tha)-7B* {0169}.

In cross AC Domain/Haruyutaka, one major QTL in chromosome 4AL and two lesser possibly homoeologous QTLs for dormancy in 4BL and 4DL {0226} were found. Tolerance to preharvest sprouting (PHS) in the cross SPR8198/HD2329 was associated with *Xwmc104-6B* and *Xmst101-7D* {0032}. QTL for preharvest sprouting were identified on chromosomes 3A (associated with *Xfbb293-3A* at P=0.01), 3B (associated with *Xgwm403-3B* and *Xbcd131-3B* at P=0.001), 3D (associated with *Xgwm3-3D* at P=0.001) and 5A (associated with *Xbcd1871-5A* at P=0.001) in the population Renan/Recital {0347}. The resistant alleles on the group 3 chromosomes and on 5A were contributed by Renan and Recital, respectively. All QTL for preharvest sprouting co-located with QTL for grain colour {0347}

18. Ear Emergence

QEet.ocs-4A.1{0047}. 4AL{0047}. **v:** CS/CS(Kanto107 4A) mapping population. **ma:** Associated with *Wx-B1*{0047}.

QEet.ocs-5A.1{0068}. 5AL{0068}. **v:** CS(*T. spelta* 5A)/CS(Cappelle-Desprez 5A) RI mapping population{9903}. **ma:** Associated with *Xcdo584-5A* and morphological locus *Q*{0068}.

QEet.ocs-5A.2{0026}. 5AL{0026}. **ma:** *Xcdo 412-5A - Xbcd9-5A* region{0026}.

QEet.ipk-2D{0255}. *QEet.ipk-2D* coincides with a QTL for flowering time, *QFlt.ipk-2D*. Both QTLs may correspond to *Ppd-D1* {0255}. 2DS{0255}. **v:** Opata/W-7984 (ITMI) RI mapping population{0255}; Lateness was contributed by W-7984{0255}. **ma:** Associated with *Xfba400-2D* and *Xcdo1379-2D*{0255}.

QEet.ipk-5D{0255}. *QEet.ipk-5D* coincides with a QTL for flowering time, *QFlt.ipk-5D*. Both QTLs probably correspond to *Vrn-D1* {0255}. 5DL{0255}. **v:** Opata/W-7984 (ITMI) RI mapping population{0255}; Lateness was contributed by W-7984{0255}. **ma:** Associated with *Xbcd450-5D*{0255}.

19. Earliness Per Se

Genes for earliness *per se* {0023} affect aspects of developmental rate that are independent of responses to vernalization and photoperiod.

Eps-IA^m{0364}. [*Eps-A^mI*]. 1AL{0364}. **dv**:: T. monococcum. DV92 allele for late flowering, G3116 early flowering.{0364}. **ma**:: 0.8 cM distal to Xwg241 {0364}.

Eps-A1a{0024}. 3A{0023}.3AL{0024}. **v**: Chinese Spring{0024}.

Eps-A1b{0024}. **v**: Timstein{0024}.

epsCnn{0025}. **v**: Cheyenne{0025}.

EpsWi{0025}. 3A{0025}. **su**: Cheyenne*7/Wichita 3A{0025}. **ma**: Linked to QTLs for plant height, kernel number per spike, and 1,000-kernel weight in RSLs derived from CNN/CNN(WI3A){0025}.

QTL: Analysis in Courtot/CS {0132}.

20. Flowering Time

QFt.ipk-3A{0255}. 3AL{0255}. **v**: Opatá/W-7984 (ITMI) RI mapping population{0255}; Lateness was contributed by W-7984{0255}. **ma**: Associated with *Xbcd451-3A*{0255}.

21. Flour Colour

Loci controlling flour colour were identified and mapped in a recombinant inbred population derived from hexaploid wheat cultivars Schomburgk and Yarralinka {9936}. Regions in 3A and 7A accounted for 13% and 60% of the genetic variation, respectively, and *Xbcd828-3A*, *Xcdo347-7A* and *Xwg232-7A.1* were significantly associated with flour colour. The association was highly significant in all three replicates only for the 7A QTL. Symbols were not assigned to the flour colour loci.

22. Free-threshing Habit

QFt.mgb-5A{0046}. 5AL{0046}. **tv**: Messapia/*T. dicoccoides* MG4343 mapping population{0046}. **ma**: Associated with *XksuG44-5A*{0046}.

QFt.mgb-6A{0046}. 6A{0046}. **tv**: Messapia/*T. dicoccoides* MG4343 mapping population{0046}. **ma**: Associated with *Xpsr312-6A*{0046}.

23. Frost Resistance

Fr1{1446}. 5AL{1446}. **v**: Hobbit{1446}. **ma**: Mapped to the mid-region of 5AL, 2.1 cM distal from *Xcdo504-5A* and *Xwg644-5A* and proximal to *Xpsr426-5A*{419}; Mapped 2cM proximal to *Xwg644-5A* and *Vrn-A1*{0291}; and flanked by deletion points 0.67 and 0.68{0292}.

Fr2{0291}. 5DL{0291}. **s**: CS*7/Cheyenne 5D{0291}. **ma**: *Fr2* mapped 10 cM proximal to *Vrn-D1*{0291}.

QWin.ipk-6A. 6AS{0255}. **v**: Opatá/W-7984 (ITMI) RI mapping population{0255}; Winter hardness was contributed by W-7984{0255}. **ma**: Associated with *Xfba85-6A* and *Xpsr10(Gli-2)-6A*{0255}.

Responses to cold exposure and their genetics are reviewed in {0020,0274}.

24. Gametocidal Genes

24.1. Gametocidal activity

Gcl-B1a{1485}. [*Gcl1a*{1490},*Gcl1*{1487}]. 2B{1490}. **i**: CS*8/*Aegilops speltoides*. subsp. *aucheri*{1487}.

Gc1-B1b{1485}. [*Gc1b*{1490}]. 2B{1490}. **i**: S^{*}8/*Ae. Speltoides* subsp. *ligustica*{1490}.
Gc1-C1{0188}. 2CL{0189}. **ad**: CS/2C{0189}. **su**: CS2C(2A), CS2C(2B),
 CS2C(2D){0189}.

Gc1-SII{1485}. [*Gc-S^l3*{1485}]. 2S¹{334}. **ad**: CS/*Ae. sharonensis*{334}.

Gc2-SIIa{1485}. [*Gc-S^l1*{1485}]. 4S¹{866}. **ad**: CS/*Ae. longissima*{866}.

Gc2-SIIb{1485}. [*Gc-S^l2*{1485}]. 4S¹{1013}. **ad**: S/*Ae. sharonensis*{1013}.

Gc3-CI{1485}. [*Gc-C*{1485}]. 3C{333}. **ad**: CS/*Ae. triuncialis*{338}.

Gc1-B1a, *Gc1-B1b* and *Gc1-S^l*, classified in the same functional group, are hypostatic to the genes *Gc2-S^l1a* and *Gc2-S^l1b*. *Gc3-CI* does not interact with the *Gc* genes in the other two groups. In addition to these genes, chromosomes carrying gametocidal genes occur in *Ae. caudata* {337} and *Ae. cylindrica* {336} and other strains of *Ae. longissima* and *Ae. sharonensis* {335,1484}.

Gametocidal genes in chromosomes in the same homoeologous group have the same gametocidal action {0190}. In monosomic additions of chromosomes with gametocidal effects, chromosome deletions and translocations are produced in gametes not having the gametocidal genes. This feature has been exploited to isolate genetic stocks suitable for physical mapping of wheat {0191} chromosomes, and of rye {0192} and barley {0193,0194,0195} chromosomes in a wheat background.

Genes with gametocidal activity (*Sd1* {1647} and *Sd2* {1161}) in wheat are present in homoeologous group 7 chromosomes of *Thinopyrum elongatum* {653,1647}. A segment earlier believed to be derived from *Thin. distichum* {889,892} is probably the same as that from *Thin. elongatum* {1162}.

In the presence of both *Sd1* and *Sd2*, *Lr19* is transmitted preferentially in heterozygotes, the degree of distortion being determined by genetic background. In heterozygotes with the same background, and in the presence of only *Sd2*, *Lr19* shows strong self-elimination. Based on these results, it seems likely that the Sears' translocation 7D-7Ag#7 does not carry *Sd1* {939}. See also Pollen Killer.

Sd1{1647}. 7D{1647}. **v2**: Agatha *Sd2*{1647,1161}.

Sd2{1161}. 7BL{1163}. **v**: 88M22-149{1163,1161}.

24.2. Suppression of gametocidal genes

Igc1{1489}. Causes suppression of the 3C chromosome gametocidal gene of *Ae. triuncialis*. This alien gametocidal factor also promotes chromosome breakage {1486}. 3B{1488}. **v**:

Norin 26{1483,1488}; Nineteen wheats listed in{1483,1488}.

igc1. **v**: Chinese Spring{1483,1488}; Forty wheats are listed in{1483,1488}.

25. Gibberellic Acid Response (insensitivity)

Gai1. [*GAI1*{565,1246}]. 4B{406}.4BS{980}. **i**: See{408}. **v**: Norin 10 Der.{565; List in{407}. **ma**: *Xpsr622-4B* (distal) - 1.9 cM - *Gai1* - 8.3 cM - *Xbcd110-4B* (proximal){9959}. **tv**: Messapia{9959}.

Gai2. [*GAI2*{565,1246}]. 4D{411}.4DS{980}. **i**: See{408}. **v**: Maris Hobbit{411}; Norin 10 Der.{565}; List in{407}.

Gai3. [*GAI3*{565,1246}]. 4B{413}.4BS{980}. **i**: See{408}. **v**: Minister Dwarf{413}; Selection D6899{359}; Tom Thumb{405}; Tom Thumb Der.{565,567}.

In wheats with *Gai3*, the aleurone layer fails to respond to applied GA {405}.

Two studies involving crosses between Tom Thumb derivatives and tall parents suggested that gibberellic acid insensitivity and reduced height were controlled by one gene, i.e., *Gai3* {359,413}. In a third study involving a Tom Thumb derivative, recombinants were isolated,

indicating separate but linked genes, i.e., *Gai3* and *Rht-B1c* {565,567}. Further evidence was obtained for linkage between genes for gibberellic acid insensitivity and Norin 10 genes for reduced height in hexaploid {568} and durum {720} wheats. Hu & Konzak {567} reported 27% recombination between *Gai1* and *Rht-B1b* and 10% recombination between *Gai2* and *Rht-D1b* in hexaploid wheats involving Norin 10 and Suwon 92 derivatives. In durum derived from crosses involving Norin 10, 15% recombination was obtained between one of the genes for reduced height and gibberellic acid insensitivity {1246,1247}. Gale & Law {403} considered *Gai1* and *Rht-B1b*, *Gai2* and *Rht-D1b*, *Gai3*/ and *Rht-B1c* to be pleiotropic genes.

26. Glaucousness (Waxiness/Glossiness)

Glaucousness refers to the whitish, wax-like deposits that occur on the stem and leaf-sheath surfaces of many graminaceous species. The expression of glaucousness depends on the arrangement of wax deposits rather than the amount of wax {603}. Non-glaucous variants also occur and genetic studies indicate that non-glaucousness can be either recessive or dominant. Recessive forms of non-glaucousness are apparently mutants of the genes that produce the wax-like deposits.

Dominant non-glaucous phenotypes (as assessed visually) appear to be due to mutations that affect the molecular structure, and reflectance, of the wax-like substances {10001}. The genes involved in wax production and the "inhibitors" are duplicated in chromosomes 2B and 2D. There appear to be independent genes for wax production and "inhibitors" {912,1493,10001}. In earlier issues of the gene catalogue the two kinds of genes were treated as multiple alleles {1432}. All forms of wild and cultivated einkorn are non-glaucous {10001}.

Orthologous loci occur in barley chromosome 2HS (*gs1*, *gs6*, *gs8*) {467}, rye chromosome 7RL (*wa1*) {725} and maize (*gl2*) {211}.

A gene for spike glaucousness, *Ws*, was mapped distally on the short arm of chromosome 1B in the cross *T. durum* cv. Langdon / *T. dicoccoides* acc. Hermon H52 {0171}.

26.1. Genes for glaucousness

W1. 2BS{267,1493}. **i:** Chinese Spring mono-2D/S615//10*wS615{10001}. **v:** Chinese Spring{1493}. **itv:** LD222*11/*T. turgidum* var. *pyramidale* recognitum{1546}. **v2:** S615 W2{10001}.

w1. Recessive allele for reduced glaucousness. 2BS{1432}. **v:** CS mono-4B mutant{1064}; Mentana{1432}; Salmon{1493}.

W2. **i:** Chinese Spring mono-2B/S615//11*wS615{10001}. **v:** *T. compactum* cv. No 44{10001}. **v2:** S615 W1{10001}.

W2a. **dv:** Glaucous forms of *Ae. tauschii*.

W2b. **v:** Chinese Spring - weak hypomorph recognized at increased dosage{1432}.

A non-glaucous spike phenotype in line L-592, a 7S(7A) substitution line, is described in {0113}.

w1w2{10001}. **i:** w-S615 = S615*11/Salmon{10001}. **v:** Salmon{10001}; Mentana{1432}; CS mono-4B mutant{1064}.

26.2. Epistatic inhibitors of glaucousness

Each inhibitor inhibits all genes for glaucousness.

Iw1{10001}. [**W1'**{1493}, **II-W**{1493}]. 2BS{10001}. **i:** S615/Cornell 5075//10*S615{10001}.

- Iw2**{10001}. [I2-W{1493}]. 2DS{10001}. **i**: S615/Golden Ball Synthetic//10-*S615{10001}. **v**: Golden Ball Synthetic{10001}; Vernal Synthetic{10001}. **dv**: Non-glaucous forms of *Ae. tauschii*{1493}.
- Iw3**{277}. [IW3{277},I3-W{277}]. 1BL{277}. **tv**: *T. turgidum* var. *dicoccoides*{277}. A non-glaucous spike phenotype in line L-592. A 7S(7A) substitution line, is described in {0113}.

27. Glume Colour and Awn Colour

27.1. Red (brown/bronze) glumes

The majority of studies report a single dominant gene for red glume colour. A few papers report two factors {1009,1477,1520}. Red glume colour in Swedish land cultivars is apparently associated with hairy glumes {1277} suggesting, because *Hg* is located in chromosome 1A, that a red glume factor different from *Rg1* is involved in the Swedish stocks. Nothing was known of the possible association of such a gene with *Bg*, another glume colour gene on 1A. See {1640} for review. A 1A gene, *Rg3*, was eventually identified by linkage with *Gli-A1* {1405} and shown to cosegregate with *Hg* {624}.

- Rg1**. [Rg]. 1B{1517}.1BS{369}. **s**: CS*5/Red Egyptian 1B{1304}. **v**: Diamant I{9906}; Federation 41{1517}; Highbury{1121}; Red Egyptian{1304}; *T. petrapavlovskiy*{9906}. **v2**: Milturum 321 *Rg3*{9906}; Milturum 553 *Rg3*{9906}; Strela *Rg3*{9906}. **tv**: Ward{792}. **ma**: *Xytv1518-1B* (distal) - 7.7cM - *Rg1* - 0.8cM - *Gli-B1* (proximal){9959}.
- Rg2**. Derived from *Aegilops squarrosa*. 1DL{769,1241}.1DS. **i**: Saratovskaya 29*5/*T. timopheevii*/*T. tauschii*{9906}. **v**: (*Triticum dicoccoides*/*Ae. squarrosa*){769}; (*Tetra Canthatch*/*Ae. squarrosa* var. *strangulata* RL 5271), RL 5404{1240}; (*Tetra Canthatch*/*Ae. squarrosa* var. *meyeri* RL 5289), RL 5406{648,1240}. **dv**: *Aegilops squarrosa* accessions. **QTL**: *QRg.ipk.1D* was mapped in the Opata/W-7984 (ITMI) mapping population{0255}; Linkage with *Gli-D1* implied *Rg2*. This QTL coincided with a QTL for awn colour, *QRaw.ipk-1D*{0255}.
- Rg3**{924,562}. 1AS{924,562,9906}. **i**: Saratovskaya 29*3 //F2 CS mono 1A/Strela{924}. **v**: CS/Strela Seln{9906}; Iskra{9906}; L'goskaya-47{1405}; L'govskaya-47{1405}; Zhnitstra{9906}. **v2**: Milturum 553 *Rg1*{9906}; Milturum 321 *Rg1*{9906}; Strela *Rg1*{9906,924}; Sobko & Sozinov reported a further group of 30 international wheats which, by inference from their *Gli-A1* alleles, probably carry *Rg3*. A linkage order of *Glu-A1* - cent - *Hg* - *Rg3* was reported Strela *Rg1* {9906,924}{1405}. Kovel {729} described a brown or smokey-grey glume phenotype in *T. aestivum* var caesium K-28535. This phenotype was also present in accession K-40579 and botanical varieties cinereum, columbina and albiglucum. Close linkage to *Gli-D1* was shown and a gene designated *Brg* was assumed to be an allele of *Rg2* present in *Ae. tauschii* and synthetic hexaploid wheats. **v**: K-28535 {729}. **i**: ANK-23 = Novosibirskaya 67*10/ K-28535 {729}. A 1B gene controlling red glume colour was mapped in a cross between durum wheat cv. Messapia and *T. turgidum* ssp. *dicoccoides* acc. MG4343. **ma**: *Xutv1518-1B* (distal) - 7.7 cM - *Rg1* - 0.8 cM - *Gli-B1* (proximal) {9959}.
- QRg.ipk-1D**{0255}. This QTL coincides with a QTL for awn colour, *QRaw.ipk-1D* {0255}. 1DS{0255}. **v**: Opata/W-7984 (ITMI) RI mapping population{0255}; The glume colour was contributed by W-7984{0255}. **ma**: Associated with *Gli-D1*{0255}.

27.2. Black glumes

Bg{282,1304}. 1A{282,1304}. **s**: CS*7/Indian 1A{1304}. **dv**: G1777{282}; G3116{282}.
ma: *Bg* and *Nor9* co-segregated in *T. monococcum*{282}³; *Xutv1391-1A* (distal) - 3cM - *Bg* - 1.6cM - *Hg* - 2.4cM - *Gli-A1* (proximal){9959}.
Bga{282}. [*Bg(a)*]{282}. **dv**: G1777.
Bgb{282}. [*Bg(b)*]{282}. **dv**: G3116.
bg{282}. **dv**: DV92, G2528.

Bga and *Bgb* are dominant and cause a solid black glume and a black line at the margins of the glume, respectively. *bg* is recessive and confers non-black glumes.

A single factor for black glumes was reported in diploid, tetraploid and hexaploid wheats {1347}. Linkage with *Hg* was demonstrated at all levels of ploidy, indicating a common gene on chromosome 1A; *Bg* is epistatic to *Rg*.

27.3. Pseudo-black chaff

This is a blackening condition transferred from Yaroslav emmer to Hope wheat by McFadden at the same time as stem-rust resistance was transferred. The association of this condition with mature-plant stem-rust reaction (*Sr2*) has been noted in a number of papers. According to {742}, the condition is recessive. Pan {1102} considered linkage with stem-rust reaction could be broken, but this seems unlikely.

Pbc. 3B{742}.3BS. **s**: CS*6/Hope 3B{742}; CS*6/Ciano 5B{939}.

27.4. Black-striped glumes

This phenotype was reported in group *dicoccon*. **v**: E4225 {1417}.

27.5. Inhibitor of glume pigment

An inhibitor of glume pigment was reported on chromosome 3A {106}.

27.6. Chocolate chaff

cc{719}. 7B{719}.7BS{665}. **tv**: Langdon mutant{719}; PI 349056{665}. **dv**: CBC-CDd1{665}.

The chocolate chaff phenotype was suppressed by a gene(s) in chromosome 7D {719}.

27.7. Awn colour

The literature on awn colour is not clear. In general, awn colour is associated with glume colour {045}. Occasionally, however, awn colour and glume colour may be different. According to Panin & Netsvetaev {1103}, black awns were determined by three complementary genes designated *Bla1*, *Bla2*, *Bla3*. *Bla1* was located in chromosome 1A and linked with *Gld 1A* (= *Gli-A1*) and *Hg*.

QRaw.ipk-1A{0255}. 1AS{0255}. **v**: Opata/W-7984 (ITMI) RI mapping population{0255}; The awn colour was contributed by W-7984{0255}. **ma**: Associated with *Gli-A1*{0255}.

QRaw.ipk-1D{0255}. 1DS{0255}. **v**: Opata/W-7984 (ITMI) RI mapping population{0255}; The awn colour was contributed by W-7984{0255}. **ma**: Associated with *Gli-D1*{0255}.

28. Grain Hardness/Endosperm Texture

Grain hardness or endosperm texture significantly influences flour milling, flour properties and end-use. The difference in particle size index between a hard wheat (Falcon) and a soft wheat (Heron) was reported by Symes {1452} to be due to a single major gene. Symes {1452} also found evidence for "different major genes or alleles" which explained differences amongst the hard wheats Falcon, Gabo and Spica. Using Cheyenne (CNN) substitution lines in CS and a Brabender laboratory mill, Mattern et al. {915} showed that the hard wheat milling and flour properties of Cheyenne were associated with 5D. Using Hope 5D substitution line in CS [CS(Hope 5D)] crossed to CS, and CS(Hope 5D) crossed to CS ditelosomic 5DL, Law et al. {777} showed that grain hardness was controlled by alleles at a single locus on 5DS. The dominant allele, Ha, controlling softness was present in Chinese Spring and the allele for hardness, ha, was present in the other varieties mentioned. A similar study using CS (CNN5D) x CS recombinant inbred lines was reported by Morris et al. {03106}.

A pleiotropic result of hardness is the decreased level of a 15 kD starch granule protein, friabilin, on the surface of water-isolated starch {470}. In endosperm, soft and hard wheats have similar amounts of friabilin, consequently the distinction between the two textural types depends upon the manner in which the friabilin co-purifies with starch. Friabilin is also referred to by the name 'Grain Softness Protein' (GSP) {0380}, and was later shown to be comprised primarily of puroindoline a and puroindoline b {0295}. Grain hardness of reciprocal soft x hard F1 kernels was well correlated with friabilin occurrence on starch in triploid endosperm {0381}. See IV, Proteins: 5.8 Puroindoline. GSP-1 genes, which are closely related to puroindolines, are also listed in section 5.8.

Ha{777}. Soft phenotype. 5DS{777}. **i:** Falcon/7*Heron, Heron/7*Falcon{03109}; Paha*2//Early Blackhull/5*Paha{0203,0298}; Early Blackhull Derivative/5*Nugaines{0203,0298}. **v:** Chinese Spring {777,03106}; Cappelle Desprez {470}; Heron {1452,470}; Paha, Nugaines {0203,0298}; NY6432-18 {0241}.

ha{777}. Hard phenotype **i:** Falcon/7*Heron, Heron/7*Falcon {03109}; Paha*2//Early Blackhull/5*Paha {0203,0298}; Early Blackhull Derivative/5*Nugaines {0203,0298}. **s:** CS*6/Cheyenne 5D {915}; CS*6/Hope 5D {777}; Cappelle Desprez/Besostaya 5D {470}. **v:** Falcon {1452,470}; Holdfast {470}; Early Blackhull, Early Blackhull Derivative{0203,0298}; Cheyenne {03106}; Clark's Cream {0241}. **ma:** Ha was closely linked to *Xmta9(Puil)* - 5D {1414}.

Single factor effects on hardness were found for chromosome 2A, 2D, 5B and 6D, and interactive effects were found for chromosomes 5A, 6D and 7A {1414}.

The addition of King II rye chromosome 5R converted Holdfast wheat from hard to soft {470}. A 14.5 kD rye analogue was also isolated from 6x triticales which have soft texture {470}. All ryes are thought to have soft texture.

Two genes for grain hardness were reported in {055}.

Hard and soft NILs are listed in {0298}.

QTL: In a DH population of Courtot/CS a major locus in chromosome 5DS coincided with *Ha*; minor QTLs mapped in chromosomes 1A (associated with *Xfba92-1A*) and 6D (associated with *Xgwm55-6D*) {0141}.

Ten QTLs for kernel hardness (54 % of the variation) were mapped in a cross 'Forno'/ 'Oberkulmer' spelt {0280}.

29. Grain Quality Parameters

29.1. Sedimentation value

Qsev.mgb-6A{9920}. 6AL{9920}. **tv:** Nessapia/*T. dicoccoides* MG4343 mapping population{9920}. **ma:** Associated with *Xrsq805-6A*{9920}.

Qsev.mgb-7A{9920}. **7BS**{9920}. **tv**: Messapia/*T. dicoccoides* MG4343 mapping population{9920}. **ma**: Associated with *Xpsr103-7A*{9920}.

QTL: Associated with *Glu-1* on chromosome arms 1AL and 1DL and *Gli-1/Glu-3* on 1BS in RSLs from the cross Cheyenne (high quality)/CS (low quality) {0251}. Cultivar Cheyenne contributed the higher SDS sedimentation values {0251}. The QTL on 1AL coincided with a QTL for bread loaf volume {0251}. The QTL on 1DL and 1BS coincided with QTL for bread mixing time {0251}.

29.2. Flour, semolina and pasta colour

QTL: A QTL was detected on chromosome 7A {9936}. Cultivar Schomburgk contributed the yellow colour allele in a cross Schomburgk/Yarralinka {9936}. Markers *Xcdo347-7A* and *Xwg232-7A* accounted for 60% of the genetic variation {9936}. A Sequence Tagged Site PCR marker is available {0180}.

QTL: A major QTL was detected in the distal region of chromosome 7BL in the cross Omrabi 5/ *T. dicoccoides* 600545. The QTL explained 53% of the variation and was completely linked to microsatellite marker *Xgwm344-7B*. Omrabi 5 contributed the allele for high level of yellow pigment. Two additional small QTLs were detected on 7AL {0365}. Other references to flour colour are given under *Lr19* and *Sr25*.

29.3. Amylose content

Amylose content has a significant effect on industrial quality; for example, reduced amylose wheats perform better in some types of noodles. The waxy protein genes have an important influence, but other genes are also involved.

QAmc.ocs-4A.1{0047}. **4AS**{0047}. **v**: CS/CS(Kanto107 4A) mapping population{0047}. **ma**: Associated with *Xbcd1738-4A* and *Xcdo1387-4A*{0047}.

29.4. Milling yield

QTL: A QTL was detected on chromosome 3A {0181}. Cultivar Schomburgk contributed an allele for the higher milling yield in cross Schomburgk/Yarralinka {0181}. RFLP markers *Xbcd115-3A* and *Xpsr754-3A* were associated with this QTL at LOD>3 {0181}.

A QTL associated with *Pinb* on chromosome arm 5DS was detected in RILs from the cross NY6432-18/Clark's Cream {0241}. Cultivar Clark's Cream contributed the higher flour yield allele {0241}. This QTL coincided with QTL for hardness, hydration traits (dough water absorption, damaged starch and alkaline water retention capacity (AWRC)), and baked product traits (cookie diameter and cookie top grain) {0241}.

29.5. Alveograph dough strength W

QTL: QTLs for W were detected on chromosome arms 5DS (associated with *Xmta10-5D*), 1AS (associated with *Xfba92-1A*), and 3B (associated with *XksuE3-3B*) in cross Courtot/Chinese Spring {0141}. The first two QTLs coincided with those for hardness. Ten QTL for W (39% of the variation), nine QTL for P (48% of the variation) and seven QTL for P:L (38% of the variation) were mapped in Forno/Oberkulmer spelt {0280}.

29.6. Mixograph peak time

QTL : A QTL associated with *Glu-Dy1* on chromosome arm 1DL was detected in RILs from the cross NY6432-18/Clark's Cream {0241}. Clark's Cream contributed the higher mixograph peak time allele {0241}. This QTL coincided with a QTL for bread mixing time {0241}.

29.7. Starch characteristics

QTL: QTLs for starch viscosity and swelling were associated with the *Wx-B1* locus in the cross Cranbrook (*Wx-B1a*) x Halberd (null *Wx-B1b*). An additional QTL for starch viscosity was found on 7BL between markers *Xgwm344-7B* and *Xwg420-7B* in the first cross. This QTL disappeared when amylase activity was inhibited indicating that it was determined by the late maturing α -amylase activity contributed by Cranbrook. A QTL for starch viscosity was associated with the *Wx-A1* locus in the cross CD87/Katepwa {0362}.

30. Grass-Clump Dwarfness/Grass Dwarfness

Complementary dominant genes. Genotypes producing dwarfness: *D1-D2-D3-*, *D1-D2D2*, *D1-D4-D3-*, *D1-D2-D4* and *D1-D4D4*.

D1{534}. [*Bi*{972}]. 2D{534,939,1595}.2DS{942}. **s:** CS*7/Kenya Farmer 2D{1000}; CS*6/Timstein 2D{534}. **v:** Big Club{534}; Burt{1000}; Federation{942}; Mus{534}; Ramona 50{358}; Selection 1403{1000}. **v2:** Hermsen's pure-breeding dwarf *D2*{1000}; Falcon *D3*{1172}; Gabo *D3*{944}; Timstein *D3*{534}; Metzger's pure-breeding dwarf *D2 D3*{1000}.

D2{534}. [*Bi*{972}]. 2B{536,574}.2BL{944}. **s:** CS*7/Cheyenne 2B{1000}; CS*4/Red Egyptian 2B{1000}. **v:** Bezostaya 1{1595}; Crete-367{1029}; Desprez 80{1595}; Florence{1000}; Kenya W744{944}; Loro{1172}; Mara{1595}; Marquis{1000}; Poros{1595}; Redman{534,574,1001}; Riebesel{534}; Tobari 66{358}. **v2:** Hermsen's pure-breeding dwarf *D1*{534,1000}; Amby *D3*{358}; Cedar *D3*{1000}; Mendel *D3*{534}; Plantahof *D3*{534}; Spica *D3*{944}; Cappelle-Desprez *D4*{1595}; Brevor *D4*{1000}; Cheyenne *D4*{1000}; Metzger's pure-breeding dwarf *D1D3*{1000}.

D3{534}. [*A*{972}]. 4A{534,1595}.4AL{939}. **s:** CS*6/Timstein 4A{534,1000}; CS*7/Kenya Farmer 4A{534,1000}. **v2:** Amby *D1*{358}; Falcon *D1*{1172}; Gabo *D1*{944}; Kenya Farmer *D1*{1000}; Timstein *D1*{534}; Metzger's pure-breeding dwarf *D1 D2*{1000}.

D4{1000}. 2D{1000,1595}.2DL{1598}. **s:** CS*7/Cheyenne 2D{1000}. **v2:** Cappelle-Desprez *D2*{1595}; Cheyenne *D2*{1000}; Brevor *D2*{1000}.

d1d2d3d4. **v:** Chinese Spring{534,1000}.

Genotype lists in can be found in {358,534,972}. The effects of multiple allelism at *D2*, and possibly at *D1*, and modifying genes were demonstrated {1595}.

Knott {683} described a lethal dwarf condition controlled by a dominant gene closely linked with *Sr30* (chromosome 5D) in Webster and a complementary recessive gene in LMPG.

Phenotypes resembling grass clump dwarfs in hybrids carrying a 2BL.2RS translocation were reported in {916}. The complementary gene{s} in wheat was not *D1*, *D2* or *D3*. The effect was suppressed at high temperature.

31. Grain Weight

QTL : Variation at locus *QGw1.ccsu-1A*, associated with *Xwmc333-1A*, accounted for 15% of the variation in a RIL population from RS111/CS {0143}.

32.Hairy/Pubescent Auricles

Pa{886,042}. 4BS{886,042}. **s**: Saratovskaya 29^{*9}/Yanetzki Probat 4B{886}; Saratovskaya 29^{*5}/Shabati Sonora 4B{886}; Saratovskaya 29^{*4}/Siete Cerros 4B{886}. **v**: Diamant 1{886}; Magali{886}; Pirotrix 28{886}; Shabati Sonora{886}; Siete Cerros{886}; Ulyanovka 9 {886}.

pa. **v**: Gabo{886}; Saratovskaya 29{886}; This phenotype is expressed in Diamant ditelo 4BL{886}.

33.Hairy Glume

Hg{1494}. 1A{1293}.1AS{947}. **i**: S-615^{*11}/Jones Fife{1500}. **s**: CS^{*7}/Indian 1A{1293}. **v**: A well-known, widespread and easily identified dominant marker - few examples will be listed. Indian{1293}; Jones Fife{1494}; Prelude{1494}. **itv**: LD222^{*11}/*T. Turgidum* var. *durum melanops*{1546}. **tv**: Golden Ball{1342,1494}. **dv**: *T. monococcum* lines{1494}. **ma**: *Xutv1391-1A* (distal) - 3cM - *Bg* - 1.6cM - *Hg* - 2.4cM - *Gli-A1* (proximal){9959}. A 1A gene controlling hairy glumes was mapped in a cross between durum cv. Messapia and *T. turgidum* ssp. *dicoccoides* acc. MG4343.

Hg1{1405}. **v**: Ulyanovka{1405}; Pionerskaya{715,1405}.

Evidence for multiple alleles in *T. monococcum* is given in {744}.

The likelihood of three alleles, *hg* (hairless), *Hg1* (weakly hairy) and *Hg* (very hairy), with *hg1* being recessive to *Hg* and causing a short (weak) hairy phenotype, was mentioned in {1405}.

34.Hairy Leaf

H11{0316}. Weakly hairy. [*H1*{884}]. 4B{884}.4BL{760}. **v**: Artemovka{925}; Caesium 111{925}; Lutescens 53/12{925}; Lutescens 62{925}; Milturum 321{884}; Poltavka{925}; Pyrothrix 28{925}; Saratov 321{884}; Saratovskaya 29{884,760}; Sarrubra{925}.

h11 h12. **v**: Chinese Spring{884}.

Kuspira *et al.* {744} provided evidence for at least three alleles at an *H1* locus in *T. monococcum*.

H12{0316}. 7BS{0316}. **v**: Hong-mang-mai {0316}.

35.Hairy Leaf Sheath

Levy & Feldman {795} concluded that complementary genes determined hairy leaf sheath in *T. dicoccoides*.

Hs{795}. [*Hls*{761}]. **v**: Certain hexaploid derivatives of G25 produced in Israel{939}. **tv**: *T. dicoccoides* G25{761}.

hs. **v**: Most hexaploid wheats{939}. **tv**: *T. dicoccoides* G7{761}.

36.Hairy Neck/Pubescent Peduncle

Hp{275}. Derived from *Secale cereale*

4BL{T4B.5R}{274,275}.**i**:S-615^{*11}/CS Derivative{1500}.

5BS{T5B-5R}{1298}.**v**:HN-2 (CS type){1298}.

6D{T6D-5R}{1298}.**v**:HN-1(CS type){1298}.

4BL{T4B.5R}{274,275}.**v**:CS Derivative{1304}.

37. Hairy Node/Pubescent Node

Inheritance of hairy (glabrous) node versus non-hairy node was attributed to a single, dominant gene difference {396,837,910,914} and the *Hn/hn* locus was shown to be linked with *BI* (awn inhibitor). Observations on 5A trisomics and telosomics of Chinese Spring confirmed this location. Love & Craig {837} studied a cross involving Velvet Node CI 5877, and Gaines & Carstens {396} studied an offtype single plant designated Velvet Node Wash. No. 1981.

Hn. 5AL. **v:** Aurore{722}; Fylgia{722}; Extra-Kolben II{722}; Marquis{910}; Tammi{765}; *T. vulgare erythrospermum*{910}. **tv:** *T. polonicum vestitum*{910}.

hn. **v:** Garnet{722}; Kimno{722}; Pika{722}; Timantii{722}.

Levy & Feldman {795} concluded that complementary genes determined hairy leaf sheath in *T. dicoccoides*.

Multiple alleles were reported in *T. monococcum*{744}.

38. Heat tolerance

QTL: QTLs contributing to grain-filling duration (GFD) under high temperatures were associated with Xgwm11-1BS (11% of variability) and Xgwm293-5AS (23% of variability) in Ventnor (tolerant) // Karl 92 (Non-tolerant) {0327}.

39. Height

Ht is the general symbol.

39.1. Reduced Height : GA-insensitive

Rht-1{371,0019}.

The *Rht-1* homoeoloci are orthologous with the *D8* locus in maize and the *GAI* locus in *Arabidopsis*. They encode proteins resembling nuclear transcription factors and are involved in sensing gibberellin levels {0019}. Common wheat and durum NIL pairs are listed in {02102}.

Rht-A1a{0019}. **v:** Chinese Spring{0019}; All wheats are assumed to be monomorphic.

Rht-B1{116}. 4B{109,406,1040}.4BS{089,116}. **ma, tv:** *Gai1/Rht-B1b* - 1.8cM - *Xpsr622-4B*{110}.

Rht-B1a{116}. **v:** Tall wheats{116}; e.g. Chinese Spring{0019}.

Rht-B1b{116}. Partially recessive {024}, recessive {357}, semi-dominant {408}.

[*Rht1*{015}, *Sd1*{015}]. **i:** See{408,414,02102}. **v:** Frontier{1597}; Guardian{1597}; Selection 14-53/Burt, 5{015}; Siete Cerros{407}; Wren{1174}; WW15{407}. **v2:** Norin 10-Brevor, 14 *Rht-D1b*{015}; Oleson *Rht-D1b*{357}; Selection D6301 *Rht-D1b*{357}; Shortim *Rht-D1b*{243}; See{407,415,1062,1386}. **tv:** Cocorit 71{109,416}; Creso{109,416,451}; Malavika{1442}; Mida{450}; Sansone{109}; Valgerado{109,416}; Valnova{450}; Valselva{450}.

The development of allele-specific primers for *Rht-B1b* was reported in {0378}.

QTL: QTL for reduced plant height, peduncle length and coleoptile length contributed by Cranbrook were associated with XcsMe1-4B (up to 49% of variability for plant height and peduncle length and 27-45% of variability for coleoptile length) in the cross Cranbrook (dwarf) / Halberd (tall). The dwarfing effect underlying the QTL is caused by the *Rht-B1b* allele {0379}.

Rht-B1c{116}. Semi-dominant {1040}. [*Rht3*{565}, *Sd3*{565}]. **i:** Tom Thumb/7*

Kharkov// Lancer{1040}; See{408}. **v:** Minister Dwarf{404}; Selection D6899 (Tom Thumb-Sonora 64/Tacuari){357}; Tom Thumb{405}; Tom Pouce Blanc{407,1634};

- Tom Pouce Barba Rouge{407,1634}; Topo; Tordo. **ma:** *Xmwig634-4B* (distal) - 30.6 cM - *Rht-B1c* - 11.9 cM - *Xpsr144-4B* (proximal){117}.
- Rht-B1d**{116}.Semi-dominant {1599,116}. [*Rht1S*{1599}]. **v:** Saitama 27{1599}; Occurs frequently in Italian and Yugoslavian wheats{1599}; Argelato, Centauro, Chiarano, Etruria, Farnesse, Gallo, Gemini, Lario, Pandas, Produttore, Orlandi, Orso, Salvia, Sprint, Strampelli.
- Rht-B1e**{116}. [*RhtKrasnodari1*{452},*Rht1(B-dw)*{1600}]. **v:** Krasnodari 1 (a spontaneous GA-insensitive offtype of Bezostaya 1){1600}.
- Rht-B1f**{116}.Semi-dominant {116}. [*RhtT. aethiopicum*{116}]. **tv:** *T. aethiopicum* accessions W6824D{116}; W6807C{116}.
- Rht-B1g**{0019}. **v:** Highbury mutants M3 103-3 and M3 103-9{0019}; Allele *Rht-B1g* is a fast neutron-induced mutation of *Rht-B1b* and produces a tall gibberellin responsive phenotype{0019}.
- Rht-D1**{116}. 4D{411,583,1544}.4DS{980,1266,116}. **i:** Common wheat and durum NIL pairs are listed in {02102}. **ma:** *Xpsr1871(Pki)-4D* - 4cM - *Rht-D1* - 6 cM - *Xubc821(PhyA)-4D*{410}; *Rht-D1* - 2.8cM - *Xglk578-4D*{9966}; *Xpsr1871* - 1cM - *Rht-D1b* - 4cM - *Xpsr821(PhyA)*{0019}.
- Rht-D1a**{116}. **v:** Tall wheats{116}; e.g. Chinese Spring.
- Rht-D1b**{116}.Partially recessive {024}, recessive {357}, semi-dominant {408}. [*Rht2*{015},*Sd2*{015}]. 4D{411}.4DS{980}. **i:** See{408,414,02102}. **v:** Combe{567}; Era{407}; Gaines Sib 2{015}; Jaral{407}; Kite{1174}; Maris Hobbit {411}; Pitic 62 {567}; Songlen{243}; Oleson *Rht-B1b*{357}; Norin 10-Brevor 14 *Rht-B1b*{015}; Selection D6301 *Rht-B1b*{357}; List in{1386}.
The development of allele-specific primers for *Rht-D1b* was reported in {0378}.
- Rht-D1c**{116}.Dominant {114}. [*Rht10*{1266}]. **v:** Ai-bian{1544,1266}. **ma:** *Xpsr921-4D* (4DS) - 0.8 cM - *Rht-D1c* - 28 cM - *Xgwm165-4D* (4DL){117}.
- Rht-D1d**{116}.Semi-dominant {116}. [*RhtAi-bian 1a*{115}]. **v:** Ai-bian 1a (spontaneous mutant of Ai-bian 1){115}.
The line XN004, earlier considered to have *Rht21*{0230}, was shown to carry an allele at the *Rht-D1* locus {0231}.
Various common wheat and durum NILs differing at the *Rht-B1* and *Rht-D1* loci are listed in {02102}. Genotype lists in {402,1382,1612,1613}.

39.2. Reduced Height : GA-sensitive

Borner *et al.* {116} found no evidence of orthologous GA-sensitive genes in rye, but reviewed evidence for orthologous GA-insensitive gene. The close linkage of *Rht8* and *Xgwm261-2D* permitted the use of the microsatellite as a marker for the detection of allelic variants at the *Rht8* locus{9962}.

- Rht4**{568}. Recessive. **v:** Burt *ert* 937, CI 15076{566,717}.
- Rht5**{717}. **v:** Marfed *ert* 1, M1, CI 13988{717,718,1593}.
- Rht6**{718}. Recessive. **v:** Brevor{569}; Burt{569,718}. **v2:** Norin 10-Brevor, 14 *Rht-B1b* *Rht-D1b*{569}.
- Rht7**{1602}. 2A{1602}. **v:** Bersee Mutant A{1602}; Bersee Mutant C{1602}.
- Rht8**. 2D{772,1601,1598}.2DL. **s:** Cappelle-Desprez^{*}/ Mara 2D{1601}. **v:** Novasadska Rana 1{1604}; Sava{1601,414}. **v2:** Akakomugi *Rht9*{1191}; Mara *Rht9*{1191}. **ma:** *Xgwm484-2D* (proximal) - 19.9 cM - *Rht8* - 0.6 cM - *Xgwm261-2D* (distal){727}.
The close linkage of *Rht8* and *Xgwm261-2D* permitted the use of the microsatellite as a marker for the detection of allelic variants at the *Rht8* locus{9962}.
- Rht8a**.Associated with a 165-bp fragment of WMS 261 {9962}. **v:** Autonomia{9962}; Bobwhite{9962}; Brevor{9962}; Chaimite{9962}; Ciano 67{9962}; Chris{9962};

Dugoklasa{9964}; Federation{9962}; Frontana{9962}; Glennson 81{9962}; Jupateco 73{9962}; Kenya{9962}; Klein 32{9962}; Lerma Rojo{9962}; Lusitano{9962}; Maringa{9962}; Mentana{9962}; Nainari 60{9962}; Newthatch{9962}; Opatá 85{9962}; Othello{9962}; Penjamo 62{9962}; Quaderna{9962}; Rex{9962}; Riete{9962}; Saitama 27{9962}; Spica{9962}; Veery S{9962}; Victo{9962}; Hope{0243}; Marquis{0243}; Michigan Amber{0243}.

Rht8b. Associated with a 174-bp fragment of WMS 261 {9962}. **s:** Cappelle Desprez^{*}/Mara 2D{1601}. **v:** Arthur{0243}; Balkan{9962}; Bunyip{9962}; Cappelle-Desprez{9962}; Carstens{0243}; Diakovchanka{0243}; Eureka{9962}; Festival{9962}; Fronteira{9962}; Fultz{9962}; Gabo{9962}; Heine VII{9962}; Inaltable 95{9962}; Jena{9962}; Klein Rendidor{9962}; Leonardo{9962}; Lutescens 17{9962}; Mironovskaya 808{9962}; Norin 10{9962}; Norin 10/Brevior 14{9962}; Oasis{0243}; Odom{0243}; Podunavka{9962}; Purdue Abe{0243}; Record{9962}; Red Coat{9962}; Salzmunder Bartweizen 14/44{0243}; Soissons{9962}; Talent{9962}; Tevere{9962}; Timstein{9962}; Tp114/65{0243}; Wilhelmina{9962}; Wiskonsin 245 C/11226{0243}.

Rht8c. Associated with a 192 bp fragment of WMS 261 {9962}. **v:** Akakomugi{1191}; Alfa{9962}; Aquila{9962}; Ardito{9962}; Argelato{9962}; Avrora{9962}; Banija{9964}; Baranjka{9964}; Beauchamps{9962}; Bezostaya{9962}; Biserka{9962}; Campodoro{9962}; Centauro{9962}; Chikushi-Komugi (Norin 121){9962}; Damiano{9962}; Djerdanka{9964}; Dneprovskaya{9962}; Duga{9964}; Etoile-de-choisy{9962}; Etruria{9962}; Fakuho-Komugi (Norin 124){9962}; Farnese{9962}; Favorite{9962}; Fedorovka{0243}; Fiorello{9962}; Fortunato{9962}; Funo{9962}; Gala{9962}; Haya Komugi{9962}; Impeto{9962}; Irnerio{9962}; Jarka{9964}; Jugoslavia{9962}; Kavkas{9962}; Kaloyan{0243}; Khar'kovskaya 50{0243}; Khar'kovskaya 93{0243}; Khersonskaya 86{0243}; Kolubara{9964}; Kosava{9964}; Libellula{9962}; Lonja{9964}; Lovrin 32{9962}; Macvanka-2{9964}; Mara{119,9962}; Marzotto{9962}; Mv 03-89{0243}; Mv 06-88{0243}; Mv 17{0243}; Neretva{9962}; Nizija{9962}; Novasadska Rana 1{1604}; N.S. Rana 1{9962}; N.S. Rana 2{9962}; N.S. 649{9962}; N.S. 3014{9962}; Obrii{0243}; Odesskaya 51{0243}; Odesskaya 117{0243}; Odesskaya 132{0243}; Odesskaya Krasnokolosaya{0243}; Odesskaya Polukarlikovaya{0243}; Orlandi{9962}; Osjecanka{9964}; OSK 5 5/15{9964}; OSK 4 57/8{9964}; OSK 3 68/2; Partizanka{9962}; Partizanka Niska{9962}; Poljarka{9964}; Posavka 1 {9964}; Posavka 2{9962}; Pomoravka{9962}; Produttore{9962}; Radusa{9962}; Roazon{0243}; Salto{9962}; Sanja{9962}; San Pastore{9962}; Sava{1601,414,9962}; Siete Cerros{9962}; Sinvalocho{9962}; Simvol Odesskii{0243}; Sivka{0243}; Strumok{0243}; Skopjanka{9962}; Skorospelka 3B{9962}; Slavonija{9964}; Somorka{9964}; Sremica{9964}; Superzlatna{9962}; Svezda{9962}; Tira{0243}; Tisa{9964}; Transilvania{9962}; Ukrainka Odesskaya{0243}; Una{9962}; Villa Glori{9962}; Vympel{0243}; Yubileinaya 75{0243}; Zagrebanka{9964}; Zelengora{9964}; ZG 6103/84{9964}; ZG 7865/83{9964}; Zitarka{9964}; Zitnica{9962}; Zlatna Dolina{9964}; Zlatoklasa{9964}; Zolotava{0243}.

Although CS carries a 192 bp fragment, sequencing showed it was a different allele than other genotypes with *Rht8c* {02103}.

Rht8d. Associated with a 201-bp fragment of WMS 261 {9962}. **v:** Pliska{9962}; Courtot{9962}.

Rht8e. Associated with a 201-bp fragment of WMS 261 {9962}. **v:** Chino{9962}; Klein Esterello{9962}; Klein 157{9962}.

Rht8f. Associated with a 215-bp fragment of WMS 261 {9962}. **v:** Klein 49{9962}.

Rht8g. Associated with a 196-bp fragment of WMS 261 [{0243}]. **v:** Mirleben{0243}.

- Rht8h**. Associated with a 206-bp fragment of WMS 261 [0243]. **v**: Weihenstephan M1{0243}.
- Rht9**. 7BS{772,1601}. **s**: Cappelle-Desprez*/Mara 5BS-7BS{1601}. **v**: Acciao{718}; Forlani{718}; Akakomugi *Rht8*{1601}; Mara *Rht8*{1601}.
- Rht11**{718}. **v**: Karlik 1{718}.
- Rht12**{718}. Dominant. 5A{1445,1606}. **v**: Karcagi 522M7K{721}. **ma**: *Rht12* is located distally on 5AL cosegregating with *B1* and closely linked to *b-Amy-A1*{1606}; *Xgwm291-5A* - 5.4cM - *Rht12*{726}.
- Rht12* delayed ear emergence by 6 days{1606}. *Rht12* delayed ear emergence by 6 days {1606}.
- Rht13**{718}. **v**: Magnif 41M1 CI 17689{718}.
- Rht14**{718}. **v**: Cp B 132 {123} = Castelporziano PI 347331{718}.
- Rht15**{718}. **tv**: Durox{718}.
- Rht16**{718}. **v**: Edmore M1{718}.
- Rht17**{718}. **v**: Chris Mutant CI 17241{1129}.
- Rht18**{718}. **tv**: Icaro{718}.
- Rht19**{718}. **tv**: Vic M1{718}.
- Rht20**{718}. **v**: Burt M860{718}.
- Rht21**{0230}. The existence of this gene was not confirmed {0231}.

39.3. Reduced Height : QTL

- QHt.fra-1A**{9957}. **ma**: Linkage with *Xfba393-1A*.
- QHt.fra-1B**{9957}. **ma**: Linkage with *Xcdo1188-1B.2*.
- QHt.fra-4B**{9957}. **ma**: Linkage with *Xglk556-4B*.
- QHt.fra-7A**{9957}. **ma**: Linkage with *Xglk478-7A*.
- QHt.fra-7B**{9957}. **ma**: Linkage with *XksuD2-7B*.
- QHt.ocs-4A.1**{0047}. 4AL{0047}. **v**: CS/CS(Kanto107 4A) mapping population{0047}. **ma**: Associated with *Xpsr119-4A* and *Wx-B1*{0047}.
- QHt.ocs-4A.2**{0047}. 4AS{0047}. **v**: CS/CS(Kanto107 4A) mapping population{0047}. **ma**: Associated with *Xbcd1738-4A* and *Hd*{0047}.
- QHt.ocs-5A.1**{0068}. [*Qt.ocs-5A.1*{0068}]. 5AL{0068}. **v**: CS(*T. spelta* 5A)/CS(Cappelle-Desprez 5A) RI mapping population{9903}. **ma**: Associated with the interval *Xcdo1088 - 5A - Xbcd9 - 5A*{0068}.
- This QTL coincided with a QTL for culm length, *QCl.ocs-5A.1* {0068}.
- QHt.ipk-4A**{0255}. 4AL{0255}. **v**: Opatá/W-7984 (ITMI) RI mapping population{0255}; the height is contributed by Opatá{0255}. **ma**: Associated with *Xmwig549 - 4A*, *Xabg390 - 4A* and *Xbcd1670 - 4A*{0255}.
- QHt.ipk-4A* coincided with QTLs for ear length (*QEl.ipk-4A*), grain number (*QGnu.ipk-4A*) and grain weight per ear (*QGwe.ipk-4A*) {0255}.
- QHt.ipk-6A**{0255}. 6A{0255}. **v**: Opatá/W-7984 (ITMI) RI mapping population{0255}; The height is contributed by W-7984{0255}. **ma**: Associated with *Xcdo29 - 6A* and *Xfba234 - 6A*{0255}.
- QHt.ipk-6A* coincided with QTLs for peduncle length (*QPdl.ipk-6A*) and ear length (*QEl.ipk-6A*) {0255}.
- Two QTLs for plant height were assigned to chromosome 3A in RSLs from Cheyenne*/Wichita 3A substitution line{0025}.
- Seven QTLs on chromosomes 1A, 1D, 2B, 2D and 4B affected plant height among RILs of CS/*T. spelta duhamelianum*. Effects linked with the CS alleles of *Xbcd1160-1A*, *Xksu127-1D* and *XksuF11-2D* increased height whereas those CS alleles associated with *Xpsr131-2B*, *Xpsr125-2B*, *Xpsr934-2D* and *Xcs22.2-4B* reduced it {0196}.

40. Herbicide Response

40.1. Difenzoquat insensitivity

Dfq1{1396}. Insensitive. 2B{1396}.2BL{789}. **v:** CS{1396}.

dfq1. Sensitive. **s:** CS*6/Ciano 67 2B{1396}; CS*7/Marquis 2B{789}; CS*/Sicco 2B{1396}.
v: Ciano 67{1396}; Sicco{1396}.

Busch *et al.* {153} reported a single dominant gene for tolerance of Era and Marshall compared with the susceptibility of Eureka and Waldron, but its relationship to *Dfq1* is unknown.

40.2. 2,4-D tolerance

Randhawa *et al.* {1190} reported a single dominant gene in each of WL711, CPAN1874 and CPAN1922 controlling tolerance. HD2009 and PBW94 were described as susceptible.

40.3. Chlortoluron Insensitivity

Su1{1402}. Insensitive. 6B{1402}.6BS{799}. **v:** Cappelle-Desprez{1402}. **tv:** B-35{735}.

su1. Sensitive. **v:** Chinese Spring{1402}; Poros{1402}. **tv:** B-7{735}. **ma:** *Xpsr312-6B* - 5.3cM - *Su1* - 6.8cM - *Xpsr477(Pgk2)-6B*{736}. **ma, tv:** *Nor2* (6BS) - 2.7cM - *Su1*{1401}; *Su1* - 5.2cM - *Xpsr371-6B* (6BL){735}.

Su1 also controls insensitivity to metoxuron {1402}. A single dominant gene for tolerance to isoproturon was found in tetraploid wheats derived from a tolerant *T. monococcum* source {1044}. This gene is presumably different from *Su1*.

41. Hybrid Weakness

41.1. Hybrid necrosis

[Progressive lethal necrosis {155}; Firing {971}].

Complementary dominant genes. Descriptive alleles *w* (weak), *m* (medium) and *s* (strong) were allocated by Hermesen {532}. Phenotype is affected by modifying genes (and/or genetic background) and environment {566}. According to Dhaliwal *et al.* {257} progressive necrosis is suppressed at 28C.

Ne1{530}. [*Le*{155,550}, *F*{971}, *Le1*{1491}]. 5B{1491}.5BL{1636}.

Ne1m{530}. **i:** S-615*11/Prelude{1500}. **v:** Carpo{532}; Eskisehir 220-39{532}; Garnet{532}; Klein Aniversario{532}; Koga{532}; Mus XII/80/22{532}; Prelude{532,1491}.

Ne1s{530}. **v:** Big Club{155,532,550}; C306{1475}; Felix{531}; Gaza 141 PI 220429 {532}; Luteseens 1163{1264}; Marquillo{115,532,550}; Ponca{532}; Spica{939}. **tv:** Gaza 1E PI 133460; Gaza PI 189262{532}; Iumillo{532}; Kubanka{532}; PI 94587{155,532}; Quanah{532}.

Ne1s is common in tetraploid wheats {1080}.

Unknown *Ne1* allele. **tv:** HW75 {697}; HW178 {697}. Chinese Spring carries the weakest allele {532} and its effect can be observed in CS*7/Atlas 66 2B {939} relative to CS.

Ne1w{530}. **v**: Bobin group{532}:Kenya Farmer{532};The Bobin selection used in breeding Gabo {532}; and its sister selection, Timstein{532,1556}; was in fact Gular. Hence Gular, not Steinwedel, is the presumed source. The Sydney University accession Bobin W39 was the parent of Gabo and Timstein, whereas "true" Bobin carried the accession number W360. The particular accession tested by Hermsen is not clear. According to Metzger{1000}; Steinwedel is a non-carrier ; Federation group{532}: Cadia{532}; Cleveland{971}; Minister group{532}: ; Rieti group{532}: Mentana{532}; Mara{532}.

Ne2. [*Le2*{155,550,1491},*F*{971}]. 2B{1491}.2BS{1085}.

Ne2m{530}. **v**: Squarehead group{532}: European wheats{532}; Fronteira group{532}: Sonalika{1475}; South American wheats and derivatives, e.g. Atlas 40{532}: Wheats possessing *Lr13*{939}, e.g. Manitou{939}.

Ne2m?{530}. **v**: Barleta group{532}: South American wheats, e.g. Klein Titan{532}; La Prevision 25{532}; Lin Calel{532}.

Ne2ms{530}. **v**: Mediterranean group{532}: Dawson{155,550}; Fultz{550}; Fulcaster{550}; Fulhard{550}; Honor{550}; Jones Fife{1491}; Shepherd{550,971}; Trumbull{155}; Vermillion{530}; Wabash{155}. (Although placed in this group on basis of pedigree, the last three stocks, as well as Fultz selection of CI 19293, appear to have the stronger allele of the Crimean group{532}; Noe group{532}: Vilmorin 27{532}; Unknown **Ne2** allele{532}; Harvest Queen{532}. **tv**: Acme{532}; Arnautka{532}; Carleton{532}; Langdon{1498}; Mindum{532}; Stewart{532}. However, **Ne2** was stated to be absent or rare in tetraploid wheats {1080}.

The Chinese Spring 2BS telosome carries an **Ne2** allele that is not present in Chinese Spring {1085}.

Ne2s{530}. **i**: S-615*11/Kharkov{1500}. **v**: Crimean group{532}: Blackhull{550}; Chiefkan{550}; Clarkan{550}; Kharkov{1491}; Michigan Amber{532}; Minhardi{155}; Red Chief{550}; Stepnaja 135{1264}; Turkey{532}.

Ne2w{530}. **v**: Vakka{532}; Varma{532}.

ne1 ne2. **v**: Chancellor{531}; Elgin{1491}; Gladden{155}; Leap{155}; Purkof{155}; Red Bobs{1491}; Red Egyptian{1491}; Steinwedel{1000}; S-615 {1491}; Wichita{531}.

Genotype lists in

{531,532,535,640,696,698,1093,1135,1264,1381,1473,1474,1475,1492,1496,1497,1502,1503,1512,1505,1506,1507,1508,1509,1510,1630,1631,1632,1633,1637,1638,1639,0112}.

Rye line 1R136-2 carries *Ner1* {1210} that complements wheat gene **Ne2** {1289,1210} and rye gene **Ne2** {1210} to produce necrosis. Rye lines L155 and L256 carry **Ne2** {1210} that complements *Ne1* {630,1210} and *Ne1* {1210}.

Ner1{1210}. 5RL{1211}. **al**: *S. cereale* 1R136-2{1210}.

Ner2{1210}. 7RL{1211}. **al**: *S. cereale* L155, L256{1210}.

41.2. Hybrid chlorosis type 1

Ch1{535}. [*m^a*{1245}]. 2A{538,939}. **i**: Steinwedel*2/Khapli{939}; *T. macha* var. colchicum{535}. **v**: *T. macha* var. subletschumicum{1245,1493}. **tv**: Khapli{1080,1549}; *T. dicoccoides* var. kotschyianum{535}; *T. dicoccoides* var. straussianum{535}.

36 group dicoccon wheats are listed in {697}.

Ch2{535}. [*m^b*{1245},*Ne3*{1504}]. 3D{1495,1504}.3DL{692,939}. **v**: Chinese Spring{535,1504}; *T. vavilovi*.

Extremely widespread, very few wheats lack this gene.

Allelic variation at the *Ch2* locus was suggested {537,1000}. Prelude, Reward and Red Bobs

were exceptional in producing severe symptoms and death at an early stage. Konosu 25 may carry a weak allele {1000}. Different alleles in C306 (strong) and Sonalika (medium) were suggested in {697}.

chl ch2. v: Albit{1000,1509}; Burt{1000,1509}; Chancellor{1000}; Garra{1549}; Kharkof{535}; Steinwedel{1549}. **su:** TAP 67 (= Pawnee 3Ag(3D)){1644}.

Lists appear in

{535,697,1381,1473,1474,1475,1496,1497,1502,1503,1512,1505,1506,1507,1508,1509,1510}.

A gene, *Chr1*, in rye produces chlorosis symptoms in hybrids with wheats such as C306, HD2939 and NI5439 possessing *Ch2* {1472}. Evidence for multiple alleles of *Chr1* was also presented {1472}.

Chr1{1472}. **dv:** Cereal rye lines, EC179188 = WSP527A{1472}; EC143825 = WSP506A{1472}; EC338685 = Blanco{1472}; others{1472}.

chr1{1472}. **dv:** EC179178{1472}; EC179185 SAR/SWPY5{1472}.

41.3. Hybrid chlorosis (type 2) {1511}.

Cs1{1511}. [*Chl¹*]. 5A{1498}. **v:** *T. dicoccum* cv. Hokudai{1511}.

Occurs at high frequency in the *T. paleocolchicum* group of emmers.

Cs2{1511}. [*Chl²*]{1501}. 4G{1498}. **tv:** Many accessions of *T. timopheevi* and *T. araraticum*{637,1511}.

Multiple allelism at the *Cs2* locus is discussed in {637}.

42. Iron Deficiency

Fe1{926}. 7DL{927}. **v:** Saratovskaya 29{926}.

Fe2{926}. 7BS{927}. **v:** CS{927}.

43. Lack of Ligules

The liguleless character is controlled by complementary recessive genes in hexaploid wheat {077,738,942} and by a single recessive in tetraploid wheat {047,050,939}. One gene at the tetraploid level is allelic with one of those in the hexaploid {939}. Evidence for orthology of *lg1* and *lg2* with *lg* of rice {170}, *lg1* of maize {004}, *li* of barley {1155} and *al* of rye was presented in {725}. **al:** Imperial rye chromosome 2R restored the liguled condition to a liguleless CS derivative {939}.

lg1{047}. 2B{942}. **v:** Partial backcross derivative of CS{939}.

lg2. 2D{942}. **v:** Eligulate W1342 *lg1*{942}; Partial backcross derivative of CS{939}.

Because diploid wheats are liguled, polyploid wheats presumably carry a third recessive factor in chromosome 2A.

44. Leaf Erectness

QLer.ipk-2A{0255}. 2AS{0255}. **v:** Opata/W-7984 (ITMI) RI mapping population{0255};

The erect leaf phenotype was contributed by Opata{0255}. **ma:** Associated with *Xbcd348-2A*{0255}.

Mutants lacking ligules are known to have erect leaves. However, the QTL for leaf erectness reported here is not related to liguleless mutants {0255}.

45. Leaf Tip Necrosis

- Ltn*{1361}. 7D{1361}. **v:** Wheats with *Lr34/Yr18*{301,1361}; See *Lr34, Yr18*.
QLtn.sfr-1B{0050}. 1BS{0050}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population{0050}. **ma:** Associated with *Xgwm18-1B* and *Xglk483-1B*{0050}.
QLtn.sfr-3A{0050}. 3A{0050}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population{0050}. **ma:** Associated with *Xpsr570-3A* and *Xpsr543-3A*{0050}.
QLtn.sfr-4B.1{0050}. 4B{0050}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population{0050}. **ma:** Associated with *Xpsr921-4B* and *Xpsr593-4B*{0050}.
QLtn.sfr-4B.2{0050}. 4B{0050}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population{0050}. **ma:** Associated with *Xpsr593-4B* and *Xpsr112-4B*{0050}.
QLtn.sfr-4D{0050}. 4DL{0050}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population{0050}. **ma:** Associated with *Xpsr302-4D* and *Xpsr1101-4D*{0050}.
QLtn.sfr-5A{0050}. 5A{0050}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population{0050}. **ma:** Associated with *Xpsr549-5A* and *Xglk163-5A*{0050}.
QLtn.sfr-6A{0050}. 6A{0050}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population{0050}. **ma:** Associated with *Xpsr563-6A* and *Xpsr966-6A*{0050}.
QLtn.sfr-7B.1{0050}. 7B {0050}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population{0050}. **ma:** Associated with *Xpsr350* and *Xbzh232(Tha)-7B*{0050}.
QLtn.sfr-7B.2{0050}. 7B{0050}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population{0050}. **ma:** Associated with *Xglk750-7B* and *Xmwg710-7B*{0050}.
QLtn.sfr-7D{0050}. 7DS{0050}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population{0050}. **ma:** Associated with *Xpsr160-7D* and *Xgwm44-7D*{0050}.

46. Lodging

- QLd.sfr-1B*{0052}. 1BS{0052}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population{0052}. **ma:** Associated with *Xpsr949-1B* and *Xgwm18-1B*{0052}.
 This QTL coincided with QTL for reduced height, increased culm stiffness and broader leaf width {0052}.
QLd.sfr-2A{0052}. 2AS{0052}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population{0052}. **ma:** Associated with *Xpsr958-2A* and *Xpsr566-2A*{0052}.
 This QTL coincided with QTL for reduced height, increased culm stiffness, broader leaf width, more erect growth habit, later ear emergence and increased culm thickness {0052}.
QLd.sfr-2D{0052}. 2D{0052}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population{0052}. **ma:** Associated with *Xpsr933-2D* and *Xglk529-2D*{0052}.
QLd.sfr-3A{0052}. 3AS{0052}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population{0052}. **ma:** Associated with *Xpsr598-3A* and *Xpsr570-3A*{0052}.
 This QTL coincided with QTL for increased culm stiffness and reduced culm thickness {0052}.
QLd.sfr-4A{0052}. 4AS{0052}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population{0052}. **ma:** Associated with *Xgwm397-4A* and *Xglk315-4A*{0052}.
 This QTL coincided with QTL for reduced height, increased culm stiffness and more erect growth habit {0052}.
QLd.sfr-5A{0052}. 5AL{0052}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population{0052}. **ma:** Associated with *Xpsr918-5A* and *Xpsr1201-5A*{0052}.
 This QTL coincided with QTL for reduced height, increased culm stiffness, reduced leaf width, more erect growth habit, later ear emergence and increased culm thickness{0052}.
QLd.sfr-5B{0052}. 5BL{0052}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population{0052}. **ma:** Associated with *Xpsr370-5B* and *Xpsr580-5B*{0052}.

This QTL coincided with QTL for increased culm stiffness, broader leaf width and more erect growth habit {0052}.

QLd.sfr-6B{0052}. 6BL{0052}. **v**: Forno/*T. spelta* var. Oberkulmer mapping population{0052}. **ma**: Associated with *Xpsr964-6B* and *Xpsr142-6B*{0052}.

QLd.sfr-7B{0052}. 7BL{0052}. **v**: Forno/*T. spelta* var. Oberkulmer mapping population{0052}. **ma**: Associated with *Xpsr927-7B* and *Xpsr350-7B*{0052}.

This QTL coincided with QTL for reduced height and later ear emergence {0052}.

47. Male Sterility

47.1. Chromosomal

ms1. Recessive alleles for sterility 4B{268}.4BS{064}.

ms1a{268}. **v**: Briggles Chancellor Derivative{268}; Pugsley's Male Sterile{268}.

ms1b{268}. **v**: Probus mutant{268}.

ms1c{064}. **v**: Cornerstone{064}.

ms1d{0290}. **v**: Mutant FS2{0290}.

ms1e{0290}. **v**: Mutant FS3{0290}.

ms1f{0290}. **v**: Mutant FS24{0290}.

ms2{806}. Dominant allele for sterility. [*Tal*{240}]. 4DS{806}. **v**: Taigu = Line 223{240,807,806}; *ms2* confers sterility when present in octaploid triticales{597}.

ms3{872}. Dominant allele for sterility. 5AS{872}. **i**: Chris derivative{872}; KS87UP9{219}.

ma: *Xwg341-5A* - 0.8cM - *ms3*.....cent{0289}; *Xcdo-677-5A* and *Xbcd1130-5A* also cosegregated with *Xwg341-5A* but were located in a different region in the physical map{0289}.

ms4{0293}. Dominant allele for sterility, distinguished from *ms2* on the basis of different degrees of recombination with the 4D centromere. 4DS{0293}. **v**: Konzak's male sterile.

ms5{0290}. 3A{0290}. **v**: Mutant FS20{0290}.

47.2. Sterility in hybrids with wheat

Shw{0331}. [*IHL*{0331}]. **ad**: Additions of 1H and 1HL to wheat and certain translocation lines {0331}. **ma**: Located in a 16.4 cM interval flanked by *Xmwig800-1H* and *Xmwig943-1H*. A possible relationship with *Ncc* genes is discussed {0331}.

48. Manganese Efficiency

QTL: Variation associated with *Xcdo583-4B* explained 42% of the variation for Mn efficiency in the durum cross Stojocri 2 (Mn efficient)/Hazar (MN inefficient) {0320}.

49. Megasporogenesis

49.1. Control of megasporogenesis

Msg{625}. 7AS{625}. **tv**: Langdon{625}.

50. Meiotic Characters

50.1. Low-temperature pairing

ltp{527}. **v:** Chinese Spring{527}.

Expressed in the absence of chromosomes 5D at 12°C - 15°C, but not at 20°C. A contrasting allele, *Ltp*, for normal pairing at the lower temperature range was demonstrated in *T. dicoccum*.

50.2. Pairing homoeologous

Ph1{1537}. 5BL{1301}. **ma:** PCR-based assays for presence and absence of *Ph1* have been described{0214,0217,9965,0359}; The *Ph1* factor(s) was restricted to a region flanked by *Xrgc846-5B* and *Xpsr150-5B*{0219}; *Ph1* was physically mapped in 5BL to fraction length 0.55, bracketed by deletions 5BL-1 and *ph1b*{446}.

ph1a.- Not applicable - see *ph2b* {1303}.

ph1b{1301}. **v:** Sears' high pairing mutant{1301}. **ma:** A PCR-based detection system for *ph1b ph1b* individuals is described in {9965}.

ph1c{593}. **tv:** Cappelli *ph1* mutant{449,593}; This mutant is deficient for a terminal portion of chromosome 5BL{449}. **ma:** Mutant lines with *ph1b* and *ph1c* carry deletions of the chromosome segment possessing *Ph1* in the respective parent lines{593,447}.

Several *ph1* mutants are described in {0219}.

Ph2{1302}. 3DS{1302}.

ph2a{1302}. **v:** Sears' intermediate pairing mutant{1301,1302}.

ph2b{1304,1303}. [*ph1a*{1537}]. **v:** Chinese Spring mutant 10/13{1537}.

50.3. Inhibitor of pairing homoeologous

Ph1^I. **al:** *Aegilops speltoides*{1218,439}.

51. Nitrate Reductase Activity

Nra{424}. **v:** UC44-111{424}.

nra{424}. **v:** Anza{424}.

52. Nuclear-Cytoplasmic Compatibility Enhancers

scs{869}. Derived from *T. timopheevii* {869}. 1AL{870,027}. **v:** *T. timopheevii*{869}. **ma:** A number of completely linked RAPD makers were identified{044}.

Asakura *et al.* {044} used the symbol *Ncc* as a synonym for *scs* pointing out that the effects of the gene are not limited to a single species.

53. Nucleolus Organizer Regions

53.1. 18S - 5.8S - 26S rRNA genes

NORs have been observed as secondary constrictions associated with nucleoli on satellited chromosomes {e.g., 221}, and by *in situ* hybridization to chromosome spreads {039,294,1014} of 18S-5.8S-26S ribosomal-DNA probes {038,433}. Allelic variation in gene number has been demonstrated at all wheat *Nor* sites and at *Nor-RI* by filter {367} and *in situ* hybridization {1012}. Allelic variants of the *Nor* loci are detected by hybridization of

- rDNA probes to restriction endonuclease-treated DNA on Southern blots {037,288,917,1399}. Alleles *Nor-B2a* to *Nor-B2f* were identified using *TaqI* digests of genomic DNAs hybridized to derivatives of the plasmid pTa250 {433} containing spacer-DNA fragments pTa250.4 {367,917} and pTa250.15 {288}.
- Other variants may have been isolated {1399} using *BamHI/EcoRI* double digests and pTa71 {433}. The variants may or may not be equivalent to those described below.
- Nor1a and Nor2a.** v: Maris Huntsman{1399}.
- Nor1b and Nor2b.** v: Bezostaya 1{1399}.
- Nor1c and Nor2c.** v: Cappelle-Desprez, Maris Ranger{1399}.
- Nor-A1.** 1AS{221,367,835,1012}. v: *T. spelta*{221,367,835,1012}. dv: *T. monococcum*{658}.
- Nor-B1.** [*Nor1*{1120}]. 1B{037,288}.1BS{221,367,835,1041}. v: CS{288}. Deletion mapping divided the *Nor-B1* in a proximal subregion *Nor-B1p* (short repeat) and a distal subregion *Nor-B1d* (long repeat) {0275}
- Nor-B1a**{918}. v: Cheyenne, Chinese Spring, Hope, Kite, Oxley, Teal, Timstein{037,288}; Vasco, 8 others{288}.
- Nor-B1a-**{918}. v: A derivative allele of *Nor-B1a* with a significantly reduced amount of spacer. Condor 64-1{918}; Sonora 64-1{918}.
- Nor-B1b.** v: Olympic, Robin, Shortim{917}.
- Nor-B1c**{918}. v: Banks{917}; Corella{917}; Warigal{917}; 5 others{917}.
- Nor-B1c-**{918}. v: Rosella{918}.
- Nor-B1d**{918}. v: Maris Huntsman{918}.
- Nor-Agⁱ1**{374}. 1Agⁱ{374}. ad: Vilmorin27/*Ag. intermedium*{374}.
- Nor-H1.** [*Nor-II*{794}]. 1HS{794}. dv: Sultan barley{794}.
- Nor-R1.** 1RS{039}. ad: CS/Imperial{039}.
- Nor-S1.** 1SS{294}. al: *Ae. speltoides*{294}.
- Nor-U1.** 1U{906}. su: CS/*Ae. umbellulata*{906}.
- Nor-V1**{241}. 1V{241}. ad: CS/*D. villosum*{241}.
- Nor-B2.** [*Nor2*{1120}]. 6BS{1041,221,366,835}. v: CS.
- Nor-B2a**{918}. 6B{288}. v: CS{037,917}.
- Nor-B2a-**{918}. v: Blueboy{918}; Sonora 64-1{918}.
- Nor-B2b.** T6B{288}. v: Banks, Oxley, Shortim, Timstein{037}; 12 others{917}.
- Nor-B2c.** v: Corella, Robin, Teal, 1 other{917}.
- Nor-B2d**{918}. H6B{288}. v: Hope{037}; Olympic{917}; Warigal{917}.
- Nor-B2d-**{918}. v: Harrier{918}; Kite{917,918}.
- Nor-B2e.** v: Vasco{917}.
- Nor-B2f.** Ch6B{288}. v: Cheyenne{037,917}.
- Nor-B2g**{918}. v: Falcon; Gluclub; La Prevision{918}.
- Nor-B2h**{918}. v: Yaktana{918}.
- Nor-B2i**{918}. v: Maris Huntsman; Thatcher{918}.
- Nor-E2.** 6ES{294}. ad: CS/*E. elongata*{294}.
- Nor-G2.** 6G{578}. tv: *T. timopheevii* IPSR (PBI) No. 1{294}.
- Nor-H2.** [*Rnr1*{1248}]. 6H{1070,039,1248}.6HS{794}. al: Clipper barley{039}; Sultan barley{794}.
- Nor-S2.** 6SS{294}. al: *Ae. speltoides*{294}.
- Nor-A3.** 5AS{1014,658}. dv: *T. monococcum*, *T. urartu* IPSR (PBI) Acc. A.
- Nor-D3.** 5DS{221,835}. v: CS; most wheats{037,288,917}.
- Nor-Agⁱ3.** 5Agⁱ{374}. ad: CS/*Ag. intermedium*{374}.
- Nor-E3.** 5ES{294}. ad: CS/*E. elongata*{294}.
- Nor-H3.** [*Rnr2*{1248}]. 5H{1070,039,1248}.5HS{794}. al: Clipper barley{039}; Sultan barley{794}.

- Nor-U3*. 5U{906}. **ad,su**: CS/*Ae umbellulata*{906}.
- Nor-D4*{1042}. 7DL{1042}. **v**: CS{1042}. **dv**: *Ae squarrosa*{1042}.
- Nor-H4*. [*Nor-I4*{794}]. 7HS{794,793}. **al**: Sultan barley{794}.
- Nor-H5*. [*Nor-I5*{794}]. 2HS{794,793}. **al**: Sultan barley{794}.
- Nor-B6*{601}. 1BL{601}. **v**: CS; Cheyenne, Wichita{601}. **tv**: Langdon{601}.
- Nor-A7*{601}. 5AL{601}. **v**: CS; Cheyenne, Wichita{601}. **tv**: Langdon{601}.
- Nor-D8*{601}. 3DS{601}. **v**: Wichita{601}.
- Nor-A9*{00120}. [*Nor-A1*{221,367,835,1012}]. 1AS{282,276}. **v**: *T. spelta*{221,367,835,1012}.
- Nor-A10*{00120}. [*Nor-A3*{1014,658}]. 5AS{282,276}. **dv**: *T. monococcum*{282,276}; *T. urartu* IPSR (PBI) Acc. A.

More detailed listings for allelic variation at *Nor-B1* and *Nor-B2* are given in {917,918}. Two sites designated temporarily as *Nor-Ax* and *Nor-Ay* were identified in *T. monococcum* ssp. *boeoticum*, but were absent in ssp. *urartu*.

54. Osmoregulation

Osmoregulation is a specific form of solute accumulation regulating turgor pressure and hydration during periods of stress with positive effects on growth. Wheat lines selected for higher osmoregulation in the greenhouse have greater growth and seed yields under water limited conditions in the field.

- Or*{1030}. Low osmoregulation. **s**: CS {Red Egyptian 7A}. **v**: Cappelle Desprez; Condor*4/3Ag14{1030}; Red Egyptian. **ma**: *Or* (proximal in 7AS) - 13 cM - *Xpsr119-7A*{1031}.
- or*{1030}. High osmoregulation. 7A{1030}.7AS{1031}. **v**: CS, Condor, Songlen, Takari{1030}.

55. Pollen Killer

- Ki*{1306}. Killing allele is dominant. 6BL{1306}. **v**: Chinese Spring{1306}; Mentana{929}.
- ki*. **v**: Probably the majority of wheats including Timstein, Gabo and Yalta{1306}.
- Modifiers also appear to be involved as Luig {840, and unpublished} found variation among *kiki* parents. Some F2 and F3 *Sr11sr11* plants from Yalta/Chinese Spring crosses segregated with less than 50% *Sr11*- phenotypes among the progeny indicating that killing extended to eggs as well as pollen. See also, Gametocidal Activity.

56. Polyphenol Oxidase (PPO) Activity

3,4 dihydroxyphenylalanine (L-DOPA) was used as a substrate in a non-destructive test of polyphenol oxidase activity in seeds. Chromosome 2D was shown to carry PPO gene(s) based on Langdon/Chinese Spring (2D) substitution lines and nullisomic-tetrasomic analysis {0342}.

QTL: A QTL on 2D, associated with Xfba314-2D was identified in an M6 / Opata 85 population using the L-DOPA assay. The high PPO activity was contributed by M6 {0344}. Markers significantly associated with PPO activity were also detected on chromosomes 2A, 2B, 3B, 3D and 6B in the population NY18 / Clark's Cream {0344}.

57. Red Grain Colour

Red colour is dominant to white. At each locus, the white allele is assigned *a* and the red allele, *b*. White-grained *T. aestivum* and amber-grained *T. durum* wheats carry recessive *a* alleles at each locus. White-grained CS*7/Kenya Farmer and CS*6/Timstein are considered near-isogenic to CS with *R-D1b*.

R-A1{548}. [R2]. 3AL{957,1003}. **i**: Novosibirskaya 67*9/Solo{730}. **ma**: (Proximal) *Xpsr483(Cxp1)-3A - 28cM - R-A1 - Xpsr904-3A*{370} (distal).

R-A1b. [R2]. **i**: Novosibirskaya 67*9/Solo{730}. **v**: Baron{370}; Diamant 2{014}; Hustler{370}; Norin 10- Brevor, 14{017}; Maris Widgeon{370}; Mercia{370}; Motto{370}; Red Bobs{1003}; Sapphire{370}; Slejpner{370}; Talent{370}; Wembley{370}.

R-B1{548}. [R3]. 3BL{1003,370}. **i**: Novosibirskaya 67*9/k-28536{730}. **ma**: *Xbcd131-3B - 5cM - R-B1 - 5cM - Xabc174-3B*{410}.

R-B1b. [R3]. **i**: Novosibirskaya 67*9/k-28536{730}. **v**: Canon{370}; Dollar{370}; Grana{370}; Supreme{370}.

R-D1{549}. [R1]. 3DL{1291,1293}. **i**: Novosibirskaya 67*9/CS{730}. **ma**: *Xbcd131-3D* cosegregation with *R-D1 - 15cM - Xabc174-3D*{410}. **v**: CS.

R-D1b. [R1]. **i**: Novosibirskaya 67*9/CS{730}. **v**: Alexandria{370}; Apollo{370}; Axona{370}; CS; Pawnee{549}; Dwarf A{370}; Fortress{370}; Jerico{370}; Longbow{370}; Luna{370}; Mardler{370}; Maris Huntsman{370}; Minaret{370}; NFC 75/93/27A; Rapier{370}; Voyage{370}; Vuka{370}.

R-N1{1018}. 3N{1018}. **su**: CS/*Ae. uniaristata*{1018}.

R-R1{1011}. 6RL{1011}. **ad**: Holdfast/King II{1011}.

R-V1{1518}. 3VL{1518}. **ad**: Creso/*D. villosum*{1518}.

A 3Ag chromosome from decaploid *Ag. elongatum* carries an allele for red grain colour which was transferred to Agent and the majority of Sears' 3D-3Ae#1 translocations {939}. Other studies have identified wheats carrying either one or two, unidentified *R-1* alleles: {056,437,549, 631,654,659,1078,1148,1333,1349,1454,370}.

See also Variegated Red Grain Colour.

R-A1b R-B1b R-D1a. [R2,R3]. **v**: Red Chief{548}; Avalon{370}; Bersee; Cappelle Desprez; Feuvert; Mission; Parade; Rendezvous; Yuri{370}.

R-A1b R-B1a R-D1b. [R2,R1]. **v**: Broom{370}; Bezostaya 1{370}; Brigand{370}; Brock{370}; Kronjuwel{370}.

R-A1a R-B1b R-D1b. [R3,R1]. **v**: Kharkov{1003}; Fenman{370}; Norman{370}; Pastiche{370}; Riband{370}; Sperber{370}; Squadron{370}; Urban{370}.

R-A1b R-B1b R-D1b. [R1,R2,R3]. **v**: Bowie; Frondoso{1148}; Frontiera{437}; Hope{204,206}; Japanese Bearded{1548}; Kanred{1078,1426}; Lin Calel{1078}.

58. Response to Photoperiod

One-gene {1169} and two-gene {638,1137,1170} differences were reported in inheritance studies. In Chinese Spring/Hope substitution lines for chromosomes 1A, 4B and 6B greater sensitivity to short photoperiod was found, whereas substitutions of 3B and 7D were less sensitive {487}.

'a' alleles are dominant.

There is an orthologous gene series on the short arms of homoeologous group 2. The "a" alleles confer the insensitive response {0063}, the contrasting allele may be referred to as "b".

Ppd-A1a{0063}. [*Ppd3*{1141}]. 2AL{1268}. **v**: C591{0057}.

Ppd-B1a{0063}. [*Ppd2*{1566}]. 2BS{1566,1268,1269}. **s**: Cappelle-Desprez*/CS 2B{0058}. **v**: Chinese Spring{1268}; Spica{557}; Timstein{1269}. **v2**: Sharbati Sonora *Ppd-A1a*{887}. **ma**: *Xpsr666-2B - 1.2cM - Xpsr109-2B - 4.4cM - Ppd-B1 - 4.8cM - Xpsr804-2B* Cent{0062}.

Ppd-D1a{0063}. [*Ppd1*{1566}]. 2DS{1268}. **s**: Cappelle Desprez*/Ciano 2D{1598}; Cappelle-Desprez*/Mara 2D{1598}; CS*/Ciano 2D *Ppd-B1a*{1268}. **v**: Akakomugi{1604}; Bezostaya 1{1604}; Mara{1604}; Sava{1604}; Sonora 64{1566}. **v2**: Sharbati Sonora *Ppd-D1a*{887}.

Ppd-A1b Ppd-B1b Ppd-D1b. **v**: Cheyenne{1141}; Diamont 1{887}; Lancer{638}; Saratovskaya 29{887}; Warriar{638}.

Two genes control photoperiod response in *T. turgidum* {788}.

Gene *Ppd-H2* on barley chromosome 2HS may be a member of the *Ppd-1* orthologous series {766}.

QTL : A QTL was detected in chromosome 4BS in Courtot/CS {0132}.

59. Response to Salinity

59.1. K⁺/Na⁺ discrimination

Variation in K⁺/Na⁺ discrimination ratios correlate with salt tolerance, high ratios being indicative of higher tolerance.

Kna1{290}. 4DL{290}.4BS.4BL-4DL{283}.4BS.4BL-4DL-4BL{849}. **v**: Hexaploid wheats{290}. **tv,su**: Langdon 4D(4B){283}. **tv,tr**: Various lines{290}; Selection 3*5-4{849}. **ma**: *Kna1* was completely linked with *Xabc305-4B*, *Xabc305-4D*, *Xbcd402-4B*, *Xbcd402-4D*, *Xpsr375-4D*, *Xpsr567-4B*, *Xpsr567-4D*, *Xwg199-4B* and *Xwg199-4D* in recombinant *T. turgidum* 4B and *T. aestivum* 4D chromosomes {283,849}.

Lophopyrum elongatum chromosome arms 1ES, 7ES, and 7EL enhance K⁺/Na⁺ selectivity in wheat under salt stress {0065}.

60. Response to Tissue Culture

Qtr.ipk-2B.1{084}. [*Tcr-B1*{084}]. **ma**: Weakly associated with *Xpsr102-2B*{084}.

Qtr.ipk-2B.2{084}. [*Tcr-B2*{084}]. **ma**: Closely linked and distal to *Ppd-B1*{084}.

Qtr.ipk-2B.3{084}. [*Tcr-B3*{084}]. **ma**: Linked with *Yr7/Sr9g*{084}.

QGpp.kvl-2A{0253}. 2AL{0253}. **v**: Ciano/Walter DH mapping population. The green plant percentage was contributed by Ciano{0253}. **ma**: Associated with *Xpsp3045-2A*{0253}.

QGpp.kvl-2B.1{0253}. 2BL{0253}. **v**: Ciano/Walter DH mapping population. The green plant percentage was contributed by Ciano{0253}. **ma**: Associated with *Xgwm388-2B*{0253}.

QGpp.kvl-2B.2{0253}. 2BL{0253}. **v**: Ciano/Walter DH mapping population. The green plant percentage was contributed by Ciano{0253}. **ma**: Associated with AFLP markers{0253}.

61. Response to Vernalization

Winter cultivars carry recessive alleles at all *Vrn* loci. Differences among winter wheats with respect to vernalization requirements seem to be due to multiple recessive alleles {1173,0202}. Two genes may determine differences between winter wheats requiring 20 days and 60-65 days of vernalization {461,1173,9902}.

New combinations of *vrn* alleles from Mironovskaya 808 with a high vernalization requirement and Bezostaya 1 with a lower requirement gave progenies with higher and lower vernalization requirements than the respective parents {9902}. The allelic variants were designated with subscripted letters *vrn1^B*, *vrn2^B*, *vrn3^B* and *vrn1^M*, *vrn2^M*, *vrn3^M*. Spring and

intermediate genotypes carry dominant alleles leading to no or reduced vernalization response.

Vrn-1{1398}. Orthologous series in long arms of chromosomes of homoeologous group 5. 'a' alleles are the dominant alleles for insensitivity or low vernalization response. *Vrn-1* should be orthologous to *Vrn-H1* {*Sh2/Sgh2*} of barley {726,419,767} and *Vrn-R1*{*Sp1*} of rye {726,1142} based on map locations using common RFLP

Vrn-A1a{1398}. [*Vrn1*{1172},*Sk*{002}]. 5AL{775,883}. **i**: Triple Dirk{1171,1172}. **s**: Kharkov 22MC*/Rescue 5A{358}; Winalta*8/Rescue 5A{876}; Rescue*/Cadet 5A *Vrn-D1a* *Vrn-B1a*{1221}. **v**: Cadet{1221}; Conley{1171}; Diamant II{885}; Falcon{1172}; Koga II{1611}; Kolben{001,1171,1172}; Konosu 25{460}; Marquis{001}; Reward{1171}; Saitama 27{460}; Saratov 29{883}; Saratovskaya 29{885}; Saratovskaya 210{883}; Shabati Sonora{885}; Thatcher{1171}; WW15{1172}. **v2**: Shortandinka *Vrn-B1a*{885}; Takari *Vrn-B1a*{253}; Hope *Vrn-B4a*{1424}. **ma**: *Vrn-A1* - 7.5cM - *Xwg644-5A*{726}; Located mid 5A cosegregating with *Xcdo504-5A*, *Xwg644-5A* and *Xpsr426-5A*{419}; *Vrn-A1* - 0.8cM - *Xbcd450-5A/Xrz395-5A* - 4.2cM - *Xpsr426-5A*{9903}.

Cultivars possessing *Vrn-A1a* are insensitive to vernalization. *Vrn-A1a* is epistatic to other genes. According to {1221}, *Vrn-A1a* is not always fully dominant and not always epistatic. Kuspira *et al.* {745} attributed single gene variation in *T. monococcum* to the *Vrn-A1a* locus. Multiple recessive alleles were suggested {745}. *Vrn-A^m1* was mapped on the long arm of chromosome 5A^m closely linked to the same RFLP markers as *Vrn-A1* {279}. *Vrn-A^m1* was mapped to the *Xcdo504-5A* - *Xpsr426-5A* region {0312}. In the opinion of the curators this location may not be correct

Multiple alleles also were reported in {9930}, and the dominant allele of Novosibirskaya 67 and the weaker dominant allele of Pirotrix 28 were designated *Vrn1a* and *Vrn1b*, respectively.

Vrn-B1a{1398}. [*Vrn4*{1173},*Vrn2*{1172},*Ss*{002},*Vrn2a* = *Vrn2*{921,920},*Vrn2b* = *Vrn2*{921,920}]. 5B{885}.5D{635}.5BL{885}.5B{921,920}.5BL or 7BL{635,0282}. **i**: Ank-18{921,920}; Triple Dirk B{1172}. **s**: Diamant 1*8/Mironovskaya 5A{920}; Diamant 1*8/Skorospelka 35 5A{920}; Rescue*/Cadet 5A *Vrn-A1* *Vrn-D1a*{885}; Saratovskaya 29*8/Mironovskaya 808 5A{920}; Saratovskaya 29*8/Odesskaya 51 5A{920}. **v**: Bersee{557}; Brown Schlanstedt{001,002,1171,1172}; Cadet{1221}; Festiguay{1172}; Magali; Mara{1611}; Milturum 321{885,920}; Milturum 885{885,920}; Noe{002}; Pyrothrix 28{920}; Spica{557}; Ulyanovka 9{920}. **v2**: Borsum *Vrn1-A1a*{001}; Dala *Vrn1-A1a*{001}; Diamant 1 *Vrn1*{001,920}; Gabo *Vrn4*{1172}; Halland *Vrn-A1a*{001}; Harukikari *Vrn-A1a*{883}; Rubin *Vrn-A1a*{001}; Saratovskaya 29 *Vrn-A1a*{920}; Shortandinka *Vrn-A1a*{1221}; Triple Dirk *Vrn-A1a*{1173}. **ma**: A dCAPS marker derived from *Xwg644-5B* was 1.7cM from *Vrn-B1*{10006}.

When mapped as a QTL *Vrn-B1* showed closest association with *Xgwm408-5B* {10007}.

Two variants of *Vrn-B1a* were distinguished in {920,921}. Carriers of an earlier designated *Vrn2b* (characterized by Diamant 1*8/Skorospelka 35 5A) showed accelerated flowering after 15 and 30 days of vernalization, whereas carriers of *Vrn-2a*, (characterized by Ank-18 and Saratovskaya 29*8/Mironovskaya 808 5A) did not respond to these periods of vernalization. This distinction was not made in the above list.

Vrn-D1a{1398}. [*Vrn3*{1172}]. 5DL{775,883}. **i**: Triple Dirk E{1172}. **s**: Rescue*/Cadet 5A *Vrn-A1a*{1221}. **v**: Chinese Spring{1172}; Loro{1172}; Norin 61{460}; Shinchunaga{460}; Shirasagi Komugi{460}; Ushio Komugi{460}. **v2**: Rescue *Vrn-B1a*{1221}.

Stock:Genotype:Vernalization Response

Triple Dirk, Kolben: *Vrn-A1a* *Vrn-B1b* *Vrn-D1b*:No

Triple Dirk B, Festiguay:*Vrn-A1b* *Vrn-B1a* *Vrn-D1b*:Yes

Gabo:*Vrn-A1b Vrn-B1a Vrn-D1b*:Yes

Triple Dirk E, Chinese Spring:*Vrn-A1b Vrn-B1b Vrn-D1a*:Yes

Vrn-2{1398}. Orthologous series in chromosomes of homoeologous group 4. *Vrn-A^m2* was located in *T. monococcum* {279} on chromosome 5A^m on the 4A^m translocated region. *Vrn-A^m2* was mapped to the distally located *Xwg114-5A - Xwec87-5A* region {0312}. *Vrn-H2*(sh/sgh1) occurs in barley chromosome 4H {1455} and is probably orthologous to *Vrn-A^m2* based on comparative maps {279,767}.

Vrn-A2a{279}. Winter habit- dominant in diploid wheat. **dv**: G1777{279}; G3116{279}.

Vrn-A2b{279}. Spring habit. **dv**: DV92{279}.

Vrn-3{1398}. Orthologous series in chromosomes of homoeologous group 1 predicted from orthology with *Vrn-H3*(Sh3) in barley chromosome 1H {1455,1316}. Aneuploid and whole chromosome substitution experiments showed that all group 1 chromosomes of wheat carry genes affecting response to vernalization {773}.

Vrn-4{279}. To date, only *Vrn-B4* has been detected.

Vrn-B4a{279}. The distal region of 7BS was translocated with a chromosome segment with homoeology to the distal region of 5AL. It is not known if *Vrn-4* is located in the region homoeologous to 5L or 7S. [*Vrn5*{771,769},*eHi*{771,769}]. 7BS{768,771}. **s**: CS*/Hope 7B *Vrn-D1a*{768}. **v**: Hope *Vrn-A1a*{1424}.

Vrn4. 5D{10002}.5DL{10004}. **i**: Triple Dirk F. **v2**: Gabo *Vrn-B1a*{1172}; IL47/*Vrn-A1a*{10005}.

Eight land races with only *Vrn4* were detected in {10003}; others combined *Vrn4* with other *Vrn* genes. Stelmakh {1424} doubted the existence of *Vrn4*. References to additional studies are given in {1424}.

QTL: Analysis in Courtot/CS {0132}.

62. Restorers for Cytoplasmic Male Sterility

62.1. Restorers for *T. timopheevi* cytoplasm

Rf1{823}. 1A{1224,1619,873}.1AS{868}. **v**: L22{868}; (*T. timopheevi*/*Aegilops squarrosa*)/ 3*Dirk{1619}. **v2**: *T. timopheevi*/3* Marquis *Rf2*{823}; R113 *Rf4*{873}.

The second gene referred to as *Rf4*{1619} in the last stock was located in chromosome 7D, but its relationship to *Rf2* in {823} is unknown.

Rf2{823}. 7D{871}. **v**: *T. timopheevi*/3*Marquis *Rf1*{823}.

Rf3{1453}. 1B{1453}.1BS. **v**: *T. spelta* var. *duhamelianum*{1453}. **ma**: *Xcdo388-1B* - 1.2 cM - *Xabc156-1B*{9934}; RFLP markers *Xcdo442-1B* and *Xbcd249-1B* were found to be associated with *Rf3* on 1BS{860}.

Rf4{1619}. [*Rf2*{1619}]. 6B{1619,873}.1BS{868}. **v**: L3{868}; (*T. timopheevi*/*Aegilops squarrosa*) / 3*Canthatch *Rf5*{1619}; R113 *Rf1*{873}.

Rf5{1619}. [*Rf3*{1619}]. 6D{1619}. **v**: (*T. timopheevi*/*Aegilops squarrosa*) / 3*Canthatch *Rf4*{1619}.

Rf6{865,859}. 6AS [T6AL.6AS-6U]{865}.6BS [T6BL.6BS-6U]{865}. **tr**: Line 2114{865}; Lines 040-5; 061-1{865}; 061-4{865}.

Genes *Rfc3* in chromosome 6RL and *Rfc4* in chromosome 4RL were reported in {225}.

Novel *Rf* genes were identified on 5AL linked to *Xcdo786-5A* and *XksuH1-5A*{860}.

62.2. Restorers for *T. longissimum* cytoplasm

Vi{867}. 1B{870}.1BS{027}. **v**: *T. turgidum*{867}.

Probably derived from a cv. Selkirk (*T. aestivum*) line with *Ae. cylindrica* cytoplasm {867}.

62.3. Restorers for photoperiod-sensitive *Aegilops crassa* cytoplasm

Morai & Tsunewaki {1047} described photoperiod sensitive CMS caused by *Ae. crassa* cytoplasm in wheat cv. Norin 26. Almost complete sterility occurred when plants were grown in photoperiods of 15h or longer.

Rfd1{1047}. 7BL{1047}. **v:** Chinese Spring{1047}.

A different system of restoration occurs in cv. Norin 61 where at least four chromosomes, 4A, 1D, 3D and 5D, appear to be involved {1046}. Several Japanese wheats carry a similar or equally effective gene combination {0335}.

63. Ribosomal RNA

The *5S-Rrna-1* loci were physically mapped in 1AS, 1BS, and 1DS and the *5S-Rrna-2* loci were physically mapped in 5AS, 5BS and 5DS of Chinese Spring using deletion lines {1043}. Table 1 in {276} lists the chromosome or chromosome arm locations of rRNA loci in 12 Triticeae species.

63.1. 5S rRNA genes

Within the Triticeae there are basically two sets of 5S rRNA loci. One set, identified by repetitive units 320-468 bp in length, is located on group 1 chromosomes. The other set, identified by repetitive units 469-500 bp in length, is on group 5 chromosomes. Within species the repetitive units at a locus are extremely uniform in size and sequence. They remain stable in foreign genetic backgrounds.

5S-Rrna-A1. [*5SDna-A1*{295}]. 1AS{295,658}. **v:** CS{1043}.

5S-Rrna-B1. [*5SDna-B1*{295}]. 1BS{039,295}. **dv:** *T. monococcum*. **ma:** A PCR marker specific *5S-Rrna-B1* was developed{9974}.

5S-Rrna-D1. [*5SDna-D1*{295}]. 1D{295,758}.1DS{295}. **v:** CS{295,758}. **dv:** *T. tauschii*{758}. **ma:** A PCR marker specific for *5S-Rrna-D1* was developed in {9974}.

5S-Rrna-E1. [*5SDna-E1*{960}]. 1E{1290}. **dv:** *L. elongatum*.

5S-Rrna-R1. [*5SDna-R1*{1206}]. 1RS{039,1206}. **al:** *S. cereale*. **ma:** A PCR marker specific for *5S-Rrna-R1* was developed in {9974}.

5S-Rrna-Sc1. [*5SDna-Sc1*{960}]. 1S^c{1290}. **al:** *Elymus ciliaris*.

5S-Rrna-S¹1. [*5SDna-S¹1*{960}]. 1S¹{1290}. **al:** *E. trachycaulus*.

5S-Rrna-Y1. [*5SDna-Y1*{960}]. 1^Y{1290}. **al:** *E. ciliaris*.

5S-Rrna-A2. [*5SDna-A2*{295}]. 5AS{295,658}. **v:** CS{295}. **dv:** *T. monococcum*{295,658}.

5S-Rrna-B2. [*5SDna-B2*{295}]. 5BS{295}. **v:** CS.

5S-Rrna-D2. [*5SDna-D2*{295}]. 5D{295,758}.5DS{758}. **v:** CS{295,758}. **dv:** *T. tauschii*{758}.

5S-Rrna-R2. [*5SDna-R2*{1206}]. 5RS{1206}. **al:** *S. cereale*.

5S-Rrna-H²1. [*5SDna-H²1*{960}]. 5H¹{1290}. **al:** *E. trachycaulus*.

5S-Rrna-U2. [*5SDna-U2*{295}]. 5U{295}. **al:** *T. umbellulatum*.

5S-Rrna-V2. [*5SDna-V2*{960}]. 5V{1290}. **al:** *D. villosa*.

5S-Rrna-H3. [*5SDNA-H3*{793}]. 2H{710}.2HL{793}. **al:** Betzes Barley; Sultan barley.

5S-Rrna-H4. [*5SDNA-H4*{793}]. 3HL{793}. **al:** Betzes barley; Sultan barley.

5S-Rrna-H5. [*5SDNA-H5*{793}]. 4HL{793}. **al:** Betzes barley; Sultan barley.

5S-Rrna-H6. [*5SDNA-H6*{793}]. 4HS{793}. **al:** Betzes barley; Sultan barley.

64. Seedling Leaf Chlorosis

sc{149}. 3BS{149}. **s**: CS*/Hope3B{149}. **v**: Hartog{149}; Suneca{149}; wheats with *Sr2*{149}.

Leaf chlorosis is affected by temperature and light and is enhanced by infection with pathogens. *sc* is completely linked with *Pbc* (pseudo-black chaff) and *Sr2* (reaction to *Puccinia graminis*).

65. Segregation Distortion

QSD.ksu-1D{9931}. 1DL{9931}. **dv**: *Ae. tauschii* var. *meyeri* acc. TA1691/var. *typica* acc. TA1704{9925}. **ma**: Association with *Xcmwg706-1D*{9931}.

QSD.ksu-3D{9931}. 3DS{9931}. **dv**: *Ae. tauschii* var. *meyeri* acc. TA1691/var. *typica* acc. TA1704{9925}. **ma**: Association with *Xwg177-3D*{9931}.

QSD.ksu-4D{9931}. 4DS{9931}. **dv**: *Ae. tauschii* var. *meyeri* acc. TA1691/var. *typica* acc. TA1704{9925}. **ma**: Association with *XksuF8-4D*{9931}.

QSD.ksu-5D.1{9931}. 5D{9931}. **dv**: *Ae. tauschii* var. *meyeri* acc. TA1691/var. *typica* acc. TA1704{9925}. **ma**: Association with *Xcdo677-5D*{9931}.

QSD.ksu-5D.2{9931}. 5DL{9931}. **dv**: *Ae. tauschii* var. *meyeri* acc. TA1691/var. *typica* acc. TA1704{9925}. **ma**: Association with *Xglk614-5D* (synonym '*Xtag614-5D*'){9931}.

QSD.ksu-5D.3{9931}. 5DL{9931}. **dv**: *Ae. tauschii* var. *meyeri* acc. TA1691/var. *typica* acc. TA1704{9925}. **ma**: Association with *Xwg1026-5D*{9931}.

QSD.ksu-7D{9931}. 7DS{9931}. **dv**: *Ae. tauschii* var. *meyeri* acc. TA1691/var. *typica* acc. TA1704{9925}. **ma**: Association with *Xglk439-7D* (synonym '*Xtag439-7D*'){9931}.

66. Sterol Esterification in Kernels - Synthesis of b-Sitosterol Esters

Two sterol-ester phenotypes, p-L (palmitate + linoleate) and L (linoleate) are inherited as alleles at a single locus.

Pln{428}. [*P-L*]{428}. 7DS{1476}. **v**: Aradi{428}; Aragon 03{428}.

pln{428}. [*L*]{428}. **v**: Mara{428}; Pane 247{428}.

67. Temperature-Sensitive Winter Variegation

This phenotype involves reduced vigour and chlorotic patches on leaves of certain genotypes in *Ae. umbellulata* cytoplasm when grown at low temperatures {1596}.

Vgw. Variegation is dominant {1596}. [*Vg*]{1021}. 5BL{1021}. **v**: Bersee{1596}; Cappelle-Desprez{1596}; Hobbit Sib{1596}; Mara{1596}.

vgw{1021}. **v**: Besostaya I{1596}; CS{1596}; Poros{1596}; Sava{1596}; *T. spelta*{1596}.

68. Tenacious Glumes

Tg1{1240}. Derived from *T. tauschii*. Dominant. [*Tg*]{1240}. 2DS{1240}. **v**: Synthetic ABD wheats{652}.

Tg2{0046}. Derived from *T. dicoccoides* 2BS{0046}. **ma**: *Tg2* is associated with *Xrsq805(Embp)-2B* and *Xpsr899-2B*{0046}.

69. Tiller Inhibition

tin1{1212}. Restricted tiller number is recessive{1212} [*Tin*{1212}]. 1AS{1212}. **v:** Israel Uniculm 494{1212}.

tin2{1212}. Tiller-reducing affect of this allele was dominant {9909}. [*Tin*{9909}]. 2A{9909}. **v:** 88 F2 185{9909}.

70. Uniculm Stunt

Stunting is favoured by a combination of long days and low night temperatures {581}. Caused by duplicate recessive genes, *us1* and *us2*, located in chromosomes 4A and 5B, respectively {200}.

Genotypes: Normal **v:** *Us1 us2*: Alfa {581}; Jaral {581}.

Normal **v:** *us1 Us2*: Mabruk {581}.

Stunted **v:** *us1 us2*: Line 492 {581}.

71. Variegated Red Grain Colour

vg{498}. **v:** Line 10859{498}.

vgvg genotypes in Line 10859 are variegated. The *Vg/vg* locus was independent of the single red gene locus in Line 10859. In a cross to Selkirk (*R-A1b*, *R-B1b*, *R-D1b*) *vgvg* was expressed only in plants with one *R* gene{498}. Variegated red pericarp was also studied in crosses of cv. Supreme. In this case, two red colour genes were present{0136}.

72. Yield Components

72.1. Grain weight

72.1.1. 50-grain weight

QFgw.ocs-4A.1{0047}. 4A{0047}. **v:** CS/CS(Kanto107 4A) mapping population{0047}. **ma:** Associated with *Xbcd265-4A* and *Xbcd1738-4A*{0047}.

72.1.2. 1000-grain weight

QTL: Two QTLs for 1,000-kernel weight were assigned to chromosome 3A in RSLs from Cheyenne*7/Wichita 3A {0025}. QTLs for grain size were identified on chromosome arms 1DS, 2DL and 6BL in a RIL population from RS111/CS {0236}. Eight QTLs for 1,000-kernel weight (54 % of the variation) were mapped in Forno/ Oberkulmer spelt {0280}.

QGw1.ccsu-1A{0165}. 1AS{0165}. **v:** RS111/CS mapping population{0165}. **ma:** Associated with *Xwmc333-1A*{0165}.

QTgw.ipk-5A{0255}. 5AL{0255}. **v:** Oyata/W-7984 (ITMI) RI mapping population{0255}; The higher yielding allele was contributed by W-7984{0255}. **ma:** Associated with *Xfba351-5A* and *Xcdo1312-5A*{0255}.

72.2. Grain weight/ear

QGwe.ocs-4A.1{0047}. 4AS{0047}. **v:** CS/CS(Kanto107 4A) mapping population{0047}. **ma:** Associated with *Xbcd1738-4A*{0047}.

QGwe.ipk-2D{0255}. 2DS{0255}. **v:** Oyata/W-7984 (ITMI) RI mapping population{0255}; Higher grain weight was contributed by Oyata{0255}. **ma:** Associated with *Xcdo1379-2D* and *Xbcd1970-2D*{0255}.

QGwe.ipk-4A{0255}. 4AL{0255}. **v:** Opata/W-7984 (ITMI) RI mapping population{0255}; Higher grain weight was contributed by Opata{0255}. **ma:** Associated with *Xmwig549-4A*, *Xabg390-4A* and *Xbcd1670-4A*{0255}.

QGwe.ipk-4A coincided with QTLs for height (*QHt.ipk-4A*), spike length (*XEl.ipk-4A*) and grain number (*QGnu.ipk-4A*) {0255}.

72.3. Grain number per spike

QGnu.ipk-4A{0255}. 4AL{0255}. **v:** Opata/W-7984 (ITMI) RI mapping population{0255}; Higher grain number was contributed by Opata{0255}. **ma:** Associated with *Xmwig549-4A*, *Xabg390-4A* and *Xbcd1670-4A*{0255}.

QGnu.ipk-4A coincides with QTL for height (*QHt.ipk-4A*), spike length (*XEl.ipk-4A*) and grain weight per ear (*QGwe.ipk-4A*) {0255}.

QTL: Three QTLs for kernel number per spike were assigned to chromosome 3A in RSLs from Cheyenne*7/Wichita{0025}.

72.4. Plant yield

QYld.ocs-4A.1{0047}. 4AS{0047}. **v:** CS/CS(Kanto107 4A) mapping population{0047}. **ma:** Associated with *Xbcd1738-4A*{0047}.

72.5. Spikelet number/ear

QSpn.ocs-4A.1{0047}. 4AS{0047}. **v:** CS/CS(Kanto107 4A) mapping population{0047}. **ma:** Associated with *Xbcd1738-4A*{0047}.

72.6. Spike number per square metre

QTL: A QTL for spike number per square metre was assigned to chromosome 3A in RSLs from Cheyenne*7/Wichita 3A {0025}.

72.7. Spike length

QEl.ipk-1B{0255}. 1BL{0255}. **v:** Opata/W-7984 (ITMI) RI mapping population{0255}; Longer ear was contributed by Opata{0255}. **ma:** Associated with *Xbcd388-1B* and *Xwg605-1B*{0255}.

QEl.ipk-4A{0255}. 4AL{0255}. **v:** Opata/W-7984 (ITMI) RI mapping population{0255}; Longer ear was contributed by Opata{0255}. **ma:** Associated with *Xmwig549-4A*, *Xabg390-4A* and *Xbcd1670-4A*{0255}.

This QTL is likely to be a pleiotropic effect of the gene underlying the height QTL, *QHt.ipk-4A* {0255}.

QEl.ipk-5A{0255}. 5AL{0255}. **v:** Opata/W-7984 (ITMI) RI mapping population{0255}; Longer ear was contributed by W-7984{0255}. **ma:** Associated with *Xmwig522-5A*{0255}. QTL: Five QTLs for spike length were detected in Courtot/Chinese Spring{0114} but only one on chromosome arm 5AL was consistent for at least two years.

72.8. Tiller number/plant

QTn.ocs-4A.1{0047}. 4AS{0047}. **v:** CS/CS(Kanto107 4A) mapping population{0047}. **ma:** Associated with *Xpsr163-4A*{0047}.

73. Yellow Berry Tolerance

QTL : A QTL for yellow berry tolerance, contributed by RS111, was associated with *Xgwm190-5D* and *Xgwm174-5D* in a RIL population from RS111/CS {0237}. A tolerance QTL contributed by CS, the susceptible parent, was detected on 6B {0237}.

Proteins

74. Proteins

74.1. Grain protein content

Pro1{777}. 5DL{777}. **s**: CS*6/Hope 5D{777}.

May be identical to *Vrn3*.

Pro2{777}. 5DS{777}. **s**: CS*6/Hope 5D{777}.

QGpc.ccsu-2D{0015}. 2DL{0015}. **ma**: Association with microsatellite locus *Xwmc41-2D* accounted for 19% of the variation in grain protein content between PH132 and WL711{0015}.

QGpc.ndsu-6B{623}. 6BS{623}. **tv**: Langdon{623}.

QGpc.ndsu-6Ba{623}. **tv**: Langdon{623}.

QGpc.ndsu-6Bb{623,0071}. **tv**: Langdon-*T. dicoccoides* 6B{623}. **v**: Glupro{0179}.

ma: *QGpc.ndsu-6B* was associated (LOD score = 18.9) with the interval *Xmwig79-6B* - *Xabg387-6B*. These loci were mapped in 6BS: *Xmwig79-6B* - 5.9 cM - *Xabg387-6B* - 9.0 cM - centromere{623}; Located in the 4 cM interval flanked by *Xmwig79-6B* and *Xcdo365-6B*{0244}; Flanking microsatellite markers and PCR-specific markers for Glupro are available{0179}.

QPro.mgb-4B. Associated with *Gail* and *Xpsr622-4B* {110}².

QPro.mgb-5A. Associated with *Xpsr911-5A* {110}² and *Xcdo412-5A*{0343}^{*}.

QPro.mgb-6A.1. Associated with *Xpsr167-6A* and *XksuG8-6A* {110}².

QPro.mgb-6A.2. Associated with *Xmgb56-6A* {110}² and *Xpsr627-6A*{0343}^{*}.

QPro.mgb-6B. Associated with *Gli-B2-6B* {110}² and *Nor-2*{0343}^{*}. **ma**: *QGpc.ndsu-6B* was associated (LOD score = 18.9) with the interval *Xmwig79-6B* - *Xabg387-6B*. These loci were mapped in 6BS: *Xmwig79-6B* - 5.9cM - *Xabg387-6B* - 9.0 cM - centromere{623}.

Qpro.mgb-7A. Associated at $P \leq 0.01$ with *Pan2*{0343}^{*}.

QPro.mgb-7B. Associated with *Xpsr490(Ss1)-7B*, *Pc* {110}² and *Xutv913-7B*{0343}^{*}.

QTLs for grain protein content were detected on chromosome arms 6AS (associated AFLP marker, *XE38M60*₂₀₀) and 1BL (associated RFLP marker, *Xcdo1188-1B*) in Courtot/Chinese Spring {0141}.

Nine QTLs (51% of the variation) were mapped in cross 'Forno'/'Oberkulmer' spelt {0280}. A QTL for grain and flour protein content, contributed by CS, was associated with *XTri-ID*/Centromere in a RSL population from the cross Cheyenne (high quality wheat)/CS (low quality wheat) {0251}.

74.2. Enzymes

74.2.1. Acid phosphatase

Acph-A1{504}. [*Acph2*{516},*Acph3*{516},*Acph-B1*{936}]. 4AS{504,516}. **v**: CS.

Acph-B1{504}. [*Acph4*{516},*Acph8*{516},*Acph-A1*{936}]. 4BL{504,516}. **v**: CS.

Acph-D1. [*Acph5*{516},*Acph6*{516}]. 4DL{504,516}. **v**: CS.

Acph-H1{1153}. 4H{1153}. **ad**: CS/Betzes.

Acph-M^v1{237}. [*Aph-v*{237},*Acph-M^v1*{985}]. 4M^v{237}. **tr**: H-93-33{984}.

Acph-R1. 7R{1457}.7RS{506}. **ad**: CS/Imperial.

Acid phosphatase gene loci were reported for 7RL in *S. cereale* {1251}, chromosomes L1 (= 7Agⁱ) and L4 (= 4Agⁱ) of *Thin. intermedium* {361}, and chromosome E of *Ae. umbellulata* {69}. Two loci on 7R were separated by 25 +or- 5.2cM {1534}. Wehling {1559} identified four acid phosphatase loci in *S. cereale*, three of which were located in 7R.

Acph-S^sI{1140}. 4S^s{1140}. **ad**: CS/*T. searsii*.

74.2.2. Alcohol dehydrogenase (Aliphatic)

Adh-AI{502}. [*Adh_B*{502},*Adh-BI*{504}]. 4A{502}.4AL{504,516}. **v**: CS.

Adh-BI{501,502}. [*Adh_I*{501},*Adh_A*{502},*Adh-AI*{504}]. 4B{502}.4BS{504,516}. **v**: CS.

Adh-BIa{1442}. [*Adh_{I1}*{501},*Adh-AIa*{1442}]. **v**: CS. **tv**: PI 226951{501}; Malavika{1442}.

Adh-BIb{1442}. [*Adh_{I2}*{501},*Adh-AIb*{1442}]. **v**: Rageni derivative{1443}. **tv**: CI 4013{501}; Bijaga Yellow{1442}.

Adh-BIb was the only variant *Adh-I* allele detected in study of a large number of *T. aestivum* and *T. turgidum* accessions {503}.

Adh-CI{1278}. [*G*{1278}]. **ad**: *T. aestivum* cv. Alcedo / *Ae. caudata* line G.

Adh-DI{504}. [*Adh_D*{502}]. 4D{502}.4DS{504,516}. **v**: CS. **ma**: *Adh-DI* [*Adh₁*, *Adh₂*] was mapped 4cM distal to *Xpsr163-4D* and closely proximal to *XcsiHA114-4D.1* [*XcsiHA114-1a*] {757}.

Adh-AgⁱI{560},{374}. [*Adh-XI*{361}]. 4Agⁱ{560}. **ad**: Vilmorin 27/*Thin. intermedium*; Caribo/*Thin. intermedium*.

Adh-EI{518}. 4ES{518}. **ad**: CS/*E. elongata*.

Adh-HI{520}. 4H{520}. **ad**: CS/Betzes.

Adh-M^vI{984}. [*ADHmu*{984},*Adh-M^vI*{985}]. 4M^v{984}. **v**: H-93-33.

Adh-RI{1457}. [*AdhR2*{582}]. 4R{582,1457}.4RS{506}. **ad**: CS/Imperial{1457,506}; FEC28/Petkus{043}; Holdfast/King II{582}.

Adh-VI{1026,242}. 4V{1026}. **ad**: CS/*D. villosum*.

Three *Adh* genes were identified in *Hordeum vulgare* and *H. spontaneum* {144,490,493,520}. Two of these were tightly linked at the *Adh-HI* locus {144}. The third gene was tentatively located in 5H {490}.

A low-level of aliphatic alcohol dehydrogenase activity is commonly observed on zymograms in the absence of added substrate {513}; this may account for the observation of wheat lactate dehydrogenase that was reported in {1465}.

The gene series formerly designated *Adh-2* and *Adh-3* appear under 2.20. Aromatic Alcohol Dehydrogenase

74.2.3. Aminopeptidase

Amp-AI{504}. 6AS{504,516}. **v**: CS.

Amp-AIa. **v**: CS{1533}.

Amp-AIb. **v**: Vitka{1533}.

Amp-BI{504}. 6BS{504,516}. **v**: CS.

Amp-BIa. **v**: CS{1533}.

Amp-BIb. **v**: Iskra{1533}.

Amp-BIc{703,1244}. Null allele **v**: *T. spelta* IPSR 1220017{703}; Sinvalocho M.A{1244}.

Amp-CI{1278}. 6D{1278}. **ad**: Alcedo/*Ae. caudata* line D.

Amp-DI{504}. 6DS{504,516}. **v**: CS.

Amp-DIa{703}. **v**: CS.

Amp-DIb{703}. **v**: Sears' Synthetic IPSR1190903.

Amp-Ag^eI{1575}. 6Ag^e{1575}. **ad,su**: Rescue/*Thin. elongatum*.

Amp-AgⁱI{703}. 6Agⁱ{703}. **ad**: Vilmorin 27/*Thin. intermedium*.

Amp-EI{518}. 6E{518}. **ad**: CS/*E. elongata*.

Amp-HI{520}. 6H{520}. **ad**: CS/Betzes.

Amp-RI{1457}. 6R{1457,1280}. **ad**: CS/Imperial{1457}; Holdfast/King II{1280}.

- Amp-A2*{703}. 4AL{703}. **v:** CS.
Amp-A2a{703}. **v:** CS.
Amp-A2b{703}. **v:** *T. spelta* IPSR 1220017.
Amp-B2{703}. 4BS{703}. **v:** CS.
Amp-B2a{703}. **v:** CS.
Amp-B2b{703}. **v:** Timstein.
Amp-B2c{703}. **v:** Hope.
Amp-D2{703}. 4DS{703}. **v:** CS.
Amp-D2a{703}. **v:** CS.
Amp-D2b{703}. **v:** Sears' Synthetic IPSR 1190903.
Amp-D2c{703}. **v:** Bersee.
Amp-Agⁱ2{703}. 4Agⁱ{703}. **ad:** Vilmorin27/*Ag. intermedium*.
Amp-E2{703}. 4E{703}. **ad:** CS/*E. elongata*.
Amp-H2{703}. 4H{703}. **ad:** CS/Betzes.
Amp-H^{ch}2{703}. 4H^{ch}{703}. **ad:** CS/*H. chilense*.
Amp-J2{703}. 4J{703}. **ad:** CS/*Thin. junceum*.
Amp-M^v2{235}. 4M^v{235}. **su:** H-93-33{235}.
Amp-R2{703}. 4R{703}, 4RS{702,093}. **ad:** CS/Imperial.
Amp-S^l2{703}. 4S^lL{703}. **ad:** CS/*Ae. sharonensis*{180}. **tr:** 4DS.4DL-4S^lL{660}.
Amp-V2{703}. 4V{703}. **ad:** CS/*D. villosum*.
Amp-A3{703}. 7AS{703}. **v:** CS.
Amp-A3a{703}. **v:** CS.
Amp-A3b{703}. **v:** Timstein.
Amp-H3{703}. 7H{703}. **ad:** CS/Betzes.

74.2.4. Alpha-amylase

- a-Amy-A1*{007}. [*Amy*6A{1082}]. 6AL{412,1082}. **v:** CS.
a-Amy-A1a{007}. [*Amy* 6AI{1084}]. **v:** CS.
a-Amy-A1b⁵{007}. **v:** Bezostaya 1; Kavkaz.
a-Amy-A1c⁵. [*Amy* 6AI^m{1084}]. **v:** Aka.
a-Amy-B1{007}. [*Amy*6B{1082}]. 6BL{412,1082}. **v:** CS.
a-Amy-B1a{007}. [*Amy* 4{1084}, *Amy* 6BI{1084}, *Amy* 6B2^o{1084}]. **v:** CS{007}; Rare.
a-Amy-B1b{007}. [*Amy* 4^m{1084}, *Amy* 6BI^o{1084}, *Amy* 6B2{1084}]. **v:** Mara{007}.
a-Amy-B1c{007}. [*Amy* 4{1084}, *Amy* 6BI{1084}, *Amy* 6B2{1084}]. **v:** Sava{007}; Rare.
a-Amy-B1d{007}. [*Amy* 4^m{1084}, *Amy* 6BI^o{1084}, *Amy* 6B2^o{1084}]. **v:** Sicco{007}; Rare.
a-Amy-B1e{007}. [*Amy* 4^m{1084}, *Amy* 6BI^{4'}{1084}, *Amy* 6B2^o{1084}]. **v:** Cappelle-Desprez{007}.
a-Amy-B1f{007}. [*Amy* 4^m{1084}, *Amy* 6BI⁴{1084}, *Amy* 6B2^o{1084}]. **v:** Sappo{007}.
a-Amy-B1g{007}. [*Amy* 4{1084}, *Amy* 6BI⁴{1084}, *Amy* 6B2^o{1084}]. **v:** Cheyenne{007}.
a-Amy-B1h{007}. [*Amy* 4{1084}, *Amy* 6BI^o{1084}, *Amy* 6B2^o{1084}]. **v:** *T. macha* Line 1{007}; Rare.

Two types of nomenclature were assigned to the genes encoding the a-AMY-1 isozymes. In one, allelic states were defined for individual isozymes {1084} whereas in the other, several isozymes were considered to be the products of compound loci {007,412}. This listing shows the 'alleles' described in {1084} which are assumed in {007} to be synonymous with the *a-Amy-B1a* through *a-Amy-B1h* nomenclature. *Amy* 4 and *Amy* 4^l are unmapped alternatives {1084} which appear to be identical to zymogram bands [bands 9 and 9b {007}] forming part of the *a-Amy-B1* phenotype. *Amy* 6BI [with forms *Amy* 6BI^o, and *Amy* 6BI^{4'}, considered to be mutually exclusive {1084}] and *Amy*

- 6B2 [with forms *Amy* 62 and *Amy* 6B2^o {1084}] describe further aspects of *a-Amy-B1* {007}. See *a-Amy1* below for further consideration of *Amy* 6B2 {1084}.
- a-Amy-D1*{007}. [*Amy*6D{1082}]. 6DL{412,1082}. **v:** CS.
- a-Amy-D1a*{007}. [*Amy*6D1{1084},*Amy* 6D2{1084}]. **v:** CS.
- a-Amy-D1b*{007}. [*Amy*6D1{1084},*Amy* 6D2{1084}]. **v:** Prelude{1082}; Capelle-Desprez{007}.
- a-Amy-D1c*. [*Amy*6D1^m{1084},*Amy* 6D2{1084}]. **v:** *T. spelta* var. *duhamelianum*.
- a-Amy-Agⁱ1*{374}. 6Agⁱ{374}. **ad:** Vilmorin 27/*Thin. intermedium*.
- a-Amy-E1*{013}. 6E{013}. **ad:** CS/*E. elongata*.
- a-Amy-H1*. [*a-Amy1*{146}]. 6H{146,1051}. **ad:** CS/Betzes.
- a-Amy-R1*{013}. 6RL{013}. **su,ad:** CS/Imperial; CS/King II; Holdfast/King II.
- a-Amy-R^m1*{013}. 6R^mL{013}. **ad:** CS/*S. montanum*.
- a-Amy-S1*{598}. 6SS{598}. **v:** Wembley derivative 31. **al:** *Ae. speltoides*.
- It was estimated {902} that there are two *a-Amy-1* genes in 6A and five or six in both 6B and 6D, and three or four *a-Amy-2* genes at each of the 7A, 7B, and 7D loci.
- a-Amy-A2*{007}. [*Amy*_{7A}{1082}]. 7AL{412,1082}. **v:** CS.
- a-Amy-B2*{007}. [*Amy*_{7B}{1082}]. 7BL{412,1082}. **v:** CS.
- a-Amy-B2a*{412}. [*Amy* 7B1{1084},*Amy* 7B2{1084}]. **v:** CS.
- a-Amy-B2b*{412}. [*Amy* 7B1{1084},*Amy* 7B2^m{1084}]. **v:** Hope.
- The alternative states of *Amy* 7B2, namely, *Amy* 7B2 and *Amy* 7B2^m {1084}, are identical to the variation in band 2 {412}. The complete description of the *a-Amy-B2* variation also includes variation in band 11 {412}.
- a-Amy-D2*. [*Amy*_{7D}{1082}]. 7DL{412,1082}. **v:** CS.
- a-Amy-D2a*{412}. [*Amy* 7D1{1084}]. **v:** CS.
- a-Amy-D2b*{417}. [*Amy* 7D1^o{1084}]. **v:** Largo{007}; Sears' Synthetic{007}; VPM1{417}.
- a-Amy-Agⁱ2*{374}. 7Agⁱ{374}. **ad:** Vilmorin 27/*Thin. intermedium*.
- a-Amy-E2*{013}. 7EL{013}. **ad:** CS/*E. elongata*.
- a-Amy-H2*. [*a-Amy2*{146}]. 7HL{146,1051,793}. **ad:** CS/Betzes.
- a-Amy-H^{ch}2*{1015}. 7H^{ch}beta{1015}. **su,ad:** CS/*H. chilense*.
- a-Amy-R2*{013}. 7RL{013}. **su,ad:** CS/Imperial; CS/King II; Holdfast/King II.
- a-Amy-S^b2*{013}. 7S^b{013}. **ad:** Holdfast/*Ae. bicornis*.
- a-Amy-U2*{013}. 7U{013}. **ad:** CS/*Ae. umbellulata*.
- Three other *a-Amy* loci, namely, *Amy* 6B2, *Amy* 6D2, and *Amy* 7B2, were reported {1084}. No variation was observed for the products of *Amy* 6D2 and *Amy* 7B2, although nullisomic analysis located the genes in 6DL and 7B, respectively. In accordance with the Guidelines, these genes are assumed to be part of the *a-Amy-D1* and *a-Amy-B2* loci, respectively. *Amy* 6B2 was observed to produce alternative phenotypes {1084}. In a test of the segregation of these phenotypes relative to two alternative products of *Amy* 6B1, the two loci were found to be linked with a recombination frequency of 20.6% {1084}. However, an attempt to confirm the presence of more than one *a-Amy* locus in 6BL was unsuccessful {007}.
- a-Amy1*{1084,1083}. [*Amy* 6B2{1084},*Amy*-B2{1083}]. 6BL{1084,1083}. **v:** CS.
- a-Amy1a*{1083}. [*a-Amy-B1a*]. **v:** CS.
- a-Amy1b*{1083}. [*a-Amy-B1b*]. **v:** CS.
- a-Amy1c*{1083}. [*a-Amy-B4*]. **tv:** *T. durum* ssp. *georgicum*.

The presence of *a-Amy1* reported in {1084} was confirmed by segregational tests in a CS/Jones Fife population and in a population derived from a tetraploid cross {1083}. The recombinations with *a-AmyB1* were 9.3% and 22.3%, respectively.

A further set of *a-amylase* genes, *Xa-Amy-5* [*a-Amy3*], was identified in 5A, 5B and 5D by cross-hybridization with *a-AMY-1* and *a-AMY-2* probes {080}. Only one gene copy appears to be present at each locus. In rye, evidence was obtained for three *a-Amy-1*

genes, two or three *a-Amy-2* genes and three *a-Amy-3* genes {907}.
 Synthesis of α -amylase isozymes controlled by *a-Amy-1* genes on chromosomes 6A and 6D is reduced in DT6BS compared to euploid CS. This result suggests the presence of a gene(s) on the long arm of chromosome 6B, which is (are) required for GA-induced α -amylase synthesis in the aleurone {0072}.

74.2.5. Beta-amylase

b-Amy-A1{008,227}. [*b-Amy-A2*{008},*b-Amy-B1*{1331}]. 5AL{008,227}. **v:** CS{008}. **s:** CS/Federation{227}.

b-Amy-A1a{008}. [*b-Amy-A2a*{008},*b-B1a*{936}]. **v:** CS.

b-Amy-A1b{008}. [*b-Amy-A2b*{008},*b-B1b*{936}]. **v:** Koga II.

b-Amy-A1c{008}. [*b-Amy-A2c*{008},*b-B1c*{936}]. **v:** *T. macha* IPSR 1240005.

b-Amy-A1d{008}. [*b-Amy-A2d*{008},*b-B1d*{936}]. **v:** Holdfast.

b-Amy-A1e{008}. [*b-Amy-A2e*{008},*b-B1e*{936}]. **v:** Bezostaya I.

b-Amy-B1{628}. [*b-Amy-A1*{008}]. 4BL{008,628}. **v:** CS.

b-Amy-B1a{1330}. [*b-Amy-A1a*{008,1330}]. **v:** CS.

b-Amy-B1b{1330}. [*b-Amy-A1b*{008,1330}]. **v:** Sears' Synthetic IPSR 1190903.

b-Amy-B1c{1330}. [*b-Amy-A1c*{008},*b-Amy-A1c*{1330}]. **v:** Ciano 67.

b-Amy-B1d{1330}. [*b-Amy-A1c*{1330,400}]. **v:** Manella.

b-Amy-C1{1278}. B{1278}. **ad:** *Aestivum* cv. Alcedo /*Ae. caudata* line B.

b-Amy-D1{008}. 4DL{008,628}. **v:** CS.

b-Amy-D1a{008}. **v:** CS.

b-Amy-D1b{008}. **v:** Bersee.

b-Amy-D1c{008}. **v:** Sears' Synthetic. Rare.

Previously listed alleles *b-Amy-D1d* and *-D1e* were found to be *b-Amy-B1* alleles {400}.

Two *b-Amy-D1* alleles were predominant in 60 accessions of *T. tauschii* {1578}.

b-Amy-Agⁱ1{168,013}. 4Agⁱ{168}. **ad:** Vilmorin27/*Thin. intermedium*.

b-Amy-E^b1{661}. 5E^bL{661}. **tr:** 5AS.5E^bL.

b-Amy-H1. 4H{1153}. **ad:** CS/Betzes.

b-Amy-H^{ch}1{013}. 4H^{ch}{013}. **ad:** CS/*H. chilense*.

b-Amy-R1. [*b-Amy-R2*{013},*b-AmyR1*{043}]. 5R{103,1280}.5RL{043}. **ad:** FEC 28/Petkus{043,82}; Holdfast/King II{043,1280}. **tr:** CS/Imperial 5BL-5RL{043}.

b-Amy-S^l1{013}. 4S^l{013}.D{013}. **ad:** CS/*Ae. sharonensis* D{013}. **su:** CS/*Ae. sharonensis*. **ad:** CS/*Ae. longissima*.

b-Amy-U1{013}. [*b-Amy-U2*{013}]. 5U{013}. **su:** CS/*Ae. umbellulata*.

A second set of loci with homology to *b-Amy-1* genes was identified in 2AS, 2BS and 2DS and designated the *Xb-Amy-2* [*b-Amy-2* {1331}] set. Evidence for these genes derives from cross-hybridization with a *b-AMY-H1* cDNA probe {1331}. Further members of the same set were identified in 2H {732}, and 2R and 2U {1331}.

Sixty *Ae. tauschii* lines revealed two *b-Amy-D^l1* alleles {1578}.

74.2.6. Endopeptidase

Ep-A1{516}. 7AL{516}. **v:** CS.

Ep-A1a{516,708}. **v:** CS.

An EP isozyme encoded by *Ep-A1a* of CS is visible on zymograms following starch gel electrophoresis {516}. The product of this allele is not observable, however, on zymograms following isoelectric focusing {708}.

Ep-A1b{708}. **v:** Cappelle-Desprez{708}; Hobbit{704}; Rendezvous{1603}.

Ep-A1c{708}. **v:** Sears' Synthetic.

- Ep-A1d*{894}.Isozyme 6. **v:** PI 294994{894}.
- Ep-B1*{516}. [*Ep1*{516}]. 7BL{516}. **v:** CS.
- Ep-B1a*{708}. **v:** CS.
- Ep-B1b*{708}. **v:** Cappelle-Desprez.
- Ep-B1c*{708}. **v:** Ciano 67.
- Ep-B1d*{708}. **v:** Bersee.
- Ep-B1e*{708}. **v:** Sears' Synthetic.
- Ep-D1*{516}. 7DL{516}. **v:** CS.
- Ep-D1a*{708}. **v:** CS.
- Ep-D1b*. [*EP-VI*{973}]. **v:** 5L 219{1521}; H-93-70{1521}; Hyak{021}; Madsen{020}; Rendezvous{708}; VPM1{973}.
- Ep-D1c*{708}. **v:** Sears' Synthetic.
- Ep-D1d*{1587}. Null allele. **v:** Wheats with *Lr19*{1587}.
- Ep-D1e*{894}.Isozyme 5. **v:** PI 294994{894}.
- Ep-E1*{518}. 7EL{518}. **al:** CS/*E. elongata*.
- Ep-H1*{520}. 7HL{520}. **al:** CS/Betzes.
- Ep-H^{ch}1*{708}. 7H^{ch}{708}. **su:** CS/*H. chilense*.
- Ep-H^t1*{1037}. 7H^t{1037}. **ad:** CS/*E. trachycaulus*.
- Ep-M^v1*{985}. [*Ep-M^v1*{985}]. 7M^vL. **su:** 7M^v{7D}.
- Ep-R1*{092,266,708}. 6RL{092}. **ad:** CS/Imperial.
- Ep-S^b1*{708}. 7S^b{708}. **su:** Holdfast/*Ae. bicornis*.
- Ep-S^l1*{517}. 4S^l{517}. **ad:** CS/*Ae. longissima*.
- Ep-S^s1*{1140}. 7S^s{1140}. **ad:** CS/*T. searsii*.
- Ep-U1*{708}. 7U{708}. **su:** CS/*Ae. umbellulata*.
- Ep-V1*{708}. 7V{708}. **ad:** CS/*D. villosum*.
- Ep-B2*{599}. 6BS{599}.

An *Ep* locus was located in 4RS in King II {1280}, using Holdfast/King II addition lines and in 4R in Imperial {266} using Chinese Spring/Imperial addition lines.

74.2.7. Esterase

Genetic control of esterases [carboxylic ester hydrolases (E.C.3.1.1.1)] was the subject of a comparative study {814}.

74.2.7.1. EST-1

EST-1 is a dimeric enzyme that electrofocuses around pH4.0 and is expressed in all tissues except endosperm {814}.

- Est-A1*. [*Est_A*{061}]. 3AS{060}. **v:** CS.
- Est-B1*. [*Est_B*{061}]. 3B{060}.3BS{100}. **v:** CS.
- Est-D1*. [*Est_D*{061}]. 3D{060}.3DS{100}. **v:** CS.
- Est-E1*{518}. 3ES{518}. **ad:** CS/*E. elongata*.
- Est-H1*{814}. 3H{814}. **ad:** CS/Betzes.
- Est-R1*. [*Est_R*{061}]. 3R{060,1254}. **ad:** CS/Imperial{060}; Holdfast/King II{100}; Kharkov/Dakold{100}.
- Est-S^l1*{814}. 3S^l{814}. **ad:** CS/*Ae. longissima*.

Each of 208 hexaploid accessions carried the same *Est-1* alleles except accessions of *T. compactum* var. rubriceps, each of which carried an *Est-B1* or *Est-D1* electrophoretic mobility variant {585}.

74.2.7.2. EST-2

EST-2 is a coleoptile-specific monomeric enzyme that electrofocuses at low pI.

Est-A2. [*Est-2_A*{585}]. 3A{585}. **v:** CS.

Est-B2. [*Est-2_B*{585}]. 3BL{585}. **v:** CS.

Est-D2. [*Est-2_D*{585}]. 3DL{585}. **v:** CS.

Among 208 hexaploid accessions, an apparent *Est-B2* null allele occurred frequently in accessions of *T. macha* and *T. sphaerococcum* and occasionally in accessions of *T. compactum*. The allele was not observed in *T. aestivum* and *T. spelta* accessions {585}.

74.2.7.3. EST-3

EST-3 is a monomeric enzyme that is expressed in young seedlings (this enzyme was not observed in {814}).

Est-B3. [*Est-3_B*{585}]. 7BS{585}. **v:** CS.

Est-D3. [*Est-3_D*{585}]. 7DS{585}. **v:** CS.

Est-H3{520}. 7H{520}. **ad:** CS/Betzes.

One accession carrying an apparent *Est-B3* null allele and one carrying an apparent *Est-D3* null allele were found among 208 hexaploid accessions {585}.

A 7AS locus encodes three esterase isozymes in immature grains {009}.

74.2.7.4. EST-4

EST-4 is a monomeric, leaf-specific enzyme that electrofocuses around pH 4.5.

Est-A4. [*Est-4_A*{585}]. 6AL{585,919}. **v:** CS.

Est-B4. [*Est-4_B*{585}]. 6BL{585,919}. **v:** CS.

Est-D4. [*Est-4_D*{585}]. 6DL{585,919}. **v:** CS.

Probable *Est-A4* and *Est-D4* null alleles were detected in several accessions of *T. compactum* var. *rubriceps* {585}; otherwise, no *Est-4* variant occurred among 208 hexaploid accessions {585}.

An esterase gene was located in chromosome L7 (= 6Ag¹) of *Thin. intermedium* {361}.

74.2.7.5. EST-5

EST-5 consists of 20 or more monomeric, grain-specific isozymes that electrofocus between pH 5.6 and 7.0.

Est-A5{009}. 3AL{009}. **v:** CS.

Est-A5a{009}. **v:** CS.

Est-A5b{009}. **v:** Kalyansona{009}; *T. compactum* AUS12084{756}.

Est-B5{009}. 3BL{009}. **v:** CS.

Est-B5a{009}. **v:** CS.

Est-B5b{009}. **v:** Big Club.

Est-B5c{009}. **v:** Timstein.

Est-B5d{009}. **v:** Sears' Synthetic.

Est-D5{009}. 3DL{009}. **v:** CS.

Est-D5a{009}. **v:** CS.

Est-D5b{009}. **v:** *T. macha*.

Est-D5c{009}. **v:** Hobbit 'S'.

Est-D5d{009}. **v:** *T. macha* Line 1.

Est-D5e{756}. **v:** *T. macha* WJR 38548.

Encoding of the endosperm esterases of hexaploid wheat by 12-15 genes in five compound loci located in 3AL, 3BL, 3DL, 3AS and 3DS was postulated in {1204}. Three and six alleles at *Est-D⁵* (in *T. tauschii*) were reported in {756} and {1578},

respectively.

In *S. cereale*, in addition to *Est-R1*, genes encoding leaf esterases were located in three chromosomes {1561}. These included a gene designated *Est8* in 6R in cvs. Imperial and King II, a gene designated *Est2* and two genes, designated *Est6* and *Est7*, which are part of a separate compound locus {1560}, in 5RL in Imperial, and a gene designated *Est10* in 4R of King II and 4RL of Imperial. In *Hordeum vulgare*, genes encoding leaf esterases were located in 3H {1071; see also, 520,580} and 7H {520}.

Est-Agⁱ5{374}. 3Agⁱ{374}. **ad**: Vilmorin 27/*Thin. intermedium*.

Est-H5{010}. 3H{010}. **ad**: CS/Betzes.

Est-H^{ch}5{010}. 3H^{ch}{010}. **ad**: CS/*H. chilense*.

Est-R5{010}. [*EstA*{737}]. 6R{043,1280}. **ad**: CS/Imperial{010,043}; Kharkov/ Dakold 6RL{010,1280}; CS/King II{010}; Holdfast/King II{043,1280}.

A second *S. cereale* gene encoding grain esterases, designated *EstB*, was located in 4RL in King II and Petkus and in 7RS in Imperial {737}.

Est-R^m5{010}. [*EstB*{737}]. 6R^m{010}.6R^mL{737}. **ad**: CS/*S. montanum*.

Est-S^b5{010}. 3S^b{010}. **su,ad**: CS/*Ae. bicornis*.

Est-S^l5{010}. 3S^l{010}. **ad**: CS/*Ae. longissima*.

Sixty *Ae. tauschii* lines revealed six *Est-D^t5* alleles {1578}.

74.2.7.6. EST-6

EST-6 is a dimeric enzyme that electrofocuses around pH 7.6 and is specific to endosperm.

Est-A6{1130}. 2AS{1130}. **v**: CS.

Est-A6a{1130}. **v**: CS.

Est-A6b{1130}. **v**: Ceska Previvka.

Est-B6{1130}. 2BS{1130}. **v**: CS.

Est-B6a{1130}. **v**: CS.

Est-B6b{1130}. **v**: Hope.

Est-D6{1130}. 2DS{1130}. **v**: CS.

Est-D6a{1130}. **v**: CS.

Est-D6b{1130}. **v**: Sears' Synthetic IPSR 1190903.

Est-M6{1130}. 2MS{1130}. **su**: CS/*Ae. comosa*.

Est-R6{370}. 2RS{370}. **al**: DS2 x RxL10 rye popn.

EST-7 is a monomeric enzyme that electrofocuses in the same region as EST-6 but is specific to green tissues.

A group of leaf esterase isozymes controlled by the long arms of the homoeologous group 3 chromosomes were reported {919}. The relationship of these esterases to EST-2 and to the leaf esterases designed EST-6 reported in {629} has not been determined.

A group of leaf esterase isozymes controlled by the long arms of the homoeologous group 3 chromosomes were reported {919}. The relationship of these esterases to EST-2 and to the leaf esterase designed EST-6 reported in {629} has not been determined.

74.2.7.7. EST-7

EST-7 is a monomeric enzyme that electrofocuses in the same region as EST-6 but is specific to green tissues.

Est-A7{812}. 2AL{812}. **v**: CS.

Est-B7{812}. 2BL{812}. **v**: CS.

Est-D7{812}. 2DL{812}. **v**: CS.

Est-D7a{812}. **v**: CS.

Est-D7b{812}. **v**: Synthetic {IPSR 1190903}.

- Est-E7*{812}. 2E{812}. **ad:** CS/*E. elongata*.
Est-H7{812}. 2HL{812}. **ad:** CS/Betzes.
Est-R7{812}. 2RL{812}. **ad:** CS/Imperial. **su:** Holdfast/KingII.
Est-R^m7{812}. 2R^malpha{812}. **ad:** CS/*S. montanum*.
Est-U7{812}. 2U{812}. **ad:** CS/*Ae. umbellulata*.
Est-V7{812}. 2V{812}. **ad:** CS/*D. villosum*.

74.2.7.8. EST-8

EST-8 consists of about 10 isozymes that electrofocus between pH 4.5 and 6.5 and are expressed only in vegetative tissues. EST-8 is likely to be the enzyme previously described in {919} and {629}.

- Est-A8*{629,814}. [*Est-A6*{629}]. 3AL{629}. **v:** CS.
Est-B8{613,814}. [*Est-B6*{629}]. 3BL{629}. **v:** CS.
Est-D8{629,814}. [*Est-D6*{629}]. 3DL{629}. **v:** CS.
Est-R8{613,814}. 6RL{629}. **ad:** CS/Imperial, CS/King II.

74.2.7.9. EST-9

EST-9 is a monomeric enzyme that electrofocuses around pH 5.0 and is expressed only in embryos.

- Est-A9*{814}. 3AS{814}. **v:** CS.
Est-B9{814}. 3BS{814}. **v:** CS.
Est-D9{814}. 3DS{814}. **v:** CS.

EST-2, EST-5 and EST-8 are controlled by genes on 3L and where a recombination test was possible between *Est-D5* and *Est-D8*, no segregation was observed. The different gene symbols were retained because of the different tissue specificities and polymerisation profiles of the enzymes. The same arguments surround the EST-1 and EST-6 genes located in the 3S arms {814}.

The *Est-6* gene of rye was mapped {249}. The *Est-6* genes of wheat were mapped comparatively in the proximal regions of chromosomes 2S {256}. The *Est-2*, *Est-5* and *Est-8* were mapped to the extreme distal regions in the 3L arms {247}.

74.2.8. Glucosephosphate isomerase

- Gpi-A1*{507}. 1AS{195,507}. **v:** CS.
Gpi-B1{507}. 1BS{195,507}. **v:** CS.
Gpi-D1{507}. 1DS{195,507}. **v:** CS.

Gpi-D1a{195}. **v:** CS.

Gpi-D1b{195}. **v:** CS variant and certain CS aneuploids. Rare.

Varietal differences in GPI zymograms were noted in {1127}.

GPI zymogram phenotypes observed in *Triticum* and *Aegilops* species are reported in {456,457}.

No allelic variation at *Gpi-D¹* was found in 60 accessions of *Ae. tauschii* {1578}.

- Gpi-Agⁱ1*{361},{374}. [*Gpi-X1*{361}]. 1Agⁱ{361}. **ad:** Vilmorin 27/*Thin. intermedium*..
Gpi-E1{518}. 1ES{518}. **ad:** CS/*E. elongata*.
Gpi-H1{1153}. 1HS{1153}. **ad:** CS/Betzes.
Gpi-H^{ch}1{195}. 1H^{ch}{195}. **ad:** CS/*H. chilense*.
Gpi-R1{195}. 1R{195}.1RS{779}. **ad:** CS/King II{195}. **al:** 2a, 2b, and R14{779}.
Gpi-R^m1{195}. 1R{195}. **ad:** CS/*S. montanum*.

Gpi-S^l1{1228}. 1S^l{517}.1S^lS{1228}. **ma**: In *Ae. longissima* 2 x *Ae. longissima* 10, *Gpi-S^l1*, two glutenin loci, and three gliadin loci were mapped relative to one another as follows: *Glu-S^l1* - 15.9 cM - *Gpi-S^l1* - 38 cM - *Gli-S^l4* - 7.1 cM - *Glu-S^l3* - 0.9 cM - *Gli-S^l1* - 5.6 cM - *Gli-S^l5*{1228}; *Glu-S^l1* is located in 1S^lL and the other loci are in 1S^lS.

Gpi-S^s1{1140}. 1S^s{1140}. **ad**: CS/*Ae. searsii*.

Gpi-UI{195}. 1U{195}. **ad**: CS/*Ae. umbellulata*.

Gpi-VI{1026}. 1V{1026,241}. **ad**: CS/*D. villosum*.

74.2.9. Glutamic oxaloacetic transaminase

Got-A1{505}. 6AS{505}. **v**: CS.

Got-B1{505}. 6BS{505}. **v**: CS.

Got-D1{505}. 6DS{505}. **v**: CS.

Got-A2{505}. 6AL{505}. **v**: CS.

Got-B2{505}. 6BL{505}. **v**: CS.

Got-D2{505}. 6DL{505}. **v**: CS. **ma**: Cent - *Got-D2* - 2cm - *Xpsr154-6D*{757}.

Got-Ag^e2{1575}. 6Ag^e{1575}. **ad,su**: Rescue/*Thin. elongatum*.

Got-E2{518}. 6EBeta{518}. **ad**: CS/*E. elongata*.

Got-H2{520}. 6H{520}. **ad**: CS/Betzes.

Got-R2{1457}. [*Got3*{1559}]. 6R{1457}.6RL{1280}. **ad**: CS/Imperial 6R{1457}; Holdfast/King II 6RL{1280}.

Got-V2{1026,242}. 6V{1026}. **ad**: Creso/*D. villosum*.

Got-H²{1037}. 6H¹{1037}. **ad**: CS/*E. trachycaulus*.

Got-A3{505}. 3AL{505}. **v**: CS.

Got-B3{505}. 3BL{505}. **v**: CS.

Got-C3{1278}. F{1278}. **ad**: *T. aestivum* cv. Alcedo /*Ae. caudata* line C.

Got-D3{505}. 3DL{505}. **v**: CS.

Got-Ag^e3{521}. 3Ag^eL{521}. **ad**: CS/TAP 67. **su**: CS/TAP 67. **tr**: Certain CS 3D/Ag lines.

Got-E3{518}. 3EL{518}. **ad**: CS/*E. elongata*.

Got-H3. [*Got-b3*{090}]. 3H{090}. **ad**: CS/Betzes.

Got-H^{ch}3{351}. 3H^{ch}{351}. **ad**: MA/*H. chilense*.

Got-R3{1457}. [*Got3*{1559}]. 3R{1457}. **ad**: CS/Imperial{1457}; Holdfast/ King II{1253}; Kharkov/Dakold{1253}.

Got-S^s3{1140}. 3S^s{1140}. **ad**: CS/*Ae. searsii*.

Got-V3{1518,242}. 3VL{1518}. **ad**: Creso/*D. villosum*.

Got-R4. [*Got1*/7R{1203},*Got2*{1559}]. 7RL{1203}. **al**: *S. cereale*.

Wehling {1559} identified a GOT locus designated *Got1* in 4RL of *S. cereale*.

74.2.10. Hexokinase

Hk-B1{006}. 1BS{006}. **v**: CS.

Hk-D1{006}. 1DS{006}. **v**: CS.

Hk-A2{810}. 3A{810}. **v**: CS.

Hk-A2a{810}. **v**: CS.

Hk-A2b{810}. **s**: CS*/Sears' Synthetic 3A. **v**: Sears' Synthetic IPSR 1190903.

Hk-B2{006}. 3BS{006,810}. **v**: CS.

Hk-D2{810}. 3DS{810}. **v**: CS.

Hk-D2a{810}. **v**: CS.

Hk-D2b{810}. **v**: Sears' Synthetic IPSR 1190903.

Hk-E2{006}. 3ES{006}. **ad**: CS/*E. elongata*.

Allelic variation was observed in three of 55 hexaploid accessions {006}.

74.2.11. Lipoxygenase

- Lpx-A1*{516}. [*Lpx-B1*{516}]. 4AL{516}. **v:** CS. **ma:** *Xksu919(Lpx-1)-4A*{0091}.
Lpx-B1{516}. [*Lpx-A1*{516}]. 4BS{516}. **v:** CS. **ma:** *Xcn110(Lpx-1)-4B*{0269,0367}.
Lpx-B1a{1533}. [*Lpx-A1a*{936}]. **v:** CS.
Lpx-B1b{1533}. [*Lpx-A1b*{936}]. **v:** Bosanka{1533}.
Lpx-D1{516}. 4DS{516}. **v:** CS.
Lpx-E1{518}. 4ES{518}. **ad:** CS/*E. elongata*.
Lpx-H1{716}. 4H{716}. **ad:** CS/Betzes.
Lpx-A2{516}. 5AL{516}. **v:** CS. **ma:** *Xksu919(Lpx-2)-5A*{0091}.
Lpx-B2{516}. 5BL{516}. **v:** CS. **ma:** *Xksu919(Lpx-2)-5B*{0091}; *Xcn111(Lpx-2)-5B*{0269}.
Lpx-D2{516}. 5DL{516}. **v:** CS.
Lpx-E2{518}. 5EL{518}. **ad:** CS/*E. elongata*.
Lpx-H2{716}. 5H{716}. **ad:** CS/Betzes.
Lpx-S^s2{1140}. 5S^s{1140}. **ad:** CS/*Ae. searsii*.
Lpx-V2{242}. 5V. **ad:** CS/*D. villosum*.

74.2.12. Malate dehydrogenase

- Mdh-A1*. [*Mdh2A*{087}]. 1AL{087}. **v:** CS.
Mdh-B1. [*Mdh2B*{087}]. 1BL{101,087}. **v:** CS.
Mdh-D1. [*Mdh2D*{087}]. 1DL{087}. **v:** CS.
Mdh-H1{1153}. 1HL{1153}. **ad:** CS/Betzes.
Mdh-H^{ch}1{352}. 1H^{ch}{352}. **ad:** MA/*H. chilense*.
Mdh-R1. [*Mdh2-1*{1252}]. 1RL{1252}. **ad:** CS/Imperial 1R; Kharkov/Dakold 1R; Holdfast/King II 1RL.
Mdh-S^s1{1140}. 1S^s{1140}. **ad:** CS/*T. searsii*.
Mdh-H2. [*Mdh2-b2*{090}]. 3H{090}.
Mdh-R2. [*Mdh2-2*{1252}]. 3R{1252}. **ad:** CS/Imperial.
 A third set of dimeric MDH isozymes identified in mature grain are separable from MDH-1 and MDH-2 by their higher pI's in IEF {811}.
Mdh-A3{811}. 5AS. **v:** CS.
Mdh-A3a{811}. **v:** CS.
Mdh-A3b{811}. **v:** Bersee.
Mdh-B3{811}. 5BS. **v:** CS.
Mdh-B3a{811}. **v:** CS.
Mdh-B3b{811}. **v:** Hope.
Mdh-D3{811}. 5DS. **v:** CS.
Mdh-D3a{811}. **v:** CS.
Mdh-D3b{811}. **v:** Sears' Synthetic.
Mdh-E3{811}. 5ES. **ad:** CS/*E. elongata*.
Mdh-H3{811}. 5H. **ad:** CS/Betzes.
Mdh-U3{811}. 5U. **ad:** CS/*Ae. umbellulata*.
Mdh-R4{360}. 1RL{360}. **v:** Various crosses.

74.2.13. Peroxidase

Peroxidase (EC1.11.1.7) isozymes have high tissue specificity. Staining and electrophoretic systems are reviewed in {118}. PER-1, -2, -3, -4 and -5 are all reported in {816}.

74.2.13.1. PER-1

PER-1 is expressed in leaf {012} and coleoptile {816} tissues.

Per-B1{012}. 1BS{012,919}. v: CS.

Per-D1{012}. 1DS{012,919}. v: CS.

Per-D1a{012}. v: CS.

Per-D1b{012}. v: Sears' Synthetic.

Per-H^{ch}1{012}. 1H^{ch}{012}. ad: CS/*H. chilense*.

Per-R1{012}. [*Prx*{1561}]. 1RS{012,1561}. ad: CS/King II{012}; Holdfast/King II{1561}.

tr: Veery 'S'{012}.

Per-V1{241}. 1V{241}. ad: Creso/*D. villosum*.

74.2.13.2. PER-2

PER-2 is expressed in young leaf {118}, coleoptile and root {816} tissues.

Per-A2. 2AS. v: CS.

Per-A2a{816}. v: CS.

Per-A2b{816}. v: Timstein.

Per-B2{118}. 2BS{118}. v: CS.

Per-B2a{816}. v: CS.

Per-B2b{816}. v: Sears' Synthetic IPSR1190903.

Per-D2{118}. 2DS{118}. v: CS.

Per-H2{118}. [*Per-5*{095}]. 2H{118}. ad: CS/Betzes.

Per-R2{118}. 2RS{118}. ad: CS/Imperial; Kharkov/Dakold.

74.2.13.3. PER-3

PER-3 is expressed in embryo {119,816} and scuteller {119} tissues.

Per-A3{119}. 3AL{119}. v: CS.

Per-A3a{816}. v: CS.

Per-A3b{816}. v: Timstein.

Per-A3c{816}. v: Hobbit 'S'.

Per-B3{086},{119}. [*Per4*{961}]. 3BL{086,119}. v: CS.

Per-B3a{816}. v: CS.

Per-B3b{816}. v: Hope.

Per-B3c{816}. v: *T. macha* IPSR1240005.

Per-B3d{816}. v: Timstein.

Per-B3e{816}. v: Sears' Synthetic IPSR1190903.

Per-D3{086},{119}. [*Per5*{961}]. 3DL{086,119}. v: CS.

Per-D3a{816}. v: CS.

Per-D3b{816}. v: Hope.

Per-D3c{816}. v: Timstein.

Per-D3d{816}. v: *T. macha* IPSR 142005.

Per-D3e{816}. v: Sava.

Per-D3f{816}. v: Cheyenne.

Per-D3g{816}. v: Sears' Synthetic IPSR 1190903.

Varietal variation for *Per-3* was reported in {094}.

74.2.13.4. PER-4

PER-4 is expressed in endosperm tissue {086,119}.

Per-A4{695},{119}. [*Per3*{961}]. 7A{695}.7AS{694,086,119}. **v:** CS.

Per-A4a{816}. **v:** CS.

Per-A4b{816}. **v:** Hope.

Per-A4c{816}. **v:** Sicco.

Per-B4{695},{119}. [*Per2*{961}]. 4A{695}.4AL{086,119,694}. **v:** CS.

Per-B4a{816}. **v:** CS.

Per-B4b{816}. **v:** Hope.

Per-B4c{816}. **v:** Thatcher.

Per-D4{695},{119}. [*Per1*{961}]. 7D{695}.7DS{694,086,119}. **v:** CS.

Per-D4a{816}. **v:** CS.

Per-D4b{816}. **v:** Thatcher.

Per-Ag^e4. 7Ag^eS{694}. **tr:** Certain CS 7D/Ag^e lines.

Per-Agⁱ4. [*Per-Agⁱ3*{374}]. 7Agⁱ{168}. **ad:** Vilmorin 27/*Thin. intermedium*.

Cultivar variation for *Per-4* was reported in {094}.

74.2.13.5. PER-5

PER-5 is expressed in roots {816}.

Per-D5{816}. 2DS{816}. **v:** CS.

Per-S^l5{816}. 2S^l{816}. **ad:** CS/*Ae. longissima*.

74.2.14. Phosphodiesterase

Pde-A1. [*Pde-A3*{1590}]. 3A{1590}.3AS{1589}. **v:** CS.

Pde-B1. [*Pde-B3*{1590}]. 3B{1590}.3BS{1589}. **v:** CS.

Pde-D1. [*Pde-D3*{1590}]. 3DS{1590}. **v:** CS.

Pde-S^l1. 3S^lS{172}. **ad:** CS/*Ae. longissima*.

Pde-VI{1518}. 3VS{1518}. **ad:** CS/*D. villosum*.

74.2.15. Phosphogluconate dehydrogenase

Pgd1{282}. [*Pgd3*{282},*Pgd-A3*{963}]. 7A^{ms}{282}. **v:** *T. monococcum*{664}.

PgdR1. 4RL{1191}. **ad:** CS/Imperial; Holdfast/King II.

PgdR2. 6RL{1191}. **ad:** CS/Imperial; Holdfast/King II.

Loci were also identified in 6B {1435}, 1EL {1435}, 1HL {147,1072}, 1H^{ch} {352} and 1RL {779}.

74.2.16. Phosphoglucomutase

Pgm-A1{088}. [*Pgm-B1*{088}]. 4AL{088}. **v:** CS.

Pgm-D1{088}. 4DS{088}. **v:** CS.

Pgm-Agⁱ1{361},{374}. [*Pgm-X1*{361}]. 4Agⁱ{361}. **ad:** Vilmorin 27/*Thin. intermedium*.

Pgm-H1. [*Pgm-b1*{090}]. 4H{090}. **ad:** CS/ Betzes.

Pgm-H^{ch}1{351}. 4H^{ch}{351}. **ad:** MA/*H. chilense*.

Pgm-R1. 4RS{1561,1253}. **ad:** CS/Imperial 4RS{1253,1561}; Kharkov/Dakold 4R{1253}; Holdfast/King II 4RS{1253,1561}.

74.2.17. Shikimate dehydrogenase

- Skdh-AI*{706,1065}. 5AS{706,1065}. **v:** CS.
Skdh-BI{706,1065}. 5BS{706,1065}. **v:** CS.
Skdh-DI{706,1065}. 5DS{706,1065}. **v:** CS.
Skdh-HI{085}. 5H{085}. **ad:** CS/Betzes.
Skdh-H^lI{1037}. 5H^l{1037}. **ad:** CS/*E. trachycaulus*.
Skdh-M^vI{985}. [*Skdh-M^vI*{985}]. 5M^v. **su:** 5M^v(5A), 5M^v(5D).
Skdh-RI{706}. 5RS{706}.5R{085}. **ad:** CS/King II{085}; CS/Imperial{706};
 Kharkov/Dakold{085}. **tr:** CS 4AS-5RL; CS 5BL-5RL.
Skdh-S^lI{085}. 5S^lS{085}. **ad:** CS/*Ae. longissima*.
Skdh-S^sI{1140}. 5S^s{1140}. **ad:** CS/*Ae. searsii*.
Skdh-VI{085}. 5V{085}. **ad:** CS/*D. villosum*.
Skdh-UI. 5U{706}. **ad,su:** CS/*Ae. umbellulata*.

74.2.18. Superoxide dismutase

- Sod-AI*{1066}. 2AL{1066}. **v:** CS.
Sod-BI{1066}. 2BL{1066}. **v:** CS.
Sod-DI{1066}. 2DL{1066}. **v:** CS.
Sod-EI{808}. VI E{808}. **ad:** CS/*E. elongata*.
Sod-HI{716}. 2H{716}. **ad:** CS/Betzes.
Sod-RI{1066}. [*Sod-3*{586}]. 2R{1066}. **ad:** CS/Imperial.
Sod-S^sI{1140}. 2S^s{1140}. **ad:** CS/*Ae. searsii*.
Sod-VI{1026}. 7V{1026}. **ad:** CS/*D. villosum*.

74.2.19. Triosephosphate isomerase

- Tpi-AI*{1139}. 3AS{1139}. **v:** CS.
Tpi-BI{1139}. 3BS{1139}. **v:** CS.
Tpi-DI{1139}. 3DS{1139}. **v:** CS.
Tpi-EI{1139}. 3E{1139}. **ad:** CS/*E. elongata*.
Tpi-HI{1139}. 3H{1139}. **ad:** CS/Betzes.
Tpi-RI{1139}. 3R{1139}. **ad:** CS/Imperial; Kharkov/Dakold.
Tpi-S^lI{1139}. 3S^l{1139}. **ad:** CS/*Ae. longissima*.
Tpi-A2{1139}. 5AL{1139}. **v:** CS.
Tpi-B2{1139}. 5BL{1139}. **v:** CS.
Tpi-D2{1139}. 5DL{1139}. **v:** CS.
Tpi-H2{1139}. 5H{1139}. **ad:** CS/Betzes.
Tpi-R2{1139}. 5R{1139}. **ad:** CS/Imperial; Kharkov/Dakold.
Tpi-S^l2{1139}. 5S^l{1139}. **ad:** CS/*Ae. longissima*.
Tpi-U2{1139}. 5U{1139}. **ad:** CS/*Ae. umbellulata*.
Tpi-Agⁱ2{374}. 5Agⁱ{374}. **ad:** Vilmorin 27/*Ag. intermedium*.

74.2.20. Aromatic alcohol dehydrogenase

- Aadh-AI*. [*Adh-A2*{584}]. 5AL{584}. **v:** CS. **ma:** *XksuG44-5A*(proximal) - 6.9cM - *Aadh-AI* - 24.7cM - *Xcdo412-5A*(distal){9959}.
Aadh-AIa. **v:** CS; 133 other accessions{584}.
Aadh-AIb. **v:** *T. spelta*; K-24696; other accessions{584}.

- Aadh-B1*. [*Adh-B2*{584}]. 5BL{584}. **v**: CS.
Aadh-B1a. **v**: CS{1533}.
Aadh-B1b. **v**: Drina {1533}.
Aadh-C1{1278}. C{1278}. **ad**: Alcedo/*Ae. caudata* line C.
Aadh-D1. [*Adh-D2*{584}]. 5DL{584}. **v**: CS.
Aadh-E1. [*Adh-E2*{518}]. 5EL{518}. **ad**: CS/*E. elongata*.
Aadh-R1. 5RL{1280}. **ad**: Holdfast/King II.
Aadh-A2. [*Adh-A3*{508}]. 6A{1279}.6AL{513,587}. **v**: CS{513}; Carola{1279}.
Aadh-B2. [*Adh-B3*{508}]. 6B{1279}.6BL{513}. **v**: CS{513}; Carola{1279}.
Aadh-D2. [*Adh-D3*{508}]. 6D{1279}.6DL{513}. **v**: CS{513}; Carola{1279}.
Aadh-Ag^e2{1575}. 6Ag^e{1575}. **ad,su**: Rescue/*Thin. elongatum*.
Aadh-E2. [*Adh-E3*{518}]. 6EBeta{518}. **ad**: CS/*E. elongata*.
Aadh-R2. 6RL{1280}. **ad**: Holdfast/King II.
Aadh-V2{241}. 6V{241}. **ad**: CS/*D. villosum*.

The *Aadh-1* and *Aadh-2* loci were designated with the synonyms *Adh-2* and *Adh-3*, respectively, in a number of publications in addition to {508,518,584}. These include: {510,509,511,519,517,587,1066,1139}.

74.2.21. Aconitase

- Aco-A1*{189}. 6AL{189}. **v**: CS.
Aco-A1a. **v**: CS{1533}.
Aco-A1b. **v**: Dubravka{1533}.
Aco-B1{189}. 6BL{189}. **v**: CS.
Aco-B1a. **v**: CS{1533}.
Aco-B1b. **v**: Dubravka{1533}.
Aco-B1c. **v**: Slavonka{1533}.
Aco-D1{189}. 6DL{189}. **v**: CS.
 Further alleles at *Aco-A1* and *Aco-B1* are listed in {1127}; these have not been tested against those found in {1533}.
Aco-Ag^e1{1575}. 6Ag^e{1575}. **ad,su**: Rescue/*Thin. elongatum*.
Aco-E1{189}. 6Ebeta{189}. **ad**: CS/*E. elongata*.
Aco-H1{147},{189}. [*Aco-I*{147}]. 6H{147}.6HL{189}. **ad**: CS/Betzes.
Aco-R1{189}. 6RL{189}. **ad**: Sturdy/PI 252003.
Aco-S^l1{189}. 6S^l{189}. **ad**: CS/*Ae. longissima*.
Aco-S^s1{1140}. 6S^s{1140}. **ad**: CS/*Ae. searsii*.
Aco-UI{189}. CSU-31{189}. **ad**: CS/*Ae. umbellulata*.
Aco-A2{189}. 5AL{189}. **v**: CS.
Aco-B2{189}. 4BL{1513}. **v**: CS.
Aco-B2a{1513}. **v**: CS.
Aco-B2b{1513}. **v**: PI 278437.
Aco-B2c{1513}. **v**: PI 182575.
Aco-B2d{1513}. **v**: PI 157589.
Aco-D2{189}. 4DL{1513}. **v**: CS.
Aco-E2{189}. 4EL{189}. **ad**: CS/*E. elongata*.
Aco-M^v2{1341}. [*Aco-M^v2*{985}]. 5M^v. **ad**: 5M^v(5A),5M^v(5D).
Aco-R2{189}. 5RL{189}. **ad**: CS/King II 5R; Holdfast/ King II 5RL.
Aco-S^s2{1140}. 4S^s{1140}. **ad**: CS/*Ae. searsii*.

74.2.22. NADH dehydrogenase

74.2.22.1. Ndh-1

- Ndh-A1*{513},{1037}. [*Ndh-B1*{513}]. 4AL{513}. **v:** CS.
Ndh-A1a{1533}. [*Ndh-B1a*{936}]. **v:** CS.
Ndh-A1b{1533}. [*Ndh-B1b*{936}]. **v:** Sutjeska.
Ndh-A1c{1533}. [*Ndh-B1c*{936}]. **v:** Fruskogorka.
Ndh-A1d{1037}. [*Ndh-A1b*{1037}]. **v:** Hope, Timgalen.
Ndh-B1{513}. [*Ndh-A1*{513}]. 4BS{513}. **v:** CS.
Ndh-D1{513}. 4DS{513}. **v:** CS.
Ndh-E1{362}. 4E{362}. **ad:** CS/*Ag. elongatum*.
Ndh-H1{147},{513}. [*Nadhd-1*{147}]. 4H{147},4HS{813}. **ad:** CS/Betzes.
Ndh-H^{ch}1{813}. 4H^{ch}{813}. **ad:** CS/*H. chilense*.
Ndh-V1{241}. 4V{241}. **ad:** CS/*D. villosum*.
Ndh-R1{813}. 4R{362},4RS{813}. **ad:** CS/Imperial, CS/King II{813,362}; CS/Dakold{362}.
Ndh-S^l1{813}. 4S^l{813}. **ad:** CS/*Ae. longissima*.
Ndh-U1{362}. A{362}. **ad:** CS/*Ae. umbellulata*.

Based on the correspondence of the electrophoretic patterns, isoelectric points (pIs) and chromosomal location, it was proposed that the *Ndh1* (NADH dehydrogenase) and *Dia3* (diaphorase) represent the same locus {0356}.

74.2.22.2. Ndh-2

- Ndh-A2*{813}. 7A{813}. **v:** Hope.
Ndh-D2{813}. 7DS{813}. **v:** CS.
Ndh-R2{813}. 7RS{813}. **ad:** CS/Imperial, CS/King II, Holdfast/King II (7R).

Based on the correspondence of the electrophoretic patterns, isoelectric points (pIs) and chromosomal location, it was proposed that the *Ndh-2* (NADH dehydrogenase) and *Dia2* (diaphorase) represent the same locus {0356}.

74.2.22.3. Ndh-3

- Ndh-A3*{813}. 3AL{813}. **v:** CS.
Ndh-B3{813}. 3BL{813}. **v:** CS.
Ndh-B3a{813}. **v:** CS.
Ndh-B3b{813}. **v:** Carmen.
Ndh-D3{813}. 3DL{813}. **v:** CS.
Ndh-H3{813}. 3HL{813}. **ad:** CS/Betzes.
Ndh-R3{813}. 6RL{813}. **ad:** Holdfast/King II, CS/Imperial (6R), CS/King II (6R).
Ndh-S^l3{813}. 3S^lL{813}. **ad:** CS/*Ae. longissima*; CS/*Ae. sharonesis* (3S^l).

Based on the correspondenc of the electrophoretic patterns, isoelectric points (pIs) and chromosomal location, it was proposed that the *Ndh-3* (NADH dehydrogenase), *Dial* (diaphorase) and *Mnr1* (menadione reductase) represent the same locus {0356}.

74.2.22.4. Ndh-4

- Ndh-A4*{813}. 3AS{813}. **v:** CS.
Ndh-B4{813}. 3BS{813}. **v:** CS.
Ndh-E4{813}. 3ES{813}. **ad:** CS/*E. elongata*.
Ndh-H4{813}. 3HS{813}. **ad:** CS/Betzes, CS/King II.
Ndh-R4{813}. 3RS{813}. **ad:** CS/King II, CS/Imperial (3R).

74.2.23. Dipeptidase

- Dip-AI*{454},{700}. [*Pept-AI*{454}]. 6AL{454,700}. **v:** CS.
Dip-A1a{700}. **v:** CS.
Dip-A1b{700}. **v:** Cheyenne.
Dip-BI{454},{700}. [*Pept-BI*{1533}]. 6BL{454,700}. **v:** CS.
Dip-B1a{700}. **v:** CS.
Dip-B1b{700}. **v:** Cappelle-Desprez.
Dip-DI{700}. 6DL{700}. **v:** CS.
Dip-HI{147},{700}. [*Pept-I*{147},*Dip I*{145}]. 6H{147,145,700}. **ad:** CS/Betzes.
Dip-JI{700}. 6J{700}. **ad:** CS/*Thin. junceum*.
Dip-VI{700}. 6V{700}. **ad:** CS/*D. villosum*.

74.2.24. Malic enzyme

A dimeric enzyme extractable from mature grains.

- Mal-AI*{809}. 3AL. **v:** CS.
Mal-BI{809}. 3BL. **v:** CS.
Mal-B1a{809}. **v:** CS.
Mal-B1b{809}. **v:** *T. spelta* IPSR line 1.
Mal-B1c{809}. **v:** Sears' Synthetic.
Mal-DI{809}. 3DL. **v:** CS.
Mal-EI{809}. 3E. **ad:** CS/*E. elongata*.
Mal-HI{809}. 3H. **ad:** CS/Betzes.
Mal-R1{809}. 3R. **ad:** CS/Imperial.

74.2.25. Adenylate kinase

- Adk-AI*{091}. [*Adk-a*{091}]. 7AL{091}. **v:** CS.
Adk-BI{091}. [*Adk-b*{091}]. 7BL{091}. **v:** CS.
Adk-DI{091}. [*Adk-d*{091}]. 7DL{091}. **v:** CS.
Adk-EI{091}. 7E{091}.7E{1435}. **ad:** CS/*E. elongata*.
Adk-HI{091}. 7H{091}.7HS{1435}. **ad:** CS/Betzes.
Adk-M^vI{985}. [*Adk-M^vI*{985}]. 7M^vL. **su:** 7M^v(7D).
Adk-R1{091}. 7RL{091}. **ad:** CS/Imperial; Holdfast/King II.
Adk-UI{091}. E{091}. **ad:** CS/*Ae. umbellulata*.
Adk-AgⁱI{091}. 7Agⁱ{091}. **ad:** CS/*Thin. intermedium*.
Adk-H2. 6HL{1435}. **ad:** CS/Betzes.

74.2.26. Glutamate-pyruvate transaminase

- Gpt-AI*{1435}. 1AS{1435}. **v:** CS.
Gpt-BI{1435}. 1BS{1435}. **v:** CS.
Gpt-DI{1435}. 1DS{1435}. **v:** CS.
Gpt-EI{1435}. 1ES{1435}. **ad:** CS/*E. elongata* 1E.
Gpt-HI{1435}. 1H{1435}. **dv:** *H. vulgare* cv. Betzes.

74.2.27. Catalase

- Cat-BI*{1466}. [*Cat-AI*{1466}]. 4BL{1466}. **v:** CS.

74.2.28. Beta-glucosidase

b-Gls{282}. 2A^mL{282}. **dv**: DV92.

b-Glsa{282}. **dv**: DV92.

b-Glsb{282}.Null allele **dv**: G3116.

74.2.29. Starch branching enzyme

SbeI1{9937}. 1DL{9937}. **v**: CS{9937}.

SbeI2{9937}. 7BL{9937}. **v**: CS{9937}.

74.3. Endosperm storage proteins

74.3.1. Glutenins

These are heterogeneous mixtures of proteins comprising subunits linked by disulfide bonds. 'A' are high-molecular-weight (HMW) and 'B', 'C' and 'D' are low-molecular-weight (LMW) subunits.

Using proteomic analysis of 2D gels of seed storage proteins in 39 ditelocentric lines of cv. CS, 105 protein spots were resolved {03129}. Locations of structural genes controlling 26 spots were identified in 10 chromosomal arms (4 on 1BL, 5 on 1BS, 4 on 1DL, 4 on 1DS, 2 on 6AS, 3 on 6BS, 1 on 6DL, 1 on 6DS, 1 on 3BS and 1 on 3BL). Multiple regulators of the same protein located on various chromosome arms were observed. Two novel subunits, named 1Bz and 1BDz, were found to have very similar structures to HMW glutenin subunit 12 (encoded by *Glu-D1-2a* - see the relevant list below) and were located to chromosome arms 1BL and 1DL, respectively.

74.3.1.1. Glu-1

The *Glu-1* loci, all of which are compound, encode HMW glutenin subunits.

Each *Glu-1* locus in hexaploid wheat contains two genes, the products of which were described as 'x-type' and 'y-type' based on differences in molecular weight and isoelectric point {1118}.

Other evidence has shown that these gene products differ in electrophoretic fingerprint pattern {1124} and cysteine content {1028}, and the genes themselves differ in nucleotide sequence {1470,1433,373}.

Although early evidence suggested up to 6 genes in total at each locus {1471,373}, it appears likely that only a single copy of each gene is present at the 1AL, 1BL, and 1DL loci {495}. No 'y-type' protein from the *Glu-A1* locus has been demonstrated in hexaploid wheat {1118}, although they are found in diploid wheats {1535,798}, and sequencing experiments have shown the presence of a terminating sequence inside the transcribed portion of the gene {373}. Definitive evidence that subunit 21* {602}, which has a mobility close to that of subunit 21, is a 'x-type' protein rather than a 'y-type' protein has not been obtained. The gene coding for 'x-type' proteins within *Glu-A1* is also often silent {1118,420}.

The symbols for the genes within the *Glu-1* loci coding for 'x-type' and 'y-type' proteins will be *Glu-1-1* and *Glu-1-2*, respectively, rather than *Glu-1x* and *Glu-1y* {1470}. The genes are closely linked but recombination has been observed between *Glu-B1-1* and *Glu-B1-2* with a frequency of 3 in 3,450 {1117}. The gene order, relative to the centromere, has not been ascertained.

The subunit nomenclature used is that devised in {1116}; however, an alternative system

based upon molecular weight was proposed in {1068}. A system of naming the *Glu-A1-1*, *Glu-A1-2*, *Glu-B1-1* and *Glu-B1-2* alleles in *T. turgidum* var. *dicoccoides* is given in {796}.

In {00116}, a comparison between spelt wheats (*T. spelta*) and bread wheat was carried out for the glutenins using a nomenclature system described in {00117}.

The *Glu-1* loci may be recognised by the DNA probe pTag1290 {1471} and probe pwhe1(Dy10) {{030}}. Individual *Glu-1-1* loci on 1A, 1B and 1D and the *Glu-1-2* loci may be recognised by specific primers {263}.

In {00105}, the evolution of the high molecular weight glutenin loci of the A, B, D and G genomes of wheat was explored; 30 partial allele sequences were compared, designated by Greek letters (alpha, beta, gamma, etc.) (5 of which were cited as Schlumbaum, pers. comm.; the remaining 25 were deposited as GenBank, accession nos. X98583-X98592, X98711-X98715 and Y12401-Y12410). These partial alleles derive from all six *Glu-1-1* and *Glu-1-2* loci in current-day samples taken from seven species of wheat, as well as from DNA extracted from charred grain of two samples from archaeological excavations, dated 3000 and 5000 years old, respectively.

Following the first listing which considers the *Glu-1* set for hexaploid wheat as a single locus, there is a provisional listing based on x- and y- type glutenins. These are not referenced.

The importance of the HMW glutenin subunits for bread-making quality was first noted from observations in wheat cultivars of related pedigree on the effects of the presence of subunit 1 encoded by *Glu-A1a* {0197}, effects that have repeatedly been confirmed since (for example {0198,0199,01100}).

A nomenclature system for prolamins banding patterns of triticale was proposed in {03139}. Extensive allelic variation in triticale at *Glu-A1*, *Glu-B1*, *Glu-R1* and *Gli-R2* loci was reported in {03121}.

- Glu-A1***{780,1125}. [*Glt-A1*{420},*Glt-A2*{420},*Glu 1A*{1415}]. 1A{780}.1AL{781,1125}.
s: CS^{*}/Hope 1A{1125}. **v:** CS{780,781}; various{420}.
Glu-A1a{1116}. 1{1116}. **v:** Hope.
Glu-A1b{1116}. 2^{*}{1116}. **v:** Bezostaya 1.
Glu-A1c{1116}. Null allele{1116}. **v:** CS.
Glu-A1d{1535}. **v:** V74, Spain{1115}.
Glu-A1e{1535}. **v:** 132c, Poland{1115}.
Glu-A1f{1535}. **v:** 112-29, Sudan{1115}.
Glu-A1g{1535}. **v:** Landrace 1600.
Glu-A1h{1527}. [*GLU-A1-I*{1527}]. **tv:** PI 94683, USSR, *T. dicoccum*.
Glu-A1i{1527}. [*GLU-A1-II*{1527}]. **tv:** CI 12213, India, *T. dicoccum*; Lambro{1523}.
Glu-A1j{1527}. [*GLU-A1-III*{1527}]. 1'{125}. **tv:** PI 352359, Germany, *T. dicoccum*.
Glu-A1k{478}. 26{478}. **v:** BT-2288{478}.
Glu-A1l{847}. **tv:** Chinook, Canada.
Glu-A1m{1069}. **tv:** Nugget Biotype 1, Canada, *T. durum*.
Glu-A1n{1526}. [*Glu A1-IV*{1526},*Glu-A1m*{959}]. 1'{125}. **tv:** Corado, Portugal{1526}.
Glu-A1o{1526,125}. [*Glu A1-V*{1526,125},*Glu-A1n*{959}]. 2^{**}{125}. **tv:** Aric 581/1{125}; PI 61189{1525}; USSR.
Glu-A1p{1146}. 3^{*}{1146}. **v:** David 1.
Glu-A1q{125}. [*Glu A1VI*{125}]. 2^{***}{125}. **tv:** Melianopus 1528.
Glu-A1r{1232}. 39+40{1232}. **i:** *T. thaoudar* IPSR 1020006/6^{*}Sicco.
Glu-A1s{1231}. 41+42{1231}. **i:** *T. thaoudar* G3152/6^{*}Sicco.

Glu-A1t{602}. 21^{*}{602}. v: W29323, W3879, W31169.

Glu-A1u{02106}. 2^{*B}{02106}. v: Bankuti 1201.

The allele designated *Glu-A1u* and *Glu-A1-Iu* in the appropriate list below encodes a high molecular weight glutenin subunit (denominated 2^{*B}) that is identical to subunit 2^{*} apart from one amino acid difference involving the exchange of serine for cysteine (which itself is due to a C to G point mutation at the 1181 bp point of the coding region of 2^{*}). The authors of {02106} suggest that the additional cysteine residue facilitates the formation of further disulphide bonds (cf. the 1Dx5 subunit) which might lead to an improvement in gluten quality characters.

Glu-A1v{03137}. [*Glu-A1-VII*{03137}]. VII{03137}. v: PI-308879 emmer {03137}.

There is a possibility that *Glu-A1* alleles *i*, *j* {1527} and *k* {478} correspond to alleles *d*, *e*, *f* or *g* {1535} that were published shortly earlier. *Glu-A1m* [{1526}] was changed to *n*, because the *m* allele in {1069} has precedence. Allele *n* [{1526}] was changed to *o*. An earlier reference to an allele designated *Glu-A1d* {1411} was withdrawn {1114}. There appears to be a minor band associated with subunit 2^{*} encoded by *Glu-A1b* {1516}; this may be the same as a band named A5 in {420}.

Six combinations involving 5 HMW subunits [1A (u-z)] are listed in {420}, from a study of 109 genotypes including representatives of botanical varieties. A number of alleles in *T. turgidum* var. *dicoccoides* populations, 12 at *Glu-A1-1* and 3 at *Glu-A1-2*, were described in {798}. In a further study using different germplasm of this species {205}, 14 alleles at *Glu-A1* were observed, including 12 not previously found; the 15 alleles included up to 15 alleles at *Glu-A1-1* (with up to 10 not previously observed), and 5 alleles at *Glu-A1-2* (with 4 not previously observed) (numbers take the null allele into account). The uncertainty in numbers is due to the very similar electrophoretic mobilities of some of the subunits compared with others observed either in this study or previously. In a study including emmers (*T. dicoccon*) {00115}, new subunits named 1⁺ and 2⁻ were found in accessions MG4378/1 and MG5380/1, respectively, and provisionally assigned to *Glu-A1*. Until confirmed, they are not included in the *Glu-A1* list.

Glu-B1{107},{1125}. [*Glt-B1*{420},*Glt-B2*{420},*Glt-B3*{420},*Glu 1B*{1415}].

1BL{107,780,1125}. v: CS.

Glu-B1a{1116}. 7{1116}. v: Flinor.

Glu-B1b{1116}. 7+8{1116}. v: CS.

Glu-B1c{1116}. 7+9{1116}. v: Bezostaya 1.

Glu-B1d{1116}. 6+8{1116}. v: Hope.

Glu-B1e{1116}. 20{1116}.20x+20y{03133}. v: Federation.

Glu-B1f{1116}. 13+16{1116}. v: Lancota (rare).

Glu-B1g{1116}. 13+19{1116}. v: NS 335 (rare).

Glu-B1h{1116}. 14+15{1116}. v: Sappo (rare).

Glu-B1i{1116}. 17+18{1116}. v: Gabo.

Glu-B1j{1116}. 21{1116}.21x+21y{03116}. v: Dunav (rare); Foison{03116}.

Glu-B1k{1116}. 22{1116}. v: Serbian (rare).

Glu-B1l{778}. 23+24{778}. v: Spica D.

Glu-B1m{1527}. [*GLU-B1-I*{1527}]. tv: PI 94640, Iran, *T. dicoccum*.

Glu-B1n{1527}. [*GLU-B1-II*{1527}]. tv: PI 355505, Germany, *T. dicoccum*.

Glu-B1o{1527}. [*GLU-B1-III*{1527}]. tv: PI 352354, Ethiopia, *T. dicoccum*.

Glu-B1p{1527}. [*GLU-B1-IV*{1527}]. 23+18{125}. tv: Dritto{1523}; Ethiopia, PI 94655, *T. dicoccum*{1527}.

Glu-B1q{1527}. [*GLU-B1-V*{1527}]. tv: PI 94633, Morocco, *T. dicoccum*.

Glu-B1r{1527}. [*GLU-B1-VI*{1527}]. 19{125}. tv: PI 946669, Bulgaria, *T. dicoccum*{1527}; Lambro{1523}.

Glu-B1s{478}. 7+11{478}. v: BT-2288.

- Glu-B1t*{847}. v: Supreza, Canada.
- Glu-B1u*{1069}. 7^{*}+8{1146}. v: Owens{1069}; Fiorello{1146}.
- Glu-B1v*{1069}. v: Mondor.
- Glu-B1w*{1069}. 6^{*}+8^{*}{1146}. v: Dawbull{1069}; Sieve{1146}.
- Glu-B1x*{1526}. [*Glu-B1-VII*{1526},*Glu-B1t*{959}]. tv: Canoco de Grao Escuro, Portugal, *T. turgidum*.
- Glu-B1y*{1526}. [*Glu-B1-VIII*{1526},*Glu-B1u*{959}]. tv: Tremez Mollez, Portugal, *T. durum*.
- Glu-B1z*{1524}. [*Glu-B1-IX*{1524},*Glu-B1v*{959}]. 7+15{125}. tv: Roccia, Italy, *T. durum* {1523,125}.
- Glu-B1aa*{1524}. [*Glu-B1-X*{1524},*Glu-B1w*{959}]. tv: Quaduro, Italy, *T. durum*.
- Glu-B1ab*{1523}. [*Glu-B1-XI*{1523},*Glu-B1x*{959}]. tv: Athena, Italy, *T. durum*.
- Glu-B1ac*{125}. [*Glu B1XIII*{125}]. 6+16{125}. tv: Espal8914, *T. durum*.
- Glu-B1ad*{125}. [*Glu B1XIV*{125}]. 23+22{125}. tv: Greece 20, *T. durum*.
- Glu-B1ae*{1146}. 18^{*}{1146}. v: David.
- Glu-B1af*{1146}. 26+27{1146}. v: Cologne 1.
- Glu-B1ag*{1146}. 28+29{1146}. v: Forlani.
- Glu-B1ah*{782}. null allele{782}. v: Olympic mutant.
- Glu-B1ai*{714}. 7{714}. v: Adonis.
- Glu-B1aj*{759}. 8{759}. v: AUS 14444, Afghanistan.
- Glu-B1ak*{899}. 7^{*}+8^{*}{899}. v: Norstar.
- Glu-B1al*{899}. 7+8^{*}{899}. v: Glenlea.
- Glu-B1am*{1229}. 18{1229}. v: Royo.
- Glu-B1an*{1229}. 6{1229}. v: BG-2013.
- Glu-B1ao*{1229}. 7+16{1229}. v: BG-3545.
- Glu-B1ap*{1229}. 30+31{1229}. v: Marinar.
- Glu-B1aq*{1229}. 32+33{1229}. v: BG-1943.
- Glu-B1ar*{1229}. 34+35{1229}. v: Jeja Almendros.
- Glu-B1as*{1229}. 13{1229}. v: PI 348435.
- Glu-B1at*{1229}. 13+18{1229}. v: PI 348449.
- Glu-B1au*{1032}. 37{1032}. v: Shedraya Polesja.
- Glu-B1av*{03116}. [*Glu-B1r*{03116}]. 7-18{03116}. v: Triticor hexaploid *triticales*{03116}.
- Glu-B1aw*{03116}. [*Glu-B1s*{03116}]. 6.8-20y{03116}. v: Carnac hexaploid *triticales*{03116}.
- Glu-B1ax*{03137}. [*Glu-B1-XV*{03137}]. XV{03137}. tv: PI-190922, BG-012302 emmers{03137}.
- Glu-B1ay*{03137}. [*Glu-B1-XVI*{03137}]. XVI{03137}. tv: PI-277681 emmers{03137}.
- Glu-B1az*{03137}. [*Glu-B1-XVII*{03137}]. XVII{03137}. tv: PI-348620 emmers{03137}.
- Glu-B1ba*{03122}. [*Glu-B1-XVIII*{03122}]. 13^{*}+16{03122}. v: PI-348767 spelt {03122}.
- Glu-B1bb*{03122}. [*Glu-B1-XLX*{03122}]. 6+18{03122}. v: PI-348631 spelt wheat accession{03122}.
- Glu-B1bc*{03138}. 6+17{03138}. v: ICDW 20975{03138}.
- Glu-B1bd*{03140}. 20+8{03140}. v: Abadja{03140}.

The alleles formerly designated *t* to *x* in {959} were renamed *x* to *ab* because allele *t* in {847} and alleles *u*, *v* and *w* in {1069} had precedence. Subunit 8 of *Glu-B1b* (7+8) is more acidic in isoelectric focusing than subunit 8 of *Glu-B1d* (6+8) {555}. Variation in the mobility of subunits designated 7 has been observed {1118}, which accords with more recent observations {714,1069}. The subunit encoded by *Glu-B1v* {1069} has the

same mobility as subunit 7 of *Glu-B1c* (7+9); it could be the same subunit as 7' encoded by *Glu-B1ai* [{714}].

Variation in the staining intensity of subunit 7 in different lines was observed {1069}; a duplication of the gene encoding subunit 7 probably occurred in cultivar 'Red River 68', as evidenced by increased intensity of the subunit in SDS-PAGE and by approximately doubled intensity of restriction fragments carrying the gene in Southern blotting {9989}. Possible low gene expression at *Glu-B1* was noted for *Glu-B1w*, where subunits 6*+8* stain very faintly {1146}.

One of the *Glu-B1af* subunits was numbered 26 in {1146}; 26 was previously used to number the subunit encoded by *Glu-A1k* {478}. Subunit 28 of *Glu-B1ag* (28+29) {1146} is referred to as subunit 19* in {1068}. Subunit 23 of *Glu-B1p* {23+18} and *Glu-B1ad* (23+22) {125} may not be the same subunit as that numbered 23 of *Glu-B1l* {23+24} {778}. *Glu-B1z* carried by Rocchia was numbered (7+15) and named *Glu-B1-XII* in {125}; however, the earlier name, *Glu-B1-IX* {1523}, has precedence; also, {1523} states that the *Glu-B1-IX* subunit of faster mobility is slightly slower than subunit 15. Subunit 11 of *Glu-B1s* {7+11} was so numbered in {478} because its mobility is the same as one of the subunits encoded by a *Glu-D1* allele (2+11) described in {755}.

Eight alleles at *Glu-B1-1* and 10 alleles at *Glu-B1-2* in *T. turgidum* var. *dicoccoides* populations were described in {798}. In a further study using different germplasm of this species {205}, 19 alleles at *Glu-B1* were observed, including 15 not previously observed; the 19 alleles included 11 alleles at *Glu-B1-1* and 14 alleles (including the null allele) at *Glu-B1-2*, although, as the authors pointed out, it was not conclusively clear how many of these alleles were distinct from each other, or from others previously observed.

In a study including emmer wheats (*T. dicoccon*) {00115}, new subunits named 7⁺ (in accessions MG5400/5 and MG30835/1), 8⁻ (in accessions MG5400/5, MG30835/1, MG5333/1 and MG5507) and 13⁻ (in accession MG5282/2) were found and provisionally assigned to *Glu-B1*. Until confirmed, they are not included in the *Glu-B1* list.

Glu-D1{1100,1125}. [*Glt-D1*{420},*Glt-D2*{420},*Glu 1D*{1415}].

1DL{107,150,780,1100,1125}. v: CS.

Glu-D1a{1116}. 2+12{1116}. v: CS.

Glu-D1b{1116}. 3+12{1116}. v: Hobbit.

Glu-D1c{1116}. 4+12{1116}. v: Champlein.

Glu-D1d{1116}. 5+10{1116}. v: Hope.

Glu-D1e{1116}. 2+10{1116}. v: Flinor (rare).

Glu-D1f{1116}. 2.2+12{1116}. v: Danchi (rare).

Glu-D1g{478}. 5+9{478}. v: BT-2288.

Glu-D1h{1145}. 5+12{1145}. v: Fiorello, Italy.

Glu-D1i{107}. null{107}. v: Nap Hal, Nepal.

Glu-D1j{1146}. 2+12*{1146}. v: Tudest.

Glu-D1k{421}. 2{421}. s: CS/Timstein 1D.

Glu-D1l{759}. 12{759}. v: AUS 10037, Afghanistan.

Glu-D1m{759}. 10{759}. v: AUS 13673, Afghanistan.

Glu-D1n{759}. 2.1+10{759}. v: AUS 14653, Afghanistan.

Glu-D1o{755}. 2.1+13{755}. v: AUS 14519, *T. macha*.

Glu-D1p{1233}. 36{1233}. i: Iranian landrace accession 3048/5* Sicco.

Glu-D1q{124}. 2+11{124}. v: Flinor.

Glu-D1r{1229}. 2.3+12{1229}. v: PI 348465.

Glu-D1s{1032}. 38{1032}. v: Leningradka.

Glu-D1t{668}. 43+44{668}. i: *Ae. tauschii* accession TA2450/2*.

Glu-D1u{836}. 2+10⁺{836}. v: Coker 68-15.

Glu-D1v{755}. 2.1+10.1{755}. dv: *Ae. tauschii*.

- Glu-D1w*{03124}. 5^{*}+10{03124}. **v**: Fiorello{03124}.
Glu-D1x{755}. 2+T2{755}.2^t+12.2^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1y{755}. 3+T2{755}.3^t+12.2^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1z{755}. 3+10{755}. **dv**: *Ae. tauschii*.
Glu-D1aa{755}. 3+10.3{755}. **dv**: *Ae. tauschii*.
Glu-D1ab{755}. 4.1+10{755}. **dv**: *Ae. tauschii*.
Glu-D1ac{755}. 4+10{755}. **dv**: *Ae. tauschii*.
Glu-D1ad{755}. 5.1+10.2{755}. **dv**: *Ae. tauschii*.
Glu-D1ae{1578}. 2.1+T2{1578}.2.1^t+12.2^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1ag{1578}. 1.5+T2{1578}.1.5^t+12.2^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1ah{1578}. 1.5+10{1578}. **dv**: *Ae. tauschii*.
Glu-D1ai{1578}. 2.1+10.5{1578}. **dv**: *Ae. tauschii*.
Glu-D1aj{1578}. 1.5+12{1578}. **dv**: *Ae. tauschii*.
Glu-D1ak{1578}. 3+10.5{1578}. **dv**: *Ae. tauschii*.
Glu-D1al{02107}. 2.2^{*}{02107}. **v**: MG315.
Glu-D1am{03122}. [*Glu-DI-I*{03122}]. 2+12^t{03122}. **v**: PI-348495 spelt {03122}.
Glu-D1an{03122}. [*Glu-DI-II*{03122}]. 2+12^{*}{03122}. **v**: PI-348672 spelt {03122}.
Glu-D1ao{03122}. [*Glu-DI-III*{03122}]. 2.4+12{03122}. **v**: PI-348473 spelt {03122}.
Glu-D1ap{03122}. [*Glu-DI-IV*{03122}]. 2.5+12{03122}. **v**: PI-348572 spelt {03122}.
Glu-D1aq{03124}. 1.5^t+10.1^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1ar{03124}. 2^t+10.1^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1as{03124}. 1.5^t+10.2^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1at{03124}. 3^t+10.1^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1au{03124}. 2.1^t+10.2^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1av{03124}. 2^t+12.3^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1aw{03124}. 1^t+10^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1ax{03124}. 1^t+12^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1ay{03124}. 1^t+10.1^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1az{03124}. 4^t+12.2^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1ba{03124}. 1^t+12.3^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1bb{03124}. 1.5^t+11^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1bc{03124}. 1.5^t+10.3^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1bd{03124}. 1^t+11^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1be{03124}. 2.1^t+12.4^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1bf{03124}. 2^t+12.1^t{03124}. **dv**: *Ae. tauschii*{03124}.
Glu-D1bg{03124}. 3^t+10.2^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1bh{03124}. 4^t+10.1^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1bi{03124}. 4^t+10.2^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1bj{03124}. 5^t+11^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1bk{03124}. 5^t+10.1^t{03124}. **dv**: *Ae. Tauschii*.
Glu-D1bl{03124}. 5^t+12.2^t{03124}. **dv**: *Ae. tauschii*.
Glu-D1bm{03124}. 5^{*}+null{03124}. **dv**: *Ae. tauschii*.
Glu-D1bn{03124}. 5^{*}+12{03124}. **dv**: *Ae. tauschii*.

Glu-DI {421} appears to have arisen as the result of a deficiency of subunit 12 from *Glu-D1a* (2+12); subunits 2 and 12 are referred to as D1 and D5 in {421}. One of the *Glu-D1o* subunits has been numbered 13 in {755}; 13 was previously used to number a subunit encoded by *Glu-B1f* {13+16} and *Glu-B1g* {13+19} {1116}. Subunit 9 of *Glu-D1g* (5+9) was so numbered in {478} because its mobility is the same as one of the subunits encoded by *Glu-B1c* (7+9).

Five combinations involving 6 HMW subunits [1D {p-t}] are listed in {420}. Eleven additional *Glu-DI* alleles in *T. tauschii* were described {755}.

Seven transfers of *Glu-D1a* and 10 of *Glu-D1d* (5+10) from chromosome 1D to chromosome 1A in triticale were described {846}.

The subunit 2.2* encoded by *Glu-D1al* above and *Glu-D1-1m* in the appropriate list below has an unusually high Mr comparison of its N-terminal sequence and amino acid composition with those of subunit 2 (encoded by *Glu-D1-1a* indicated that its greater Mr, could be due to the presence of a larger central repetitive domain, although further evidence suggested that this does not affect the conformational properties of the subunit {02107}. The alleles originally designated *Glu-D1w* (encoding 'subunits' 2 (or 2^t denoting its origin in the *Ae. tauschii* genome) +T1+T2), *Glu-D1af* (encoding 3 9or 3^t)+T1+T2) and *Glu-D1ag* (encoding 1.5 (or 1.5^t)+T1+T2) share the component T1 that was originally classified as a HMW glutenin. However, it has since been shown {02108} that this protein is soluble in aqueous ethanol, casting doubt upon this classification. More recently, it has been shown {02109}, from one and two dimensional gel electrophoresis based upon SDS-PAGE and A-PAGE, and from N-terminal sequencing, that this protein is an omega-gliadin of unusually low electrophoretic mobility in SDS-PAGE, encoded by a locus located on the short arm of chromosome 1D, though distant 913.18cM) from the principle gliadin-encoding locus on 1D, *Gli-D1*, and 40.20cM from the high molecular weight encoding locus, *Glu-D1*. The authors named the locus *Gli-DT1* (see below, section Gliadins). Reference to T1 was consequently removed from the *Glu-D1* list. As a consequence of this finding, allele *Glu-D1w* was reused for a distinct allele, and *Glu-D1af* was omitted and will be reused for a future allele, since the combinations of subunits that these alleles originally represented are no longer unique.

In {03124}, null alleles were observed for both *Glu-D1-1* and *Glu-D1-2*, which, naturally, are not necessarily the same as those previously reported for this locus, meaning that composite alleles involving them in this study and corresponding to combinations apparently already listed in the Catalogue, may, in fact, represent novel alleles. It is also found that certain subunits of apparently identical relative mobility in SDS-PAGE showed different surface hydrophobicities in RP-HPLC; and the reverse situation was also observed (the same hydrophobicity, but different electrophoretic mobilities).

It was shown {03126} that the relatively small size of a y-type HMW glutenin subunit, named 12.4^t (encoded by *Glu-D1-1t* {03124} - see the relevant list below) and carried by accession CPI110750 of *Ae. tauschii*, is due to the deletion of blocks of repetitive motifs, amounting to approximately 200 amino acids, probably caused by unequal crossing-over. Note that the cultivar Fiorello is given as a standard for *Glu-D1h* encoding subunits 5+12 and for *Glu-D1w* encoding subunits 5*+10. An attempt to resolve this apparent conflict will be made in a future update.

Alleles and subunits at *Glu-A1-1* and *Glu-A1-2*: *Glu-A1-1* encodes X-type glutenins and *Glu-A1-2* encodes y-type glutenins.

Glu-A1-1.

Glu-A1-1a. Null. v: CS.

Glu-A1-1b. 1. v: Hope.

Glu-A1-1c. 2*. v: Bezostaya 1.

A PCR marker specific for the *Glu-A1-1c* (Ax2*) allele was developed in {0147}.

Glu-A1-1d. v: V74, Spain.

Glu-A1-1e. v: 132c, Poland.

Glu-A1-1f. v: 112-29, Sudan.

Glu-A1-1g. v: Landrace 1600.

Glu-A1-1h. tv: PI 94683, USSR, *T. dicoccum*.

Glu-A1-1i. tv: CI 12213, India, *T. dicoccum*.

Glu-A1-1j. 1'. tv: PI 352359, Germany, *T. dicoccum*; Lambro.

Glu-A1-1k. 26. v: BT-2288.

- Glu-A1-1l*. tv: Chinook, Canada.
Glu-A1-1m. tv: Nugget Biotype 1, Canada.
Glu-A1-1n. 1". tv: Corado, Portugal.
Glu-A1-1o. 2**. tv: PI 61189, USSR, Aric 581/1.
Glu-A1-1p. 3*. v: David 1.
Glu-A1-1q. 2***. tv: Melianopus 1528.
Glu-A1-1r. 39. i: *T. thaoudar* IPSR 1020006/6* Sicco.
Glu-A1-1s. 41. i: *T. thaoudar* G3152/6* Sicco.
Glu-A1-1t{602}. 21*{602}. v: W29323, W 3879, W 31169.

Glu-A1-1t is a provisional designation; definitive evidence that subunit 21*, which has a mobility similar to that of subunit 21, is a 'x-type' and not a 'y-type' protein has not been obtained.

- Glu-A1-1u*{02106}. 2*B{02106}. v: Bankuti 1201.

Glu-A1-2.

- Glu-A1-2a*. Null. v: CS.
Glu-A1-2b. 40. i: *T. thaoudar* IPSR1020006/6* Sicco.
Glu-A1-2c. 42. i: *T. thaoudar* G3152/6* Sicco.

Glu-B1-1.

- Glu-B1-1a*. 7. v: CS.
 A PCR marker (2373 bp) for the *Glu-B1-1a* (Bx7) allele was developed in {0145}.
Glu-B1-1b. 7,7*. v: Flinor, Bezostaya 1, Owens, Norstar.
Glu-B1-1c. 7'. v: Adonis.
Glu-B1-1d. 6. v: Hope.
Glu-B1-1e. 20. v: Federation.
Glu-B1-1f. 13. v: Lancota.
Glu-B1-1g. 14. v: Sappo.
Glu-B1-1h. 17. v: Gabo.
Glu-B1-1i. 21.21x{03116}. v: Dunav; Foison{03116}.
Glu-B1-1j. 23. v: Spica D.
Glu-B1-1k. tv: PI 94640, Iran, *T. dicoccum*.
Glu-B1-1l. tv: PI 355505, Germany, *T. dicoccum*.
Glu-B1-1m. tv: PI 352354, Ethiopia, *T. dicoccum*.
Glu-B1-1n. tv: PI 94633, Morocco, *T. dicoccum*.
Glu-B1-1o. v: Supreza, Canada.
Glu-B1-1p. v: Mondor.
Glu-B1-1q. tv: Canoco de Grao Escuro, Portugal.
Glu-B1-1r. tv: Tremez Mollez, Portugal.
Glu-B1-1s. tv: Quaduro, Italy.
Glu-B1-1t. tv: Athena, Italy.
Glu-B1-1u. 26. v: Cologna 1.
Glu-B1-1v. 28. v: Forlani.
Glu-B1-1w. Null. v: Olympic mutant.
Glu-B1-1x. 30. v: Marinar.
Glu-B1-1y. 32. v: BG-1943.
Glu-B1-1z. 34. v: Jeja Almendros.
Glu-B1-1aa. 37. v: Shedraya Polesja.
Glu-B1-1ab. 6*. v: Dawbill.
Glu-B1-1ac{03116}. 6.8{03116}. v: Carnac hexaploid triticale{03116}.
Glu-B1-1ad{03122}. 13*{03122}. v: PI-348767 spelt {03122}.

Glu-B1-2.

- Glu-B1-2a*. 8. v: CS.

- Glu-B1-2b*. 9. **v**: Bezostaya 1.
Glu-B1-2c. 16. **v**: Lancota.
Glu-B1-2d. 19. **v**: NS 335.
Glu-B1-2e. 15. **v**: Sappo.
Glu-B1-2f. 18. **v**: Gabo.
Glu-B1-2g. 22. **v**: Serbian.
Glu-B1-2h. 24. **v**: Spica D.
Glu-B1-2i. **tv**: PI 355505, Germany, *T. dicoccum*.
Glu-B1-2j. **tv**: PI 352354, Ethiopia, *T. dicoccum*.
Glu-B1-2k. **tv**: PI 94633, Morocco, *T. dicoccum*.
Glu-B1-2l. 11. **v**: BT-2288.
Glu-B1-2m. **v**: Supreza, Canada.
Glu-B1-2n. **v**: Mondor.
Glu-B1-2o. 8*. **v**: Dawbull.
Glu-B1-2p. **tv**: Canoco de Grao Escuro, Portugal.
Glu-B1-2q. **tv**: Tremez Mollez, Portugal, *T. durum*.
Glu-B1-2r. **tv**: Quaduro, Italy, *T. durum*.
Glu-B1-2s. 18*. **v**: David.
Glu-B1-2t. 27. **v**: Cologne 1.
Glu-B1-2u. 29. **v**: Forlani.
Glu-B1-2v. Null. **v**: Olympic mutant.
Glu-B1-2w. 31. **v**: Marinar.
Glu-B1-2x. 33. **v**: BG-1943.
Glu-B1-2y. 35. **v**: Jeja Almendros.
Glu-B1-2z{03116}. 20y{03116}. **v**: Carnac hexaploid triticale{03116}.
Glu-B1-2aa{03122}. 18'{03122}. **v**: PI-348631 spelt {03122}.
Glu-B1-2ab{03116}. 21y{03116}. **v**: Foison{03116}.

Glu-D1-1.

- Glu-D1-1a*. 2. **v**: CS.
Glu-D1-1b. 3. **v**: Hobbit.
Glu-D1-1c. 4. **v**: Champlein.
Glu-D1-1d. 5. **v**: Hope.
 PCR markers specific for the *Glu-D1-1d* (Dx5) allele were developed in {0145} and {0147}.
Glu-D1-1e. 2.2. **v**: Danchi.
Glu-D1-1f. Null. **v**: Nap Hal, Nepal.
Glu-D1-1g. 2.1. **v**: AUS 14653, Afghanistan.
Glu-D1-1h. 2.3. **v**: PI 348465.
Glu-D1-1i. 38. **v**: Leningradka.
Glu-D1-1j{668}. 43{668}. **i**: *Ae. tauschii* accession TA2450/2*.
Glu-D1-1k{755}. 4.1{755}. **dv**: *Ae. tauschii*.
Glu-D1-1r{755}. 5.1{755}. **dv**: *Ae. tauschii*.

This allele was previously designated *Glu-D1-1j* in the 1998 Catalogue.

- Glu-D1-1l*{1578}. 1.5{1578}. **dv**: *Ae. tauschii*.
Glu-D1-1m{02107}. 2.2*{02107}. **v**: MG315.
Glu-D1-1n{03122}. 2.4{03122}. **v**: PI-348473 spelt wheat accession{03122}.
Glu-D1-1o{03122}. 2.5{03122}. **v**: PI-3484572 spelt wheat accession{03122}.
Glu-D1-1p{03124}. 1^t{03124}. **dv**: *Ae. tauschii*{03124}.
Glu-D1-1q{03124}. 5*^t{03124}. **dv**: *Ae. tauschii*{03124}.

Glu-D1-2.

- Glu-D1-2a.** 12. **v:** CS.
A PCR marker (612 bp) for the *Glu-D1-2a* (Dy12) allele was developed in {0145}.
- Glu-D1-2b.** 10. **v:** Hope.
PCR markers (576 bp and 2176bp) for the *Glu-D1-2b* (Dy10) allele were developed in {0145} and {0147}, respectively.
- Glu-D1-2c.** 9. **v:** BT-2288.
- Glu-D1-2d.** Null. **v:** Nap Hal, Nepal.
- Glu-D1-2e.** 12*. **v:** Tudest.
- Glu-D1-2f.** 13. **v:** AUS 14519, *T. macha*.
- Glu-D1-2g.** 36. **i:** Iranian landrace 3048/5* Sicco.
- Glu-D1-2h.** 11. **v:** Flinor.
- Glu-D1-2i**{668}. 44{668}. **i:** *Ae. tauschii* TA2450/2*.
- Glu-D1-2j**{836}. 10^t{836}. **v:** Coker 68-15.
- Glu-D1-2k**{755}. T1{755}. **dv:** *Ae. tauschii*.
- Glu-D1-2l**{755}. T2{755}. **dv:** *Ae. tauschii*.
- Glu-D1-2m**{755}. 10.1{755}. **dv:** *Ae. tauschii*.
- Glu-D1-2n**{755}. 10.2{755}. **dv:** *Ae. tauschii*.
- Glu-D1-2o**{755}. 10.3{755}. **dv:** *Ae. tauschii*.
- Glu-D1-2p**{1578}. 10.5{1578}. **dv:** *Ae. tauschii*.
- Glu-D1-2q**{03122}. 12^t{03122}. **v:** PI-348495 spelt wheat accession{03122}.
- Glu-D1-2r**{03124}. 12.1^t{03124}. **dv:** *Ae. tauschii*.
- Glu-D1-2s**{03124}. 12.3^t{03124}. **dv:** *Ae. tauschii*.
- Glu-D1-2t**{03124}. 12.4^t{03124}. **dv:** *Ae. tauschii*.
- Glu-Agⁱ1**{374}. 1Agⁱ{374}. **ad:** Vilmorin 27/*Thin. intermedium*.
- Glu-E1**{781}. 1ES{781}. **ad:** CS/*E. elongata*.
- Glu-H1**{781}. [*Hor* 3{1337}]. 1H{781}.1HL{1337}. **ad:** CS/Betzes{781}. **al:** Various barley cultivars{1337}.
- Glu-H^{ch}1.** 1H^{ch}{1123}. **ad:** CS/*H. chilense*.
- Glu-H^{ch}1a**{03114}. 1^{Hch}{03114}. **al:** *H. chilense* Accession H1{03114}.
- Glu-H^{ch}1b**{03114}. 2^{Hch}{03114}. **al:** *H. chilense* Accession H11{03114}.
- Glu-H^{ch}1c**{03114}. 3^{Hch}{03114}. **al:** *H. chilense* Accession H7{03114}.
- Glu-H^{ch}1d**{03114}. 4^{Hch}{03114}. **al:** *H. chilense* Accession H16{03114}.
- Glu-H^{ch}1e**{03114}. 5^{Hch}{03114}. **al:** *H. chilense* Accession H47{03114}.
- Glu-H^{ch}1f**{03114}. 6^{Hch}{03114}. **al:** *H. chilense* Accession H220{03114}.
- Glu-H^{ch}1g**{03114}. 7^{Hch}{03114}. **al:** *H. chilense* Accession H293{03114}.
- Glu-H^{ch}1h**{03114}. 8^{Hch}{03114}. **al:** *H. chilense* Accession H297{03114}.
- Glu-H^{ch}1i**{03114}. 9^{Hch}{03114}. **al:** *H. chilense* Accession H252{03114}.
- Glu-H^{ch}1j**{03114}. 10^{Hch}{03114}. **al:** *H. chilense* Accession H210{03114}.
- 38 accessions (natural populations) of *Hordeum chilense* carrying the following 10 subunits were used as the maternal parents of 121 lines of primary tritordeum, and evaluations for associations with bread-making quality initiated {03114}. Subunits 1^{Hch}, 2^{Hch} and 3^{Hch} were previously referred to as H^{ch}a, H^{ch}b and H^{ch}c {03112}.
- Glu-H^t1**{1037}. 1H^tL{1037}. **ad:** CS/*E. trachycaulum*.
- Glu-R1**{781,1356}. [*Sec* 3{1336}]. 1R{781,1336}.1RL{1356,1340}. **ad:** CS/Imperial; Holdfast/ King II{1340}. **tr:** CS Imperial 1DS.1RL{1356}.
- Glu-R1a**{03116}. 1^r-4^r{03116}. **v:** Indiana hexaploid triticales{03116}.
- Glu-R1b**{03116}. 2^r-6.5^r{03116}. **v:** Graal hexaploid triticales{03116}.
- Glu-R1c**{03116}. 6^r-13^r{03116}. **v:** Almao hexaploid triticales{03116}.
- Glu-R1d**{03116}. 2^r-9^r{03116}. **v:** Olympus hexaploid triticales{03116}.
- Glu-R1e**{03116}. 6.5^r{03116}. **v:** Clercal hexaploid triticales{03116}.
- Glu-R1f**{03115}. 0.8^r-6^r{03115}. **v:** Carmara hexaploid triticales{03115}.

Glu-R1g{03115}. 5.8^r{03115}. **v**: Arrayan hexaploid triticales{03115}.

There is a difficulty in the assignment of subunit 6^r in the *Glu-R1-1* and *Glu-R1-2* lists, since it appears as an x-type subunit in allele *Glu-R1c* and as a y-type subunit in allele *Glu-R1f*. It is currently provisionally assigned to the *Glu-R1-1* list since, based upon its relative electrophoretic mobility, it is considered more likely to be an x-type subunit. Some of the remaining designations should also be considered as provisional since they too are not free of ambiguity.

From study of chromosome substitutions in bread wheat {03117}, it was found that a chromosome 1R carrying HMW secalin subunit 6.5^r (*Glu-R1e*), originally derived from the 'Petkus' rye population, was associated with bread making quality (i) intermediate between chromosome 1A carrying the null allele *Glu-A1c* and chromosome 1A carrying HMW glutenin subunit 2* encoded by *Glu-A1b*; (ii) equivalent to a chromosome carrying HMW glutenin subunit 7 encoded by *Glu-B1a*; and (iii) inferior to chromosomes 1D with distinct alleles.

Glu-R1-1.

Glu-R1-1a{03116}. 1^r{03116}. **v**: Indiana hexaploid triticales{03116}.

Glu-R1-1b{03116}. 2^r{03116}. **v**: Graal hexaploid triticales{03116}.

Glu-R1-1c{03116}. 6^r{03116}. **v**: Alamo hexaploid triticales{03116}.

Glu-R1-1d{03115}. 0.8^r{03115}. **v**: Carmara hexaploid triticales{03115}.

Glu-R1-1e{03115}. 5.8^r{03115}. **v**: Arrayan hexaploid triticales{03115}.

Glu-R1-2. 1R, 1RL.

Glu-R1-2a{03116}. 4^r{03116}. **v**: Indiana hexaploid triticales{03116}.

Glu-R1-2b{03116}. 6.5^r{03116}. **v**: Graal hexaploid triticales{03116}.

Glu-R1-2c{03116}. 13^r{03116}. **v**: Alamo hexaploid triticales{03116}.

Glu-R1-2d{03116}. 9^r{03116}. **v**: Olympus hexaploid triticales{03116}.

Glu-R^m1{1339}. 1R^mL{1339,1340}. **ad**: CS/*S. montanum*{1339,1340}.

Glu-S^l1{1228}. 1S^lL{1228}. **ma**: In *Ae. longissima* 2/*Ae. longissima* 10, *Glu-S^l1*, *Glu-S^l3*, one glucose phosphate isomerase locus, and three gliadin loci were mapped relative to one and other {1228} as follows: *Glu-S^l1* - 15.9 cM - *Gpi-S^l1* - 38 cM - *Gli-S^l4* - 7.1 cM - *Glu-S^l3* - 0.9 cM - *Gli-S^l1* - 5.6 cM - *Gli-S^l5*. *Glu-S^l1* is located in 1S^lL and the other loci are in 1S^lS.

Glu-UI{150}. 1U{150,781}. **ad**: CS/*Ae. umbellulata* {150,781}.

Glu-VI{111,242,1026}. 1V{1026,111}. **ad**: CS/*D. villosum*; Creso/*D. villosum*.

Glu-VIa{1651}. 71{1651}. **al**: *D. villosum*.

Glu-VIb{1651}. 72{1651}. **al**: *D. villosum*.

Glu-VIc{1651}. 73{1651}. **al**: *D. villosum*.

Glu-VId{1651}. 74{1651}. **al**: *D. villosum*.

Glu-VIe{1651}. 75{1651}. **al**: *D. villosum*.

Glu-VIf{1651}. 76{1651}. **al**: *D. villosum*.

Glu-VIg{1651}. 77{1651}. **al**: *D. villosum*.

Glu-VIh{1651}. 78{1651}. **al**: *D. villosum*.

Glu-VIi{1651}. 79{1651}. **al**: *D. villosum*.

Glu-VIj{1651}. 80{1651}. **al**: *D. villosum*.

Glu-VIk{1651}. null{1651}. **al**: *D. villosum*.

Glu-VIl{1651}. 81+82{1651}. **al**: *D. villosum*.

Glu-VIm{1651}. 83+84{1651}. **al**: *D. villosum*.

Glu-VIn{1651}. 85+86{1651}. **al**: *D. villosum*.

Alleles and subunits at *Glu-VI* and *GLU-VI-2*: The following is analogous to the *Glu-1-1* and *Glu-1-2* lists given earlier to identify x-type and y-type subunits in wheat. It was assumed that where an allele at *Glu-VI* produces only a single subunit, it is an x-type subunit and so encoded by *Glu-VI-1* rather than by *Glu-VI-2*; the electrophoretic

mobilities of the subunits are all greater, though some only marginally so, than subunit 7 encoded by *Glu-B1-1a* (an x-type subunit), and extend beyond the mobility of subunit 12 encoded by *Glu-D1-2a* (a y-type subunit) {1651}; therefore, it is quite possible that any one of the subunits designated as encoded by *Glu-VI-1* is, in fact, encoded by *Glu-VI-2*. The designation given here is intended to be the most practically useful until the identities of the genes encoding the alleles are directly established.

Glu-VI-1.

- Glu-VI-1a*{1651}. 71{1651}. **al:** *D. villosum*.
Glu-VI-1b{1651}. 72{1651}. **al:** *D. villosum*.
Glu-VI-1c{1651}. 73{1651}. **al:** *D. villosum*.
Glu-VI-1d{1651}. 74{1651}. **al:** *D. villosum*.
Glu-VI-1e{1651}. 75{1651}. **al:** *D. villosum*.
Glu-VI-1f{1651}. 76{1651}. **al:** *D. villosum*.
Glu-VI-1g{1651}. 77{1651}. **al:** *D. villosum*.
Glu-VI-1h{1651}. 78{1651}. **al:** *D. villosum*.
Glu-VI-1i{1651}. 79{1651}. **al:** *D. villosum*.
Glu-VI-1j{1651}. 80{1651}. **al:** *D. villosum*.
Glu-VI-1k{1651}. null{1651}. **al:** *D. villosum*.
Glu-VI-1l{1651}. 81{1651}. **al:** *D. villosum*.
Glu-VI-1m{1651}. 83{1651}. **al:** *D. villosum*.
Glu-VI-1n{1651}. 85{1651}. **al:** *D. villosum*.

Glu-VI-2.

- Glu-VI-2a*{1651}. null{1651}. **al:** *D. villosum*.
Glu-VI-2b{1651}. 82{1651}. **al:** *D. villosum*.
Glu-VI-2c{1651}. 84{1651}. **al:** *D. villosum*.
Glu-VI-2d{1651}. 86{1651}. **al:** *D. villosum*.

A Chinese cultivar of *T. aestivum*, Xiaoyanmai 7, carries a subunit with electrophoretic mobility in 10% SDS-PAGE well beyond that of subunits so far observed in *T. aestivum*. It may derive from *Agropyron elongatum*, which was used in the breeding programme that led to the variety {1538}. It has not been given a subunit number or allelic designation, because its genetic control has not been elucidated.

74.3.1.2. *Glu-2*

Glu-B2{819,277}. [*XGlu-B2*{277}]. 1BS. **s:** CS*/Cheyenne 1B{277}. **stv:** Langdon*/*T. turgidum* var. *dicoccoides* 1B{277}.

Glu-B2a{00114}. 12{00114}. **tv:** Mexicali.

Glu-B2b{00114}. Null{00114}. **tv:** Langdon.

Gli-B3 was designated *Glu-B2* {589} until the name of the locus was changed in {1119}.

74.3.1.3. *Glu-3*

The *Glu-3* loci are defined as the cluster of LMW glutenin genes previously considered a component of the compound *Gli-1* loci.

More than 30 LMW glutenin complete genes, partial genes or pseudogenes have been sequenced from *Triticum* species (reviewed in {0245}).

In *T. aestivum*, only *Glu-B3* was shown to recombine with the gliadin genes (1.7 +/- 0.8) {1355,1358}. However, in *T. durum*, recombination was observed for both *Glu-A3* and *Glu-B3* with their respective *Gli-1* loci: the map distance between *Glu-A3* and *Gli-A1* has been estimated as 1.3 +/- 0.4 cM {1242}, and that between *Glu-B3* and *Gli-B1* as 2.0 +/- 0.8 in

{1144} and as 2.0 +/- 0.4 in {1242}. It appears that *Glu-B3* is proximal to *Gli-B1*, and there is some evidence, albeit only tentative as the authors acknowledge, that *Glu-A3* is proximal to *Gli-A1* {1242}.

Whereas hitherto it has been widely thought that all the LMW subunits of glutenin were encoded by genes located on the chromosomes of homoeologous group 1, it has been demonstrated that, although the majority of the subunits are indeed controlled by genes on this group, some of the C subunits must be controlled by loci elsewhere in the genome {482}. A novel type of polymeric protein (M_r approx. 71,000) was reported in the Australian advanced breeding line DD118 {03125}. It participates in the polymeric structure of glutenin (possibly as a chain terminator), and with an M_r of approximately 71,000, could be considered as a D-subunit of LMW glutenin. However, N-terminal sequencing suggests it to be a *Gli-B1* type omega-gliadin that has acquired a cysteine residue through mutation.

In an electrophoretic survey of 51 primary tritordeums {03113}, 20 distinct whole banding patterns (a-t), each consisting of between one and three bands, were observed for D-zone prolamins exhibiting glutenin-like solubility characteristics.

In 85 Japanese common wheat cultivars and 61 elite F_6 breeding lines, 3 alleles were observed at each of *Glu-A3* and *Glu-B3*, and 2 alleles at *Glu-D3* were named according to their parental origins in three doubled haploid mapping populations {03135}.

C-type LMW glutenin subunits in CS were assigned to chromosome groups 1 and 6, and shown to have sequences very similar to those of alpha- and gamma-gliadins {03134}. The authors suggest that they may be encoded by novel genes at loci tightly linked or present within the *Gli-1* and *Gli-2* loci, unlike other LMW glutenin subunits encoded by the *Glu-3* loci.

The HMW and LMW glutenin subunits carried by chromosome 1A^m of *T. monococcum* accession G1777 were characterised electrophoretically and evaluated for quality characteristics using recombinant chromosome substitution lines with chromosome 1A of CS {03142}. The HMW subunits from G1777 are promising for bread-making quality, whereas its LMW subunits are promising for biscuit-making quality.

The bread wheat cv. Salmone has been shown to carry two DNA fragments designated as SF720 and SF750 located on the chromosome 1B satellite and associated with the presence of two LMW glutenin subunits {03143}. However, the authors suggest that they occur at a locus other than *Glu-B3* due to their relatively high frequency of recombination with *Gli-B3*.

A naming system in which roman numerals are assigned to whole banding patterns for the LMW glutenin subunit is given in {03131} as an alternative to the LMW-1/-2 system described in {03136}. A further system naming whole banding patterns from LMW-1 to LMW-23 in emmer wheat is described in {03137}.

In {00111}, in a study of common and durum wheats from Portugal, the authors used the nomenclature system described in {00113} for the LMW subunits in common wheat, and that described in {00114} for the LMW subunits in durum wheat. The latter system was updated according to {02110}, but has been changed herein to new alleles with the earlier durum designation {00114} given as synonyms. In {03116}, it was suggested that *Glu-B3d* (common wheat standard genetic stock) is equivalent to *Glu-B3r* (durum wheat standard genetic stock), and that (referring to article {03127}) LMW subunits observed in some Portuguese triticales could be of the durum type.

Glu-A3{1358}. 1AS{1358}. v: CS.

- Glu-A3a*{481}. **v**: CS.
Glu-A3b{481}. **v**: Gabo.
Glu-A3c{481}. **v**: Cheyenne.
Glu-A3d{481}. **v**: Cappelle Desprez, Orca.
Glu-A3e{481}. **v**: Hope, Insignia.
Glu-A3f{481}. **v**: Rescue.
Glu-A3g{00113,00114}. 6+10+20{00114}. **tv**: Claro de Balazote.
Glu-A3h{00114,03116}. [*Glu-A3d'*{03116}]. null{00114}. **v**: Magistral hexaploid triticale{03116}.
Glu-A3i{02110}. 8^{*}+11{02110}. **tv**: Mourisco Fino.
 In 112 common wheat cultivars from Argentina, 11 microsatellite alleles plus a null allele were found at the *Glu-A3* locus {03123}.
Glu-A3j{00114}. [*Glu-A3a*{00114}]. 6{00114}. **tv**: Mexicali.
Glu-A3k{00114}. [*Glu-A3b*{00114}]. 5{00114}. **tv**: Langdon.
Glu-A3l{00114}. [*Glu-A3c*{00114}]. 6+10{00114}. **tv**: Cocorit.
Glu-A3m{00114}. [*Glu-A3d*{00114}]. 6+11{00114}. **tv**: Alaga.
Glu-A3n{00114}. [*Glu-A3e*{00114}]. 11{00114}. **tv**: Blatfort.
Glu-A3o{00114}. [*Glu-A3f*{00114}]. 6+11+20{00114}. **tv**: Clarofino.
Glu-A3p{00114}. [*Glu-A3h*{00114}]. Null{00114}. **tv**: Jiloca.
Glu-B3{1358}. 1BS{1358}. **v**: CS.
Glu-B3a{481}. **v**: CS.
Glu-B3b{481}. **v**: Gabo, Timstein, Hope.
Glu-B3c{481}. **v**: Insignia, Halberd.
Glu-B3d{481}. **v**: Orca.
Glu-B3e{481}. **v**: Cheyenne.
Glu-B3f{481}. **v**: Radja.
Glu-B3g{481}. **v**: Kharkov, Bungulla.
Glu-B3h{481}. **v**: Thatcher, Rescue.
Glu-B3i{481}. **v**: Norin-61.
Glu-B3j{476,02110}. 4+6^{*}+15+19{02110}. **tv**: Duramba-B, Duramba-D, Langdon; Mourisco Fino.
Glu-B3k{476,02110}. 8+9+13+16+19{02110}. **tv**: ALP-153, Dural, Durati, Edmore; Faisca.
Glu-B3l{476}. **tv**: Gionp-1954.
Glu-B3m{03120}. [*Glu-B3b'*{03120}]. **v**: Soissons{03120}.
Glu-B3n{03120}. [*Glu-B3c'*{03120}]. **v**: Courtot{03120}.
Glu-B3o{03116}. [*Glu-B3i'*{03116}]. **v**: Olympus hexaploid triticale{03116}.
Glu-B3p{03116}. [*Glu-B3k*{03116}]. **v**: Alamo hexaploid triticale{03116}.
Glu-B3q{03115}. [*Glu-B3h'*{03115}]. **v**: Torote hexaploid triticale{03115}.
Glu-B3r{00114}. [*Glu-B3a*{00114}]. 2+4+15+19{00114}. **tv**: Mexicali.
Glu-B3s{00114}. [*Glu-B3b*{00114}]. 8+9+13+16{00114}. **tv**: Langdon.
Glu-B3t{00114}. [*Glu-B3c*{00114}]. 2+4+14+15+19{00114}. **tv**: Jiloca.
Glu-B3u{00114}. [*Glu-B3d*{00114}]. 2+4+15+17+19{00114}. **tv**: Mundial.
Glu-B3w{00114}. [*Glu-B3f*{00114}]. 2+4+15+17{00114}. **tv**: Ardente.
Glu-B3v{00114}. [*Glu-B3e*{00114}]. 2+4+15+16+18{00114}. **tv**: Granja Badajoz.
Glu-B3x{00114}. [*Glu-B3g*{00114}]. 2+4+15+16{00114}. **tv**: Claro de Balazote.
Glu-B3y{00114}. [*Glu-B3h*{00114}]. 1+3+14+18{00114}. **tv**: Alaga.
Glu-D3{1358,707}. 1DS{707,1358}. **v**: CS.
Glu-D3a{481}. **v**: CS.
Glu-D3b{481}. **v**: Gabo.
Glu-D3c{481}. **v**: Insignia, Cappelle Desprez.

Glu-D3d{481}. **v:** Norin-61A.

Glu-D3e{481}. **v:** Orca, Thatcher.

Glu-E3{480}. 1ES{480}. **su:** CS/*E. elongata*.

Glu-S^l3{480,1228}. 1S^l{480}.1S^l1S{1228}. **su:** CS/*Ae. longissima*{480,1228}. **ma:** In *Ae. longissima 2* /*Ae. longissima 10* glucose phosphate isomerase locus, and three gliadin loci were mapped relative to one another in {1228} as follows: *Glu-S^l1* - 15.9 cM - *Gpi-S^l1* - 38 cM - *Gli-S^l4* - 7.1 cM - *Glu-S^l3* - 0.9 cM - *Gli-S^l1* - 5.6 cM - *Gli-S^l5*. *Glu-S^l1* is located in 1S^lL and the other loci are in 1S^lS.

Glu-U3{480}. 1U{480}. **su:** CS/*Ae. umbellulata*.

A series of papers {00106, 00107, 00108 and 00109} describe considerable variation in primitive wheats not present in bread wheat (A genome species *T. boeoticum*, *T. urartu*, *T. thaoudar*, *T. aegeolopoides*, *T. monococcum*, and D-genome species *T. tauschii*) for the low molecular weight subunits, sufficient to use them as a source for potentially changing flour properties in bread wheat.

In {00110}, variants for LMW glutenin subunits have been reported from study of twenty-four accessions of einkorn wheat (*T. monococcum* ssp. *monococcum*). Nine of these showed two electrophoretic bands for LMW subunits, arbitrarily designated 'a' and 'b', that appeared to be associated with good bread-making quality. The isolation of a new low-molecular-weight glutenin subunit gene, located on chromosome 1D, was reported in {0350}.

74.3.1.4. Glu-4

The following loci, *Glu-D4* and *Glu-D5*, encoding low molecular weight subunits of glutenin (30-32 kDa) were described in {02111}; the proteins encoded by them were first observed earlier {02114, 02115}, and the former was later tentatively assigned the symbol *Glu-4* {02116}, before its chromosomal location was established and the locus definitively named as *Glu-D4* in {02111}. While this locus is located on chromosome 1D (in accordance with the position on the group 1 chromosomes of the remaining glutenin encoding loci found to date), the locus *Glu-D5* is located on chromosome 7D. In SDS-PAGE, the proteins from both loci are detected only in the presence of 4-vinylpyridine added to the sample extract. Their amino acid compositions do not match those of the major prolamin groups; nonetheless, they classify as glutenins based upon solubility, immunological behaviour and N-terminal amino acid sequence (the latter suggesting an evolutionary link with the major (B and C) low molecular weight glutenin subunits).

Glu-D4{02111}. 1D{02111}. **su:** CS/Langdon 1D(1A); CS/Langdon 1D(1B){02111}.

Glu-D4a{02111}. **v:** J 24.

Glu-D4b{02111}. **v:** PBW 154.

Glu-D4c{02111}. Null allele. **v:** NI 4.

74.3.1.5. Glu-5

Glu-D5{02111}. 7D{02111}. **su:** CS/Langdon 7D(7A); CS/Langdon 7D(7B){02111}.

Glu-D5a{02111}. **v:** PBW 154.

Glu-D5b{02111}. Null allele. **v:** K 68.

A collection of 173 *Ae. tauschii* accessions were analysed for low molecular weight glutenin subunits by SDS-PAGE {02112}. Thirty three different patterns for B-subunits and 43 for C-subunits were identified, some of which were of identical electrophoretic mobility to those observed in common wheat. Also observed were subunits with the same mobilities as the D-subunits and as the subunits encoded by the *Glu-D4* and *Glu-D5* loci. This variation

represents a source of novel germplasm of potential value for breeding programmes aimed at improving the D-genome of common wheat in the context of bread-making quality.

PCR amplification of genomic DNA has been used to isolate three LMW glutenin genes in cultivar Chinese Spring, named LMWG-MB1, LMWG-MB2 and LMWG-MB3 {01101}. The deduced amino-acid sequences showed a high similarity between these ORFs and with those of other LMW glutenin genes. The authors state that the study provided direct evidence that insertions and/or deletions provide a mechanistic explanation for the allelic variation, and hence the resultant evolution, of prolamin genes, and comment on relationships with gamma-secalins and beta-hordein families. Single-base substitutions at identical sites generate premature stop codons in both LMWG-MB2 and LMWG-MB3, indicating that these clones are pseudogenes.

74.3.2. Gliadins

These are heterogeneous mixtures of alcohol-soluble polypeptides without quaternary structure. The *Gli-1* loci are compound and are now considered to comprise the omega-gliadin and gamma gliadin {982,1415} multigene families {494}, which in some circumstances may be divided into *Gli-1-1* and *Gli-1-2*, respectively. The LMW glutenin multigene families, which are closely linked to the *Gli-1* loci {588}, are listed separately as the *Glu-3* set {1358}; information on map distance and gene order in relation to *Glu-3* and the centromere is given in the preamble for the *Glu-3* loci. There is evidence that a few of the omega-gliadin genes are separated from the main omega-gliadin gene cluster {993}. Variation at the *Gli-1* loci was described earlier {634,996,1126} and applied in mapping experiments {1243,1125,196,422,1120}. A rational system of naming the alleles was produced by Dr. E.V. Metakovsky {988}. This nomenclature is reproduced below. A considerable number of alleles were added to the original list given in {988}, and referenced here accordingly. A few alleles have been deleted, because, following much detailed comparison, there is now doubt that they can be reliably distinguished from existing alleles {9981}. The allelic letter in these cases has not been reused. To facilitate practical use of the list, the aim was to give at least three standard cultivars from a range of countries for each allele {9981}. This was achieved for the vast majority of entries and is a change from the original list compiled from {988}, where up to two standards were given. While the three or more standards described almost always include the original standards, some have been replaced for various reasons, such as international awareness of the cultivar, availability of seed, or the ease with which an allele can be identified in a particular genetic background {9981}. In the original list, where two cultivars were given as prototypes for an allele, the first named was from the USSR and the second from elsewhere; this is no longer the case, although care was taken to include a Russian cultivar where possible, to maintain a wide base of germplasm in which the alleles are available, as well as to acknowledge the research groups in the country where much of the pioneering work was carried out.

For discussion of null alleles at the *Gli-1* and *Gli-2* loci, see {9984}.

Recombination was observed within the gliadin multigene family at *XGli-A1* {277}. These closely linked genes may correspond to *Gli-A1* and *Gli-A5*, but they were temporarily designated *XGli-A1.1* and *XGli-A1.2* until orthology with *Gli-A1* and/or *Gli-A5* is established.

Note: The catalogue entries reproduced here only refer to alleles in *T. aestivum*; there is, however, enormous variation in the gliadins in the close relatives of wheat; see, for example, {989} for studies in *T. monococcum* (more than 80 gliadin electrophoretic patterns observed in 109 accessions), {990} for studies in *T. boeoticum* (more than 50 electrophoretic patterns in 60 accessions), and {1076} studies in *T. durum* (19 electrophoretic patterns, referring only to variation in the omega-gliadins, in 243 accessions).

In {00110}, variants for omega-gliadins were reported from study of twenty-four accessions of einkorn wheat (*T. monococcum* ssp. *monococcum*). In {00111}, in a study of common wheat and durum from Portugal, the authors used the nomenclature system described in {00112} for the omega-gliadins. In {00116}, a comparison between spelt and common wheat was carried out for the gliadins using a nomenclature system described in {00118}.

The *Gli-1* loci may be recognised by probes pcP387 {372} and pTag1436 {065}, and by specific microsatellites primers {252}. Furthermore, it was shown that probe pTag1436 differentiates gliadin alleles rather well; using this probe, families of gliadin alleles and some of their relationships were described {9988}.

Based upon morphological observation and RFLP analysis, it was proposed that the cultivar 'Chinese Spring' is a strain of the landrace 'Chengdu-guangtou' from the Chengdu Plain, Sichuan Province; this proposal is supported by the observation that CS and the landrace share the same alleles at all nine *Gli-1*, *Gli-2* and *Glu-1* loci {see 01102}.

PCR primers GAG5 and GAG6 were applied to 35 cultivars of closely related spelt and hexaploid wheat, and to eight cultivars of durum, to yield products originating from two gamma-gliadin genes mapped to chromosomes 1B (termed GAG56B) and 1D (termed GAG56D) {01103}. Two alleles for GAG56D (differing in a 9 bp deletion/duplication and single nucleotide polymorphism) were found, one a new allele and the other previously published {01104}. Meanwhile two alleles found for GAG56B among the durum wheats correlated with the presence of gluten quality markers, gamma-gliadins 42 or 45.

1B and 1D sulphur-poor omega-gliadins in cultivar Butte 86 were characterised by RP-HPLC, SDS-PAGE, two-dimensional PAGE, amino acid composition determination and sequencing, matrix assisted laser desorption ionisation-time of flight mass spectrometry and circular dichroism spectroscopy to reveal the detailed nature of the peptides belonging to the two groups, and showing that the complexity of mixtures of the peptides of the 1B group was greater than that of the 1D group {01105}. Although circular dichroism spectra were similar for the two groups of peptides, and suggested a mainly flexible random structure, there was evidence for a significant amount of left-handed polyproline II helical conformation in the case of the 1D components. The authors placed some of the results in the context of the possible ancestor of the B-genome and relationships with the barley C-hordeins and rye omega-secalins.

Eleven new gliadin alleles were found in a collection of 52 Spanish landraces of common wheat {03141}. These will be added to the *Gli-1* and *Gli-2* allelic lists in the next Supplement.

74.3.2.1. Gli-1

Gli-AI{1334,1125}. [*Gld 1A*{1415}]. 1AS{150,634,1334,1607}. s: CS*/Cheyenne{634}. v: CS{150,1334,1607}.

Gli-A1a{988}. v: Castan{991}; CS{988}; Mara{9986}; Mentana{9986}; Millewa{00119}.

Gli-A1b{988}. v: Bezostaya 1, Mercia{988}; Tracy{991}.

Gli-A1c{988}. v: Ukrainka{998}; Gazul{9985}; Sava{994}; Hopps{00119}.

Gli-A1d{988}. v: Dankowska{988}; Cabezorro{9985}.

Gli-A1e{988}. v: Falchetto{988}; Open{991}; Touzelle{991}.

Gli-A1f{988}. v: Mironovskaya 808, Maris Freeman{988}; Arminda{991}.

Note: An allele *Gli-A1f** is mentioned in {03130}.

Gli-A1g{988}. v: Gabo{988}; Adalid{9985}.

Gli-A1h{988}. v: Sadovo I{988}; Predela{9981}; Krajinka{9981}.

Gli-A1i{988}. v: Saratovskaya 36{988}.

Gli-A1j{988}. v: Lutescens 62{988}.

- Gli-AIk*{988}. v: Courtot{991}; Skala (heterogeneous){988}; Soissons{991}; Spada{9986}.
- Gli-AIl*{988}. v: Lesostepka 75{988}; David{9986}; Salmone{9986}; Mura{9981}.
- Gli-AIm*{988}. v: Marquis{988}; Dneprovskaya 521{988}; Carat{991}; Liocorno{9986}.
- Gli-AIn*{988}. v: Intensivnaya{988}.
- Gli-AIo*{988}. v: Odesskaya 16 (heterogeneous){988}; Oderzo{9986}; Cappelle-Desprez{991}; Capitole{991}.
- Gli-AIp*{988}. v: Pyrotrix 28{988}; Zagore{9981}.
- Gli-AIq*{988}. v: Akmolinka 1{988}.
- Gli-AIr*{988}. v: Ranniaya 73{988}; Barbilla{9985}.
- Gli-AIs*.
Although reported {9986}, this gene is omitted because it requires further confirmation {9981}.
- Gli-AIt*{9985}. v: Jeja del Pais{9985}; Milturum 553{9981}; Strela{9981}.
- Gli-AIu*{9985}. v: Candéal Alcalá{9985}.
- Gli-AIv*{9981}. v: Japhet{9981}; Rouge de Bordeaux{9981}.
- Gli-AInull*{9984,9987}. v: Saratovskaya 29 (mutant){9987}; E. Mottin{9981}.
- Gli-B1*{1607,1125}. [*Gld 1B*{1243,1415},*Gld-B1*{420},*Gld-B2*{420},*Gld-B3*{420},*Gld-B4*{420},*Gld-B5*{420},*Gld-B6*{420}]. 1B{1607}.1BS{150,634}. s: CS^{*}/Cheyenne{634}. v: CS{1607,150}.
- Gli-B1a*{988}. v: CS{988}.
- Gli-B1b*{988}. v: Bezostaya 1{988}; Carat{991}; Marquis{988}; Liocorno{9986}; Soissons{991}.
- Gli-B1c*{988}. v: Siete Cerros 66{988}; Prinqual{991}; Loreto{9986}.
- Gli-B1d*{988}. v: Dneprovskaya 521{988}; Chopin{991}; Petrel{991}; Tiberio{9986}; Yecora{9985}; Neepawa{995}; Suneca{00119}.
- Gli-B1e*{988}. v: Apexal{991}; Fournil{991}; Lutescens 62{988}; Oderzo{9986}.
- Gli-B1f*{988}. v: Capitole{991}; Cappelle-Desprez{991}; Dankowska{988}; Maris Freeman{988}; Mercia{998}.
- Gli-B1g*{988}. v: Champtal{991}; Galahad{988}; Mara{9986}; Sadovo 1{988}; Tracy{991}.
- Gli-B1h*{988}. v: Cabezorro{9985}; Krasnodonka{988}; Pepital{991}; Rudi{991}Tincurrin{00119}.
- Gli-B1i*{988}. v: Ghurka{988}; Insignia{988}.
- Gli-B1j*{988}. v: Cluj 650{988}.
- Gli-B1k*{988}. v: Crverkapa{994}; De Carolis{9986}; Kremena{988}; Mentana{9986}.
- Gli-B1l*{988}. v: Avrova{9981}; Clement{991}; Damier{991}; Fiocco{9986}; Kavkaz{9981}.
- Gli-B1l* encodes secalins associated with the 1BL.1RS translocation.
- Gli-B1m*{988}. v: Costantino{9986}; Et.d'Choisy{991}; Pyrotrix 28{988}.
- Gli-B1n*{988}. v: Intensivnaya{988}.
- Gli-B1o*{988}. v: Aragon 03{9985}; Levent{988}; Pippo{9986}; San Rafael{9985}.
- Gli-B1p*{988}. v: Inia 66{9985}; New Pusa 834{988}.
- Gli-B1q*{9986}. v: Gallo{9986}; Goelent{991}; Goya{991}.
- Gli-B1r*{995}. v: Chinook{995}; Gazul{9985}; Sevillano{9985}.
- Gli-B1s*{9986}. v: Salmone{9986}; Resistente{9986}; E.Mottin{9981}.
- Gli-B1t*{9985}. v: Jeja del Pais{9985}.
- Gli-B1u*{9985}. v: Negrillo{9985}.
- Gli-B1v*{9985}. v: Montjuich{9985}.
- Gli-B1w*{9981}. v: Ardica{9981}; Barbilla (MCB-1017){9981}.

- Gli-B1null***{9984,9987,991}. **v:** Touzelle{991}; Florence Aurora{9985}.
 In 112 bread wheat cultivars from Argentina, 12 microsatellite alleles plus a null allele were found at the *Gli-B1* locus tightly linked to *Glu-B3* {03123}.
- Gli-D1***{121,1125}. [*Gld 1D*{1415},*Gld-D1*{420},*Gld-D2*{420},*Gld-D3*{420}].
 1DS{121,150,634,1334,1607}. **s:** CS*/Cheyenne{634}. **v:** CS{121,150,1334,1607}.
- Gli-D1a***{988}. **v:** CS{988}; Marquis{988}; Mentana{9986}; Prinqual{991}; Saratovskaya 36{988}.
- Gli-D1b***{988}. **v:** Bezostaya 1{988}; Cappelle-Desprez{991}; Et.d'Choisy{991}; Galahad{988}.
- Gli-D1c***{988}. **v:** Skorospelka Uluchshennaya (biotype){988,9982}.
- Gli-D1d***{988}. **v:** De Carolis{9986}; Solo{988}.
- Gli-D1e***{988}. **v:** Gerek 79{988}.
- Gli-D1f***{988}. **v:** Carlos{991}; Gabo{988}; Maris Freeman{988}; Orso{9986}.
- Gli-D1g***{988}. **v:** Fournil{991}; Ghurka{988}; Mironovskaya 808{988}; Open{991}.
- Gli-D1h***{988}. **v:** Sadovo I{988}; Zlatostrui{9981}.
- Gli-D1i***{988}. **v:** Insignia{988}; Napayo (biotype){995}; San Rafael{9985}; Tselinogradka{988}.
- Gli-D1j***{988}. **v:** Aubain{991}; Chinook{995}; Inia 66{9985}; Petrel{991}; Promin{988}.
- Gli-D1k***{988}. **v:** Cargimarec{991}; Kremena{988}; Mara{9986}; Pippo{9986}.
- Gli-D1l***{988}. **v:** Artaban{991}; Corin{991}; Longbow{988}.
- Gli-D1m***{991}. **v:** Heurtebise{991}.
- Gli-D1n***{981}. **v:** Blanquillo de Toledo (MCB-0950){9981}.
- Gli-D1null***{9984,9987,991}. **v:** Darius{991}; Touzelle{991}; Saratovskaya 29 (mutant){9987}.
- Gli-Agⁱ1***. 1Agⁱ{168}. **ad:** Vilmorin 27/*Thin. intermedium*.
- Gli-DT1***{02109}. 1DS{02109}. **dv:** AUS18913 *Ae. tauschii*. **v:** L/18913 (synthetic).
 A locus designated *Gli-DT1* controlling an omega-gliadin of *T. tauschii* was mapped on the short arm of chromosome 1D between loci *Gli-D1* (strictly *Gli-D¹*) and *Glu-D1* (strictly *Glu-D¹*), 13.18 cM proximal to the former and 40.20 cM from the latter {02109}. The only omega-gliadin to date identified as being encoded by this locus, namely T1, is of unusually low electrophoretic mobility in SDS-PAGE gels and was formally thought to be a high molecular weight glutenin encoded by the *Glu-D¹* locus of *T. tauschii* (see note following the *Glu-D1* list in section '74.3.1 Glutenins'). The authors speculate that, due to their similar relative map positions, the loci *Gli-A4*, *Gli-D4*, *Gli-R3*, *Gli-S⁴* and this locus, *Gli-DT1*, form a series of '*Gli-4*' orthologous loci. However, this should be interpreted in the light of the above discussion on *Gli-A3* and *Gli-A4*.
- Gli-DT1a***{02109}. T1. **dv:** AUS18913 *Ae. tauschii*. **v:** L/18913 (synthetic).
- Gli-E1***{781}. 1ES{781}. **ad:** CS/*E. elongata*.
- Gli-H¹***{1037}. 1H¹p{1037}. **ad:** CS/*E. trachycaulum*.
 In barley, the B and C hordeins are controlled by the *Hor2* and *Hor1* loci, respectively, which are linked {1341} on chromosome 1HS {1063,1153}. The map distances and homology of the proteins indicate that *Hor1*, the locus closest to the centromere, is equivalent to the omega-gliadins (*Gli-1-1*) in *Gli-1* {1338}.
- Gli-RI***{1334}. [*SecR1*{1356},*Sec1*{1336}]. 1RS{781,1334,1336,1340}. **ad:** CS/Imperial{781,1334,1336,1340}; Holdfast/King II{1334,1340}. **tr:** CS 1DS. Imperial 1RL{1356}.
- Sec-12* and *Sec13* are given as allelic alternatives in 1BL.1RS translocation lines by {03132}.
- Gli-R^m1***{1340}. 1R^mS{1340}. **ad:** CS/*S. montanum*.
- Gli-S¹***{573}. 1S¹{573}. **ad:** CS/*Ae. longissima*.
- Gli-U1***{1335}. 1U{1335,150}. **ad:** CS/*Ae. umbellulata*.
- Gli-V1***{1026,111}. 1V{1026,111}. **ad:** CS/*D. villosum*{1026}; Creso/*D. villosum*{111}.

Three alleles at each of the *Gli-I-1* (omega gliadin) loci were noted {1358}. The complexity of the *Gli-I* compound loci is further emphasized by a report of individual genes being separable by recombination, where *Gld-1A* (a block of gamma and omega genes) is separable by 0.3% from *Gld4-1A* (omega gliadins) which is in turn, separable by 1.5% from *Gld3-1A* (omega gliadins) {1103}.

Elsewhere, variation was described {634,996,1126} and applied in mapping experiments {107,196,422,1120,1125,1243}. Sixteen combinations of *Gli-B1* and 4 combinations of *Gli-D1* subunits are listed in {420}. Multiple alleles described in {996}, number 15 at *Gli-A1*, 18 at *Gli-B1*, and 8 at *Gli-D1*.

The *Gli-I* alleles present in 57 Yugoslav wheat varieties were reported in {994}.

74.3.2.2. Gli-2

Gli-A2{1334,1125}. [*Gld 6A*{1415}]. 6A{1334}.6AS{1122}. v: CS.

Gli-A2a{988}. v: Cabezorro{9985}; CS{988}; Insignia{988}; Rieti DIV{9986}.

Gli-A2b{988}. v: Aradi{9985}; Bezostaya 1{988}; Rivoli{991}; Tiberio{9986}.

Gli-A2c{988}. v: Eagle{00119}; Escualo{9985}; Loreto{9986}; Prinqual{991}; Siete Cerros 66{988}.

Gli-A2d{988}. v: Dneprovskaya 521{988}; Kenyon (biotype){995}; Mocho Sobarriba{9985}.

Gli-A2e{988}. v: Cobra{991}; Mentana{9986}; Resistente{9986}; Sadovo 1{988}; Sevillano{9985}.

Gli-A2f{988}. v: Adalid{9985}; Gala{991}; Maris Freeman{988}; Sistar{9986}.

Gli-A2g{988}. v: Cappelle-Desprez{991}; Ducat{988}; Mahissa 1{9985}; Mara{9986}.

Gli-A2h{988}. v: Apollo{991}; Basalt{9981}; Hereward{988}; Montjuich{9985}; N. Strampelli{9986}.

Gli-A2i{988}. v: Krasnodonka{988}; Lesostepka 75{988}.

Gli-A2j{988}. v: Avalon{9981}; Camp Remy{991}; E. Mottin{9981}; Recital{991}.

Gli-A2k{988}. v: Akmolinka 1{988}; Estica{991}; Pyrotrix 28{988}; Renan{991}; Zena{9986}.

Gli-A2l{988}. v: Chamorro{9985}; Champlein{991}; Longbow{988}.

Gli-A2m{988}. v: Marquis{988}; Rex{991}; Suneca{00119}.

Gli-A2n{988}. v: Mironovskaya 808{988}.

Gli-A2o{988}. v: Calatrava{9985}; Castan{991}; Glenwari{9981}; Lontra{9986}; Touzelle{991}.

Gli-A2p{988}. v: Cajeme 71{9985}; Capitole{991}; Clement{991}; Pliska{988}; S. Lorenzo{9986}; Yecora{9985}.

Gli-A2q{988}. v: Candeal Alcala{9985}; Montcada{9985}; Saratovskaya 39{988}.

Gli-A2r{988}. v: Genial{991}; Open{991}; Riband{988}.

Gli-A2s{988}. v: Saratovskaya 36{998}.

Gli-A2t{988}. v: Courtot{991}; Prostor{9981}; Rinconada{9985}; Soissons{991}.

Gli-A2u{988}. v: Aragon 03{9985}; Kirgizskaya Yubileinaya{988}; Saunders{995}; Titien{991}.

Gli-A2v{988}. v: Kzyl-Bas{988}.

Gli-A2w{988}. v: Bezenchuskaya 98 (biotype){988}.

Gli-A2x{988}. v: Solo{988}.

Gli-A2y{9981}. v: Gentil Rosso 202{9981}; PI 191245{9981}.

Gli-A2z{9986}. v: Gallo{9986}; Giuliana{9986}.

Gli-A2aa{9985}. v: Navarro 122{9985}.

Gli-A2ab{9985}. v: Navarro 150{9985}.

Gli-A2ac{9981}. v: Blanquillo de Barcarrota (MCB-0893){9981}.

- Gli-A2ad*{9981}. v: Hembrilla Soria (MCB-1298){9981}.
Gli-A2ae{9981}. v: Candéal de S.Lorenzo Parrilla (MCB-0932){9981}.
Gli-A2af{9981}. v: Barbilla de Leon (MCB-1292){9981}.
Gli-A2ag{9981}. v: Gluclub{9981}; Tincurrin{9981}.
Gli-A2ah{9981}. v: Candéal de Nava del Rey (MCB-0892){9981}.
Gli-A2ai{9981}. v: Blanquillo (MCB-0908){9981}.
Gli-A2null{9984,9987}. v: Saratovskaya 29 (mutant){9987}.
Gli-B2{1607,1125}. [*Gld 6B*{1415}]. 6B{1607}.6BS{1122}. v: CS.
Gli-B2a{988}. v: CS{988}.
Gli-B2b{988}. v: Bezostaya 1{988}; Cobra{991}; Gladio{9986}; Sideral{991}.
Gli-B2c{988}. v: Courtot{991}; Escuela{9985}; Gabo{988}; Loreto{9986};
 Manital{9986}; Prinqual{991}; Siete Cerros 66{988}; Sinton{995}; Yecora{9985}.
Gli-B2d{988}. v: Akmolinka 1{988}; Cesar{9981}; Friedland{991}; Tselinnaya 20{988}.
Gli-B2e{988}. v: Arsenal{991}; Veronese{9986}; Zlatna Dolina{994}.
Gli-B2f{988}. v: Basalt{9981}; Maris Freeman{988}; Master{991}.
Gli-B2g{988}. v: Capitole{991}; Cappelle-Desprez{991}; Galahad{988}; Forlani{9986}.
Gli-B2h{988}. v: Castan{991}; Mentana{9986}; Pane 247{9985}; Partizanka{994};
 Sadovo 1{988}; Sistar{9986}.
Gli-B2i{988}. v: Insignia{988}; Robin{9981}.
Gli-B2j{988}. v: Farnese{9986}; Funo R250{9986}; Novosadska Rana 1{994}.
Gli-B2k{988}. v: Skala{988}.
Gli-B2l{988}. v: Clement{991}; Longbow{988}; Tracy{991}.
Gli-B2m{988}. v: Mironovskaya 808{988}; Open{991}; Renan{991}.
Gli-B2n{988}. v: Japhet{9981}; Rouge de Bordeau{9981}; Solo{988}.
Gli-B2o{988}. v: Hardi{9981}; Mara{9986}; Odesskaya 16{988}; Pippo{9986};
 Rivoli{991}; Slavjanka{9981}.
Gli-B2p{988}. v: Pliska{983}; Champtal{991}; Oderzo{9986}; Recital{991};
 Gazul{9985}.
Gli-B2q{988}. v: Saratovskaya 39{988}.
Gli-B2r{991}. v: Arminda{991}; Estica{991}; Genial{991}.
Gli-B2s{988}. v: Aquila{9981}; Saratovskaya 36{988}.
Gli-B2t{988}. v: Tselinogradka{988}.
Gli-B2u{988}. v: Kirgizskaya Yubileinaya{988}.
Gli-B2v{988}. v: Declic{991}; Garant{991}; Libellula{9986}; Mahissa 1{9985};
 Poljarka{988}.
Gli-B2w{995,9986}. v: Palata{9986}; Pembina{995}; Rieti DIV{9986}.
Gli-B2x{994}. v: Super Zlatna (biotype){994}; Prostor{9981}; 251/83{9981}.
Gli-B2y{9986}. v: Centauro{9986}; E. Morandi{9986}.
Gli-B2z{9985}. v: Maestro{9985}.
Gli-B2aa{9986}. v: Salmone{9986}; E. Mottin{9981}.
Gli-B2ab{991}. v: Bordier{9981}; Orepi{991}.
Gli-B2ac{991}. v: Scipion{991}; Artaban{991}; Riol{991}; Lontra{9981}.
Gli-B2ad{991}. v: Champion{991}; Chopin{991}.
Gli-B2ae{991}. v: Priam{991}; Et.d'Choisy{991}; Campeador{9985}; Krajinka
 (biotype){994}.
Gli-B2af{9985}. v: Montjuich{9985}; Mocho Sobarriba{9985}.
Gli-B2ag{9981}. v: Jeja del Pais{9985}; Barbilla de Leon (MCB-1292){9981}.
Gli-B2ah{9981}. v: Rojo de Humanes (MCB-1262){9981}; Grano de Miracolo{9981}.
Gli-B2ai{9981}. v: Blanquillo (MCB-0908){9981}.
Gli-B2aj{9981}. v: Negrete de Malaga (MCB-1754){9981}.
Gli-B2ak{9981}. v: HY320{9981}; Leader{9981}.

- Gli-B2al*{9981}. v: Dankowska{991}.
- Gli-B2am*{9981}. v: TM-275{9981}; Uralochka{9981}.
- Gli-B2an*{9981}. v: Eagle{9981}; Glenwari{9981}.
- Gli-B2ao*{9981}. v: Olympic{9981}; Mokoan{9981}.
- Gli-B2ap*{9981}. v: Veda{9981}; Magnif 27{9981}.
- Gli-B2aq*{9981}. v: Winglen{9981}; Isis{9981}.
- Gli-B2ar*{9981}. v: Arbon{9981}; Roazon{9981}.
- Gli-B2as*{9981}. v: Strela{9981}; Sredneuralskaya{9981}.
- Gli-B2at*{9981}. v: Raneë{9981}; Javelin 48{9981}.
- Gli-B2null*{9984,9987}. v: Saratovskaya 29{9987}.
- Gli-D2*{1334,1125}. [*Gld 6D*{1415}]. 6D{1334}.6DS{1122}. v: CS.
- Gli-D2a*{988}. v: CS{988}; Maris Freeman{988}; Sistar{9986}; Tracy{991}.
- Gli-D2b*{988}. v: Bezostaya 1{988}; Cobra{991}; Farnese{9986}; Partizanka{994}.
- Gli-D2c*{988}. v: Escualo{9985}; Eridano{9986}; Rieti DIV{9986}; Siete Cerros 66{988}.
- Gli-D2d*{988}. v: Dneprovskaya 521{988}.
- Gli-D2e*{988}. v: Dollar{9985}; Lada{9981}; Mironovskaya 808{988}; Open{991}.
- Gli-D2f*{988}. v: Creneau{991}; Kirgizskaya Yubileinaya{988}; Rempart{991}.
- Gli-D2g*{988}. v: Capprelle-Desprez{991}; Futur{991}; Galahad{988}; Ghurka{988}; Mec{9986}.
- Gli-D2h*{988}. v: Capitole{991}; Chinook{995}; Eagle{00119}; Garant{991}; Sadovo 1{988}; Thatcher{995}.
- Gli-D2i*{988}. v: Insignia 49{00119}; Lario{9986}.
- Gli-D2j*{988}. v: Arcane{991}; Gallo{9986}; Gazul{9985}; Inia 66{9985}; Mentana{9986}.
- Gli-D2k*{988}. v: Crvencapa{944}; Kzyl-Bas{988}; Skala{988}.
- Gli-D2l*.
Omitted. No reliable differences compared to existing alleles {9981}.
- Gli-D2m*{988}. v: Marquis{988}; Rex{991}; Rinconada{9985}; Suneca{00119}; Veronese{9986}; Yecora{9985}.
- Gli-D2n*{988}. v: Castan{991}; Champlein{991}; Mahissa 1{9985}; Mercia{988}; Pippo{9986}.
- Gli-D2o*{988}. v: Omskaya 12{988}.
- Note: cultivars Salmone and Resistente, which carry *Gli-D2aa* {9981}, were erroneously given as standards for allele *Gli-D2o* in {9986}.
- Gli-D2p*{988}. v: New Pusa {988}.
- Gli-D2q*{988}. v: Cook{9981}; E. Mottin{9981}; Fournil{991}; Volshebnitsa (biotype){988}; Winglen{9981}; Soissons{991}.
- Gli-D2r*{988}. v: Kremena{988}; Mara{9986}; Montcada{9985}.
- Gli-D2s*{988}. v: Akmolinka 1{988}; Bezenchukskaya 98{988}; Selkirk (biotype){995}.
- Gli-D2t*{9986}. v: Golia{9986}; Gabo{9981}; Manital{9986}; Bokal{9981}.
- Gli-D2u*{9986}. v: Loreto{9986}; Martial{991}; Cibalka{9981}.
- Gli-D2v*{991}. v: Epiroux{991}; Arbon{991}.
- Gli-D2w*{9985}. v: Navarro 150{9985}; Javelin{9981}; Hopps{9981}; Canaleja{9985}.
- Gli-D2x*{9985}. v: Montjuich{9985}; Blanquillo{9985}.
- Gli-D2y*{9985}. v: Candeal Alcalá{9985}.
- Gli-D2z*{9985}. v: Aragon 03{9985}.
- Gli-D2aa*{9981}. v: Salmone{9981}; Resistente{9981}.
- Gli-D2ab*{9981}. v: Rojo de Boadilla de Campos (MCB-1031){9981}.
- Gli-D2ac*{9981}. v: Albatros{9981}.
- Gli-D2ad*{9981}. v: Hembrilla Soria (MCB-1298){9981}.

- Gli-D2null***{9984,9987}. **v:** Saratovskaya 29 (mutant){9987}.
- Gli-Ag²***{374}. 6Ag¹{374}. **ad:** Vilmorin 27/ *Thin. intermedium*.
- Gli-R2***{781}. [*Sec 2*{1336}]. 2R{781,1336}.2RS{1340}. **ad:** CS/Imperial{781,1336,1340}; Holdfast/King II{1340}.
- Gli-R2a***{03116}. d1{03116}. **v:** Carnac hexaploid triticales{03116}.
- Gli-R2b***{03116}. d2{03116}. **v:** Mostral hexaploid triticales{03116}.
- Gli-R2c***{03116}. t1{03116}. **v:** Alamo hexaploid triticales{03116}.
- Gli-R2d***{03116}. null{03116}. **v:** Triticor hexaploid triticales{03116}.
- Gli-R2e***{03115}. t2{03115}. **v:** Tornado hexaploid triticales{03115}.
- Gli-R^m2***{1339}. 6R^m{1339,1340}. **ad:** CS/*S. montanum*.
- The location of *Gli-R2* in *S. cereale* is thought to have evolved from *S. montanum* {1339} via a translocation between 2R and 6R {1530}.
- Gli-S²***{573}. 6S¹{573}. **ad,su:** CS/*Ae. longissima*.
- Gli-U2***{1335}. 6U{1335}. **ad:** CS/*Ae. umbellulata*.
- Gli-V2***{111}. 6VS{111}. **ad:** Creso/*D. villosum*.

Prior to the publication of {988}, allelic variation was demonstrated at all of the wheat *Gli-2* loci, including 13 alleles at *Gli-A2*, 11 at *Gli-B2*, and 10 at *Gli-D2*, in a study of 39 cultivars {996}.

The *Gli-2* alleles present in 57 Yugoslav wheat varieties were determined {994}.

74.3.2.3. *Gli-3*

A *Gli-3* set of loci coding for omega-type gliadins are located 22 to 31cM proximal to *Gli-1* on the short arms of group 1 chromosomes {422,1403,589}.

- Gli-A3***{1403,1119}. [*Gld-2-1A*{1416}]. 1AS{1403}. **v:** Bezostaya 1.
- Each of the following *Gli-A3* alleles, apart from *Gli-A3d*, which is a null, controls one minor omega-gliadin with molecular mass about 41k that occurs in the middle of the omega-region of APAGE fractionation. Gliadins controlled by these alleles differ in their electrophoretic mobility in APAGE in that the fastest of three known *Gli-A3*-gliadins is controlled by *Gli-A3a* and the slowest by *Gli-A3c* {9983}.
- Gli-A3a***{9983}. **v:** CS, Prinqual, Courtot, Tselinogradka, Bezenchukskaya 98.
- Gli-A3b***{9983}. **v:** Bezostaya 1.
- Gli-A3c***{9983}. **v:** Anda.
- Gli-A3d***{9983}. Null{9983}. **v:** Saratovskaya 210, Kharkovskaya 6, Richelle.
- Gli-B3***{422,1119}. [*Gld-B6*{422},*Glu-B2*{589}]. 1BS{422,589}. **s:** CS*/Thatcher{422}. **v:** Sicco{589}.
- Gli-B3a***{422,589,1119}. **v:** CS.
- Gli-B3b***{589}. **v:** Sicco.
- Gli-B3c***{422,1119}. **s:** CS*/Thatcher.
- Gli-R3***{164}. 1RS{164}. **al:** Four inbred lines (R2, J14, 8t, E2666).
- Gli-S³***{1228}. 1S¹S{1228}. **ad,su:** CS/*Ae. longissima*. **ma:** In *Ae. longissima 2/Ae. longissima 10*, three gliadin loci, one glucose phosphate isomerase, and two glutenin loci were mapped relative to one another {1228} as follows: *Glu-S¹* 15.9 cM - *Gpi-S¹* - 38 cM - *Gli-S⁴* - 7.1 cM - *Glu-S³* - 0.9 cM - *Gli-S¹* - 5.6 cM - *Gli-S⁵*. *Glu-S¹* is located in 1S¹L and the other loci are in 1S¹S.
- Gli-V3***{111}. 4VL{111}. **ad:** Creso/*D. villosum*.

74.3.2.4. *Gli-4*

It is not clear how *Gli-S⁴* and *Gli-S⁵* relate to the *Gli-4* and *Gli-5* sets described below.

Gli-A4{1205}. 1AS{1205}. v: Perzivan biotype 2.

A locus designated *Gli-A4* controlling omega-gliadins was mapped at 10 cM proximal to *Gli-A1* on the short arm of chromosome 1A {1205}.

However, Metakovsky *et al.* {9983} have since shown that this locus and *Gli-A3* are, in fact, the same locus. Furthermore, Dubcovsky *et al.* {277} did not find evidence for the simultaneous presence of both *Gli-A3* and *Gli-A4* in five 1A or 1A^m mapping populations and concluded that *Gli-A4* should be considered to be *Gli-A3* until conclusive evidence for the former is obtained. For these reasons, the locus *Gli-A4* is deleted from the catalogue.

74.3.2.5. *Gli-5*

A locus designated *Gli-5* controlling omega-gliadins was mapped to the short arms of chromosomes 1A and 1B, distal to *Gli-1* {1147}. The map distance between *Gli-B5* and *Gli-B1* was estimated as 1.4 cM (recombination value of 1.4 +/- 0.4%), although there was significant variation in recombination values over crosses, ranging from 0 % to 5.9 % over the six crosses analysed. This variation was attributed to genotypic influence on the frequency of recombination.

Gli-A5{1147}. 1AS{1147}. v: Salmone.

Gli-A5a{9983}. Null{9983}. v: CS.

Gli-A5b{9983}. v: Marquis.

Allele *Gli-A5b* controls two slow-moving, easily-recognizable omega-gliadins. It is present in all common wheat cultivars having alleles *Gli-A1m* and *Gli-A1r* (and, probably, in those having *Gli-A1e*, *Gli-A1l* and *Gli-A1q*), because earlier (for example, in {988}) two minor omega-gliadins encoded by *Gli-A5b* were considered to be controlled by these *Gli-A1* alleles {9983}.

Gli-B5{1147}. 1BS{1147}. v: Salmone.

Gli-B5a{1147}. v: CS.

Gli-B5b{1147}. v: Salmone.

In {988}, omega-gliadins controlled by *Gli-B5* (allele *Gli-B5b*) were attributed to alleles at the *Gli-B1* locus (alleles *Gli-B1c*, *i*, *k*, *m*, *n* and *o*).

74.3.2.6. *Gli-6*

Gli-A6{9983,993}. 1AS{9983}.

Gli-A6 was first explicitly described in {9983}, but it is now known that it was first observed without designation in {993}. There is strong evidence that it is distinct from *Gli-A3* and *Gli-A5*, mapping distally to *Gli-A1*, with which it recombines at a frequency of 2-5%. Currently three alleles are known, of which *Gli-A6c* is particularly well-described in {9983}: the molecular mass of the omega-gliadin controlled by this allele is slightly lower than those of the omega-gliadins controlled by *Gli-A3* alleles. In {988}, the omega-gliadin controlled by *Gli-A6c* was attributed to *Gli-A1f*. *Gli-A6c* is rather frequent in common wheat and may relate to dough quality (preliminary data {9983}). *Gli-A6a* is null {9983}.

Gli-A6a{9983}. Null{9983}. v: CS, Bezostaya 1.

Gli-A6b{9983}. v: Bezenchukskaya 98.

Gli-A6c{9983}. v: Courtot, Anda, Mironovskaya 808.

Four new classes of low molecular weight proteins related to gliadins, though not sufficiently similar to be classified as such, have been reported in {02113}. One of the classes has no close association to previously described wheat endosperm proteins.

74.3.3. Other endosperm storage proteins

Triticin proteins {1360} [Triplet proteins {1357}].

Storage globulins with homology to pea legumins and related proteins in oats, rice and several dicotyledonous species {1360}.

Tri-A1{1357},{1358}. 1AS{1357}. **v:** CS.

Tri-A1a. [cs{1358}]. **v:** CS.

Tri-A1b. [h{1358}]. **v:** Hope.

Tri-D1{1357},{707,1358}. 1DS{1357}. **v:** CS.

Tri-D1a. [cs{1358}]. **v:** CS.

Tri-D1b. [i{1358}]. **v:** India 115.

74.4. Enzyme Inhibitors

74.4.1. Trypsin inhibition

Ti-H1. [*Itc 1*{528}]. 3H{528}. **ad:** CS/Betzes.

Ti-R1. 3R{529}. **ad:** CS/Imperial.

Ti-A2{699}. 5AL{699}. **v:** CS.

Ti-B2{699}. 5BL{699}. **v:** CS.

Ti-D2{699}. 5DL{699}. **v:** CS.

Ti-D2a{699}. **v:** CS.

Ti-D2b{699}. **v:** Champlein.

Ti-D2c{699}. **v:** Synthetic.

Ti-Agⁱ2{699}. 5Agⁱ{699}. **ad:** Vilmorin 27/ *Thin. intermedium*.

Ti-M^t2{699}. 5M^t{699}. **ad:** CS/*Ae. mutica*.

Ti-R2{699}. 5RL{699}. **ad:** CS/Imperial. **su:** CS/King II.

Ti-S^l2{699}. 5S^l{699}. **ad:** CS/*Ae. sharonensis*.

Ti-U2{699}. 1U{699}. **ad:** CS/*Ae. umbellulata*.

74.4.2. Subtilisin inhibition

Si-R1{529}. 2R{529}.2RS{701}. **ad:** CS/Imperial, Holdfast/King II.

Si-H1{528}. [*Isa 1*{528}]. 2H{528}. **ad:** CS/Betzes.

Si-B2{701}. 1BS{701}. **su:** Bersee {Koga II}.

Si-D2{701}. 1DS{701}. **v:** Koga II.

Si-H2{528},{701}. [*Ica 1*{528},*Ica 2*{528}]. 1H{528}. **ad:** CS/Betzes.

Si-R2{529},{701}. 1R{529}.1RS{701}. **ad:** CS/Imperial{529}. **tr:** Gabo 1BL.1RS{701}.

Si-S^l2{701}. 1S^l{701}. **ad:** CS/*Ae. longissima*.

Si-U2{701}. 1U{701}. **ad:** CS/*Ae. umbellulata*.

Considerable genetic variation for *Si-2* was noted in {701}. A chromosome location for *Si-H2* on 1HL was inferred in {528} but questioned in {701}.

Three subunits of the wheat tetrameric inhibitor of insect α -amylase, CM1, CM3 and CM16, with homology to the dimeric and monomeric α -amylase inhibitors and the trypsin inhibitors, were located by Southern analysis of cDNAs pCT1, pCT2, and pCT3 to 4A, 4B, 4D; 7A, 7B, 7D; and 4A, 4B, 4D, respectively {427}.

Genes encoding proteins which inhibit the action of mammalian and insect, but not cereal, α -amylases, were located in chromosomes 3BS, 3DS and 6DS of Chinese Spring {1260}. Also,

genes encoding inhibitors of insect α -amylases were located in *H. chilense* chromosomes 4H^{ch} and 7H^{ch} {1262}.

74.4.3. Inhibitors of alpha-amylase and subtilisin

Isa-AI{908}. 2AL{908}. **v**: CS.

Isa-A1a{908}. **v**: CS.

Isa-A1b{908}. Null allele. **v**: Cajeme 71.

Isa-BI{908}. 2BL{908}. **v**: CS.

Isa-B1a{908}. **v**: CS.

Isa-B1b{908}. **v**: Bihar.

Isa-DI{908}. 2DL{908}. **v**: CS.

Orthologous genes were identified in *Ae. speltooides* and *T. timopheevii* {908}. All durum wheats investigated had the genotype *Isa-A1b*, *Isa-B1b*.

74.4.4. Inhibitors (dimeric) of heterologous alpha-amylases

Chromosome 3BS has duplicated loci controlling two dimeric inhibitors of exogenous α -amylases, one known as 0.53 or Inh I {1260}, and the other as WDA I-3 {1260}.

Chromosome 3DS has a homoeologous locus controlling a dimeric inhibitor of exogenous α -amylases, known as 0.19 or Inh III {1260,0124}, that is closely related to 0.53/Inh I.

Intervarietal polymorphism for the WDA-3 protein was identified by isoelectric focussing of water-soluble endosperm proteins {0124}. This was interchromosomely mapped on 3BS using both a DH population of Cranbrook/Halberd, and a set of RILs of Opata 85/W-7984 (ITMI population) {0125}.

Iha-B1.1{1260}. 3BS{1260}. **v**: CS{1260}.

Iha-B1.2{0124}. 3BS{0124}. **v**: CS{0124}.

Iha-B1.2a{0124}. **v**: CS{0124,0125}.

Iha-B1.2b{0125}. Null allele. **v**: Cadoux{0125}; Cranbrook{0125}; Tasman{0125}.

Iha-DI{1260}. 3DS{1260}. **v**: CS{1260}.

74.5. Other proteins

74.5.1. Lipopurothionins

Pur-AI{351}. 1AL{351}. **v**: CS{351}.

A PCR marker specific for *Pur-AI* was developed in {9976}.

Pur-BI{351}. 1BL{351}. **v**: CS{351}.

A PCR marker specific for *Pur-BI* was developed in {9976}.

Pur-DI{351}. 1DL{351}. **v**: CS{351}.

A locus in chromosome 5DS affects the level of lipopurothionin {351}.

PCR marker specific for *Pur-DI* was developed in {9976}.

Pur-RI. 1RL{1261}.=IRS,1BL. **ad**: CS/Imperial. **su**: Several 1R(1B) lines. **tr**: Aurora, Kavkaz.

A PCR marker specific for *Pur-RI* was developed in {9976}.

74.5.2. Lectins

Lec-AI. 1AL{1427}. **v**: CS.

Lec-BI. 1B{1427}. **s**: CS*/Hope 1B.

Lec-DI. 1DL{1427}. **v**: CS.

Lec-UI. 1U{1427}. **ad:** CS/*Ae. umbellulata*.

74.5.3. Iodine binding factor

A monomeric water soluble protein from mature grain which preferentially binds iodine {818}.

- Ibf-A1*{818}. 5AL{818}. **v:** CS.
Ibf-A1a{818}. **v:** CS.
Ibf-A1b{818}. **v:** Cappelle-Desprez.
Ibf-A1c{818}. **v:** Hope.
Ibf-A1d{818}. **v:** Chris.
Ibf-A1e{818}. **v:** Sears' Synthetic.
Ibf-B1{818}. 5BL{818}. **v:** CS.
Ibf-B1a{818}. **v:** CS.
Ibf-B1b{818}. **v:** Cappelle-Desprez.
Ibf-B1c{818}. **v:** Ciano 67.
Ibf-B1d{818}. **v:** Sears' Synthetic.
Ibf-D1{818}. 5DL{818}. **v:** CS.
Ibf-D1a{818}. **v:** CS.
Ibf-D1b{818}. **v:** Cappelle-Desprez.
Ibf-D1c{818}. **v:** Purple Pericarp.
Ibf-D1d{818}. **v:** Sears' Synthetic.
Ibf-Agⁱ1{818}. 5Agⁱ{818}. **ad:** Vilmorin/*Thin. intermedium*.
Ibf-E1{818}. 5EL{818}. **ad:** CS/*E. elongata*.
Ibf-H1{818}. 4H{818}. **ad:** CS/Betzes.
Ibf-R1{818}. 5RL{818}. **ad:** CS/Imperial, CS/KingII.
Ibf-S^l1{818}. 5S^l{818}. **ad:** CS/*Ae. sharonensis*.
Ibf-UI{818}. 5U{818}. **ad:** CS/*Ae. umbellulata*.

74.5.4. Water soluble proteins

WSP-1 are monomeric grain endosperm proteins identified by their high pI's {817}.

- Wsp-A1*{817}. 7AL{817}. **v:** CS.
Wsp-A1a{817}. **v:** CS.
Wsp-A1b{817}. **v:** Huntsman.
Wsp-A1c{817}. **v:** Hope.
Wsp-A1d{817}. **v:** Sicco.
Wsp-A1e{817}. **v:** Condor.
Wsp-B1{817}. 7BL{817}. **v:** CS.
Wsp-B1a{817}. **v:** CS.
Wsp-B1b{817}. **v:** Hope.
Wsp-B1c{817}. **v:** Condor.
Wsp-D1{817}. 7DL{817}. **v:** CS.
Wsp-D1a{817}. **v:** CS.
Wsp-D1b{817}. **v:** Sears' Synthetic IPSR 1190903.
Wsp-D1c{893}. **v:** T4 = Agatha{893,890}; Indis{890,892}.
Wsp-E1{817}. 7E{817}. **ad:** CS/*E. elongata*.
Wsp-H1{817}. 7H{817}. **ad:** CS/Betzes.
Wsp-H^{ch}1{817}. 7H^{ch}{817}. **ad:** CS/*H. chilense*.
Wsp-S^l1{817}. 7S^l{817}. **ad:** CS/*Ae. sharonensis*.
Wsp-V1{817}. 7V{817}. **ad:** CS/*D. villosum*.

74.5.5. Salt soluble globulins

GLO-1 are endosperm proteins (23-26 kDa) soluble in salt but not in water {455}.

Glo-AI{455}. 1AS{455}. **v:** CS. **ma:** Distally located: *Glo-AI*(distal) - 5.2cM - *Gli-AI*{1077}.

Glo-BI{455}. 1BS{455}. **v:** CS.

Glo-DI{455}. 1DS{455}. **v:** CS. **ma:** Distally located: *Glo-DI*(distal) - 2.9cM - *Gli-DI*{1077}.

Glo-EI{455}. 1ES{455}. **ad:** CS/*E. elongata*.

Glo-RI{455}. 1RS{455}. **ad:** CS/Imperial. **su:** 1B/(1R), eg., Salzmunde 14/44.

74.5.6. Waxy proteins

Waxy protein (granule-bound starch synthase = ADP glucose starch glycosyl transferase, EC 2.4.1.21 = GBSSI) is tightly bound within endosperm starch granules and is involved in the synthesis of amylose {1616}. Waxy variants, characterised by starch granules containing increased amylopectin and reduced amylose, are preferred for Japanese white salted or "udon" noodles {1650}. Similar waxy phenotypes are controlled by orthologous genes in barley, maize and rice but are not known to occur in rye {725}. All combinations of the null alleles were produced in Chinese Spring {0018}. Partial genomic clones of various diploid, tetraploid, and hexaploid wheats were sequenced {0278,0279}.

Wx-AI{180,1053}. [*Xwx-7A*{179,180}, *Wx-BI*{1053,1054}]. 7AS{180,1053}. **v:** CS. **ma:** Variation in the microsatellite gene *Xsun1-7A* provides a co-dominant marker for this locus{0116}.

Wx-AIa{1054}. [*Wx-BIa*{1054}]. **v:** CS; Hoshuu.

Wx-AIb{1054}. [*Wx-BIb*{1054}]. Null allele. **v:** Kanto 79; Kanto 107

Shirodaruma{1617}; Sturdy{1617}. **tv:** Asrodur{0111}; MG826{03101}; A variant allele was present in one Iranian and one Italian accession{03101}.

Wx-AIc{1617}. **v:** QT105{1617}; WB6{1617}.

Wx-AId{1616}. **tv:** *T. dicoccoides* KU 8937B{1616}.

Wx-AIe{1616}. **tv:** *T. durum* KU 3655 and KU 3659{1616}.

The complete genomic sequences for the *Wx-AIa* allele from CS {0073} and the cDNA sequence for the *Wx-AIb* allele from Kanto 107 {0075} were determined.

Wx-BI{180,1053}. [*XWx-4B*{179,180}, *XWx-4A*{961}, *Wx-AI*{1053,1054}]. 4AL{180,1054}. **v:** CS. **tv:** A variant allele was present in three accessions{03101}.

Wx-BIa{1054}. [*Wx-AIa*{1054}]. **v:** CS; Joshuu.

The complete genomic sequence for *Wx-BIa* from CS was determined {0073}.

Wx-BIb{1054}. [*Wx-AIb*{1054}]. Null allele. **v:** Kanto 79; Kanto 82; Kanto 107; Norin 98; Gabo{1617}; Satanta{1617}; For list of Australian wheats, see{1650}. **tv:**

Blaquetta (BG-13701){0111}.

Wx-BIc{1617}. **v:** Cikataba{1617}; Junbuk 12{1617}.

Wx-BId{1616}. **tv:** *T. durum* KU 4213D{1616}; KU 4224C{1616}.

Wx-BIe{0027}. **v:** Blue Boy II{0027}; Canthatch{0027}; Eureka{0027}; Gotz{0027}; Norin 44{0027}; Turkey Red{0027}.

Wx-BIf{0111}. **tv:** BG-12413{0111}; BG-12415{0111}.

Wx-DI{180,1053}. [*XWx-7D*{179,180}]. 7DS{180,1053}. **v:** CS.

Wx-DIa{1054}. **v:** CS.

Wx-DIb{1617}. Null allele. **v:** Bai Huo (Baihuomai){1617}. **ma:** DHWx12 {0117}; STS marker *Xsun1-7D* produces a distinct band of about 260bp (compared with the

standard 840bp), indicative of a smaller PCR product, but the gene is non-functional{0116,0117}; *Xsun4(Wx)-7D* is a perfect marker{0118}.

Wx-D1c{1617}. v: Scoutland{1617}.

Wx-D1d{0118}. v: K107wx1{0118}; EMS mutants{0118}; One Iranian and one Italian accession{03101}.

Wx-D1e{0117}. Null allele{0117}. v: NP150{0117}.

STS marker *Xsun1-7D* fails to produce a PCR product {0117}

Wx-D1f. [*Wx-d1e*{0234}]. v: Tanikei A6599-4{0234}; Relative to Kanto 107, Tanikei A6599-4 carries an alanine to threonine substitution at position 258 in the mature protein{0234}.

Various hard and soft wheats with the alleles *Wx-A1b*, *Wx-B1b* and *Wx-D1b* are listed in {0304}.

Lists of cultivars, lines and landraces of tetraploid and hexaploid wheats with different, mostly null, alleles at the *Wx* loci are given in {9910,9911,9912,1053,1054,9913,9915,9916,1650,9917}.

The complete genomic sequence for *Wx-D1a* from CS {0073} and the cDNA sequence for the *Wx-D1b* allele from Bai Huo {0075} were determined.

Isolation of a wheat cDNA encoding *Wx-A1* and *Wx-D1* was reported in {0123} and {0167}, respectively. Isolation of genomic sequences for the genes encoding granule-bound starch synthase (*GBSSI* or *Wx*) in *T. monococcum*, *Ae. speltoides* and *T. tauschii* was reported in {0168}. Cloning of a second set of *GBSSI* or *waxy* genes, *GBSSII*, which were shown to be located on chromosomes 2AL, 2B and 2D, was reported in {0167}.

Various hard and soft wheats with the alleles *Wx-A1b*, *Wx-B1b* and *Wx-D1b* are listed in {0304}.

74.5.7. Starch granule proteins

The proteins, designated SGP-1, are starch synthases, encoded by *SsII-A1*, *SsII-B1* and *SsII-D1* {0042}.

Sgp-A1{1615}. 7AS{1615}. v: CS.

Sgp-A1a{1615}. v: CS.

Sgp-A1b{1615}. Null allele. v: Chosen 30, Chosen 57.

Sgp-A1c{1615}. v: Hua Non 9.

Sgp-B1{1615}. 7BS{1615}. v: CS.

Sgp-B1a{1615}. v: CS.

Sgp-B1b{1615}. Null allele. v: K79.

Sgp-B1c{1615}. v: Gnatruche.

Sgp-B1d{1615}. v: Waratah.

Sgp-D1{1615}. 7DS{1615}. v: CS.

Sgp-D1a{1615}. v: CS.

Sgp-D1b{1615}. Null allele. v: T116.

Sgp-A2{1615}. v: CS.

Sgp-B2{1615}. v: CS.

Sgp-D2{1615}. v: CS.

Sgp-A3{1615}. 7AS{1615}. v: CS.

Sgp-A3a{1615}. v: CS.

Sgp-A3b{1615}. Null allele. v: Norin 61.

Sgp-B3{1615}. 7BS{1615}. v: CS.

Sgp-B3a{1615}. v: CS.

Sgp-B3b{1615}. Null allele. v: Crest.

Sgp-B3c{1615}. v: Spica.

Sgp-D3{1615}. 7DS{1615}. **v**: CS.

The proteins, designated SGP-3, are identical to wheat starch synthase I, encoded by *SsI-A1*, *SsI-A2* and *SsI-D1* {0041}.

A triple null stock (SGP-1 null wheat) is reported in {0137}. Deletion mapping indicated that the gene order on the 7S arms is; centromere - *Sgp-1* - *Sgp-3* - *Wx*{1615}.

74.5.8. Puroindolines and grain softness protein

Puroindolines a and b are the major components of friabilin, a protein complex that is associated with grain texture (see 'Grain Hardness'). The name 'puroindoline' and the complete amino acid sequence of puroindoline a were given in {0382} from cv Camp Remy. Hard grain texture in hexaploid wheat results from unique changes in the puroindoline amino acid sequence or, currently, four null forms {0295} of the completely linked genes (max. map distance 4.3 cM) {452}. Tetraploid (AABB, AAGG) wheats lack puroindolines and are consequently very hard {03103}. A searchable database of wheat varieties and their puroindoline genotype is available at <http://www.wsu.edu/~wwql/php/puroindoline.php>. Grain softness protein-1 is a closely related gene which is closely located to the puroindoline genes {03111,1185}. 'GenBank' and 'dbEST' refer to sequence databases available at NCBI (also available through EMBL and DDB).

Pina-A1{03103,03108,03104}. **dv**: *T. urartu* unspecified accession {03103}; TA763(GenBank AJ302094){03108,03104}; TA808(GenBank AJ302095){03108,03104}.

Pina-D1{452}. 5DS{452}. **v**: CS.

Pina-D1a{452}. **v**: Bellevue{0249}; Courtot{0249}; Fortuna{0249}; Galaxie{0249}; Heron{1035}; Soissons{0249}. **v2**: Aurelio *Pinb-D1a*{0249}; Bezostaja *Pinb-D1b*{0249}; Bilancia *Pinb-D1a*{0249}; Bolero *Pinb-D1a*{0249}; Brasilia *Pinb-D1b*{0249}; Centauro *Pinb-D1a*{0249}; Cerere *Pinb-D1b*{0249}; CS *Pinb-D1a*{452,0249}; Colfiorito *Pinb-D1b*{0249}; Cologna 21 *Pinb-D1b*{0249}; David *Pinb-D1b*{0249}; Democrat *Pinb-D1b*{0249}; Etruria *Pinb-D1b*{0249}; Francia *Pinb-D1b*{0249}; Gemini *Pinb-D1b*{0249}; Genio *Pinb-D1b*{0249}; Gladio *Pinb-D1b*{0249}; Lampo *Pinb-D1a*{0249}; Leone *Pinb-D1a*{0249}; Leopardo *Pinb-D1a*{0249}; Libero *Pinb-D1a*{0249}; Livio *Pinb-D1a*{0249}; Marberg *Pinb-D1b*{0249}; Mentana *Pinb-D1a*{0249}; Mieti *Pinb-D1b*{0249}; Mose *Pinb-D1a*{0249}; Neviana *Pinb-D1a*{0249}; Newana *Pinb-D1b*{0249}; Oscar *Pinb-D1a*{0249}; Pandas *Pinb-D1b*{0249}; Pascal *Pinb-D1b*{0249}; Penawawa *Pinb-D1a*{03104}; Sagittario *Pinb-D1b*{0249}; Salgemma *Pinb-D1b*{0249}; Saliente *Pinb-D1b*{0249}; Salmone *Pinb-D1b*{0249}; Serena *Pinb-D1a*{0249}; Serio *Pinb-D1b*{0249}; Veda *Pinb-D1b*{0249}; Zena *Pinb-D1b*{0249}. **dv**: *Ae. tauschii* unspecified accession (GenBank AJ249935){03103}; TA1583 (GenBank AY252029) *Pinb-D1a*, *Gsp-D1b*{03105}; TA2475 (GenBank AY252037) *Pinb-D1i*, *Gsp-D1b*{03105}; TA1599 (GenBank AY252011) *Pinb-D1j*, *Gsp-D1g*{03105}; TA1691 (GenBank AY252013) *Pinb-D1j*, *Gsp-D1h*{03105}.

Pina-D1a is present in all soft hexaploid wheats and possibly all hard hexaploid wheats that carry a hardness mutation in puroindoline b {452,1035,0082,0204,0295}.

Pina-D1b{1035}. Null allele. **i**: Falcon/7*Heron, Heron/7*Falcon{03109}; Gamenya sel.{0298,0203}; Heron/7*Falcon sel.{0298,0203}. **v**: Butte 86{1035}; Eridano{0249}; Falcon{1035}; Kalyansona{0249}; Super X{0249}; Yecora Rojo{0204}. **v2**: Amidon *Pinb-D1a*{0249}; Ciano *Pinb-D1a*{0249}; Dorico *Pinb-D1a*{0249}; Fortuna (USA) *Pinb-D1a*{0249}; Glenman *Pinb-D1a*{0249}; Golia *Pinb-D1a*{0249}; Guadalupe *Pinb-D1a*{0249}; Barra *Pinb-D1a*{0249}; Inia 66 *Pinb-D1a*{0249}; Indice *Pinb-D1a*{0249}; Jecora *Pinb-D1a*{0249}; Manital *Pinb-D1a*{0249}; Mendos *Pinb-D1a*{0249}; Padus *Pinb-D1a*{0249}; Prinquall *Pinb-D1a*{0249}; Sibilina *Pinb-D1a*{0249}.

- Present only in some hard hexaploid wheats. *Pina-D1b* is associated with harder texture than *Pinb-D1b* {0177,0206}.
- Pina-D1c***{03105}. **dv:** *Ae. tauschii* TA2369 (GenBank AY252031) *Pinb-D1h*, *Gsp-D1c*; TA2527 (GenBank AY252015) *Pinb-D1h*, *Gsp-D1e*; TA2536 (GenBank AY251998) *Pinb-D1i*, *Gsp-D1d*{03105}.
- Pina-D1d***{03105}. **dv:** *Ae. tauschii* PI452131 (GenBank AJ302098) *Pinb-D1i*{03104}; PI554318 (GenBank AJ302099) *Pinb-D1k*{03104}; TA1649 (GenBank AY251963) *Pinb-D1h*, *Gsp-D1f*{03105}; TA2374 (GenBank AY251948) *Pinb-D1i*, *Gsp-D1d*{03105}; TA2521 (GenBank AY252042) *Pinb-D1i*, *Gsp-D1e*{03105}; TA2455 (GenBank AY252022) *Pinb-D1i*, *Gsp-D1f*{03105}.
- Pina-D1e***{03105}. **dv:** *Ae. tauschii* TA2458 (GenBank AY252034) *Pinb-D1i*, *Gsp-D1d*{03105}; TA2495 (GenBank AY252041) *Pinb-D1i*, *Gsp-D1e*{03105}.
- Pina-D1f***{03105}. **dv:** *Ae. tauschii* TA2436 (GenBank AY251998) *Pinb-D1i*, *Gsp-D1d*{03105}.
- Pina-A^mI***{0083}. 5A^mS{0083}. **dv:** *T. monococcum* DV92(cultivated), G3116 (spp. *aegilopoides*) (GenBank AJ242715){0083}; unspecified accession (GenBank AJ249933){03103}; PI277138 (GenBank AJ302093){03104}; PI418582 (GenBank AJ302092){03104}; *T. monococcum* spp. *monococcum* TA2025, TA2026, TA2037{03108}; *T. monococcum* spp. *aegilopoides* TA183, TA291, TA546, TA581{03108}.
In *T. monococcum* *Pina-A^mI* is completely linked to *Gsp-A^mI*{0083}.
- Pina-SI***{03108}. **dv:** *Ae. speltoides* PI393494 (GenBank AJ302096){03104}; PI369616 (GenBank AJ302097){03104}; *Ae. speltoides* spp. *speltoides* TA2368, TA1789{03108}; *Ae. speltoides* spp. *ligustica* TA1777{03108}.
- Pina-S^bI***{03108}. **dv:** *Ae. bicornis* spp. *typica* TA1954, TA1942{03108}.
- Pina-S^lI***{03108}. **dv:** *Ae. longissima* spp. *longissima* TA1912{03108}; *Ae. longissima* spp. *nova* TA1921{03108}.
- Pina-S^sI***{03108}. **dv:** *Ae. searsii* TA1837, TA1355{03108}.
- Pina-S^{sh}I***{03108}. **dv:** *Ae. sharonensis* TA1999{03108}.
- Pinb-AI***{03108,03104}. **dv:** *T. urartu* TA763 (GenBank AJ302103){03104}; TA808 (GenBank AJ302104){03108,03104}.
- Pinb-DI***. 5DS{452}. **v:** CS{452}; Capitole (GenBank X69914){03110}.
- Pinb-D1a***{452}. **v:** Hill 81{452}. **v2:** Adder *Pina-D1a*{0317}; Amidon *Pina-D1b*{0249}; Aurelio *Pina-D1a*{0249}; Barra *Pina-D1b*{0249}; Bilancia *Pina-D1a*{0249}; Bolero *Pina-D1a*{0249}; Centauro *Pina-D1a*{0249}; CS *Pina-D1a*{452,0249}; Ciano *Pina-D1b*{0249}; Dorico *Pina-D1b*{0249}; Fortuna (USA) *Pina-D1b*{0249}; Glenman *Pina-D1b*{0249}; Golia *Pina-D1b*{0249}; Guadalupe *Pina-D1b*{0249}; Inia 66 *Pina-D1b*{0249}; Jecora *Pina-D1b*{0249}; Idice *Pina-D1b*{0249}; Karl *Pina-D1a*{0317}; Lampo *Pina-D1a*{0249}; Leone *Pina-D1a*{0249}; Leopardo *Pina-D1a*{0249}; Libero *Pina-D1a*{0249}; Livio *Pina-D1a*{0249}; Manital *Pina-D1b*{0249}; Mendos *Pina-D1b*{0249}; Mentana *Pina-D1a*{0249}; Mose *Pina-D1a*{0249}; Neviano *Pina-D1a*{0249}; Oscar *Pina-D1a*{0249}; Padus *Pina-D1b*{0249}; Penawawa *Pina-D1a*{03104}; Prinqual *Pina-D1b*{0249}; Serena *Pina-D1a*{0249}; Sibilina *Pina-D1b*{0249}; Sigyn II *Pina-D1a*{0317}. **dv:** *Ae. tauschii* unspecified accession (GenBank AJ249936){03103}; TA1583 (GenBank AY251981) *Pina-D1a*, *Gsp-D1b*{03105}.
Pinb-D1a is present in all soft hexaploid wheats and possibly all hard hexaploid wheats carrying the *Pinb-D1b*, *-D1c*, *-D1d*, *-D1e*, or *-D1f* mutations {452,1035,0082,0204,0295}.
- Pinb-D1b***{452}. 5DS{452}. **v:** Thatcher{0204}; Wanser{452}; hard component of Turkey{0204}. **i:** Paha^{*}2/Early Blackhull/5^{*}Paha{0298,0203}; Early Blackhull der./5^{*}Nugaines sel.{0298,0203}; hard sib sel. from Weston{03107}. **s:** CS^{*}7/Cheyenne 5D{452}. **v2:** Bastion *Pina-D1a*{0317}; Bezostaya *Pina-D1a*{0249};

Brasilia *Pina-D1a*{0249}; Cerere *Pina-D1a*{0249}; Colfiorito *Pina-D1a*{0249};
Cologna 21 *Pina-D1a*{0249}; David *Pina-D1a*{0249}; Democrat *Pina-D1a*{0249};
Etruria *Pina-D1a*{0249}; Francia *Pina-D1a*{0249}; Gemini *Pina-D1a*{0249}; Genio
Pina-D1a{0249}; Gladio *Pina-D1a*{0249}; Marberg *Pina-D1a*{0249}; Mieti *Pina-*
D1a{0249}; Newana *Pina-D1a*{0249}; Pandas *Pina-D1a*{0249}; Pascal *Pina-*
D1a{0249}; Sagittario *Pina-D1a*{0249}; Salgemma *Pina-D1a*{0249}; Saliente *Pina-*
D1a{0249}; Salmone *Pina-D1a*{0249}; Serio *Pina-D1a*{0249}; Veda *Pina-D1a*{0249};
Zena *Pina-D1a*{0249}.

Pinb-D1b is a "loss-of-function" mutation resulting from the replacement of a glycine by a serine at position 46 {452}.

Pinb-D1c{0082}. **v:** Avle{0082}; Bjorke{0082}; Portal{0082}; Reno{0082}; Tjalve{0082}.

Pinb-D1c is a "loss-of-function" mutation resulting from the replacement of a leucine by a proline at position 60 {0082}.

Pinb-D1d{0082}. **v:** Bercy{0082}; Mjolner{0082}.

Pinb-D1d is a "loss-of-function" mutation resulting from the replacement of a tryptophan by an arginine at position 44 {0082}.

Pinb-D1e{0204}. **v:** Gehun{0204}; Canadian Red{0204}; Chiefkan{0204}.

Pinb-D1e is a "loss-of-function" mutation resulting from the replacement of a tryptophan by a stop codon at position 39 {0204}.

Pinb-D1f{0204}. **v:** the hard component of Utac{0204}.

Pinb-D1f is a "loss-of-function" mutation resulting from the replacement of a tryptophan by a stop codon at position 44 {0204}.

Pinb-D1g{0204}. **v:** Andrews{0204}.

Pinb-D1g is a "loss-of-function" mutation resulting from the replacement of a cysteine by a stop codon at position 56 {0204}.

Pinb-D1h{03105}. **dv:** *Ae. tauschii* TA2369 *Pina-D1c*, *Gsp-D1c*{03105}; TA2527 *Pina-D1c*, *Gsp-D1e*{03105}; TA1649 *Pina-D1d*, *Gsp-D1f*{03105}.

Pinb-D1i{03105}. **dv:** *Ae. tauschii* TA2475 (GenBank AY251989) *Pina-D1a*, *Gsp-D1b*{03105}; TA2536 (GenBank AY251993) *Pina-D1c*, *Gsp-D1d*{03105}; TA2374 (GenBank AY251948) *Pina-D1d*, *Gsp-D1d*{03105}; TA2512 (GenBank AY251992) *Pina-D1d*, *Gsp-D1e*{03105}; TA2455 (GenBank AY251972) *Pina-D1d*, *Gsp-D1f*{03105}; TA2458 (GenBank AY251986) *Pina-D1e*, *Gsp-D1d*{03105}; TA2495 (GenBank AY251991) *Pina-D1e*, *Gsp-D1e*; TA2436 *Pina-D1f*, *Gsp-D1d*{03105}.

Pinb-D1j{03105}. **dv:** *Ae. tauschii* TA1599 *Pina-D1a*, *Gsp-D1g*{03105}; TA1691 *Pina-D1a*, *Gsp-D1h*{03105}.

Pinb-D1k. **dv:** *Ae. tauschii* PI554318 (GenBank AJ302108) *Pina-D1d*{03104}.

Pinb-A^mI{0083}. 5A^mS{0083}. **dv:** *T. monococcum* DV92 (cultivated), G3116 (spp. *aegilopoides* (GenBank AJ242716){0083}; unspecified accession (GenBank AJ249934){03103}; is identical to allele *Pina-D1h*{03105}; PI277138 (GenBank AJ302102){03104}; PI418582 (GenBank AJ302101){03104}.

In *T. monococcum* *Pinb-A^mI* is 0.1 cM proximal to *Pina-A^mI* and both loci are less than 36 kb apart {0083}.

Pinb-SI{03108}. **dv:** *Ae. speltoides* PI393494 (GenBank AJ302105){03104}; PI369616 (GenBank AJ302106){03104}; *Ae. speltoides* spp. *speltoides* TA2368, TA1789{03108}; *Ae. speltoides* spp. *ligustica* TA1777{03108}.

Pinb-S^bI{03108}. **dv:** *Ae. bicornis* spp. *typica* TA1954, TA1942{03105}.

Pinb-S^lI{03108}. **dv:** *Ae. longissima* spp. *longissima* TA1912{03108}; *Ae. longissima* spp. *nova* TA1921{03108}.

Pinb-S^SI{03108}. **dv:** *Ae. searsii* TA1837, TA1355{03105}.

Pinb-S^{sh}I{03108}. **dv:** *Ae. sharonensis* TA1999{03105}.

Pinb-D1b, *Pinb-D1c*, *Pinb-D1d*, *Pinb-D1e*, *Pinb-D1f*,
or *Pinb-D1g* are present in hard hexaploid wheats not carrying the *Pina-D1b* (null) mutation
{452,1035,0082,0204}.

Wheats with *Pinb-D1b* were slightly softer and a little superior to those with
Pina-D1b in milling and bread-making characteristics although there was considerable
overlap {0206}.

Transgenic rice with the *Pina-D1a* and *Pinb-D1a* alleles possessed softer grain {0207}.

Genotypes for a selection of North American wheats are given in {0204}.

74.5.9. Grain softness protein

Gsp-I{1185}.

Gsp-AI{614}. [*GSP*{614}]. 5A{614,0383}. **v:** CS{614,0383}; Rosella (GenBank
AF177218){0383}.

In {1185} partial-sequence clone TSF61 from cv Soft Falcon (GenBank X80380) is identical
to this allele.

Gsp-BI{614}. [*GSP*{614}]. 5B{614}. **v:** CS{614}; Glenlea{0385}.

In {1185} sequence of clone TSF33 from cv Soft Falcon (GenBank X80379) is identical to
this allele, as are ESTs for cv CS (dbEST BJ235798) and cv CNN (dbEST BE423845).

Gsp-DI{614}. [*GSP*{614}]. 5DS{614}. **v:** CS{614}; Glenlea{0385}. **dv:** *Ae. tauschii*
CPI1110799 (GenBank AF177219){0383}. **ma:** Co-segregation of *Gsp-DI* and *Ha*{614}.

In {1185} sequence of clone TSF69 from cv Soft Falcon (GenBank S72696) is identical, as
are ESTs for cv CS (dbEST BJ237450) and cv CNN (dbEST BE422565).

Gsp-D1b{03105}. **dv:** *Ae. tauschii* TA1583 (GenBank AY252079) *Pina-D1a*, *Pinb-*
D1a{03105}; TA2475 (GenBank AY252087) *Pina-D1a*, *Pina-D1i*{03105}.

Gsp-D1c{03105}. **dv:** *Ae. tauschii* TA2369 (GenBank AY252081) *Pina-D1c*, *Pinb-*
D1h{03105}; CPI110799 (GenBank AF177219){0383}.

Gsp-D1d. **dv:** *Ae. tauschii* TA2536 (GenBank 252093) *Pina-D1c*, *Pinb-D2i*{03105};
TA2374 (GenBank AY252046) *Pina-D1d*, *Pinb-D1i*{03105}; TA2458 (GenBank
AY252084) *Pina-D1e*, *Pinb-D1i*{03105}; TA2436 (GenBank AY252048) *Pina-D1f*,
Pinb-D1i{03105}.

Gsp-D1e. **dv:** *Ae. tauschii* TA2527 (GenBank AY252066) *Pina-D1c*, *Pinb-D1h*{03105};
TA2512 (GenBank AY252092) *Pina-D1d*, *Pinb-D1i*{03105}; TA2495 (GenBank
AY252091) *Pina-D1e*, *Pinb-D1i*{03105}.

Gsp-D1f. **dv:** *Ae. tauschii* TA1649 (GenBank AY252063) *Pina-D1d*, *Pinb-D1h*{03105};
TA2455 (GenBank AY252073) *Pina-D1d*, *Pinb-D1i*{03105}.

Gsp-D1g. **dv:** *Ae. tauschii* TA1599 (GenBank AY252062) *Pina-D1a*, *Pinb-D1j*{03105}.

Gsp-D1h. **dv:** *Ae. tauschii* TA1691 (GenBank AY252064) *Pina-D1a*, *Pinb-D1j*{03105}.

74.5.10. Starch synthase

SsI-AI{0041}. 7A{0041}.

SsI-BI{0041}. 7B{0041}.

SsI-DI{0041}. 7D{0041}.

Starch synthase I proteins are identical to the starch granule proteins SGP-3 {0041}.

SsII-AI{0042}. 7A{0042}.

SsII-BI{0042}. 7B{0042}.

SsII-DI{0042}. 7D{0042}.

Starch synthase II proteins are identical to the starch granule proteins SGP-1 {0042}.

74.5.11. Histone H1 Proteins

HstH1-A1{0215}. 5AL{0215}. v: CS{0215}.

HstH1-B1{0215}. 5BL{0215}. v: CS{0215}.

HstH1-D1{0215}. 5DL{0215}. v: CS{0215}.

HstH1-D1a{0215}. v: CS{0215}; 18 others{0215}.

HstH1-D1b{0215}. v: Grekum 114{0215}; Kirgizsky Karlik{0215}.

HstH1-A2{0215}. 5AL{0215}. v: CS{0215}.

HstH1-A2a{0215}. v: CS{0215}.

HstH1-A2b{0215}. Null allele{0215}. v: Mara{0215}; 10 others{0215}.

HstH1-B2{0215}. 5BL{0215}. v: CS{0215}.

HstH1-B2a{0215}. v: CS{0215}; 19 others{0215}.

HstH1-B2b{0215}. v: Excelsior{0215}.

HstH1-D2{0215}. 5DL{0215}. v: CS{0215}.

The relationship of this gene series with a *Hst-A1*, *Hst-B1*, *Hst-D1* series in group 5 chromosomes {0216} based on DNA hybridization studies was not established.

Pathogenic Disease/Pest Reaction

For disease/pest reaction gene guidelines see Introduction, no. 8.

Note: In listings of multiple alleles, the chromosomes locations and ma: citations with generally be given with the particular allele that was located of mapped.

75.Reaction to Barley Yellow Dwarf Virus

Bdv1{1363,1379}. 7D{1379}.7DS{1363}. **i:** Jupeteco 73R (compared to Jupeteco 73S){1363}. **v:** Anza{1379}; Condor BW3991{1379}; Tyrant BW3872{1379}; Hahn BW4097{1379}; Parrot BW10817{1379}; Siren BW18643{1379}; Many CIMMYT genotypes. *Bdv1* is completely linked with *Ltn*, *Lr34* and *Yr18*. See *Ltn*, *Lr34*, *Yr18*. Note: BW = CIMMYT wheat accession number.

Bdv2{058}. **v:** TC14²/Hartog{0225}; TC14²/Spear{0201}; TC14²/Tatiara{0225}. 7Ai#1S{552}.**su:**TAF2{059}; Lines 5395 & 5395-243AA{552}. 7DL= T7DS.7DL-7Ai#1L{552,0182}.**tr:**TC14{059,0201}; H960642{0182}. 7D = T7DS-7Ai#1S.7Ai#1L{552}.**tr:**TC5, TC6, TC8, TC9, TC10{059}. 1B = T1BS-7A#1S.7Ai#1L{552}.**tr:**TC7{447}. **ma:** Distal 10% of 7DL, translocation point between RFLP markers *Xpsr680* and *Xpsr965*{0182}; Complete association with *Xpsr129-7D*, *Xpsr548-7D*, *XksuD2-7D*, *XcslH81-7D*, and *Xgwm37-7D* selected as a diagnostic marker{0225}.

76.Reaction to *Blumeria graminis* DC.

Disease: Powdery Mildew.

76.1. Designated genes for resistance

Note: Chancellor, used as a susceptible genetic background, for some near-isogenic lines probably carries *Pm10* and *Pm15* {1479}.

Pm1.

Pm1a{562}. [*Pm1*{130},*Mlt*{1175},*Mla*{348}]. 7A{1293}.7AL{1305}. **i:** Axminster/8^{*}Chancellor{132}; CI 14114 = As II/8^{*}Chancellor{132}; CI 13836/8^{*}Chancellor{132}; Kenya C6041/5^{*}Federation{1168}; Norka/8^{*}Chancellor{132}. **s:** CS⁵/Axminster 7A{1293}. **v:** Anfield{098}; As II{130}; Axminster{130,1175}; Birdproof{165}; Bonus{1554}; CI 13836{130}; Converse{1175}; Fedka{939}; Festival{1554}; Fram I{130}; Huron CI 3315{1175,1554}; Kenora{1554}; Kenya W744 = C6041{130,1175}; Norka{130,1175}; Pika{130}; Sweden W1230{1554}; Thew{1175}; TU 4{130}; Zhengzhou 871124{570}. **v2:** Anfield *Pm9*{1287}; BGRC 44514 *Pm3a*{1628}; Mephisto *Pm2 Pm9*{540}; Normandie *Pm2 Pm9*{165}; Pompe *Pm9*{1287}; Ring *Pm9*{1287}; Sappo *Pm2 Pm4b* (Carries *Lr20*){310}; Solo *Pm2 Pm4b*{052}. **ma:** Co-seg. with *Xcdo347-7A* using NILs{864}; Co-segregation or close linkage with three RAPDs; one RAPD converted to a STS{570}; Note: In Solo, *Pm1* is translocated to chromosome 7D{052}; Complete cosegregation of several markers including *Xcdo347-7A*, *Xpsr121-7A*, *Xpsr680-7A*, *Xpsr687-7A*, *Xbzh232(Tha)-7A*, *Xrgc607-7A* and *Xsts638-7A* with *Pm1* and *Lr20* was reported in {0323}.

Pm1b{562}. **v:** MocZlatka{562}.

- Pm1c**{562}. [*Pm18*{853,562}]. **v**: Blaukorn{0011}; M1N{1628,562}; In{540}; M1N was described as an undesignated subline of Weihenstephan M1. **ma**: AFLP marker 18M2 was diagnostic for *Pm1c*{0011}.
- Pm1d**{562}. **v**: *T. spelta* var *duhamelianum* TRI2258{562}. **ma**: AFLP marker 18M1 - various *Pm1* alleles 0.9 cM{0011}.
- Pm1e**{0322}. [*Pm22*{1134}]. **v**: Elia{1134}; Est Mottin{1134}; Ovest{1134}; Tudest{1134}; Virest{1134}.
- Pm2**{130}. [*Mlu*{1175},*Mlx*{1088}]. 5D{1007}.5DS{945}. **i**: CI 14118 = Ulka/8*Chancellor{132}; CI 14119 = CI 12632/8*Chancellor{132}; Federation*4/Ulka{1168}. **v**: Avalon{096}; Bounty{096}; Fenman{096}; Galahad{1531}; H8810/47{130}; Longbow{1531}; Maris Beacon{1592}; Maris Nimrod{1592}; Maris Sportsman{096}; Maris Templar{1592}; Norman{096}; Orestis{1079}; PI 92378{1168}; PI 181374{1168}; Sea Island{130}; Sentry{096}; S2303{945}; Synthetic(Iumillo/*T. tauschii*){1168}; TP 114/2*Starke deriv{626}; Ulka{130,1175}; XX186 = *T. durum* Santa Maria/Aeg. *squarrosa* BGRC 1458 *Pm19*{853}. **v2**: Apollo *Pm4b Pm8*{541}; Brigand *Pm6*{096}; Brimstone *Pm6*{1531}; CI 12632 *Pm6*{130}; CI 12633 *Pm6*{133}; Compal *Pm4b*{854}; Crossbow *Pm5 Pm6*{098}; Gawain *Pm6*{1531}; Halle Stamm 13471 *Mld*{097}; Heiduck *Pm6*{541}; Hustler *Pm6*{096}; Hornet *Pm8*{1531}; Kinsman *Pm6*{096}; Mardler *Pm6*{096}; Maris Dove *Mld*{1592}; Maris Fundin *Pm6*{096}; Maris Huntsman *Pm6*{1592}; Mephisto *Pm1 Pm9*{540}; Normandie *Pm1 Pm9*{165}; Parade *Pm5 Pm6*{1531}; Rendezvous *Pm4b Pm6*{1531}; Solo *Pm1 Pm4b*{052}; Timmo *Pm4b*{096}; TP 114 *Pm6*{626}; Virtue *Pm6*{096}; Walter *Pm4b Pm6*{1428}. **dv**: *Aeg. squarrosa* BGRC 1458{853}; Forty accessions of *T. tauschii*{852}. **ma**: *Pm2* - 3.5cM - *Xbcd1871-5D* using F2s{864}.
- Pm3**. 1A. **ma**: *Xgdm33-1A* - 2.3 cM - *Pm3/Xpsp2999-1A*{0313}.
Genotype list: {0313}
- Pm3a**{130,132}. [*Mla*{1168}]. 1A{1007}.1AS{943,947}. **i**: Asosan/8*Chancellor{132}; = CI 14120; Asosan/3*Federation{1168}. **v**: Asosan{130,1168}; BGRC 44514 *Pm1a*{1628}; Coker 797{786}; Florida 301{786}; Florida 302{786}; Hadden{097}; Halle Stamm{097}; Norin 3{1134}; Norin 29{1134}; PI 46890{1439}; Saluda{786}; Tyler{1419}. **ma**: *Xbcd1434-1A* - 1.3 cM - *Pm3* using NILs{864}; *Xwhs179-1A* - 3.3 cM - *Pm3*{522}.
- Pm3b**{130,132}. [*Mlc*{165}]. 1A{1007}. **i**: Chul*8/Chancellor{132}; *T. sphaerococcum**8/Chancellor = CI 15887{539}. **v**: Chul{165}. **ma**: *Xbcd1434-1A* - 1.3 cM - *Pm3b* using NILs{864}.
- Pm3c**{130,132}. [*Mls*{1175}]. 1A{134,1007}. **i**: Sonora/8*Chancellor{132}; = CI 14122; Sonora/4*Federation{1168}; Triticale/8*Chancellor{539}. **s**: CS*7/Indian 1A{134}. **v**: Borenos{854}; Cawnpore{1628}; CI 3008{130}; CI 4546{130}; Hindukusch{1628}; Indian{1175}; Sonora{130,1168}; Sturgeon{1175}.
- Pm3d**{1628}. [*Ml-k*{540},*Mlk*{434}]. 1A{1628}. **v**: Axona{0313}; Cornette{0313}; Herold{540}; Indian 4{0313}; Kadett{0313}; Kanzler{0011}; Kleiber{0313}; Kolibri{540,542,1628}; Ralle{540}; Socrates {heterogeneous}{540}; Star {heterogeneous}{540}; Syros{540}. **v2**: Kadett *Pm4b*{540}; Turbo *Pm4b*{540}.
- Pm3e**{1628}. **v**: Sydney University Accession W150 = AUS 6449{939,1628}.
- Pm3f**{1628}. **i**: Michigan Amber/8*Chancellor{1628}; This allele was distinguished from *Pm3c* with only one of 13 pathogen cultures.
- Pm3g**{0070}. [*Mlar*{854}]. 1A{0070}.1AS{0363}. **v**: Avo{1629}; Aristide{1629}; Champetre{0313}; Courtot{1629}; Lutin{0313}; Oradian{0313}; Rubens{0313}; Soissons{0313}; Valois{0313}. **ma**: *Pm3g* - 5.2 cM - *Gli-A5* - 1.9 cM - *Gli-A1*{0070}; *Pm3g* was completely linked to microsatellite *Xpsp2999*{0363}.
- Pm4**{131}.

Pm4a{1464}. [*Pm4*{131}]. 2AL{1464}. **i**: CI 14123 = Khapli/8*Chancellor{131}; CI 14124 = Yuma/8*Chancellor{131}. **v**: Steinwedel*2/Khapli{939}. **tv**: Khapli{131}; Valgerado{097}; Yuma{131}. **ma**: Co-seg with *Xbcd1231-2A.2* & *Xcdo678-2A* using F2s{864}; *Xbcd1231-2A.1* - 1.5cM - *Pm4* - 1.56cM - *Xbcd292-2A*{864}; *Pm4a* - 3.5cM - AFLP markers 4aM1 and 4aM2{0011}; *Xbcd1231* was converted to a STS marker{0069}.

Pm4b{1464}. [*Mle*{1591}]. 2A{052}.2AL{1464}. **i**: Federation*7/*T. carthlicum* W804{1464}. **v**: Achill{540}; Ajax{540}; Arkas{540}; Armada{096}; Atlantis{0011}; Boheme{0011}; Botri (heterogeneous){854}; ELS{1591}; Facta{854}; Factor (heterogeneous){854}; Fakon{854}; Fazit{854}; Hermes{540}; Horizont{540}; Maris Halberd; Max{540}; Olymp{540}; Orbis{540}; RE714{1220}; Renan{0016}; Ronos{1079}; S-25{052}; S-28{052}; TP 229{626,1591}; Weihenstephan M1{1591}; VPM1{097}. **v2**: Apollo *Pm2 Pm8*{541,802}; Boxer *Pm5*{541}; Compal *Pm2*{854}; Kadett *Pm3d*{540}; Kronjuwel *Pm8*{541}; Mission *Pm5* {78,541,1531}; Rang *Pm1*{052}; Rendezvous *Pm2 Pm6*{1531}; Solo *Pm1 Pm2*{052,540}; Sorbas *Pm6*{541}; Timmo *Pm2 Pm6*{096}; Turbo *Pm3d*{540}; Walter *Pm2 Pm6*{1428}. **ma**: *Pm4b* - 4.8cM - *Xgbx3119b*{0272}; *Xgwm382-2A* - +/- 10 cM - *Pm4b* - +/- 2cM - *XgbxG303*{0354}.

Pm5.

Pm5a{0257}. Recessive. [*Pm5*{787}, *mlH*{771}]. 7B{964}.7BL{771}. **i**: Hope/8*Chancellor = CI 14125{570}. **s**: CS*6/Hope 7B{771,964}. **v**: Alidos{854}; Aotea{964}; Caldwell{786}; Ga 1123{786}; Galaxie{0257}; Glenwari{964}; Hardired{786}; Hope{964}; H-44{964}; Kontrast{854}; Kormoran{1079}; Kutulukskaya{0257}; Lambros{0257}; Lawrence{964}; Navid{0257}; Pagode{0257}; Redcoat{097}; Redman{964}; Regina{0257}; Renown{964}; Selpek{540}; Sicco{096,0257}; Spica{964}; Tarasque{0257}; Warigo{964}; Zolotistaya{0257}. **v2**: Arthur *Pm6*{786}; Coker 983 *Pm6*{786}; Double Crop *Pm6*{786}; Granada *Pm8*{541}; Sensor *Pm8*{541}.

Pm5a was transferred to hexaploid wheat from *T. dicoccum* via Hope and H-44.

Pm5b{0257}. [*Mli*{540,558}]. *Mli*{540,558}. **v**: Aquila{096,541}; Carimulti{541}; Cariplus{541}; Cucurova{0257}; Dolomit{541}; Falke{541}; Flanders{096}; Fruhprobst{0257}; Ilona{0257}; Ibis{096}; Kirkpinar-79{0257}; Kontrast{0257}; Kormoran{541}; Krata{541}; Markant{541}; Mercia{1531}; Milan{541}; Nadadores{0257}; Reiher{541}; Rektor{541}; Rothwell Perdix{096}; Siete Cerros{0257}; Severin{541}; Sicco{096}; Sperber{541}; Tukan{541}; Una{0257}; Urban{541}; Wattines{541}; Wettiness{0257}. **v2**: Bert *Pm6*{541}; Boxer *Pm4b*{541}; Crossbow *Pm2 Pm6*{098}; Kristall *Pm8*{541}; Mission *Pm4b*{541,1531}; Parade *Pm2 Pm6*{1531}.

Pm5c{0257}. 7B{0257}. **v**: *T. sphaerococcum* cv. Kolandi{0257}.

Pm5d{0257}. 7B{0257}. **i**: IGV 1-455 = CI 10904/7*Prins{0257}; CI 10904/7*Starke{0257}.

Pm5e{0258}. Recessive and hemizygous effective {0258}. [*mlfz*{0259}]. **v**: Fuzhuang 30{0258}. **ma**: *Xgwm1267-7B* - 6.6cM - *Pm5e* - 12.6cM - *Xubc405₆₂₈*{0258}.

Pm6{627}. [*Mlf*{626}]. 2B{1088}. **i**: CI 13250/7*Prins{0069}; CI 12559/8*Prins{0069}; PI 170914/7*Prins 6 NILs based on Prins {0139}.{0069}. **v**: 1969 IVGS Line C{626}; Abe{097,1256}; Coker747{786,1079}; Mengavi{097}; Oasis{786}; Timgalen{098}; TP 114/2*Starke deriv. B{626}. **v2**: Arthur *Pm5a*{097,786}; Brigand *Pm2*{096}; Brimstone *Pm2*{1531}; CI 12632 *Pm2*{626,1088}; CI 12633 *Pm2*{626,1088}; Crossbow *Pm2 Pm5*{098}; Double Crop *Pm5a*{786}; Garwain *Pm2*{1531}; Greif *Pm5a*{0011}; Heiduck *Pm2*{541}; Hustler *Pm2*{096}; Kinsman *Pm2*{096}; Mardler *Pm2*{096}; Maris Fundin *Pm2*{096}; Maris Huntsman *Pm2*{1592}; Parade *Pm2 Pm5*{1531}; Rendezvous *Pm2*

Pm4b{1531}; Sorbas *Pm4b*{541}; Timmo *Pm2 Pm4b*{096}; TP 114 *Pm2*{626}; Virtue *Pm2*{096}; Walter *Pm2 Pm4b*{1428}. **ma**: Close linkage with *Xbcd135*(1.5+1.4cM), *Xbcd307*(4.7+2.5cM) and *Xbcd266*(4.5+2.4cM){0069}; Mapped to the interval *Xbcd35-2B-Xpsr934-2B*{0139}; However, the fact that Timgalen and a 'CI12632/Cc' line lacked the critical *T. timopheevii* markers {0139} is cause for concern.

Pm7. Derived from *S. cereale* cv. Rosen. 4BL{270,271,389}=T4BS.4BL-5RL{543}, but more recently revised to T4BS.4BL-2R#IL{380,389}. **i**: = Transec/8*Chancellor. **v**: Transfed{269}; Transec{273}.

Pm8. Derived from Petkus rye - see *Yr9, Lr26, Sr31*. 1R{1B}.1BL.1RS. **v**: Corinthian{1531}; Dauntless{1531}; Ambassador{1531}; Disponent{541}; GR876{753}; Halle Stamm{097}; Hammer{098}; Others{1208}; ST1-25{201}; Slejpner{1531}; Stetson{1531}; Stuart{096}. **v2**: Apollo *Pm2 Pm4b*{541}; Granada *Pm5*{541}; Hornet *Pm2*{1531}; Kristall *Pm5*{541}; Kronjuwel *Pm4b*{541}; Sensor *Pm5*{541}. **tv**: Cando*2/Veery=KS91WGRC14{381}. 1BS/1RS recombinants 2.9 cM proximal to *Gli-B1/GluB3*{0084}. **i**:MA1 and MA2, four-breakpoint double translocation lines 1RS-1BS-1RS-1BS. 1BL in Pavon{0084}. Crosses between three lines with *Pm8* and Helami-105, a 1BL.1RS line with *Pm17*, indicated that *Pm8* and *Pm17* were allelic{524}. Earlier, these genes were reported to be genetically independent{1463}. A STS marker distinguished *Pm17* from *Pm8*{0286}.

Pm9{347}. 7A{347}.7AL. **v**: N14{562}. **v2**: Anfield *Pm1a*{1287}; Mephisto *Pm1a Pm2*{540}; Normandie *Pm1a Pm2*{347}; Pompe *Pm1a*{1287}; Ring *Pm1a*{1287}.

Pm10{1482}. 1D{1482}. **v**: Norin 4{1482}; Norin 26{1482}; Norin 29{1482}; Penjamo 62{1482}; Shin-chunaga{1482}. **v2**: *T. spelta duhamelianum Pm11*{1481}.

Pm10 was detected using a culture derived from a hybrid of *B. g. tritici* and *B. g. agropyri*.

Pm11{1481}. 6BS{1481}. **v**: Chinese Spring{1481}; Salmon{1481}; *T. compactum* No. 44{1481}. **v2**: *T. spelta duhamelianum Pm10*{1481}.

Pm11 was detected using a culture derived from a hybrid of *B. g. tritici* and *B. g. agropyri*

Pm12{1017}. Derived from *Ae. speltooides*.

The earlier location of 6A {1017} was not correct. 6B = 6BS-6SS.6SL{598,572}. **v**: Wembley*6/*Ae. speltooides*, #31{1017,598}; 6S¹S{598}. **al**: *Ae. speltooides* CL214008 = K{1017}. **ma**: *Pm12* was mapped to a translocated segment proximal to *Xpsr551-6B*{598}.

Pm13. Derived from *Ae. longissima*

3B{173} = T3BL.3BS-3S¹#1S{389}. **v**:R1A{174}; R1B{0055}; R4A{0055}; R6A{0055}. 3D{173} = T3DL.3DS-3S¹#1S{389}. **tv**:R1D{174}. **v**: R2A{0055}; R2B{0055}.

3S¹#1S. **al**:*Ae. longissima*. **ma**: STS marker *Xutv13*{0036}; several other markers located in introgressed segments{0036}; *Pm13* was mapped to a translocated 3S¹S segment distal to *Xcdo-460-3B*{0036}.

Pm14. 6B{1478}. **v2**: Akabozu *Pm15*{1478}; Kokeshikomugi *Pm15*{1478}; Norin 10 *Pm15*{1478}.

Pm14 and *Pm15* were detected using hybrids between *B. g. tritici* and *B. g. agropyri* cultures.

Pm15. 7DS{1478}. **v2**: Akabozu *Pm14*{1478}; Chinese Spring *Pm11*{1478}; Kokeshikomugi *Pm14*{1478}; Norin 4 *Pm10*{1478}; Norin 10 *Pm14*{1478}; Norin 26 *Pm10*{1478}; Shinchunaga *Pm10*{1478}; *T. macha subletschumicum Pm10*{1478}; *T. compactum* No. 44 *Pm11*{1478}.

Pm14 and *Pm15* were detected using hybrids between *B. g. tritici* and *B. g. agropyri* cultures.

Pm16{1201}. 4A{1201}. **v**: Norman lines with resistance from *T. dicoccoides* CL1060025{1201}. **tv**: *T. dicoccoides* CL1060025{1201}.

Pm17{097,838,544}.

1AS = T1AL.1R#2S{1624,185,389}. **v**:Amigo{561}; Century{216}; Nekota{0021}; Neobrara{0021}; TAM107{216}; TAM200{216}; TAM201{216}; TAM202{0021}.

1BS = T1BL.1R#2S{561}. **v2**:Helami 105 *Pm5*{561}. **ma**: A STS marker distinguished

Pm17 from *Pm8*{0286}.

Pm8 and *Pm17* were reported to be allelic {524}, see note under *Pm8*.

Pm18. Deleted, see *Pm1c*.

Pm19{853}. 7D{853}. **v:** *T. durum* 'Morocco 183'/*Ae. squarrosa* AE 457/78{853}. **v2:** Synthetic XX186 *Pm2*{853}. **dv:** *Ae. squarrosa*{853}.

Pm20{386}. [*MIP6L*{543}]. 6BL = T6BS.6R#2L{543,386,389}. **v:** KS93WGRC28 = PI 583795{386,382}; 6RL. **su:** 6R{6D}{543}. **ad:** 6R addition{543}. **al:** Prolific rye{543}.

Pm21{1177}. 6AS = T6AL.6VS{1177}. **v:** 9 independent translocations{1177}. **ma:** RAPD *OPH17*₁₉₀₀ (synonym 'OPH17-1900') was associated with *Pm21* and RAPD *OPH17*₁₀₀₀ (synonym 'OPH17-1000') with its absence{1176}; RAPD *OPH17*₁₄₀₀ and SCAR markers SCAR₁₄₀₀ and SCAR₁₂₆₅ associated with *Pm21* are described in{0014}.

Pm22{1134}.

Deleted. See *Pm1e*.

Pm23{1618}. 5A{1618}. **v2:** Line 81-7241 *Pm8*{1618}.

Pm24{571}. 6D{571}.1DS{0150}. **v:** Chiyacao{571}.

Although *Pm24* had previously been located to chromosome 6D {571}, *Pm24* was mapped on chromosome arm 1DS in the cross Chinese Spring (susceptible) x Chiyacao (resistant){0150}.

Pm25{1343}. [*PmTmb*{1343,1344}]. 1A{1343}. **v:** NC94-3778{1344}. **v2:** NC96BGTA5 = Saluda*3/PI 427662 *Pm3a*{1343}. **dv:** *T. monococcum* PI 427662{1343}. **ma:** Linked with 3 RAPDs, the nearest, OPAG04950, at 12.8 +/- 4.0 cM{1343}; Associated with 3 RAPDs{1344}.

Pm26{0001}. Recessive {0001}. 2BS{0001}. **s:** Bethlehem*8/*T. turgidum* var. *dicoccoides* 2BS{0001}. **tv:** *T. turgidum* var. *dicoccoides* TTD140{0001}. **ma:** Co-segregation with Xwg516-2B{0001}.

Pm27{0002}. 6B (6B-6G){0002}. **v:** Line 146-155-T{0002}. **tv:** *T. timopheevii* var. *timopheevii* K-38555{0022}. **ma:** 6BS.....*Xpsr8/Xpsr964-6B - Pm27 - Xpsr154/Xpsr546-6B*6BL{0002}; Co-segregation with *Xpsr3131-6B*{0002}.

Pm28{0022}. 1B{0022}. **v:** Meri{0022}.

Pm29{0129}. **v:** Pova{0129}. **ma:** Location confirmed by co-segregation with molecular markers{0129}.

Pm30{0163}. [*MIC20*] 5BS{0163}. **v:** 87-1/C20//2*8866 Seletion{0163}. **ma:** *Pm30 - 5.6cM - Xgwm159-5B*{0163}.

Pm31{0301}. **v:** G-305-M/781//3*Jing411{0301}. **tv:** *T. dicoccoides* G-305-M{0301}.

Genotype lists:Chinese wheats{1608,572}; Finnish wheats {0028}; French wheats{1629}; Hungarian wheats {02104}; Western Siberian wheats{1101}

Complex genotypes:

Drabent {heterogeneous} *Pm2 Pm4bPm9/Pm1 Pm2 Pm4b Pm9* {1287}; :

Nemares *Pm1 Pm2Pm4b Pm6 Pm9* {1287}; :

Planet, Sappo & Walter *Pm1 Pm2 Pm4b Pm9* {096,097,540,1287,1428}

76.2. Suppressors of *Pm*

Some wheats which, on the basis of cytological and rust tests carry 1RS from Petkus rye, do not express resistance due to presence of a suppressor {385}. Zeller & Hsam {1625} located a suppressor of *Pm8* and *Pm17* in chromosome 7D of Caribo. Mildew resistance was suppressed in Florida, Heinrich, Ikarus, Olymp and Sabina, which are derivatives of Caribo with 1BL.1RS. According to Ren *et al.* {1209}, *SuPm8* does not suppress *Pm17*. Hanusova *et al.* {492} listed 16 wheats that carry a suppressor of *Pm8*; 111 wheats did not carry the suppressor. In contrast, a high frequency of suppression occurred in CIMMYT wheats

{108,1208}. Further genotypes are identified in {491}. Although Line 81-7241 carries *Pm8* as well as *Pm23*, evidence was presented to indicate that *Pm8* was suppressed in Line 81-7241{1618} and, by inference, indicated that Chinese Spring possessed *SuPm8*.

SuPm8{1209}. 1AS{1209}. **v**: Wheats with *Gli-A1a*{1209}; Lists in{108,491,1208}.

A suppressor of *Pm17*, as well as of *Pm8*, was located in chromosome 7D of Caribo {1625}. Gene *SuPm8* identified by Ren et al. {1209} did not suppress *Pm17*.

76.3. Temporarily designated gene for resistance to *Blumeria graminis*

MI-Ad{854}. **v**: Adlungs Alemannen{854}.

MI-Br{854}. **v**: Bretonischer Bartweizen{854}.

Mld{096}. 4B{097}. **v2**: Halle 13471 *Pm2*{096}; H8810/47 *Pm2*{096}; Maris Dove *Pm2*{096}. **tv**: *T. durum* line{096}.

MI-Ga{854}. **v**: Garnet{854}; many old German cultivars{854}.

mljy{0339}. Recessive, hemizygous-effective {0339} 7B{0339}. **v2**: Jieyan 94-1-1 *Pm8*{0339}.

mlsy{0339}. Recessive, hemizygous-effective {0339} 7B{0339}. **v**: Siyan 94-2-1 {0339}.

Mlre{1220}. 6AL{0142}. **v2**: RE714 *Pm4b*{0142,1220}. **tv**: *T. dicoccum* 119{1220}.

Mlre showed a residual effect on the quantitative expression of APR in the presence of *B. graminis* pathotypes considered virulent for *Mlre* in standard seedling tests{0016}. In addition to *Mlre*, a QTL for resistance effective at the seedling stage was associated with microsatellite marker *Xgwm174-5D* {0146}.

Mlxbd{0259}. Recessive and hemizygous-effective {0258} 7B{0259}. **v**: Xiaobaidong{0258}.

76.4. QTLs for resistance to *Blumeria graminis*

QTL: Several QTLs were detected in two RE714/Hardi populations when tested at two growth stages and with different cultures over three years. The most persistent and effective QTL was located in the vicinity of *Xgwm174-5D* {0272}. Three QTLs, *QPm.vt-1B*, *QPm.vt-2A* and *QPm.vt-2B*, with additive gene action, accounted for 50% of the variation in a population developed from Becker/Massey{0284}.

QTLs on chromosomes 1A, 2A, 2B, 3A, 5D, 6A and 7B were detected in a RE714/Festin population in multiple locations and over multiple years. The QTLs on chromosome 5D was detected in all environments and all years and is associated with markers *Xgwm639-5D* and *Xgwm174-5D*. Resistance was contributed by RE714. A QTL coinciding with *MIRE* on 6A was also detected in all environments. The QTL on chromosome 5D and 6A accounted for 45% to 61% of the phenotypic variation {0354}.

QPm.sfr-1A{0051}. 1A{0051}. **v**: Forno/T. spelta var. Oberkulmer mapping population; the resistance was contributed by Oberkulmer{0051}. **ma**: Associated with *Xpsr1201-1A* and *Xpsr941-1A*{0051}.

QPm.sfr-1B{0051}. 1B{0051}. **v**: Forno/T. spelta var. Oberkulmer mapping population; the resistance was contributed by Forno{0051}. **ma**: Associated with *Xsfr3(LRR)-1B* and *Xpsr593-1B*{0051}.

QPm.sfr-1D{0051}. 1D{0051}. **v**: Forno/T. spelta var. Oberkulmer mapping population; the resistance was contributed by Oberkulmer{0051}. **ma**: Associated with *Xpsr168-1D* and *Xglk558-1D*{0051}.

QPm.sfr-2A{0051}. 2A{0051}. **v**: Forno/T. spelta var. Oberkulmer mapping population; the resistance was contributed by Oberkulmer{0051}. **ma**: Associated with *Xpsr380-2A* and *Xglk293-2A*{0051}.

- QPm.sfr-2D**{0051}. 2D{0051}. **v**: Forno/T. spelta var. Oberkulmer mapping population; the resistance was contributed by Oberkulmer{0051}. **ma**: Associated with *Xpsr932-2D* and *Xpsr331-2D*{0051}.
- QPm.sfr-3A**{0051}. 3A{0051}. **v**: Forno/T. spelta var. Oberkulmer mapping population; the resistance was contributed by Forno{0051}. **ma**: Associated with *Xpsr598-3A* and *Xpsr570-3A* {0051}.
- QPm.sfr-3D**{0051}. 3D{0051}. **v**: Forno/T. spelta var. Oberkulmer mapping population; the resistance was contributed by Oberkulmer{0051}. **ma**: Associated with *Xpsr1196-3D* and *Xsfr2(Lrk10)-3D*{0051}.
- QPm.sfr-4A.1**{0051}. 4A{0051}. **v**: Forno/T. spelta var. Oberkulmer mapping population; the resistance was contributed by Forno{0051}. **ma**: Associated with *Xgwm111-4A* and *Xpsr934-4A* {0051}.
- QPm.sfr-4A.2**{0051}. 4A{0051}. **v**: Forno/T. spelta var. Oberkulmer mapping population; the resistance was contributed by Forno{0051}. **ma**: Associated with *Xmwg710-4A* and *Xglk128-4A*{0051}.
- QPm.sfr-4B**{0051}. 4B{0051}. **v**: Forno/T. spelta var. Oberkulmer mapping population; the resistance was contributed by Forno{0051}. **ma**: Associated with *Xpsr593-4B* and *Xpsr1112-4B*{0051}.
- QPm.sfr-4D**{0051}. 4D{0051}. **v**: Forno/T. spelta var. Oberkulmer mapping population; the resistance was contributed by Forno{0051}. **ma**: Associated with *Xglk302-4D* and *Xpsr1101-4D*{0051}.
- QPm.sfr-5A.1**{0051}. 5A{0051}. **v**: Forno/T. spelta var. Oberkulmer mapping population; the resistance was contributed by Oberkulmer{0051}. **ma**: Associated with *Xpsr644-5A* and *Xpsr945-5A*{0051}.
- QPm.sfr-5A.2**{0051}. 5A{0051}. **v**: Forno/T. spelta var. Oberkulmer mapping population; the resistance was contributed by Oberkulmer{0051}. **ma**: Associated with *Xpsr1194-5A* and *Xpsr918-5A*{0051}.
- QPm.sfr-5B**{0051}. 5B{0051}. **v**: Forno/T. spelta var. Oberkulmer mapping population; the resistance was contributed by Oberkulmer{0051}. **ma**: Associated with *Xpsr580-5B* and *Xpsr143-5B*{0051}.
- QPm.sfr-6B**{0051}. 6B{0051}. **v**: Forno/T. spelta var. Oberkulmer mapping population; the resistance was contributed by Forno{0051}. **ma**: Associated with *Xpsr167-6B* and *Xpsr964-6B*{0051}.
- QPm.sfr-7B.1**{0051}. 7B{0051}. **v**: Forno/T. spelta var. Oberkulmer mapping population; the resistance was contributed by Forno{0051}. **ma**: Associated with *Xpsr593-7B* and *Xpsr129-7B*{0051}.
- QPm.sfr-7B.2**{0051}. This QTL corresponds to *Pm5* {0051}. 7B{0051}. **v**: Forno/T. spelta var. Oberkulmer mapping population; the resistance was contributed by Forno{0051}. **ma**: Associated with *Xglk750-7B* and *Xmwg710-7B*{0051}.
- QPm.ipk-2B**{0255}. 2BS{0255}. **v**: Opata/W-7984 (ITMI) RI mapping population{0255}; Resistance was contributed by Opata{0255}. **ma**: Associated with *Xcdo405* and *Xmwg950*{0255}.
- QPm.ipk-4B**{0255}. 4B{0255}. **v**: Opata/W-7984 (ITMI) RI mapping population{0255}; Resistance was contributed by W-7984{0255}. **ma**: Associated with *Xcdo795* and *Xbcd1262*{0255}.
- QPm.ipk-7D**{0255}. 7DS{0255}. **v**: Opata/W-7984 (ITMI) RI mapping population{0255}; Resistance was contributed by Opata{0255}. **ma**: Associated with *Xwg834* and *Xbcd1872*{0255}.

77.Reaction to *Cochliobolus sativus* Ito & Kurib.

Disease: Cochliobolus root rot.

Crr{764}. Recessive. 5BL{764,765}. **v:** Apex{764}; Cadet{765}.

78.Reaction to *Diuraphis noxia* (Mordvilko)

Insect pest: Russian aphid, Russian wheat aphid.

Dn1{286}. 7D{1288}.7DS{0211}. **i:** Betta-Dn1{0004,0211}; Caledon{0004}; Gariep{0004}; Karee-Dn1{0211}; Limpopo-Dn1{0004}; Tugela-Dn1{0004,0211}. **v:** PI 137739{286}. **ma:** *Xgwm111-7D₂₁₀* - 3.20 +/- 0.20 cM - *Dn1*{0211}.

Dn2{286}. 7DL{863}.7DS{0211}. **i:** Betta-Dn2{0211}; Karee-Dn2{0211}; Tugela-Dn2{0211}. **v:** PI 262660{286,863}. **ma:** *XksuA1-7D* - 9.8 cM - *Dn2*{863}; Myburg et al.{9968} identified two SCAR markers that mapped 3.3cM proximal to *Dn2*{9968}; *Xgwm111-7D₂₀₀* - 3.05 +/- 0.18 cM - *Dn2*{0211}; *XksuA1-7D* - 9.9 cM - *Dn2* - 2.8 cM - *Xgwm437-7D*{0353}.

According to Saidi & Quick {1250}, *Dn1* and *Dn2* are probably allelic. Reference stocks with each gene showed allelism with a gene in PI 262605.

Dn3{1086}. Recessive. **v:** *T. tauschii* SQ24/*T. turgidum* TD65{1086}. **dv:** *T. tauschii* SQ24{1086}.

Dn4{1250}. 1DL{863}. **v:** CORWAI{260}; CI 2401{260}; Halt{0209}; PI 151918{260}; PI 372129{1250}. **ma:** *Xabc156-1D* - 11.6 cM - *Dn4* {863}; *Xgwm106-1D* - 7.4 cM - *Dn4* - 12.9 cM - *Xgwm337-1D*{0352}.

Dn5{1249}. 7D{259}.7DL{287}.7DS{0211}. **i:** Betta-DN5{0211}; Palmiet derivative 92RL28{287}; Palmiet DN5{0004}. **v:** STARS - 9302W-sib{259}; PI 294994{259}. **ma:** A SCAR marker developed from the RAPD fragment OPF14₁₀₈₃ mapped 5.5 cM proximal to *Dn5*{0172}; *Xgwm111-7D₂₂₀* - less than 3.20 cM - *Dn5*{0211}.

Dn6{1250}. **v:** CI 6501{260}; PI 243781{1250,1249}. **ma:** *Dn6* - 3.0 cM - *Xgwm111*{0352}.

Dn7{9918}. Derived from *S. secale* cv. Turkey 77 {9918} 1B = 1BL.1RS{9918}.1R{9918}. **v:** 93M45-14{9918}.

Dn8{0211}. 7DS{0211}. **i:** Karee-Dn8. **v2:** PI 294994 *Dn5Dn9*{0211}. **ma:** *Xgwm635-7D₁₀₀* - less than 3.20 cM - *Dn8*{0211}.

Dn9{0211}. 1DL{0211}. **i:** Betta-DN9. **v2:** PI 294994 *Dn5Dn8*{0211}. **ma:** *Xgwm642-7D₁₈₀* - less than 3.20 cM - *Dn9*{0211}.

Dnx{0211}. 7DS{0211}. **v:** PI 220127{0211}. **ma:** *Xgwm111-7D₂₁₀* - 1.52 +/- 0.15 cM - *Dnx*{0211}.

Dnx was considered to be located at a locus different from *Dn1*, *Dn2* or *Dn5* {0211}, which were likely to be identical or allelic.

79.Reaction to *Fusarium graminearum*

Disease : Fusarium head scab.

Fhs1{1096}. **v:** Line A{1096}. **v2:** Ning 7840 *Fhs2*{1096}.

Fhs2{1096}. **v:** Line B{1096}. **v2:** Ning 7840 *Fhs1*{1096}.

A major QTL was associated with several linked AFLP markers tentatively located in chromosome 7BL of Ning 7840{0005}.

QFhs.ndsu.2A{9925,0175}. 2AL{9925}. **v:** Sumai 3/Stoa RI mapping population; the QTL was contributed by Stoa{9925}. **ma:** Association with RFLP *XksuH16-2A* (LOD>3){9925,0175}.

QFhs.ndsu.3AS{0372}. 3AS{0372}. **tv:** *T. turgidum* var. *dicocoides*. Recombinant substitution lines LDN and LDN(Dic-3A). The resistant allele was contributed by

dicoccoides{0372}. **ma**: Associated with *Xgwm2-3A* (explained 37% of the phenotypic variation){0372}.

QFhs.ndsu.3B{9925,0175}. 3BS{9925}. **v**: Sumai 3/Stoa RI mapping population; the QTL was contributed by Sumai 3{9925,0175}. **ma**: Association with *Xbcd907-3B.2*(LOD>3){9925}; and microsatellite markers *Xgwm1533-3B* and *Xgwm493-3B*{0175}. This QTL explained 42% of the variation in Sumai 3/Stoa{0175}.

Two additional QTL for resistance to *Fusarium graminearum* were identified in the cross Sumai3/Stoa {0175}. The QTL on 4BS was associated with *Xwg909-4B* and the QTL on 6BS was associated with *Xbarc101-6B* and *Xbcd1383-6B* {0175}. The QTL associated with markers *Xgwm493/Xgwm533* (explaining 24.8 % of the variation), and *Xbarc101/Xbcd1383* were also identified in a RIL population from the cross ND2603/Butte 86 {0175}. In addition, one QTL on chromosome 3AL associated with *Xbcd941-3A* and one on chromosome 6AS associated with *XksuH4-6A* were identified in RILs from the cross ND2603/Butte 86 {0175}.

The resistance QTL on chromosome 3BS associated with *Xgwm493-3B* and *Xgwm533-3B* was also identified in a DH population of the cross CM-82036 (a Sumai 3 derivative) Remus {0240}. Additional QTL in this cross were detected on chromosome 5A, associated with *Xgwm293-5A* and *Xgwm304-5A*, and possibly on 1B, associated with *Glu-B1* {0240}.

Two major genes with additive effects were reported in cross between Sumai 3 (resistant) and two susceptible cultivars{0174}. One of the genes was assigned to 5AL based on linkage to the dominant awn suppressor B1 (RF 15.1-21.4%).

For review see{0283}.

Mesterhazy et al.{0006} reported a strong genetic correlation in resistance to different species of *Fusarium*.

QTLs were located in 3BS, 2BL and 2AS in Ning 7840/Clark. The most effective QTL was probably in interval, flanked by deletions 3BS-3 and -8 and was close to *Xgwm533-3B* and *Xbarc147-3B* {0328}.

80.Reaction to *Heterodera avenae*Woll.

Cereal root eelworm; cereal cyst nematode.

Cre1. [*Cre*{1388}]. 2B{1388}.2BL{1579,1580}. **i**: AP = Prins*8/AUS10894{1579}. **v**: AUS 10894{1056}; Loros CI 3779{1388}. **ma**: *Xglk605-2B* - 7.3cM - *Cre1* - 8.4cM - *Xcdo588-2B/Xabc451-2B*{1579}; A PCR-based assay was developed from *Xglk605-2B*{1580}.

Cre2{238}. Derived from *Ae. ventricosa 10* {238,9991}. 6M^v{9991} **v2**: H-93-8 Cre6{238}. Although H-93-8 is a double M^v(5A), 7M^v(7D) substitution line, *Cre2* was presumed to be located in a separate undetected translocated 6M^v segment{9991}.

Cre3. [*CcnD1*{329},*Ccn-D1*{328}]. 2DL{328}. **v**: Synthetic hexaploids{329}. **dv**: *T. tauschii* accessions AUS 18912{328}; AUS 18913{328}; CPI 110809{329}; CPI 110810{328}.

Cre4. [*CcnD2*{329},*Ccn-D2*{328}]. 2D{328}. **dv**: *T. tauschii* accessions AUS 18914{329}; CPI 110813{328}.

Cre5{0107}. Derived from *Aegilops ventricosa* {0107,0009}. [*CreX*{0009,0183}]. 2AS{0107}=2A-2N^v-6N^v. **v**: VPM1{0107}; Many VPM1 derivatives{0107}; Notable exceptions of lines with *Lr37*, *Sr38* and *Yr17*, but lacking *Cre5* include Trident and Line L22{0107}. **su**: Moisson 6N^v(6D){0183}. **dv**: *Ae. ventricosa 10*{0183}.

Two resistance gene analogues similar to the candidate gene *Cre3* were isolated from the *Ae. ventricosa* segment carrying *Cre5*

Cre6{0138}. Derived from *Aegilops ventricosa* {0138}. 5N^v{0138}. **ad**: Moisson + 5N^v{0138}. **v**: H-93-35{0138}. **v2**: H-93-8 *Cre2*{0138}.

- Cre7**{0104}. Derived from *Aegilops triuncialis* {0105}. [**CreAet**{0105}]. **v**: TR353 derivatives{0105}.
- Cre8**{0220}. [**CreF**{0012,0138}]. 6B{0220}, on basis of linkage with *Xbcd1-6B* and *Xcdo347-6B*{0220}. **v**: Barunga{0220}; Festiguay{0012,0220}; Frame{0138,0220}; Molineaux{0220}. **ma**: Associated with a unique allele when probed with CDO367 which hybridizes to group 7L{1059}.
- CreR**{0133,0318}. 6RL{0133}. **ad**: Wheat + 6R {0318}; Wheat + 6RL{0318}; Various deletion stocks{0318}. **su**: CS + 6R(6D){0133}. **al**: Rye accession T701-4-6{0133}; Triticale T-701{0318}. **ma**: Cent.....*XksuF37* - 3.7cM - **CreR**{0133}; Deletion mapping indicated **CreR** was located near *Got-R2*{0318}.

81.Reaction to *Magnaporthe grisea* (Herbert) Barr

M. grisea is a pathogen of blast on many graminaceous species, the best known of which is rice. In Brazil it has become a pathogen of wheat. The wheat pathotype(s) is different from those attacking other species such as rice, oat, millets and weeping lovegrass.

- Rmg1**{0333}. [**Rwt4**{0302}]. **v**: Norin 4{0302}.

A second gene designated *Rwt3* {0302} was present in CS and Norin 4. Genes *Rwt3* and *Rwt4* were detected using hybrids of *Triticum*- virulent and *Avena*-virulent pathogen isolates.

82.Reaction to *Mayetiola destructor* (Say) (*Phytophaga destructor*) (Say)

Insect pest: Hessian fly.

- H1**{1087}. **i**: Dawson/3^{*}Poso, 6179{1087}. **v2**: Big Club 43 **H2**{1441}; Dawson **H2**{166,1087}; Poso 42 **H2**{1441}.
- H2**{1087}. **i**: Dawson/3^{*}Poso, 6232{1087}. **v2**: Big Club 43 **H1**{1441}; Dawson **H1**{166,1087}; Poso 42 **H1**{1441}.
- H3**{156}. Recessive. 5A{425,1105}. **i**: Carol = Newton-207^{*}5/Larned{1107}. **v**: Ace{426}; Arthur{426}; Becker{749}; Cardinal{750}; Dual{1273}; Frankenmuth{341}; Georgia 1123{426}; GR855{751}; GR876{753}; Ionia{426}; Larned{824}; Logan{426}; Monon{157}; Norkan{904}; Ottawa{547}; Purdue B 36162 A13-12{156}; PI 468960{1439}; Redcoat{1273}; Reed{1273}; Riley{1273}; Roland{148}; Russell{426}; Shawnee{547}; Titan{747}; Todd{426}; W38{156}. **v2**: Clara Fay **H6**{375}. **ma**: Cosegregation of **H3** and a RAPD{296}.
Allan et al.{019} considered that **H3** and **H4** may be allelic. Also suggested by Shands and Cartwright{1317}. Linkage of 10.5 +/- 2% involving **H3** and *Pm3a* in PI 468960 was attributed to a chromosome 1A/5A translocation{1437}.
- H4**. Recessive. **H4** conferred resistance to race A, but not to race B. [**h4**{1441}]. **v**: Dixon{1441}; Java{1441}.
- H5**{1317}. Temperature sensitive {1413}. 1AS{1222}. **v**: Abe{162}; Arthur 71{162}; Beau{875}; Downy{1223}; Oasis{1109}; Ribeiro{1317}; Sullivan{1110}. **tv**: Giorgio 331-4{1090}; PI 94567-6{1317}; PI 94571-14{1317}. **ma**: Cosegregation of **H5** and two RAPDs{296}.
- H6**{019}. 5A{425}. **i**: Erin = Newton-207^{*}7/Arthur 71{1107}; Flynn = Newton-207^{*}7/Knox 62{1107}. **v**: Adder{1319}; Benhur{426}; Caldwell{1421}; Compton{1318}; CI 12855{019}; Excel{752}; Fillmore{1106}; Knox 62{426}; Lathrop{426}. **v2**: Clara Fay **H3**{375}. **tv**: Purdue 4835 A4-6{1105}. **tv2**: PI 94587 **H11 H16**{019}. **ma**: Cosegregation with three RAPDs{296}.
- H7 & H8**{425}. Duplicate factors. **H7** is located in chromosome 5D {026}. **v**: Adena{748}; Seneca{026,425}.

- H9**{1420}. 5A{162}. **i**: Iris = Newton-207*7/Ella{1107}. **v**: Ella{875}; Line 822-34{162}. **v2**: Elva CI 17714 **H10**{162}; Line 812-24 **H10**{1421}; Line 817-2 **H10**{1421}; Stella **H10**{875}. **ma**: Cosegregation with two RAPDs{296}.
- H10**{1104}. 5A{162}. **i**: Joy = Newton-207*3/IN76529A5-3-3{1107}. **v**: IN 76529{875}. **v2**: Elva CI 17714 **H9**{162}; Line 817-2**H9**{162}; Stella **H9**{875}. **ma**: Cosegregation with one RAPD and close linkage to another RAPD{296}.
- H11**{1422}. 1A{1222}. **i**: Karen = Newton-207*4/IN916-1-3-1-47-1{1107}. **v**: Kay{875,375}; Line 916{1422}; Line 920{1422}; Line 941{1422}. **tv2**: *T. turgidum* PI 94587 **H6 H16**{1422}. **ma**: Close linkage with two RAPDs{296}.
- H12**{1092}. 5A{1098}. **i**: Lola = Newton-207*4/Luso{1107}. **v**: Luso{1092}. **ma**: Cosegregation with one RAPD and close linkage of **H12** to another RAPD{296}.
- H13**{1104}. 6DL{441}. **i**: Molly = Newton-207*7/3/KU221-19/Eagle/ KS806{1107}. **v**: KS81H1640HF{441}; *T. turgidum* var. durum cv. Gulab KU 134/*Ae. tauschii* KU 2076, KU 221-14{525}; *T. turgidum* var. persicum *straminium* KU 138/*Ae. tauschii* KU 2076, KU221-19{525}. **dv**: *Ae. tauschii* KU 2076{525}. **ma**: Cosegregation with a RAPD{296}.
- H14**{875}. 5A{875}. **tv**: IN 81601A2-3-3{875}. **tv2**: ELS 6404-160 **H15**{875}. **ma**: Cosegregation with a RAPD{296}.
- H15**{875}. 5A{875}. **tv**: IN 81602C5-3-3{875}. **tv2**: ELS 6404-160 **H14**{875}.
- H16**{1106}. 5A{1098}. **tv**: IN 80164H5-2-9{1106}; N80164{1097}. **tv2**: PI 94587 **H6 H11**{1106}. **ma**: Cosegregation of **H16** and a RAPD{296}.
- H17**{1090}. 5A{1090}. **tv**: PI 428435{1090}. **ma**: Cosegregation of **H17** and a RAPD{296}.
- H18**{1090}. **v**: Marquillo{426,874}; Shield{198}.
- H19**{1089}. **tv**: PI 422297{1089}; This germplasm possesses a second gene which is allelic or closely linked with **H16**{1089}; IN84702{1097}. **tv2**: PI422297 **H29**{1097}.
- H20**{025}. 2B{025}. **tv**: Jori{025}.
- H21**. 2B {383} = 2BS.2R#2L{389}. **v**: Hamlet = KS89WGRC8{1312}; KSWR 69-2-4-3{383}; KS85HF 011-5{383}. **ad**: KSWR 297h-1-1-9{383}. **al**: Chaupon rye{383}. **ma**: A RAPD amplified by primer OPE-13 was shown to co-segregate with **H21**{9938}; A STS primer set SJ07 was developed to identify 2RL, and hence **H21**{0233}.
- H22**{1199}. 1D{1199}. **v**: KS86WGRC1{1199}.
- H23**{1199}. 6D{442}.6DL{1199}. **v**: KS89WGRC3{442}. **ma**: **H23** - 6.9 cM - *XksuH4-6D*{861}.
- H24**{1199}. 3D{442,1199}.6DL{861}. **v**: KS89WGRC6{442}. **ma**: **H24** - 5.9 cM - *Xbcd451-6D/Xcdo482-6D*{861}.
- H25**.
 6B{384} = T6BS.6BL-6R#1L{389}.**v**:88HF16 = WGRC17{384}.
 4B{384} = T4BS.4BL-6R#1L{389}.**v**:88HF79, 88HF80 = WGRC18, 88HF81, 88HF117 = WGRC19{384}.
 4A{384} = Ti4AS.4AL-6R#1L-4AL{389}.**v**:89HF17, 89HF18, 89HF25, 88HF32, 88HF51, 88HF89 = WGRC20{384}.
 6R.**al**:Balbo rye{384}.
- H26**. 4D{217}. **v**: KS92WGRC26{217}. **dv**: *Ae. tauschii* TA2473{217}.
- H27**{235}. 4M^v{235}. **su**: H-93-33{235}. **al**: *Ae. ventricosa* No. 10{235}; *Ae. ventricosa* No. 11{235}.
- H28**{171}. 5A{171}. **tv**: PI 59190{171}.
- H29**{1095}. [H27{171}]. 5A{1097}. **tv**: PI422297 **H19**{1097}.
- H30**{0256}. Derived from *Ae. triuncialis* {0256}. **v**: TR-3531{0256}. **al**: *Ae. triuncialis*{0256}.
- H31**{0332}. 5BS{0332}. **v**: P961696{0332}. **tv**: CI3984{0332}. **ma**: STS marker *Xupw148-5B* - 3 cM - **H31**{0332}.

A recombination value of 12.0% between leaf-rust reaction {possibly *Lr10*} and Hessian-fly reaction in Selection 5240 was reported {018}.

83.Reaction to *Meloidogyne* spp.

Root rot nematode, root knot eelworm

Rkn{632}. **dv**: *Ae. squarrosa* G3489. **v**: Prosquare, a synthetic hexaploid of *Produra/A. squarrosa* G3489{632}.

Rkn-mn1{1621}. Derived from *Ae. variabilis*{1621}. 3B{590}. **v**: X8=CS/*Ae. variabilis* No. 1//Rescler/3/Lutin{1620}; X35{1620,1621}. **ma**: Co-segregation with RAPD *OpY161065* and close linkage with several markers including *Est-B5*{0103}.

84.Reaction to *Mycosphaerella graminicola* (Fuckel) Schroeter

Disease: Septoria tritici blotch

Stb1. [*Slb1*{1586}]. **v**: Bulgaria 88{1586}; Oasis{1586}; Sullivan{1586}.

Stb2. [*Slb2*{1586}]. **v**: Nova Prata{1586}; Veranopolis{1586}.

Stb3. [*Slb3*{1586}]. **v**: Israel 493{1586}.

Stb4{1410}. **v**: Cleo{1410}; Tadinia{1410}; Tadorna{1410}.

Stb4 segregated independently of *Stb1* but its relationship with *Stb2* and *Stb3* is unknown.

Stb5{0186}. Identified using *M. graminicola* IPO94269{0186}. Derived from *Aegilops tauschii* accession 37-1 {0186}. 7DS{0186}. **v**: Bezostaya{0187}; Hereward{0187}; Sears' Synthetic{0186}; Shafir{0187}; Vivant{0187}. **su**: CS*8/(Syn7D){0186}. **dv**: *Ae. tauschii* 37-1{0186}. **ma**: *Rc3* - 6.6cM - *Stb5* - 7.2cM - *Xgwm44-7D* - Centromere{0186}; *Stb6* - 2cM - *Xgwm369-3A*{0187}.

Stb6{0187}. Confers resistance to *M. graminicola* isolate IPO323 but not to isolate IPO94269 {0187}. 3AS{0187}. **v**: Flame{0187}.

Stb7{0311}. 4AL{0311}. **v**: ST6 = Estanzuela Federal{0310, 0311}. **ma**: *wmc219-4A* - 0.8cM - *Xwmc-4A* - 0.3cM - *Stb7*{0311}.

Stb8{0326}. 7BL{0326}. **v**: Synthetic hexaploid W7984 (parent of ITMI population){0326}. **ma**: *Xgwm146-7B* - 3.5cM - *Stb8* - 5.3cM - *Xgwm577-7B*{0326}.

85.Reaction to *Pratylenchus* spp.

Root lesion nematode; prats

85.1. Reaction to *Pratylenchus neglectus*

Rlnn1{0121}. 7AL{0121}. **v**: Excalibur{0121}; Krickauff{0121}. **ma**: Mapped between markers *Xpsr121-7A* and *Xgwm344-7A* and 9 cM proximal to *Lr20*{0374}.

85.2. Reaction to *Pratylenchus thornei*

QTLs were located on chromosomes 2BS and 6DS {0122}.

86.Reaction to *Phaeosphaeria nodorum* (E. Muller) Hedjaroude (anamorph: *Stagonospora nodorum* (Berk.) Castellani & E.G. Germano).

Disease: Septoria nodorum blotch.

Snb1{856}. 3AL{856}. **v**: Red Chief{856}. **v2**: EE8 *Snb2*{856}.

Snb2{856}. 2AL{856}. **v2**: EE8 *Snb1*{856}.

Snb3{1594}. 5DL{1594}. **s**: CS*/Synthetic 5D{1594}. **v**: Synthetic{1594}. **dv**: *Ae. tauschii*{1594}.

SnbTM{856,857}. 3A{857}.3AL{856}. **tv**: *T. timopheevii* /2*Wakooma{856}; *T. timopheevii* PI 290518. *T. timopheevii* derivatives: S3-6{857}; S9-10{857}; S12-1{857}. **ma**:

*UBC521*₆₅₀ - 15cM - *SnbTM* - 13.1cM - *RC37*₅₁₀{0212}.

*UBC521*₆₅₀ was converted to a SCAR marker{0212}.

87.Reaction to *Puccinia graminis* Pers.

Disease: Black rust; black stem rust; stem rust.

Note: Some near-isogenic lines are based on Marquis. The genes present in the Marquis background are not listed for those NILs.

Sr1. Deleted - see *Sr9d*.

Sr2{38,677}. Recessive allele. Adult plant response. 3BS{499}. **s**: CS*6/Hope 3B{499}. **v2**: Warigo *Sr7b Sr17*{499}; Suneca *Sr8a Sr17*{485}; Hopps *Sr9d*{499}; Lancer *Sr9d Sr17*{679}; Scout *Sr9d Sr17*{679}; See also{499,1040}. **ma**: *Xgwm389-3B* - 2.7cM - *Sr2* - 1.1cM - *Xgk683-3B*{0358}.

Sr2 is associated with pseudo-black chaff{742,1102} and seedling chlorosis (see {149}) and occurs very frequently in commercial wheats, especially in germplasm produced and distributed by CIMMYT. *Sr2* has probably remained effective since the 1920s.

Sr3 & *Sr4*{047}. **v**: Marquillo - based on early data. No stocks available.

Sr5{047}. 6D{939,1308,1626}.6DS{939}. **i**: I *Sr5*-Ra{828}; I *Sr5*-Rb{828}; *Sr5/7**LMPG{685}; Thatcher/10*Marquis{686}. **s**: CS*6/Thatcher 6D{1308}. **v**: Admonter Fruh{072}; Dacia{979}; Dong-Fang-Hong 2{564}; Dong-Fang-Hong 6{564}; Feng-Kong{563}; Hochzucht{046}; Hybrid 80-3{072}; Jubilejna{068}; Juna{076}; Kanred{1308}; Ke-Fang 1{564}; Stabil{072}; Viginta{071}; Vrakunski{072}. **v2**: Victor *Sr6 Sr8a*{979}; Glenlea *Sr6 Sr9b*{327}; Qing-Chung 5 *Sr6 Sr11*{564}; An-Hewi II *Sr8a*{564}; Erythrospermum 974 *Sr8a*{072}; N.P.789 *Sr11*{1555}; Jing-Hong *Sr17*{564}; Jing-Hong 2 *Sr17*{564}; Amika *Sr31*{076}; Dong-Xie 3 *Sr31*{563}; Dong-Xie 4 *Sr31*{563}; Istra *Sr31*{076}; Solaris *Sr31*{076}; Beijing 10 *SrTmp*{564}.

Sr6{687}. [*SrKal*{1167}]. 2D{1293,1308,1577}.2DS{942}. **i**: I *Sr6*-Ra{828}; Kenya 58/10*Marquis{468,675}; *Sr6/9**LMPG{685}. **s**: CS*5/Red Egyptian 2D{1308}. **v**: Africa 43{669}; Eureka{468,844}; Kenya stocks{669,670,673,687,689,1167,1557}; McMurachy{679}; Shield{198}. **v2**: Bowie *Sr8a*{1553}; Eurga *Sr11*{1553}; Fortuna *Sr7a*{679}; Gamut *Sr9b Sr11*{1555}; Glenlea heterogeneous*Sr5 Sr9b*{327}; Kentana 52 *Sr7a*{678,1577}; Kiric 66 *Sr7b*{979}; Lerma Rojo 64 *Sr7b Sr9a*{979}; No. 466 *Sr9b Sr10*{689}; Red Egyptian *Sr8a Sr9a*{687,1308}; Siete Cerros *Sr11*{033}; Victor I *Sr5 Sr8a*{979}.

See also {1553}.

Sr7{830}. 4A{671,830,1293}.4AL{939,1308}.

Sr7a{830}. [*Sr7*{687}]. **i**: Egypt Na101/6*Marquis{468}; Kenya 117A/6*Marquis{468}; *Sr7a/9**LMPG{685}. **s**: CS*7/Kenya Farmer 4B{830}; CS*8/Sapporo 4B{830}. **v**: Egypt Na101{669}; Kenya stocks{669,670,673,687,689}; Sapporo Haru Komugi Ichigo{689}. **v2**: Fortuna *Sr6*{679}; Kentana 52 *Sr6*{689}; French Peace *Sr9a Sr13*{680}; Egypt Na95 *Sr9b Sr10*{687}; W3746 *Sr12*{1371}; Khapstein *Sr13 Sr14*{674}.

Sr7b{830}. **i**: I *Sr7b*-Ra{828}. **v2**: Warigo *Sr2 Sr17*{499}; Kiric 66 *Sr6*{979}; Roussalka *Sr8a*{979}; Red Bobs *Sr10*{308}; Nell *Sr17*{1565}; Spica *Sr17*{939}; Marquis *Sr18 Sr19 Sr20*{675,830}.

Sr8. 6A{1293,1308}.6AS{929,1368}.

- Sr8a**{1368}. [*Sr8*{687}]. **i**: I *Sr8a*-Ra{828}; Red Egyptian/10*Marquis{686}; *Sr8a*/9*LMPG{685}. **s**: CS*5/Red Egyptian 6A{1308}. **v**: Marimp 3{979}; Mentana{844}; Strampelli{979}. **v2**: An-Hewi II *Sr5*{564}; E-Gan-Zao *Sr17*{564}; *Erythrospermum* 974 *Sr5*{072}; Frontana *Sr9b*{689}; Golden Valley *Sr17*{979}; Hartog *Sr2 Sr12*{127}; Magnif G *Sr9b*{689}; Pitic 62 *Sr9b*{033}; Red Egyptian *Sr6 Sr9a*{687}; Rio Negro *Sr9b*{689}; Roussalka *Sr7b*{979}; Suneca *Sr2 Sr17*{485}; Victor 1 *Sr5 Sr6*{979}.
- Sr8b**{1368}. [*SrBB*]. **v**: Barleta Benvenuto{1368}; Klein Titan{1368}. **v2**: Bezostaya *Sr5*{979}; Klein Cometa *Sr30*{1368}.
- Sr9**{676}. 2B{671,677,828,1308}.2BL{944,946,951,1307,1582}.
- Sr9a**{676}. [*Sr9*{687}]. **i**: I *Sr9a*-Ra{828}; Red Egyptian/10*Marquis{686}; *Sr9a*/9*LMPG{685}. **s**: CS*4/Red Egyptian 2B{1308}. **v2**: Red Egyptian *Sr6 Sr8a*{687}; French Peace *Sr7a Sr13*{680}; Excel *Sr8a Sr17*{752}.
- Sr9b**{468}. [*Sr9*{687},*SrKb1*{468}]. **i**: Kenya 117A/10*Marquis{686}; *Sr9b*/10*LMPG{685}. **s**: CS*7/Kenya Farmer 2B{939}. **v**: Gamanya{844}; Kenya stocks{669,670,673,687,689,1557}. **v2**: Egypt Na95 *Sr7a Sr10*{636}; Festival *Sr15*{1553}; Frontana *Sr8a*{689}; Gamut *Sr6 Sr11*{1555}; Glenlea *Sr5 Sr6* heterogeneous{327}; Kenora *Sr15*{1553}; Magnif G *Sr8a*{689}; No. 466 *Sr6 Sr10*{689}; Pitic 62 *Sr8a*{033}; Rio Negro *Sr8a*{689}; Robin *Sr11*{879}; Veadeira *Sr10*{687}.
- See also {1553}.
- Sr9c**.Originally reserved for *Sr36*.
- Sr9d**{678,831}. [*Sr1*{047,676,677}]. **i**: Hope/10*Marquis{677}; H-44/10*Marquis{677}; I Hope 2B-Ra{828}; *Sr9d*/8*LMPG{685}. **v**: Hopps *Sr2*{1040}. **v2**: Lancer *Sr2 Sr17*{679}; Scout *Sr2 Sr17*{679}. **tv**: Arnautka{939}; Mindum{939}; Spelmar{939}.
- Sr9e**{951}. [*Srd1v*{642},*Srv*{1391}]. **v**: SST 16{1324}; SST 33{785}; SST 66{785}; SST 3R{1324}; Vernstein{845}. **v2**: Combination III *Sr36*{841}; Sunstar *Sr8a Sr12*{939}. **tv**: Vernal emmer{1391}; CI 7778{845}; *Sr9e* occurs in many tetraploid wheats{939,1378}.
- Sr9f**{826}. **v**: Chinese Spring{826}; Not present in the near-isogenic I *Sr9a*-Ra{826}.
- Sr9g**{965}. **s**: CS*7/Marquis 2B *Sr16*{965}; CS*4/Thatcher 2B *Sr16*{965}. **v2**: Hochzucht *Sr5 Sr12*{965}; Lee *Sr11 Sr16*{965}; Celebration *Sr12 Sr16*{965}; Eagle *Sr26*{842}. **tv**: Acme{965}; Iumillo{965}; Kubanka{965}.
- See also {504}.
- Sr10**{687}. 2B{686,939}. **i**: Egypt Na95/4*Marquis{468}. **v**: Federation{939}; Geneva{1412}; Hazen{049}; Kenya stocks{669,670,673,687}. **v2**: Egypt Na95*Sr7a Sr9b*{687}; No. 466 *Sr6 Sr9b*{689}; Red Bobs *Sr7b*{308}.
- Sr11**{468}. [*Sr11*{687},*Sr12*{687}]. 6B{671,1143,1293,1309}.6BL{1297}. **i**: I *Sr11*-Ra{828}; Lee/10*Marquis{686}. **s**: CS*7/Kenya Farmer 6B{830}; CS*9/Timstein 6B{1308}. **v**: Charter{844}; Flevina{072}; Gabo{687}; Kenya stocks{670,673,844,1557}; Sonora 64{033}; Sylvia{071}; Timstein{687,1308}; Tobari 66{033}; Yalta{844}. **v2**: Eurga *Sr6*{1553}; Gamut *Sr6 Sr9b*{1555}; Lee *Sr9g Sr16*{687}; N.P.790 *Sr5*{1555}; Qing-Chung 5 *Sr5 Sr6*{564}; Robin *Sr9b*{879}; Prospect *SrWld*{197}; See also{1553}.
- A resistance gene allelic with *Sr11* was found in Chinese Spring {938}, but the *P. graminis* culture for its detection was lost.
- Sr12**{1332}. Recessive.
- 3B{1332,682}.3BS{968}. **s**: CS*7/Marquis Selection 3B *Sr16*{1332}; CS*5/Thatcher 3B *Sr16*{1332}. **v**: Marquillo{682}; Tincurrin{939}; Windebri{939}. **v2**: W3746 *Sr7a*{1371}. **tv**: Postulated for several durums{1378}.
- Sr12* is more widespread and probably more effective in conferring resistance than is usually acknowledged {939}.

- Sr13**{674}. 6AL{929}. **i**: Khapstein/10*Marquis{686}; Sr13/9*LMPG{685}. **v2**: French Peace *Sr7a Sr9a*{680}; Khapstein *Sr7a Sr13 Sr14*{674}. **tv2**: Khapli *Sr14*{674}.
- Sr14**{674}. 1BL{933}. **i**: Khapstein/10*Marquis{686}. **v**: Line A{933}. **v2**: Khapstein *Sr7a Sr13*{674}. **tv2**: Khapli *Sr13*{674}.
- Sr15**{1554}. 7A{1293,1554}.7AL{1305}. **v**: Present in stocks possessing *Pm1* and *Lr20*{931,1554}; See Reaction to *Blumeria graminis* and Reaction to *P. triticina*. **ma**: Associated with clustered markers{0323}.
- Sr16**{830}. [*Srrl2*{1238}]. 2B{830,1308}.2BL{1307}. **i**: I *Sr16*-Ra{828}; I Th3B-Ra{832}. **s**: CS*7/Marquis 2B *Sr9g*{1581}; CS*4/Thatcher 2B *Sr9g*{1308}; CS*5/Thatcher 3B *Sr12*{832}. **v2**: Thatcher *Sr5 Sr9g Sr12*{939}; Lee *Sr9g Sr11*{939}.
- Sr17**. Recessive. [*sr17*{964}]. 7B{771}.7BL{964}. **s**: CS*6/Hope 7B{964}. **v2**: E-Gan Zeo *Sr8a*{564}; Golden Valley *Sr8a*{979}; Jing-Hong 1 *Sr5*{564}; Jing-Hong 2 *Sr5*{564}; Lancer *Sr2 Sr9d*{679}; Nell *Sr7b*{1565}; Scout *Sr2 Sr9d*{679}; Suneca *Sr2 Sr8a*{485}; Present in many stocks possessing *Pm5*{964}; See Reaction to *Blumeria graminis*.
- Sr18**{054}. [*SrG2*{844},*Srrl1*{1238},*Srmq1*{099},*SrPs1*{1263},*SrMn1*{1263}]. 1D{054,1308,1582}. **i**: I Hope 1D-Ra{828}; Sr18/8*LMPG{685}. **s**: CS*6/Hope 1D{1308}. **v**: Present in the majority of wheat stocks{828}; Stocks not possessing *Sr18*: Brevit{054}; Chinese Spring{828}; Eureka{054}; Federation{054}; Gular{054}; Kenya C6042{054}; Koala{054}; Little Club{828}; Morocco{054}; Norka{054}; Prelude{828}; Yalta{054}.
- Sr19**{029}. [*Srmq2*{099}]. 2B{029}.2BS{1582}. **v**: Mq-B{029}. **v2**: Marquis *Sr7b Sr18 Sr20*{029}.
- Sr20**{029}. [*Srmq3*{1238},*Srrl3*{1238}]. 2B{029}. **v**: Mq-C{029}; RI-C{029}. **v2**: Reliance *Sr5 Sr16 Sr18*{029}; Marquis *Sr7b Sr18 Sr19*{029}.
- Sr21**{1460}. 2AL{1460,1464}. **i**: Sr21/8*LMPG{685}. **v**: Hexaploid derivatives of *T. monococcum*{939}. **tv**: Tetraploid derivatives of *T. monococcum*{939}. **dv**: Einkorn{1460}; Various *monococcum* accessions. See also *Sr45* which has similar specificity to *Sr21*.
- Sr22**{1460}. 7A{649}.7AL{1460}. **i**: Marquis*4//Stewart*3/*T. monococcum*{649,1460}; Sr22/9*LMPG{685}; Others{1112}. **v**: CS/3/Steinwedel*2//Spelmar/*T. boeoticum*{1460}; Schomburgk{880}; Steinwedel*2//Spelmar/*T. boeoticum*{1460}; Others{1112}. **tv**: Spelmar/*T. boeoticum*{1460}; Stewart*6/*T. monococcum* RL 5244{649}. **dv**: Various *T. monococcum* accessions{649,1460}. **ma**: Hexaploid derivatives with *Sr22* carried 'alien' segments of varying lengths; the shortest segment was distal to *Xpsr129-7A*{1112}; See also{0158}.
- Sr23**{950}. The following chromosome locations are consistent with the finding that the first location was based on Rescue monosomics. Rescue differs from CS by a 2B-4B reciprocal translocation {939}. 4B{950}.2BS{939}. **v**: Exchange{950}; Warden{950}; *Sr23* is always associated with *Lr16*{950}. **v2**: Etoile de Choisy *Sr29*{950}.
- Sr24**{956}. Derived from *Thin. elongatum*.
3DL.
3DL = T3DS.3DL-3Ae#1L{956,389}.**i**:Sr24/9*LMPG{685}; Sears' 3D/Ag translocations{956,1300}. **v**: Agent{956}; Blueboy II{956}; Collin{901}; Cloud{956}; Cody{1284}; Fox{956}; Gamka{785}; Karee{785}; Kinko{785}; Palmiet{785}; Sage{825,1024}; SST 23{1324}; SST 25{785}; SST 44=T4R{1324,785}; SST 102{785}; Torres{128}; Wilga{785}. **v2**: Siouxland *Sr31*{1283}. **v**: List of Australian genotypes{0340}.
1BL.T1BL = 1BS-3Ae#1L{600,389}.**tr**:Amigo{1463,600,389}; Teewon{600,389};
Note:Amigo also carries a 1AL.1RS translocation with resistance from rye{1463}.
3Ae#1.**su**:Chinese Spring 3Ag {3D}{1304}; TAP48{389}.

Sr24 is completely linked in coupling with *Lr24* {956} and often with red grain colour. See Reaction to *P. triticina*.

Sr25{956}. Derived from *Thin. elongatum*.

7DL = T7DS.7DL-7Ae#1L{291,956,388,657}. **i**: Sears' CS 7D/7Ag translocations{956,1300}; Sr25/9* LMPG{685}. **v**: Agatha *Sr5 Sr9g Sr12 Sr16* {956} = T4{1323}; Mutant 28{388}.

7AL = T7A-7Ae#1L{330}. **v**: Sears' 7A/7Ae#1L No. 12{330,1304}; Sears' 7D/7Ag#11 carries neither *Sr25* nor *Lr19*{939}.

7Ae#1L.**su**: Chinese Spring + 7Ae#1L{7D}{1304}; .

See *Lr19*, reaction to *Puccinia triticina*.

Sr25/Lr19 often show complete linkage in wheat {956}.

Knott {681} obtained two mutants (28 and 235) of Agatha with reduced levels of yellow pigment in the flour. One of these mutants lacked *Sr25*. Marais {890} reported that a gene very similar to *Sr25* was present in the putative Inia 66 x *Thinopyrum distichum* derivative, Indis. Marais {890,892} also obtained mutants with reduced yellow pigment in Indis derivatives and some of these lacked *Sr25*.

Sr26{956}. Derived from *Thin. elongatum*. 6AL{364} = T6AS.6AL-6Ae#1L{388,389}. **i**: Sr26/9* LMPG{685}. **v**: Avocet{364}; Flinders{1449}; Harrier{939}; Jabiru{956}; King{1451}; Kite{956}; Knott's 6A-6Ae#1L translocation to Thatcher{672}; Takari{253}. **v2**: Bass *Sr36*{1450}; Eagle *Sr9g*{956}. **ma**: Detected with several RFLP probes{0138}.

Sr27. Derived from *S. cereale*.

3A (T3A-3R) = T3AS.3R#1S{003,896,389}. **i**: Sr27/9* LMPG{685}. **v**: WRT wheat-rye translocation, available in CS, Thatcher and Pembina backgrounds. Translocated from Imperial rye to Chinese Spring by Acosta{003}; Widespread in triticales{966,1384}.

3B = T3BL.3R#1S{896}.:.

3A = T3A.3RS{896}. **v**: W964 = 3RS.3AL.1/4* Inia 66{}; W968 = 3RS.3AL.1/5* Condor{}; W970 = 3RS.3AL.88/5* SST3{}.

3B = T3BL.3RS{896}. **v**: W966 = 3RS.3BL.26/4* Inia 66{}.

Sr28{932}. 2BL{932}. **i**: Line AD{932}. **v2**: Kota *Sr7b Sr18*{932}.

Sr29{313}. [*SrEC*{955}]. 6DL{313}. 6DS{1626}. **i**: Prelude/8* Marquis//Etoile de Choisy{313}. **v**: Hana{071}; Hela{076}; Mara{068}; Slavia{076}; Vala{076}. **v2**: Etoile de Choisy *Sr23*{955}.

Sr30{688}. [*SrW*]. 5DL{688}. **i**: Sr30/7* LMPG - Lines 1, 2, and 3{685}. **v**: Festiguay{688}; Mediterranean W1728{1369}; Webster{688}. **v2**: Klein Cometa *Sr8b*{1368}; Relatively common in Australian and Mexican wheats. Various unnamed accessions{208,1321}.

Sr31. Derived from *S. cereale*.

1B = T1BL.1RS = T1BL.1R#1S{389} or 1R(1B). **i**: MA1 and MA2 four-breakpoint double translocation lines 1RS-1BS-1RS.1BL in Pavon{0084}. **v**: Amika {heterogeneous} *Sr5*{076}; Cougar{0267}; Derivatives of Petkus rye - see *Lr26*, *Yr9*. Feng-Kang 2{563}; Feng-Kang 8{563}; Gamtoos{785}; GR876{753}; Jing-Dan 106{563}; Jan 7770-4{563}; Lu-Mai 1{563}; Rawhide (heterogeneous){0267}; Yi 78-4078{563}. **v2**: Dong Xie 3 *Sr5*{563}; Dong Xie 4 *Sr5*{563}; Istra *Sr5*{076}; Solaris *Sr5*{076}; Siouxland *Sr24*{1283}. **tv**: Cando*2/Veery = KS91WGRC14{381}. **ma**: 1BS/1RS recombinants 4.4cM proximal to *Gli-B1/Glu-B3*{0084}; Several markers tightly linked with *Sr31* were identified in{0377}.

Sr32. Derived from *Ae. speltoides*.

2A {939,1304} = T2AL.2S#1L-2S#1S {389}. **v**: C95.24{389}.

2B {1304} = T2BL-2S#1S{389}. **v**: C82.1 = P80-14.1-2{389}.

2D {1304} = T2DL-2S#1L.2S#1S{389}. **v**: C82.2 = P80-139.1-4{389,1304}; C82.3 = P80-132.2-2{939,1304}; C82.4 = P80-153.1-2{939,1304}.

- Sr33.** (linked with *Gli-D1*). [*SrSQ*{650}]. 1DL{650}.1DS{620}. **v:** RL 5405 = Tetra Canthatch/*Aegilops squarrosa* RL 5288{650}. **ma:** *Xmwig60-1D* - 5.8cM - *Sr33* - 2.2cM - *Xwmg2083-1*{0360}.
- Sr34**{967}. Derived from *Ae. comosa*.
 2A {967} = T2AS-2M#1L.2M#1S{389}.**v:**CS 2A-2M 4/2{967}.
 2D {967} = T2DS-2M#1L.2M#1S{389}.**i:***Sr34/6**LMPG{685}. **v:** Compair{967}; CS 2D-2M 3/8{967}; Various addition, substitution and translocation lines with *Yr8*{967}.
 2M{967}.**su:**Chinese Spring 2M(2A){967}.
- Sr35**{957}. [*SrTm1*{1522}]. 3AL{957}. **v,tv:** Tetraploid and hexaploid derivatives of *T. monococcum*{957}. **dv:** *T. monococcum* C69. 69 Selection{957}; G2919{957}.
- Sr36**{939}. [*SrTt1*{949}]. 2BS{939}. **i:** *Sr36/8**LMPG{685}. **v:** Arthur{939}; Arthur 71{1324}; Flemink{1324}; GK Kincso{0235}; Gouritz{1324}; Idaed 59; Maris Fundin{070}; Mengavi{949}; SST 101{1324}; SST 107{785}; Timvera{949}; *T. timopheevii* derivatives{949}; Zaragoza{785}; Others{572}. **v2:** Bass *Sr26*{1450}; Combination III *Sr9e*{939}; Timson *Sr5 Sr6*{939}. **tv:** *T. timopheevii*{949}.
- Sr37**{939}. [*SrTt2*{949}]. 4BL{939}. **v,tv:** *T. timopheevii* and derivatives{484,949}; Line W{949}.
- Sr38**{062}. Derived from *Ae. ventricosa*. 2AS{062}.6M^v=2MS-6MS.6ML or 2MS-6ML.6MS{0009}. **i:** RL 6081 =Thatcher + *Lr37*. This line will carry additional genes from Thatcher. **v:** Moisson derivatives Mx12 and Mx22{0213}; VPM1{062}.
Sr38 is linked with *Lr37* and *Yr17*. See Reaction to *P. triticina Lr37* and *P. striiformis tritici Yr17*
- Sr39**{646}. Derived from *Ae. speltoides*. 2B{651}. **v:** RL 5711{646,651}. **tv:** Amphiploid RL 5347 = *Ae. speltoides/T. monococcum*{651}. **ma:** *Sr39* is closely linked with *Lr35*{651}; A SCAR marker was developed{9923}.
 Although *Sr39* produces similar responses to *Sr32*, also derived from *Ae. speltoides*, recombination studies based on three crosses showed independent inheritance {646}. *Sr39* segregated independently of *Lr13* {651}.
- Sr40**{302}. Derived from *T. araraticum*. 2BS {302} = T2BL/2G#2S{389}. **i:** RL 6087 = RL 6071 *7/PGR 6126; RL 6088 = RL 6071 *7/PGR 6195{302}. **tv:** *T. araraticum* PGR 6126{302}; PGR 6195{302}.
- Sr41**{1215}. 4D{1215}. **v:** WDR-B1{1214}. **v2:** Waldron *Sr5* (heterogeneous) *Sr11* (heterogeneous).
- Sr42**{667}. 6DS{938}. **v:** Norin 40{938}.
- Sr43.** Derived from *Thin. elongatum*.
 7DL = T7DL-7Ae#2L.7Ae#2S{657,389}.**tr:**KS10-2{653}.
 7D = T7DS.7Ae#2L{657,389}.**tr:**KS23-9{653}; KS24-1{653}; KS24-2{653}.
- Sr44**{389}. Derived from *Thin. intermedium*.
 T7DS-7Ai#1L.7Ai#S 7Ai#1L{389}.**v:**Line 86.187{939}; Several 7A-7Ai#1L translocations{0089}.
 7Ai#2, 7Ai#2S.**su:**Group 7 alien substitution lines with 7Ai#1 and 7Ai#1S{939}. **ad:** TAF2 = L1{169}.
- Sr45**{894}. [*SrD*{934},*SrX*{1805}]. 1D{897}.1DS{894}. **v:** 87M66-2-1{894}; 87M66-5-6{897}; Thatcher + *Lr21*, RL5406{894,934}; Various backcross derivatives developed at PBI Cobbitty{1461}. **dv:** *Ae. tauschii* RL5289{894,934}.
 Tests of natural and induced mutants of *P. graminis* f. sp. *tritici* indicated that *Sr45* has identical specificity to *Sr21* {934}.
- SrA**{323}. **v:** SW55-1{323}; SW56-1{323}. **v2:** SW33-5 *Sr9a Sr13*{323}; SW54-3 *Sr9d Sr13*{323}.
- SrR.** **ma:** Several markers tightly linked with *SrR* were identified in{0377}.

SrTmp{1230}. **v:** Bai-Yu-Bao{564}; Beijing 9{564}; Beijing 11{564}; Fertodi 293{977}; Martonvasari 5{977}; Mironovska = Mironovskaya 808{068,977}; Nung-Ta 139{564}; Parker{977}; Trison{1230}; Triumph 64{841,1230,977}; Xuzhou 14{564}; Yen-An 15{564}. **v2:** Beijing 10 *Sr5*{564}.

SrWld{1230}. **v2:** Prospect *Sr11*{197}.

SrZdar{067}. 1B{067}. **v:** Zdar{067}.

Additional temporary designations are listed in {1230}.

Genotype lists: {323,970}.

Complex genotypes:

AC Taber: *Sr2*, *Sr9b*, *Sr11*, *Sr12*{9905}.

Centurk: *Sr5* {979}, *Sr6* {979}, *Sr8a*, *Sr9a* {979}, *Sr17* {979}.

Chris: *Sr5* {679,1371}, *Sr7a* {1371}, *Sr9g* {1371}, *Sr12* {1371}.

Egret: *Sr5* {939}, *Sr8a* {939}, *Sr9b* {939}, *Sr12* {939}.

FKN: *Sr2*, *Sr6*, *Sr7a*, *Sr8a* {791}, *Sr9b* {791}.

H-44: *Sr2*, *Sr7b* {677}, *Sr9d* {677}, *Sr17*.

Hartog: *Sr2* {127}, *Sr8a*, *Sr9g*, *Sr12* {939}.

Hope: *Sr2* {677}, *Sr7b* {677}, *Sr9d* {677}, *Sr17*.

Kenya Plume: *Sr2* {1370}, *Sr5* {1370}, *Sr6* {1370}, *Sr7a* {1370}, *Sr9b* {1370}, *Sr12* {1370}, *Sr17* {1370}.

Khapstein: *Sr2*, *Sr7a*, *Sr13* {674}, *Sr14* {674}.

Lawrence: *Sr2*, *Sr7b* {939}, *Sr9d*, *Sr17*.

Lerma Rojo 64: *Sr2*, *Sr6*, *Sr7b* {979}, *Sr9a* {979}.

Madden: *Sr2*, *Sr9b*, *Sr11*, *Sr13* {842}.

Manitou: *Sr5* {679}, *Sr6* {679}, *Sr7a*, *Sr9g* {965}, *Sr12* {939}.

Mendos: *Sr7a* {939}, *Sr11* {879}, *Sr17*, *Sr36*.

Pasqua: *Sr5*, *Sr6*, *Sr7a*, *Sr9b*, *Sr12*. Gene *Lr34* acted as an enhancer of APR{9905}.

PI 60599: *Sr7a* {689}, *Sr8a*, *Sr9b*, *Sr10*.

Selkirk: *Sr2* {499}, *Sr6* {468}, *Sr7b* {499}, *Sr17*, *Sr23* {950}.

Redman: *Sr2*, *Sr7b* {939}, *Sr9d* {939}, *Sr17*.

Reliance: *Sr5* {1308}, *Sr16* {1238}, *Sr18*, *Sr20*.

Renown: *Sr2*, *Sr7b* {939}, *Sr9d* {939}, *Sr17*.

Roblin: *Sr5*, *Sr7a?* *Sr11*, *Sr12*.

Timgalen: *Sr5* {heterogeneous} {1555}, *Sr6* {1555}, *Sr8a*, *Sr36*.

Thatcher: *Sr5* {1308}, *Sr9g* {965}, *Sr12* {939}, *Sr16* {1308}.

WW15 = Anza = Karamu = T4: *Sr5* {939}, *Sr8a* {939}, *Sr9b* {939}, *Sr12* {939}.

88.Reaction to *Puccinia striiformis* Westend.

Disease: Stripe rust, yellow rust.

88.1. Designated genes for resistance to stripe rust

Yr1{851}. [*L*{1622}]. 2A{877,1610}.2AL{940}. **v:** Chinese 166{851}; Corin{230}; Dalee{083}; Durin{1459}; E2025{1267}; E7700{1267}; E8594{1267}; Feng-Kang 13{1610}; Heines 110{604}; Maris Ranger{1459}; Maris Templar{1459}; Odra{073}. **v2:** Argent *Yr3a Yr4a Yr6*{1067}; Avocet (UK)*Yr2 Yr6*{1459}; Bounty *Yr13*{1459}; Fenman *Yr2*{1459}; Galahad *Yr2* {heterogeneous} *Yr14*{1459}; Galahad *Yr14*{083}; Ibis *Yr2*{604}; Longbow *Yr2 Yr6*{083}; Mardler *Yr2 Yr3a Yr4a Yr13*{604,1459}; Maris Templar *Yr3a Yr4a*{604}; Marksman {heterogeneous} *Yr2 Yr13*{1459}; Mithras *Yr2 Yr6*{1459}; Nudif TP1 *Yr3a*{1431}; Nudif TP3 *Yr3c*{1431}; Nudif TP250 *Yr6*{1431}; Regina *Yr2*{073};

Rothwell Perdix *Yr2*{604}; Sportsman *Yr13*{1459}; Stetson *Yr9*{083}; Sylvia *Yr2*{1430}; Tadorna *Yr2*{1431}; Virtue *Yr13*{083,1459}.

A report {1267} that Kalyansona and Nadadores carried *Yr1* is not correct.

Yr2{851}. Recessive {1351}. [*U*{1622}]. 7B{746,186,184}. **v**: Derius{230}; Flevina{1431}; Hana{51,58}; HD2329{1352}; Kalyansona{1351,1352}; Laketch{050}; Leda{1430}; Manella{1431}; Merlin{1622}; Odra{071}; PBW54{1352}; PBW120{1352}; Slavia{073,071}; Soissonais Desprez{851}; WG377{1352}; WH147{1352}; WL711{1352}; WL1562{1352}. **v2**: Avocet (U.K.) *Yr1 Yr6*{1459}; Brigand *Yr14*{083}; Cleo *Yr3c*{1457}; Cleo *Yr3c Yr14*{1431}; Fenman *Yr1*{1459}; Flamingo *Yr6*{1430}; Flevina *Yr7*{1430}; Galahad (heterogeneous) *Yr1 Yr14*{1459}; Garant *Yr7*{230}; Hardi *Yr7*{230}; Heines Kolben *Yr6*{611}; Heines Peko *Yr6Yr25*{746}; Heines VII *Yr25*{851}; Ibis *Yr1*{604}; Lely *Yr7*{1430}; Liberator *Yr3c*{1431}; Longbow *Yr1 Yr6*{083}; Mardler *Yr1 Yr3a Yr4a Yr13*{1459}; Maris Beacon *Yr3b Yr4b*{1459}; Maris Huntsman *Yr3a Yr4a Yr13*{604}; Maris Nimrod *Yr13*{1459}; Marksman *Yr1* (heterogeneous) *Yr13*{1459}; Mithras *Yr1 Yr6*{1459}; Nautica *Yr9*{1430}; Norman *Yr6*{083}; Rapier *Yr4*{083}; Rothwell Perdix *Yr1*{604}; Sonalika *YrA*{1352}; Stella *Yr3*{1430}; Sylvia *Yr1*{1430}; Tadorna *Yr1*{1431}; Viginta *Yr3a Yr4a*{073,071}; Wizard (heterogeneous) *Yr14*{1459}; Yamhill *Yr3a Yr4a*{181,182, see also, 184}; Zdar *Yr4a*{073}.

Yr2 originally referred to a gene in Heines VII conferring resistance to European pathotypes. However, Heines VII possesses an additional resistance gene *Yr25* {1351} which can be detected with a geographically wider range of pathogen isolates. *Yr2* is present in Kalyansona {1351} and a range of spring wheats distributed by CIMMYT.

Yr3. Undesignated allele. **v**: Enkoy{050}; Vilmorin 23; Staring{1430}. **v2**: Minister *Yr2*{1430}; Stella *Yr2*{1430}.

Yr3a{851}. 1B{185,184}. **v**: Bon Fermier{1431}; Nudif TP1{1431}; Stephens{182,184}. **v2**: Argent *Yr1 Yr4a Yr6*{1067}; Cappelle-Desprez *Yr4a*{851}; Druchamp *Yr4a*{185,182, see also, 184}; Hobbit *Yr4a Yr14*{604}; Kinsman *Yr4a Yr6*{604}; Mardler *Yr1 Yr2 Yr4a Yr13*{1459}; Maris Huntsman *Yr2 Yr4a Yr13*{604}; Maris Freeman *Yr4a Yr6*{604}; Maris Ranger *Yr4a Yr6*{604}; Nord Desprez *Yr4a*{182,184}; Top *Yr4a*{230}; Viginta *Yr2 Yr4a*; Yamhill *Yr2 Yr4a*{182}; Zdar *Yr4a*{073,071}.

Yr3b{851}. **v**: Chen & Line {182} found that a second gene in Hybrid 46 - presumably this gene - was not located at the *Yr3* locus. **v2**: Hybrid 46 *Yr4b*{851}.

Yr3c{851}. 1B{184}. **v**: Minister{851,182,184}. **v2**: Cleo *Yr2*{1430}; Maris Beacon *Yr2 Yr4b*{1459}.

Yr4. Undesignated allele. **v**: Kenya Kubangu{050}. **v2**: Avalon *Yr14*{083}; Rapier *Yr2 Yr14*{083}.

Yr4a{851}. 6B{185,184}. **v**: Vilmorin23{184}. **v2**: Argent *Yr1 Yr3a Yr6*{1067}; Cappelle-Desprez *Yr3a*{851}; Druchamp *Yr3a*{182}; Hobbit *Yr3a Yr14*{604}; Huntsman *Yr2 Yr3a Yr13*{604}; Kinsman *Yr3a Yr6*{604}; Maris Ranger *Yr3a Yr6*{604}; Maris Freeman *Yr3a Yr6*{604}; Mardler *Yr1 Yr2 Yr3a Yr13*{1459}; Nord Desprez *Yr3a*{182}; Top *Yr3a*{230}; Viginta *Yr2 Yr3a*{073,071}; Yamhill *Yr2 Yr3a*{182,185, see also, 184}; Zdar *Yr3c*{073,071}.

Yr4b{851}. 6B{184}. **v**: Avalon{1160}; Opal{1431}; Staring{1430}. **v2**: Hybrid 46 *Yr3b*{851,182, see also, 184}; Maris Beacon *Yr2 Yr3b*{1160,1459}; Nudif TP12 *Yr3c*{1431}; Stella *Yr2*{1430}.

Yr5{877}. 2BL{034}. **v**: By 33{03102}; E5557{1267}; E8510{1267}; *T. spelta album*{877}; Seven spelt accessions from Europe and Iran{640}. **ma**: *Yr5* - 10.5 & 13.3cM - Xgwm501-2B{03102}.

Yr6{877}. [*B*{1622}]. 7B{746}. 7BS{331}. **v**: Austerlitz{230}; Fielder{181}; Heines Kolben{1622}; Koga II{746}; Maris Dove{604}; Recital{230}; Takari{368}. **v2**: Argent *Yr1 Yr3a Yr4a*{1067}; Avocet (UK) *Yr1 Yr2*{1459}; Flamingo *Yr2*{1430}; Heines Peko

- Yr2*{746,877}; Kinsman *Yr3a Yr4a*{604}; Kolben *Yr2*{611}; Longbow *Yr1 Yr2*{083,1459}; Maris Freeman *Yr3a Yr4a*{604}; Maris Ranger *Yr3a Yr4a*{604}; Mithras *Yr1 Yr2*{1459}; Norman *Yr2*{083,1459}; Nudif TP241 *Yr7*{1431}; Nudif TP250 *Yr1*{1431}; Orca *Yr3c*{1431}; Pavon 76 *Yr7*{284}; Penjamo 62 (heterogeneous) *Yr18*{1562}. **tv**: Duilio{192}; Latino{192}; Norba{192}; Quadraro{192}; Rodeo (heterogeneous){192}.
- Yr7**{877}. 2B{612,1429}.2BL{965}. **v**: Present in many hexaploid wheats with *Sr9g* - see{965}; Brock{083}; Lee; Nudif TP257{1431}; PBW12{1352}; Prinqual{230}; Renard{083}; Talent{230}; Tango{230}; Tommy{083}; WL2265{1352}. **v2**: Donata *Yr9*{1430}; Flevina *Yr2*{1431}; Garant *Yr2*{230}; Hardi *Yr2*{230}; Lely *Yr2*{1430}; Nudif TP241 *Yr6*{1431}; Pakistan 81 = Veery#5 *Yr9*{284}; Pavon 76 *Yr6*{284}; Reichersberg 2S *Yr25*{0010}. **tv**: Iumillo{965}; but not present Acme and Kubanka which also carry *Sr9g*{965}.
- Yr8**{1217,1218}. Derived from *Ae. comosa*.
 2D = T2D-2M {1218} = T2DS-2M#1L.2M#1S{389}.**tr**:Chromosome 2D-2M translocations in Hobbit Sib and Maris Widgeon{1016}; Compair{1217,1218}; CS 3D/2M 3/8{967}; See also *Sr34* and{967}.
 2A = 2A-2M = T2AS-2M#1L.2M#1S{389}.**tr**:CA 2A/2M 4/2{967}.
 2M-1.**su**:CS 2M#1(2A){967}.
- Yr9**{878}. Derived from *S. cereale*.
 1B = 1RS.1BL.**v**:Almus{998}; Aurora{1623}; Benno{998}; Bezostaya II{998}; Clement{1430,1532}; Cougar{0267}; GR876{753}; Kavkaz{1623}; Lovrin 10{998}; Lovrin 13{998}; Mildress{1027}; Perseus{998}; Predgornaya{998}; Rawhide (heterogeneous){0267}; Salmon{998}; Sarhad 82{284}; Skorospelka 35{998}; Veery{986}; Wei que{1627}; Winnetou{998}; Riebesel 47/51{878,1623}; St 2153/63{997}; Wei henstephan 1007/53{1623}. **v2**: Pakistan 81 = Veery#5 *Yr7*{284}. **tv**: Cando*2/Veery, KS91WGRC14{381}.
 1R(1B){997,1623}.**su**:Burgas 2{998}; Clement{1160}; Lovrin 13{998}; Mildress{998}; Mironovskaja 10{998}; Neuzucht{1623}; Orlando{1623}; Roseana{068}; Saladin{997}; Salzmunder Bartweizen{1623}; St 14/44{998}; Wei que{1627}; Wentzel W{1623}; Winnetou{1027}; Zorba{998}; See also{050}.
 Chromosome status not specified.**v**:Baron{083}; Branka{071}; Danubia{068}; Hammer{083}; Iris{068}; Kromerzhizhskaya{1149}; Lyutestsens 15{1149}; Roxana{068}; Sabina{068}; Selekt a{068}; Shtorm{1149}; Solaris{068}; Stuart{083}. **v2**: Stetson *Yr1*{083}; Nautica *Yr2*{1430}; Agra *Yr3*{068,071}; Sparta *Yr3*{071}; Donata *Yr7*{1430}.
ma: Several markers tightly linked with *Yr9* were identified in{0377}.
- Yr10**{878}. [*YrVav*{0262}]. 1B{641}.1BS{1002}. **v**: Moro{878}; PI 178383{878}; QLD709 = Janz*2/*T. vavilovii*{0262}; *T. spelta* 415{641}; *T. vavilovii* AUS 22498{0262}.
ma: A SCAR marker was described in{0261}; QLD709 and *T. spelta*415, both with white glumes, failed to amplify the SCAR sequence, but both carried unique alleles at the *Gli-B1* and *Xpsp3000-1B* loci{0262}. These differed from the Moro source of *Yr10*. *Yr10* - 1.5cM - *Gli-B1* - 1.1cM - *Xpsp3000-1B*{0262}.; *Yr10* - 1.2cM - *Xpsp3000-1B* - 4.0cM - *Gli-B1*{0321}; Cosegregation between a RGA marker *RgaYr10a* and *Yr10* was reported in {0376}.
- Yr11**. Adult plant resistance. [*R11*{1157}]. **v**: Joss Cambier{606}. **v2**: Heines VII *Yr2 Yr25* see{970}.
- Yr12**. Adult plant resistance. [*R12*{1157}]. **v**: Fleurus{1158}; Frontier{1159}; Pride{1157}. **v2**: Armada *Yr3a Yr4a*{1160,081}; Mega *Yr3a Yr4a*{1157,1160}. **v**: Waggoner *Yr3a Yr4a Yr6*{1158}.
- Yr13**. Adult plant resistance. [*R13*{1157}]. **v2**: Hustler *Yr1 Yr2 Yr3a Yr4a*{083,1459}; Mardler *Yr1 Yr2 Yr3a Yr4a*{1459}; Marksman *Yr1* {heterogeneous} *Yr2 Yr3a Yr4a*{1459}; Bounty *Yr1 Yr3a Yr4a*{1459}; Sportsman *Yr1 Yr3a Yr4a*{1459}; Virtue *Yr1 Yr3a*

- Yr4a*{083,1158,1459}; Guardian *Yr2*{082}; Maris Huntsman *Yr2 Yr3a Yr4a*{083,604,1459}; Pageant *Yr2 Yr3a Yr4a*{082}; Professor Marchal *Yr2 Yr3a Yr4a*{607}; Maris Nimrod *Yr2 Yr3a Yr4a*{607,1157,1459}; Brigand *Yr2 Yr3a Yr4a Yr14*{609}; Gawain *Yr2 Yr3a Yr4a Yr14*{081}; Copain *Yr3a Yr4a*{1158}; Kinsman *Yr3a Yr4a Yr6*{1459}.
- Yr14.** Adult plant resistance. [*R14*{1157}]. **v:** Kador{1158}; Score{1157}; Wembley{610}. **v2:** Avalon *Yr3b Yr4b*{083,1459}; Brigand *Yr2 Yr3a Yr4a Yr13*{083,609,1459}; Galahad *Yr1 Yr2* (heterogeneous) *Yr3a Yr4a*{083,1459}; Gawain *Yr2 Yr3a Yr4a Yr13*{081}; Hobbit *Yr3a Yr4a*{1459,1157}; Maris Bilbo *Yr3a Yr4a*{1157,1459}; Moulin *Yr6*{083}; Rapier *Yr2 Yr3b Yr4b*{083}; Wizard *Yr2* (heterogeneous) *Yr3b Yr4b*{083,1459}.
- Yr15**{432,969}. 1BS{939,969}. **v:** Agrestis{0330}; Boson{0330}; Hexaploid derivatives of *T. dicoccoides* G-25{432,466}; V763-2312{969}; V763-254{969}. **tv:** *T. dicoccoides* G-25{432,431,466}; D447 derivatives B1, B2, B9, B10{1434}. **ma:** Xgwm33-1B - 5cM - *Yr15*{9904}; Xgwm33-1B - 4.5cM - *Yr15* - 5.6cM - UBC199200 - 5.6cM Nor-B1{0110}. **ma,tv:** OPB131420 - 27.1 cM - *Yr15* - 11.0 cM - Nor-B1{1434}.
- Yr16**{1598}. Adult plant resistance. 2D{1598}. **v:** Bersee{1604}; Cappelle-Desprez{1598}.
- Yr17**{062}. 2AS{062}. 2AS-6M^v. 6M^v = 2MS-6MS.6ML or 2MS-6ML.6MS{0009}. **v:** See *Lr37* (Reaction to *Puccinia triticina*) and *Sr38* (Reaction to *Puccinia graminis*); Arche{0044}; Balthazar{0044}; Brigadier{0044}; Cordial{0044}; Eureka{0044}; Hussar{0044}; Lynx{0044}; Pernel{0044}; Renan{0044}; RL 6081{939}; Genotype list in{02105}. **ma:** *Yr17* was closely linked to the SCAR marker SC-Y15, developed from RAPD marker OP-Y15₅₈₀, and to *Xpsr150-2N^v*{0044}.
- Yr18**{1362}. 7D{1362}. 7DS{324}. **i:** Thatcher near-isogenic lines with *Lr34* including the 13 2-gene combinations reported in{434,937}. **v:** Jupateco 73R; Lerma Rojo 64{1375}; Nacazari 76{1375}; Tesia F 79{1375}; Tonichi S 81{1375}; Wheaton{1375}. **v2:** Penjamo 62 *Yr6* (heterogeneous){1375}; Wheats with *Lr34* (See *Lr34*); Others{1376}. **ma:** Complete linkage with *Lr34*{937,1362}; *Ltn*{1361}; and *Bdv1*{1363}.
- Yr19**{183}. [*YrCom*{183}]. 5B{183}. **v2:** Compair *Yr8*{183}.
- Yr20**{183}. [*YrFie*{181}]. 6D{183}. **v2:** Fielder *Yr6*{183}.
- Yr21**{183}. [*YrLem*{181}]. 1B{183}. **v:** Lemhi{183}.
- Yr22**{183}. [*YrLe1*{183}]. 4D{183}. **v2:** Lee *Yr7 Yr23*{183}.
- Yr23**{183}. [*YrLe2*{183}]. 6D{183}. **v2:** Lee *Yr7 Yr22*{183}.
- Yr24**{952}. 1BS{952}. **v:** Meering^v3/K733/*T. tauschii* AUS18911{952}. **tv:** K733{952}.
- Yr25**{158}. 1D{158}. **v:** Carina{0010}; Hugenout{0010}; TP1295{158}; TP981{158}; Tugela{0314}; Tugela-DN{0010,0314}. **v2:** Heines Peko *Yr2 Yr26*{0010}; Reichersberg 42 *Yr7*{0010}.
- Yr25* was predicted to be present in Strubes Dickkopf, Heines VII *Yr2*, Heines Peko *Yr2 Yr6*, Reichersberg 42 *Yr7* and Clement *Yr9* {158}. This prediction was confirmed for Heines VII, Heines Peko and Reichersberg 42 {0010} but the pathogen culture used in {0010} was not virulent on Clement(*Yr9*) or on Strubes Dickkopf where another, or a different gene, must be present.
- Yr26**{617}. 1BS{0285}. The earlier location of 6AS (6AL.6VS){617} is not correct.. **v:** Lines R43, R55, R64 and R77{0285}. **tv:** *T. turgidum* Gamma 80-1. **tr:** Yangmai-5{617}. **ma:** *Yr26* - 1.9cM - Xgwm11-1B/Xgwm18-1B{0285}.
- Yr27**{953}. [*YrSk*{928}]. 2BS{953}. **v:** Ciano 79{953}; Selkirk{953}; Webster{953}. Many CIMMYT wheat lines {953}. Note: *Yr27* is closely linked with *Lr13* (repulsion).
- Yr28**{1377}. *Yr22* was also reported for chromosome 4D, but in the absence of an appropriate single gene stock and the unavailability of avirulent cultures in most laboratories, tests of linkage with *Yr28* are unlikely in the foreseeable future. 4DS{1377}. **v:** Synthetic = Altar 84/*T. tauschii* W-219. Synthetic/Oyata 85 SSD population. Genotype lists: {1325,970}. **dv:** *T. tauschii* W-219{1377}. **ma:** Close association with Xmwg634-4DS{1377}.

- Yr29**{0119}. Adult plant resistance {0119}. 1BL{0119}. **v2**: Pavon F76 *Yr6 Yr7 Yr30*{0119}; *Yr29* is completely linked with *Lr46*. See *Lr46*{0119}.
- Yr30**{0120}. Adult plant resistance {0120}. 3BS{0120}. **v**: Opata 85{0120}; Parula{0120}. **v2**: Inia 66 *YrA*{0120}; Pavon F76 *Yr6 Yr7 Yr29*{0120}; *Yr30* is closely linked with *Sr2* and *Lr27*{0120}.
- Yr31**{0325}. 2BS. **v**: Pastor{0325}. **ma**: Recombination values: *Yr31* - *Yr27* 0.148; *Yr31* - *Lr23* 0.295; *Yr27* - *Lr23* 0.131{0325}.
- Yr32**. [*YrCv*{939}]. 2BS{939}. **i**: Avocet S^{*}4/Carstens V{970}; Cook^{*}6/Carstens V{970}. **v**: Caribo{1430}; Cyrano{1430}; Okapi{1430}. **v2**: Felix *Yr3*{1430}; Zdar *Yr3a Yr4a*{067}.
- Sources of additional genes for seedling (designated "12") and adult resistances ("13", "14", "15") are listed in {1430}.

88.2. Temporarily designated gene for resistance to stripe rust

- YrA**. Refers to a phenotype specificity that appears to be controlled by complementary genes {1563}. **v**: Avocet^{*} {^{*} = heterogeneous}; Anza = Karamu = Mexicani = T4 = WW15; Banks^{*}; Condor^{*}; Cocamba; Egret^{*}; Inia 66; Lerma Rojo 64; Lerma Rojo 64A; Nainari 60; Nuri 70; Sanda 73; Sonalika; Zaminder 80. **v2**: Condor selection P44 *Yr6*^{*}; Pari 73 *Yr6*; Saric 70 *Yr6*; Yecora 70 *Yr6*{1563}.
- YrCle**{186}. 4B{186}. **v2**: Clement *Yr9*{186}.
- YrD**{185}. 6A{185}. **v**: Druchamp{185,185}.
- YrDa1**{186}. 1A{186}. **v2**: Daws *YrDa2*{186}.
- YrDa2**{186}. 5D{186}. **v2**: Daws *YrDa1*{186}.
- YrDru**{184,185}. 5B{184}.6B{185}. **v**: Druchamp{184,185}.
- YrDru2**{184}.Druchamp {184}. 6A{184}.
- YrH46**. Hybrid 46 {184}.
- Not the same gene as *YrDru2* {184}. 6A{184}.
- YrH52**{0003}. 1BS{0003}. **tv**: *T. dicocoides* H52{0003}. **ma**: distal ...*Yr15* - 9.6 cM - *YrH52* - 1.4cM - *Nor-B1* - 0.8cM - *Xgwm264a* - 0.6cM - *Xgwm18*{0003}; *Xgwm273a* - 2.7cM - *YrH52* - 1.3cM - *Xgwm413/Nor1*...centromere{0108}.
- YrHVII**{186}. 4A{186}. **v2**: Heines VII *Yr2*{186}.
- YrMin**. Minister {184}. 4A{184}.
- YrMor**{186}. 4B{186}. **v2**: Moro *Yr10*{186}. **ma**: The development of an STS marker, derived from an AFLP fragment, that co-segregates with *YrMor* was reported in {0357}.
- YrND**. Nord Desprez {184}.
- May be the same as *YrMin* {184}. 4A{184}.
- YrS**{185}. 3B{185}. **v**: Stephens{185}.
- YrSte**{184}. 2B{184}. **v**: Stephens{184}.
- YrSte2**.Stephens {184}. 3B{184}.
- YrTye**{186}. 6D{186}. **v**: Tyee{186}.
- YrTr1**{186}. 6D{186}. **v2**: Tres *YrTr2*{186}.
- YrTr2**{186}. 3A{186}. **v2**: Tres *YrTr1*{186}.
- YrYam**{184,185}. 4B{185}. **v**: Yamhill{185}.
- YrV23**. Vilmorin {184}.
- Allelic but not the same as *YrSte* {184}. 2B{184}.
- Yrns-B1**{0033}. 3BS{0033}. **v**: Lgst.79-74{0033}. **ma**: *Xgwm493* (distal) - 21 cM - *Yrns-B1*{0033}.
- North American workers {181,186,184} allocated a number of temporary designations to uncatalogued genes detected with North American *P. striiformis* accessions. Druchamp,

Yamhill and Stephens were reported to carry "*Yr3a* or *Yr4a*" because these genes could not be distinguished with the cultures that were used.

88.3. Stripe rust QTLs

QTL: In the ITMI mapping population, QTLs were found in 2BS, 7DS, and possibly 5A, 3D and 6D {0287}. The 2BS gene is likely to be *Yr27*. In Camp Remy/Michigan Amber, QTLs were found in 2AL and 2BL {0287}.

Two QTLs in Camp Remy/Michigan Amber were located on chromosome 2BL (*QYR1*, LOD score 12) and 2AL (*QYR2*, LOD 2.2) {0304}. Four QTLs were scored in the ITMI population. The most effective (*QYR3*, LOD 7.4) on chromosome 2BS was probably *Yr27*, the others were located in 7DS (*QYR4*, LOD 3.4). 5A (*QYR5*, LOD 2.8), 3D(*QYR6*, LOD 2.8) and 6DL(*QYR7*, LOD 2.4) {0304}.

89.Reaction to *Puccinia triticina*

Disease: Brown rust, leaf rust.

89.1. Genes for resistance

Lr1{047}. 1B{1409}.5D{954}.5DL{945}. **i**: Centenario/6*Thatcher{317}; Malakoff/6*Prelude{317}; Wichita*4/Malakoff{613}. **v**: Centenario{317}; Chicora 'S'{143}; Daws (heterogeneous){1019}; Dirkwin{1019}; Glenlea{1255,976}; Halle 9H37{074}; Hyslop{1019}; Luke {heterogeneous}{1019}; Malakoff{047}; McDermid{1019}; Mexico 120{933}; Newton{143,1024,1023}; Norco{1019}; Shabati Sonora{842}; Sonora 64{842}; Tarsa{842}; Uruguay{954}; Walliday{1019}. **v2**: Blueboy *Lr10*{143}; Blueboy II *Lr10 Lr24*{143}; Erythrospermum 142 and 953 *Lr3*{074}; Laura *Lr10 Lr34*{712}; Norka *Lr20*{1552}; Plainsman V *Lr3*{1024}; Suneca *Lr13*{485}. **ma**: Co-seg. with *Xpsr567-5D* and *Xglk621-5D* in a Frisal/*Lr1* resistant line. pTAG621 was converted to a diagnostic STS{354}.

Lr2. 1B{1409}.2DS{843,942}.

Lr2a{320}. [*Lr2*{047}]. **i**: Prelude*6/Webster{320}; Red Bobs*6/Webster{320}; Webster/6*Thatcher{306}; Wichita*4/Webster{613}. **v**: Eureka CI 17738{143}; Festiguay{843}; Webster{047}. **v2**: Alex *Lr10*{976}; Guard *Lr10*{976}; James *Lr10*{976}; Len *Lr10*{976}; Marshall *Lr10*{976}; Mediterranean W1728 *Lr3*{1369}; Shield *Lr3 Lr10*{198}; Waldron *Lr10*{143}.

Lr2b{320}. [*Lr2*²{1409}]. **i**: Prelude*6/Carina{320}; Red Bobs*6/Carina{320}; Thatcher*6/Carina{320}; Wichita/4*Carina{613}. **v**: Carina{613}.

Lr2c{320}. [*Lr2*³{1409}]. **i**: Prelude*5/Brevit{320}; Prelude*6/Loros{320}; Red Bobs*6/Brevit{320}; Red Bobs*6/Loros{320}; Thatcher*4/Brevit{320}; Thatcher*6/Loros{320}; Wichita*4/Brevit{613}; Wichita*4/Loros{613}. **v**: Brevit{613}; Loros{317,1257}.

Lr3{047}. Because *Lr3* appears to be a complex locus {486} Democrat and Democrat/6*Thatcher should be accepted as standards. There is evidence to suggest that the allele in Mentana, and therefore many derivatives, is *Lr3b* {939}. If this is correct, many genotypes listed under *Lr3a* are likely to be *Lr3b*

Lr3a. [*Lr3*{047}]. 6B{549}.6BL{939}. **i**: Democrat/6*Thatcher{318}; Wichita*4/Mediterranean{613}. **v**: Belocerkovskaja 289{074}; Bennett{1024}; Democrat{047}; Fertodi 293{074}; Gage{1024}; Hana{068}; Homestead{1024}; Ilyitchovka{075};

- Juna{075}; Jubilejne{068}; Kawvale{143}; Lancota{1024}; Mara{068}; Mediterranean{047}; Mediterranean W3732{1369}; Mentana{842}; Mironovskaya 264 & 808{074}; Odra{075}; Osetinskaya{074}; Ottawa{143}; Pawnee{1408}; Ponca{143}; Rannaja 12{074}; Shawnee{143}; Shirahada{842}; Skorospelka 3b{074}; Sledkovicova K1004{074}; Viginta{068}; Warrior{143,1024}; Yubileynaya{075}. **v2:** Amika *Lr26*{076}; Bezostaya 1 *Lr34*{074}; Bowie *Lr14b*{319}; Erythrospermum 142 & 953 *Lr1*{074}; Istra *Lr26*{076}; Mediterranean W1728 *Lr2a*{1369}; Plainsman V *Lr1*{1024}; Shield *Lr2a Lr10*{198}; Solaris *Lr26*{076}; See also{069}. **ma:** Co-segregation with *Xmwig798-6B*{9921}.
- Lr3b**{486}. [*Lr3bg*{486}]. **i:** Thatcher^{*}6/Bage; RL6094 = Tc^{*}6/T6{307}. **v:** Bage{486}. **v2:** T6 *Lr16*{307}.
- Lr3c**{486}. [*Lr3ka*{486}]. **i:** Tc^{*}6/Klein Aniversario. **v:** Klein Aniversario{486}.
- Lr4, Lr5, Lr6, Lr7, Lr8**{365}. **v:** Purdue Selection 3369-61-1-10 = Waban{365}; Not available as separate single-gene lines.
- Lr9**{1408}. Derived from *Ae. umbellulata*. 6B{954,1296,1299}.6BL = T6BS.6BL-6U#1L{389}. **i:** T47 = Transfer = CS + *Lr9*{1408}; Thatcher^{*}6/Transfer; Wichita^{*}4/ Transfer{613}. **v:** Abe{143}; Arthur 71{1320,1024}; Clemson 201{465}; McNair 701 & 2203{143}; PI 468940{1439}; Riley 67{1320,1024}; Sullivan{1110}. **v2:** Oasis *Lr11*{1109}. **ma:** Co-seg with *XksuD27-6B*{048}; co-seg with *Xmwig684-6B* and STS *Xsfr1*{1272}; *Lr9* - 8 cM - *Xpsr546-6B*{1272}; The structures of additional translocations are given in{389}.
- Lr10**{199}. [*LrL*{031}]. 1A{312,546}.1AS{939}. **i:** Exchange/6^{*}Thatcher{306}; Gabo/6^{*}Thatcher{306}; Lee/6^{*}Thatcher{306}; Selkirk/6^{*}Thatcher{306}; Timstein/6^{*}Thatcher{306}. **s:** CS^{*}5/Timstein 1A{939}; CS/7^{*}Kenya Farmer 1A{939}. **v:** Centurk{1024}; Centurk 78{1024}; Concho{143}; Federation{939}; Mayo 52{031}; Mayo 54{031}; Parker{546,1024}; Rocky{1024}; Scout 66{02101}; Sinton{1256}; Tascosa{143}; TAM-105{055}; Unknown accessions{208}; See also{0337}. **v2:** Blueboy *Lr1*{143}; Blueboy II *Lr1 Lr24*{143}; Laura *Lr1 Lr34*{712}; Alex *Lr2a*{976}; Guard *Lr2a*{976}; James *Lr2a*{976}; Kenya Farmer *Lr23*{939}; Len *Lr2a*{976}; Marshall *Lr2a*{976}; Waldron *Lr2a*{143}; Shield *Lr2a Lr3*{198}; Exchange *Lr12 Lr16*{031}; Era *Lr13*{143}; Selkirk *Lr14a Lr16*{031,199}; Warden *Lr16*{031}; Gabo *Lr23*{031}; Lee *Lr23*{031}; Timstein *Lr23*{031}; Parker 76 *Lr24*{143}. **ma:** *Xcdo426-1A* - 5.1cM - *Lr10*{1058}; *Lr10* - 8cM - *Glu-A3*{355}; cosegregation with *Xsfr1(Lrk10-1A)* and *Xsfrp1(Lrk10-1A)*{1270}; complete linkage with *Xsfr1(Lrk10-1A)*, which encodes a protein kinase{639}.
- Lrk10*. A receptor-like kinase. The locus *Xsfr1(Lrk10-1A)*, detected by the probe *Lrk10*, is completely linked with *Lr10* in chromosome 1AS {356}. The gene encodes a receptor-like kinase with extracellular and kinase domains {0297}. Using probe p*Lrk10-A*, developed from the extracellular domain, 6 homologues were found in chromosomes 1A (1), 1B (3) and 1D (2) as well as group 1 chromosomes of *T. monococcum*, *Ae. tauschii* and barley {0296,0294}. Probes based on the kinase domain identified further homologues in chromosomes 3AS and 3BS as well as the corresponding regions in rice and maize {0294}. Both orthologous and paralogous evolution were suggested.
- Lr11**{1409}. 2A{1409}. **i:** Thatcher^{*}6/Hussar{306}; Wichita^{*}4/Hussar{613}. **v:** Bulgaria 88{142}; Hart{1024}; Hazen{049}; Hussar{1409}. **v2:** Karl 92 *Lr3 Lr10*{02101}; Oasis *Lr9*{143}.
- Lr12**{326}. Adult plant reaction. 4B{312}. **i:** Exchange/6^{*}Thatcher{306}. **v:** Opal{306}. **v2:** Sturdy *Lr13*{301}; Chinese Spring *Lr34*{301}; Exchange *Lr10 Lr16*{326}; AC Domain *Lr10 Lr34*{0228}; Unknown accessions{208}.
- Lr13**{326}. Although originally described as a gene for adult plant reaction {032,326}, *Lr13* can be detected at the seedling stage especially at high temperatures {939,1156}. 2BS{939}. **i:** Tc^{*}7/Frontana = RL4031{306}; fifteen Thatcher lines with 2-gene combinations{711}. **v:** This gene is very widespread{939}; Hereward{0288}; Hustler{608}; Kinsman{608}; Kenya

Plume{1370}; Manitou{326}; Mardler{608}; Maris Huntsman{608}; Moulin{0288}; Napayo{070}; Neepawa{143}; Norman{608}; Pastiche{0288}; Polk{143}; Virtue{608}.
v2: BH1146 *Lr34*{0268}; Biggar *Lr14a*{712}; Chris *Lr34*; Columbus *Lr16*{1258}; Cumpas 88 *Lr26*{1373}; Era *Lr10*{143}; Frontana *Lr34*{032,326,1374}; Genesis *Lr14a*{712}; Hartog *Lr1*{127}; Hobbit *Lr17a*{608}; Hobbit Sib *Lr17a*{1350}; Inia 66 *Lr14a Lr17*{1373}; Klein Aniversario *Lr3ka*{032}; Kenyon *Lr16*{300}; Lerma Rojo 64 *Lr17*{1373}; Oasis 86 *Lr19*{1373}; Parula *Lr34*{1374}; Suneca *Lr1*{485}; Yecora *Lr1*{1374}. **ma:** *Xpsr912-2B - 9.1cM - Lr13 - 7.9cM - Xbcd1709-2B - 9.8cM - Cent.*{0088}.

Lr14.

Lr14a{319,964}. 7B{964}.7BL{770}. **i:** Selkirk/6*Thatcher{319}. **s:** CS*6/Hope 7B{964}. **v:** Aotea{964}; Brigand{608}; Gala{964}; Glenwari{964}; Hofed{964}; Hope{964}; H-44{964}; Lawrence{964}; Redman{964}; Regent{964}; Renown{964}; Spica{964}. **v2:** Biggar *Lr13*{712}; Genesis *Lr13*{712}; Inia 66 *Lr13 Lr17*{939}; Selkirk *Lr10 Lr16*{319}.

Lr14b{319}. **i:** Maria Escobar/6*Thatcher{319}. **v2:** Bowie *Lr3*{9226}; Maria Escobar *Lr17*{319}; Rafaela *Lr17*{314}.

Lr14ab. **i:** *Lr14a/6*Thatcher//Lr14b/6*Thatcher Seln*{319}.

Lr15{843}. 2DS{843,942}. **i:** Thatcher*6/Kenya W1483{306}. **v:** Kenya W1483{843}.

Lr16{318}. The following chromosome locations are constant with the finding that the first location was based on the use of a Rescue monosomic series. Rescue differs from CS by a 2B-4B translocation {939}.

Lr16 is always associated with *Sr23*. [*LrE*{031}]. 4B{312}.2BS{939}. **i:** Exchange/6*Thatcher{306}; RL6096 = Tc*6/T6{307}. **v:** Arapahoe{02101}; Brule{02101}; Ciano 79{1373}; Etoile de Choiosy{074}; Imuris 79{1373}; Millennium{02101}; Papago 86{1373}; Redland{02101}; Vista{02101}. **v2:** Columbus (heterogeneous) *Lr13*{1258}; Exchange *Lr10 Lr12*{031}; Kenyon *Lr13*{300}; Selkirk *Lr10 Lr14a*{031}; T6 *Lr3bg*{307}; Warden *Lr10*{031}.

Lr17{318}.

Lr17a{318},{1350}. [*Lr17*]. 2A{314}.2AS{062}. **i:** Klein Lucero/6*Prelude{318}; Klein Lucero/6*Thatcher{318}; Maria Escobar/4*Thatcher{318}. **v:** EAP 26127{314}; Jagger{0338}; Jupateco{939}; Klein Lucero{318}. **v2:** Inia 66 *Lr13 Lr14a*{9010}; Lerma Rojo 64 *Lr13*{1373}; Maria Escobar *Lr14b*{318}; Rafaela *Lr14b*{314}.

Lr17b{1350}. [*LrH*{970},WBR2{615}]. 2A{1350}. **v:** Brock{0260}; Harrier{1350}; Maris Fundin{1350}; Norin 10-Brevor, 14{1350}; Norman{1350}; Tarso{0229}. **v2:** Hobbit Sib = Dwarf A *Lr13*{1350}.

Lr18{318}. Independently derived lines with *Lr18* possess a unique N band terminally located in chromosome 5BL {1614}. Low seedling responses conferred by *Lr18* are most effective at 15-18C. With increasing temperatures the response becomes less effective and ineffective at 25-27C {935, see also, 1614}. 5BL {935} = T5BS.5BL-5G#1L{389}. **i:** Africa 43/7*Thatcher{318}; Red Egyptian PI 170925/6*Thatcher{318}. **v:** Africa 43{318}; Red Egyptian PI 170925{318}; Red Egyptian PI 17016-2c{318}; Sabikei 12{935}; Timvera{935}; Timvera Derivative{935}; Certain WYR accessions{935}; FTF{1614}; Several Sabikei lines including Sabikei 12{1614}.

Lr19{140}. Derived from *Thin. elongatum*.

7DL = T7DS.7DL-7Ae#1L{291,956,1323,388,657,389}.**i:**Agatha = T4 = TC + *Lr19*{956,1323}. **v:** L503{1346}; L513{1346}; Mutant 28{598}; Sunnan{684}; See *Sr25*. **v2:** Oasis 86 *Lr13*{1373}.

7DL = T7DS.7DL-7Ae#1-7DL{388}.**v:**Mutant 235{681}.

7AL = T7A-7Ae#1{330}.**v:**Sears' 7A-7Ag No. 12{330}.

7BL{1163}.**v:**88M22-149{1163}; 4 further derivatives of 88M22-149{0232}.

7AgL {1304} = 7Ae#1L.**su:**Agrus. **ma:** Co-seg with 8 RFLP markers{048}; *Ep-D1c* - 0.33

cM - *Lr19*{1587}; cosegregation with *Ep-D1d*{974}; Prins *et al*{1162}; studied 29 deletion mutants in Indis and determined the gene order: *Sd-1 - Xpsr105 - 7D- Xpsr129 - 7D- Lr19 - Wsp- D1- Sr25 - Y*; The following gene order for the *Thinopyrum* segment is given in{0101}; Cent - *Sd1 - Xpsr165 - 7D - Xpsr105 - 7D - Xpsr129 - 7D - XcslH81-1 - Xwg380 - 7D - Xmwg2062 - 7D - Lr19 - Wsp-D1 - Sr25/Y*; An STS marker closely linked and distal to *Lr19* was developed from an AFLP{0273}.

Lr19 is usually associated with *Sr25*. Sears' transfer 7D-7Ag No. 11 carries neither *Lr19* nor *Sr25*. See *Lr29*.

Knott {681} obtained two mutants (28 and 235) of Agatha possessing *Lr19*, but with reduced levels of yellow pigment in the flour. Marais {890,892} obtained mutants and recombined lines with intermediate levels of, or no, yellow pigment. It was shown that in recombinant line 88M22-149 lacked yellow pigment, {1163}.

The chromosome with *Lr19* in Indis is probably identical to that in Agatha {1162}.

Lr20{140}. 7AL{1305,1554}. **s:** CS^{*}5/Axminster 7A{1293}. **v:** Axminster{348,1175,1305}; Birdproof{1554}; Bonus{1554}; Converse{1554}; Festival{1554}; Kenora{1554}; Kenya W744{1554}; Maris Halberd{608}; Normandie{348,1554}; Sappo{608}; Sicco{310}; Thew{140,1552}; Timmo{608}. **v2:** Norka *Lr1*{1554}; See *Pm1* (Reaction to *Blumeria graminis*) & *Sr15* (Reaction to *Puccinia graminis*) with which *Lr20* is always associated. *Lr20* in Sicco appears to differ from that in Sappo, Timmo and Maris Halberd{310}; *Lr20* in Norka (*Lr1+Lr20*) may differ from that in Thew{939}. **ma:** Complete cosegregation of several markers including *Xcdo347-7A*, *Xpsr121-7A*, *Xpsr680-7A*, *Xpsr687-7A*, *XbzH232(Tha)-7A*, *Xrgc607-7A* and *Xsts638-7A* with *Pm1* and *Lr20* was reported in {0323}.

Lr21{1241}. 1D{650}.1DL{1241}.1DS{448}. **i:** Thatcher^{*}6/Tetra Canthatch/*Ae. squarrosa* var. *meyeri* RL 5289{306}. **v:** Tetra Canthatch/*Ae. squarrosa* var. *meyeri* RL 5289, RL 5406{648}; McKenzie{0228}; WGRC2=TA1649/3*Wichita{0299}; WGRC7=Wichita/TA1649//2*Wichita{0299}. **v2:** AC Cora *Lr13*{713}. **dv:** *Ae. squarrosa* accessions:RL5289=TA1599{1241}; TA1649{0299}; TA1691{0299}; TA2378{0299}; TA2470{0299}; TA2483{0299}; TA2495{0299}; TA2527{0299}; TA2528{0299}. **ma:** All members of the *Lr21* family carry a STS derivative of *XksuD14-ID* that has a resistance gene analogue structure{0299}; *XksuD14-ID* was reported to map 1.8cM proximal to *Lr21* in{0375}; *Lr21 - 0cM - rgaYr10b - 0.6cM - Xgdm33-ID*{0360}.

Lr22. 2DS{1241}.

Lr22a{1241}.Adult plant reaction. **i:** Thatcher^{*}3//Tetra Canthatch/*Ae. squarrosa* var. *strangulata* RL 5271{306}. **v:** Tetra Canthatch/*Ae. squarrosa* var. *strangulata* RL 5271, RL 5404{311}. **v2:** AC Minto *Lr11 Lr13*{713}. **dv:** *Ae. squarrosa* var. *strangulata* RL 5271.

Lr22b{298}.Adult plant reaction. **v:** Canthatch{298}; Marquis{970}; Thatcher{298}; This gene will be present in near-isogenic lines based on Thatcher.

Lr23{948}. [*LrG*{951}]. 2BS{948}. **i:** Lee FL 310/6*Thatcher{948}. **s:** CS^{*}7/Kenya Farmer 2B{948}; CS^{*}6/Timstein 2B{948}. **v:** Cranbrook{02119}; Crim{1091}; Hope/Timstein{1091}; I 310678{1091}; I 310685{1091}; I 349162{1091}; K 45973{1091}; K 51070{1091}; Rocta{1091}. **v2:** Gamenya *Lr3*{1552}; Gabo *Lr10*{1552}; Kenya Farmer *Lr10*{1552}; Lee *Lr10*{1552}; Timstein *Lr10*{1552}. **tv:** Altar 84{1058}. **ma:** associated with *Xksu904(Per2)-2B*{0090}.

A QTL, which is likely to correspond to *Lr23*, was identified in the Opata 85/W-7984 (ITMI) RI mapping population. The resistance was contributed by W-7974 {0090}.

Lr24. Derived from *Thin. elongatum*.

Always present with *Sr24* {956}. See *Sr24*(Reaction to *Puccinia graminis*). [*LrAg*{141}]. 3DL{956,1389}. **v:** Cody{1284}; Osage{143}; Payne{1390,1024}; SST 23{1324}; SST 44 = T4R{1324}; Timpaw{1255}; Torres{128}; Wanken{1255}; Australian

- genotypes{0340}. **v2**: Blueboy II *Lr1 Lr10*{141}; Fox *Lr10*{141}; Parker 76 *Lr10*{143,1024}; Siouland *Lr26*{1283}. **ma**: Co-seg of *Lr24* in Agent with 8 RFLP markers; segment in Sears' 3D-3Ag#1 is shorter than in Agent{048}; Tagged with *Xpsr1203-6B*{1271}; cosegregation with RAPD marker that was converted to a SCAR{231}. 1BL {185} = T1BL.1BS-3Ae#1L{600}.**v**: Amigo{1463,600,185}; Teewon{600}.
- Lr25**. Derived from *S. cereale* cv. Rosen. 4BS{270,271,380,389}. **v**: Transec{273}; Transfed{269}; Always present with *Pm7*. **ma**: Cosegregation with a RAPD{1165}. Revised to T4BS.4BL-5RL {543} and later to T4BS.4BL-2R#1L.
- Lr26**. 1R (1B).T1BL.1RS. **i**: MA1 and MA2 four breakpoint double translocation lines 1RS-1BS-1RS-1BS.1BL in Pavon{0084}. **v**: Derivatives of Petkus rye - see *Yr9* (Reaction to *Puccinia striiformis*) & *Sr31* (Reacton to *Puccinia graminis*); Bacanora 88{1373}; GR876{753}; Iris{075}; Sabina{075}. **v2**: Cumpas 88 *Lr13*{1373}; Istra *Lr3*{076}; Siouland *Lr24*{1283}; Solaris *Lr3*{076}; Many wheats with *Lr26* also carry *Lr3*. Amika {heterogeneous} *Lr3*{076}; See also{310}. **tv**: Cando^{*}2/Veery, KS91WGRC14{381}. **ma**: Several markers tightly linked with *Lr26* were identified in {0377}. **v**: Cougar{0267}; Rawhide (heterogeneous){0267}. 1BS/1RS recombinants 4.4cM proximal to *Gli-B1/Glu-B3* {0084}. Hanusova *et al.* {492} identified 127 wheats with *Lr26* but only 16 of them were listed.
- Lr27**{1367}. One of two complementary genes; the second gene, *Lr31*, is located in chromosome 4BS {1367}. The following wheats have both *Lr27* and *Lr31*. *Lr27* is present in wheats with *Sr2*, but is not expressed in the absence of the complementary factor {1366}. [*LrGt*{1366},A{1058,1366}]. 3BS{1367}. **s**: CS^{*}6/Ciano 3B{1366}; CS^{*}6/Ciano 5B{1366}; CS^{*}6/Hope 3B{1366}. **v**: Gatcher{1366}; Ocoroni 86{1373}. **v2**: Anhuac *Lr13 Lr17*{1361}; Cocoraque 75 *Lr13 Lr17 Lr34*{1361}; Jupateco 73S *Lr17*{1361}; SUN 27A *Lr1 Lr2a*{1366}; Timgalen *Lr3* {heterogeneous} *Lr10*{1366}. **ma**: Positive association with *XksuG53-3B*{1058}.
- Lr28**{967}. Derived from *Ae. speltoides*. 4AL {967} = T4AS.4AL-7S#2S{389}. **i**: CS 2A/2M 4/2{967}; CS 2D/2M 3/8{967}. **ma**: *Lr28* was tagged using STS primer OPJ-01₃₇₈{1052}.
- Lr29**{939}. Derived from *Thin. elongatum*. 7DS {939} = T7DL-7Ae#1S{389}. **i**: Sears' CS 7D/Ag#11{939,1300}; RL6080 = Tc^{*}6/Sears' 7D/Ag#11{316}. **ma**: Co-segregation with two RAPDs{1165}.
- Lr30**{315}. Recessive {315}. [*LrT*]. 4AL{315}. **i**: RL 6049 = Thatcher^{*}6/Terenzio{315}. **v**: Terenzio{315}.
- Lr31**{1367}. One of two complementary genes, the second gene is *Lr27*. [*B*{1058,1366}]. 4BL{1367}. **v2**: Chinese Spring *Lr12 Lr34*{1367}. **v**: Ocoroni 86{1373}. **v2**: See *Lr27* for list of wheats with *Lr27 +Lr31*. **ma**: A positive association with *XksuG10-4B*{1058}.
- Lr32**. 3D{644}.3DS{645}. **v**: Tetra Canthatch/*T. tauschii* RL 5497-1, RL 5713, RL 5713/Marquis-K{644}. **dv**: *T. tauschii* RL5497-1{644}. **ma**: *Xbcd1278-3D* - 3.6 cM - *Lr32*{048}; *Xcdo395-3D* - 6.9 cM - *Lr32*{048}.
- Lr33**{325}. 1BL{325}. **i**: RL 6057 = Tc^{*}6/PI 58548{297,325,321}. **v**: PI 268454a{297}; PI 58548{297,325}. **v2**: PI 268316 *Lr2c Lr34*{297}; Others{1322}.
- Lr34**{297,299}. In addition to conferring seedling and adult plant resistance, *Lr34* responds in a complementary manner when combined with either *Lr33* or *LrT3* {321}. In the Thatcher background, *Lr34* is associated with increased resistance to stem rust {299,321}. Although the resistance gene in the near-isogenic Thatcher line, RL6077, was considered to be *Lr34* on the basis of disease response, leaf tip necrosis and its association with resistance to stripe rust, a cross with RL6058 segregated for two genes. A translocation to another chromosome was suggested {324}. [*LrT2*{321}]. 7D{299}.7DS{324,1058}. **i**: Line 897{321}; Line 920{321}. **v**: RL 6058 = Tc^{*}6/PI 58548{297}; PI 268454{297}; Westphal 12{0268}; Others{299,321,1322,1376}; See{1362}. **v2**: BH1146 *Lr13*; Chinese Spring *Lr12 Lr31*{301}; Frontana *Lr13*{1374}; Glenlea *Lr1*{327}; Lageadinho *LrT3*{321}; Laura

Lr1 Lr10{712}; Parula *Lr13*{1374}; PI 58548 *Lr33*{297,321}; RL 6059 = Tc*6/Terenzio *Lr33*{297}; RL 6069 = Tc*6/Lageadinho *LrT3*{321}; RL 6070 = Tc*5/PI 321999 *LrT3*{321}; RL 6050 = Tc*6/Terenzio *LrT3*{321}; Selections Jupateco 73R *Lr17a Lr27 + Lr31* and Jupateco 73S *Lr17a Lr27 + Lr31* and Cocoraque 75 *Lr13 Lr17a Lr27 + Lr31* and Anhuac 75 *Lr13 Lr17a Lr27 + Lr31*, can be considered near-isogenic for the presence and absence respectively, of *Lr34*{1361}; Sturdy *Lr12 Lr13*{301}; Terenzio *Lr3 Lr30 LrT3*{321}; Thirteen Thatcher lines with 2-gene combinations{434}. **ma**: Complete linkage with *Ltn* (leaf tip necrosis){1361}, *Yr18* (Reaction to *Puccinia striiformis*){1362,937} and *Bdv1* (Reaction to barley yellow dwarf virus){0090}; association with *Xwg834-7D*{0268}.

A QTL, which is likely to correspond to *Lr34*, was identified in the Oyata 85/W-7984 (ITMI) RI mapping population. The resistance was contributed by Oyata 85 {0090}.

Lr35{651}. Derived from *Ae. speltoides*{651}. Adult plant resistance {651}. 2B{651}. **v**: RL 5711{651}. **ma**: A. SCAR marker was developed{9923}.

Complete cosegregation between *Lr35* and RFLP loci *Xwg996-2B*, *Xpsr540-2B* and *Xbcd260-2B* was observed. The RFLP probe BCD260 was converted to a CAPS and STS marker {0045}.

Lr36. Derived from *Ae. speltoides*. 6BS{292}. **v**: Line 2-9-2; Line E84018. **al**: *Ae. speltoides* Popn. 2.

Lr37{062}. Derived from *Ae. ventricosa*.

Lr37 can be recognised in seedlings at low temperatures (17°C) and is effective in adult plants under field conditions. See also *Sr38* (Reaction to *Puccinia graminis*) and *Yr17* (Reacton to *Puccinia striiformis*) 2AS{062}.6M^v=2MS-6MS.6ML or 2MS-6ML.6MS{0009}.

VPM1 and derivatives: 2AS{062}=2AL.2AS-2N^vS{0213}.**i**:RL 6081 = Tc*/VPM1{939}; RL6081 = Tc*8/VPM1{316}; various NILs listed in {0213}. **v**: Hyak{021}; Madsen{020}; Rendezvous{062}; VPM1{062}; VPM1 derivatives{939}; see also Reaction to *P. striiformis tritici Yr17*.

Moisson derivatives: *Lr*{113}. 2AS=2AL.2AS-2N^vS{113}.**ad**:Moisson + 6N^v=6N^vS.6N^vL-2N^vS or 6N^vL.6N^vS-2N^vS{0009}. **v**: Mx12 {0213}; Mx22{0213}. **ma**: (relevant to both groups of derivatives.) PCR primers designed from marker csVrga1D3 {0183} producing a 383bp product allows detection of the 2N^vS segment{0213}; see also: Reaction to *P. striiformis tritici Yr17*.

A resistance gene analog containing an NBS-LRR R gene sequence was isolated from the *Ae. ventricosa* segment carrying *Lr37* {0183}.

Lr38{392}. Derived from *Thin. intermedium*.

1DL = T1DS.1DL-7Ai#2L{390,389}.**v**:T25{390}.

2AL = 2AS.2AL-7Ai#2L{392,389}.**v**:W49{392} = T33{390}.

3DS = 3DL.3DS-7Ai#2L{390,389}.**v**:T4{390}.

5AS = 5AL.5AS-7Ai#2L{390,389}.**v**:T24{390}.

6DL = 6DS.6DL-7Ai#2L{390,389}.**i**:RL6097 = Thatcher*6/T7{307}. **v**: T7{390,307};

7Ai#2(7D){392,389}; 7Ai#2(7A){390}. **su**: W52{390,389}.

Lr39{1200,02100}. Derived from *Aegilops tauschii* {02100}. 2DS{02100}. **v**: TA4186 = TA1675*2/Wichita{02100}. **dv**: *Aegilops tauschii* TA 1675{02100}. **ma**: 10.7 cM distal to *Xgwm210-2D*{02100}.

Lr40{1200}. Proposal under discussion.

Lr41{215}. 1D{215}. **v**: KS90WGRC10 = TAM107*3/*T. tauschii* TA2460{220}; Thunderbolt{02100}. **dv**: TA 2460{220}.

Lr42{218}. 1D{218}. **v**: KS91WGRC11 = Century*3/*T. tauschii* TA2450. **dv**: *T. tauschii* TA2450.

Lr43{218}. 7D{576}.7DS{577}. **v**: KS92WGRC16 = Triumph 64/3/KS8010-71/TA2470//TAM200. **dv**: *T. tauschii* TA2470.

- Lr44**{322}. 1B{322}. **i**: RL = 6147 Thatcher^{*}6/*T. spelta* 7831{322}. **v**: *T. spelta* 7831{322}; *T. spelta* 7839{322}.
- Lr45**{958}. Derived from *Secale cereale*. 2A = T2AS-2R#3S.2R#3L{958,389}. **i**: RL6144 = Thatcher^{*}7/ST-1{958}. **v**: ST-1{958}; Various Australian backcross derivatives{958}.
- Lr46**{1364}. Completely linked with *Yr29* {0119}. Adult plant resistance. 1B{1346}.1BL{0119}. **s**: Lalbahadur(Pavon 1B) *Lr1*{1364}. **v2**: Pavon F76 *Lr1 Lr10 Lr13*{1364,0119}. **ma**: An RFLP marker associated with *Lr46* with a recombination value of about 10% was identified in{0119}.
- Lr47**{9901}. Derived from *Ae. speltoides* {9901}. 7AS=Ti7AS-7S#1S-7AS.7AL{9901}.**v**:Pavon derivative PI 603918{9901}. 7A=T7AS-7S#1S.7S#1L{389}.**v**:CI 17882, CI 17884, CI 17885, KS, 90H450{9901}. 7AL=Ti7AS.7AL-7S#1L-7AL.**v**:Pavon derivative PI 603919{9901}. **ma**: *Lr47* was located in the distal one-third of 7AS, 2-10cM from the centromere and within a 20-30cM segment{9901}; Complete linkage with several RFLP markers{9901}; and PCR specific markers{0126}.
- Lr48**{0085}. Adult plant resistance {0085}. Recessive {0085}. 4BL{0329}. **v2**: CSP44 *Lr34*{0085}; Dove *Lr34*{0329}.
- Lr49**{0085}. Adult plant resistance {0085}. 2AS{0329}. **v2**: Tonichi *Lr34*{0329}; VL404 *Lr34*{0085}.
- Lr50**{0221}. Based on linkage with SSR markers. 2BL{0221}. **v**: WGR36 = TAM107^{*}3/TA870//Wichita{0221}. **tv**: *T. armeniacum* TA870{0221}.
- Lr51**{0308}. 1BL{0308}. **i**: Express^{*}7/T1{0308}; Koln^{*}7/T1{0308}; UC1037^{*}7/T2{0308}. **v**: Neepawa^{*}6/*Ae. speltoides* F-7, selections 3 and 12{0306}; Interstitial translocations T1AS.1AL-1S#F7-12L-1AL {0308} = T1; T1BS.1BL-1S#F7L-1BL{0306}. **al**: *Ae. speltoides* F-7 selections 3 and 12{0306}. **ma**: Linked with RFLP markers *Xmwig710 - 1B* and *Xaga7 - 1B*{0308}.
- LrTb**{820}. Adult plant resistance {820}. **v2**: AC Taber *Lr13 Lr14a*{820}.
- LrTm**{0277}. **dv**: *T. monococcum*. **ma**: Linked to microsatellite locus *Xgwm136*{0277}.
- LrTr**{0227}. **v**: *Aegilops triuncialis* derivatives{0227}. **ad**: WL711 BC2F5 addition lines{0227}. **al**: *Aegilops triuncialis* Acc. 3549{0227}. **ma**: Lines with *LrTr* possessed a homologue of *Xgwm368-4B*{0227}.
- LrVPM**{1603}. 7DL{7411}.
- LrW**{309}. **v2**: V618 *Lr33*{309}; V336 *Lr33 LrB*{309}.
- LrW2**{305}. A gene, identified only as *Lr*, was transferred to wheat chromosome 2AS from 6M^v {113}. Cosegregating markers were *Xpsr933-2A* and *Xpsr150-2A*.

A series of temporary designations for seedling and adult plant resistance genes in six durum is given in {1648}.

Complex genotypes:

AC Domain: *Lr10 Lr16 Lr34* {820}.

Benito: *Lr1 Lr2a Lr12 Lr13* {1256}.

Buck Manantial: *Lr3 Lr13 Lr16 Lr17 Lr34?* {300}.

Era: *Lr10 Lr13 Lr34* {342}.

Grandin: *Lr2a Lr3 Lr10 Lr13 Lr34* {821}.

Mango: *Lr1 Lr13 Lr26 Lr34* {1374}.

MN7529: *Lr1 Lr2a Lr10 Lr16* {976}.

Opata 85: *Lr10 Lr27+Lr31 Lr34* {1058}.

Pasqua: *Lr11 Lr13 Lr14b Lr30 Lr34* {304}.

Prospect: *Lr1 Lr2a Lr10 Lr13* {197}.

Roblin: *Lr1 Lr10 Lr13 Lr34* {303,713}.

Trap: *Lr1 Lr3 Lr10 Lr13 Lr34* {1374}.

Genotype lists: Australian cultivars {0288}; Chinese cultivars {0013}; Combinations with *Lr34*{1361}; Cultivars from the former USSR {1380}; Czechoslovakian cultivars {855,0102}; European cultivars {0229,0260,0288,0337}; Indian cultivars {1365,1345}; Indian Subcontinent {1365}; Mexican cultivars {1373}; U.S.A. cultivars {1219,978,0334}, see also {970}.

89.2. Suppressor of genes for resistance to *P. triticina*

SuLr23{1058}. Suppressing allele. 2DS{1058}. **v:** Altar 84/*T. tauschii* 219{1058}.
suLr23{1058}. Non-suppressing allele **v:** Opata 85{1058}.

89.3. QTLs for reaction to *P. triticina*

QTLs for leaf rust resistance were identified in {0050} and were named by the catalogue curators.

QLr.sfr-1B{0050}. 1BS{0050}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population; the resistance was contributed by Forno{0050}. **ma:** Associated with *Xpsr949-1B* and *Xgwm18-1B*{0050}.

QLr.sfr-2B{0050}. 2B{0050}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population; the resistance was contributed by Oberkulmer{0050}. **ma:** Associated with *Xpsr924-2B* and *Xglk699-2B*{0050}.

QLr.sfr-3A{0050}. 3A{0050}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population; the resistance was contributed by Forno{0050}. **ma:** Associated with *Xpsr570-3A* and *Xpsr543-3A* {0050}.

QLr.sfr-4B{0050}. 4B{0050}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population; the resistance was contributed by Forno{0050}. **ma:** Associated with *Xpsr921-4B* and *Xpsr593-4B*{0050}.

QLr.sfr-4D{0050}. 4DL{0050}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population; the resistance was contributed by Forno{0050}. **ma:** Associated with *Xglk302-4D* and *Xpsr1101-4D*{0050}.

QLr.sfr-5D{0050}. 5DL{0050}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population; the resistance was contributed by Oberkulmer {0050}. **ma:** Associated with *Xpsr906-5D* and *Xpsr580-5D*{0050}.

QLr.sfr-7B.1{0050}. 7B {0050}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population; the resistance was contributed by Forno{0050}. **ma:** Associated with *Xpsr593-7B* and *Xpsr129-7B*{0050}.

QLr.sfr-7B.2{0050}. **v:** Forno/*T. spelta* var. Oberkulmer mapping population; the resistance was contributed by Forno{0050}. **ma:** Associated with *Xglk750-7B* and *Xmwig710-7B*{0050}.

90. Reaction to *Pyrenophora tritici-repentis*

Disease: Tan spot, yellow leaf spot.

Tan spot produces two types of genetically determined symptoms, viz. extensive chlorosis and tan necrosis. Pathotypes with the ability to inflict tan spot necrosis (TSN) produce a host gene-specific toxin in culture.

90.1. Insensitivity to tan spot toxin

tsn1{346}. Insensitivity (disease resistance) is recessive {346}. 5BL{346}. **v:** BR34{0007}; CEP17{0007}; Chinese Spring{0007}; Erik{0007}; 1A807{0007}; 1A905{0007}; Synthetic W-7976 = Cando/R143/Mexicali 'S'/3/*Ae. squarrosa* C122. **tv:** Altar 84{0007}; D87450{0007}. **ma:** *Xbcd1030-5B* - 5.7cM - *tsn1* - 16.5cM - *Xwg583-5B*{346}; *tsn1* - 3.7cM - *Xbcd1030-5B*{0007}.

Tsn1. Sensitive. **v:** Cheyenne{0007}; Hope{0007}; Jagger{0007}; Kulm{346}; ND485{0007}; Timstein{0007}.

90.2. Resistance to chlorosis induction

Tsc1. **ma:** *Gli-A1* - 5.7cM - *Tsc1* (Ptr ToxC){0315}.

QTsc.ndsu-1A{9924}. Resistance is dominant {344}. [*Tsc1*{344}]. 1AS{344}. **v:** Synthetic W7984{344}. **ma:** Association with *Gli-A1*{344,0040,0264}.

QTsc.ndsu-1A, or a closely associated gene, confers insensitivity to Ptr ToxC, see {0315}. Inoculation with purified toxin Ptr ToxC was used to map this locus. *QTsc.ndsu-1A* confers resistance in both seedlings and adult plants.

QTsc.ndsu-4A. 4AL{0090}. **v:** Oyata 85/W-7984(ITMI) RI mapping population; resistance was contributed by W-7984{0090}; In W-7976/Trenton resistance was contributed by W-7976{0264}. **ma:** Association with *Xksu916(Oxo2)* - 4A and *Xksu915(14-3-3a)-4A*{0090}; In W-7976/Trenton there was association with *Xwg622-4A*{0264}; Minor QTLs in chromosomes 1AL, 7DS, 5AL and 3BL were associated with resistance in adult plants{0264}.

91. Reaction to *Sitodiplosis mosellana* (Gehin)

Insect pest: Orange blossom wheat midge, Wheat midge. This pest should not be confused with *Contarinia tritici*, the yellow blossom wheat midge.

Sm1{0218}. 2B{0218}. **v:** Augusta{0218}; Blueboy{0218}; Caldwell{0218}; Clark{0218}; FL302{0218}; Howell{0218}; Knox 62{0218}; Mono{0218}; Seneca{0218}. **ma:** Linked to a SCAR marker{0223}.

92. Reaction to *Schizaphis graminum* Rond. (*Toxoptera graminum* Rond.)

Insect pest: Greenbug

Gb1{1514}. Recessive. [*gb1*{222}]. **v:** CI 9058{222}; Dickinson Selection 28A{222}.

Gb2{1313,1514}. 1A{554}. = T1AL.1R#2S{389}. **v:** Amigo CI 17609{1313}; Century{0008}; TAM107{0008}; TAM200{0008}; TAM202{0008}.

Gb3{624,1514}. Resistance in Largo and derivatives was controlled by multiallelic complementary genes {783}. *Gb3* was postulated to be one of the loci concerned. 7D{554}. **v:** Largo CI 17895{622}.

7DL{0319}. **v:** TAM110{0319}; TXGBE373{0319}. **ma:** Completely associated with 2AFLP markers {0319}. These were also present in germplasm line KS89WGRC4, implying the likely presence of *Gb3* or a closely linked resistance gene{0319}.

Gb4{523,1514}. **v:** CI 17959{903}.

Gb5{1514,1515}. 7S(7A){391}. **su:** CI 17882; CI 17884; CI 17885{1515}.

Gb6. 1A = T1AL.1R#2S{1151}. **v:** GRS1201{1152}; GRS1202{1152}; GRS1203{1152}; GRS1204{1152}; GRS1205{1152}; see also *Pm17* (Reaction to *Brumeria graminis*). **su:** Tx4386{1150}. **ad:** Tx4333{1150}. **al:** Insave rye.

93. Reaction to *Tapesia yallundae*. (Anomorph: *Pseudocerosporella herpotrichoides* (Fron) Deighton)

Disease: eyespot, strawbreaker footrot.

Pch1. [*Pch*{261}]. 7D{591,592}.7DL{708,1603}. **s**: Courtot*/Roazon 7D{592}; Hobbit Sib*/VPM1 7D{591}. **v**: *Ae ventricosa* derivative{261}; H-93-70{236,1521}; Hyak{021}; Madsen{020}; Rendezvous{1603}; Roazon{591}; 5L 219{1521}.

7A{0224}.**tv**:Five recombinant lines{0224}. **al**: *Ae. ventricosa*{261}.

Pch1 is closely linked with *Ep-V1* {973}. Delibes *et al.* {236} concluded that *Pch1* was not located in chromosome 7D whereas Law *et al.* {776} found that H-93-70 possessed a unique allele, *Ep-D1b*, in common with VPM1 and its derivatives. Eyespot resistance and *Ep-A1b* in chromosome 7A were genetically associated {704}.

Pch2{228}. 7A{704}.7AL{228,229}. **s**: CS*/Cappelle Desprez 7A{704,228}. **v**: Cappelle Desprez{704,228}. **ma**: *Xcdo347-7A* (distal) - 11cM - *Pch2* - 18.8cM - *Xwg380-7A* (proximal){229}.

According to {0380}, this gene is not effective at the adult plant stage. Instead, the adult resistance of Cappelle-Desprez was controlled by a gene on chromosome 5A with the possibility of two less effective genes on 1A and 2B.

Pch3{616}. **ad**: CS + 4V{1050}.

Pch_{Dv}{618}. 4VL{618}. **ad**: Wheat + 4V{618}. **su**: Wheat 4VL(4D), Yangmai 5{618}. **ma**: Distally located; Cent...*Xcdo949-4V* - 16cM - *Pch_{Dv}* - 17cM - *Xbcd588* - 4V{618}.

94. Reaction to *Tilletia caries* (D.C.)Tul., *T. foetida* (Wallr.) Liro, *T. controversa*

Disease: Bunt, dwarf smut, stinking smut.

Bt1. [*MI*{135}]. 2B{1310}. **s**: CS*7/White Federation 38{1304}. **v**: Albit{129}; Banner Berkeley{129}; Federation 41{137}; Regal{129}; Sherman{137}; White Federation 38{1166}; White Odessa{137}. **v2**: Columbia *Bt6*{1005}; Hussar *Bt2*{135}; Hyslop *Bt4*{733}; Martin *Bt7*{135}; McDermid *Bt4*{734}; Odessa *Bt7*{137}; Tyee *Bt4*{022}.

Bt2. [*H*{129}]. **v**: Canus{137}; Selection PS60-1-1075{551}; Selection 1403{137}. **v2**: Hussar *Bt1*{135}.

Bt3. **v**: Florence{202,203}; Ridit{152,1000,1395}.

Bt4. Since *Bt4* and *Bt6* are very similar, as well as closely linked, only Turkey 3055 should be used as a definite source of *Bt4*, and Rio should be used as the source of *Bt6*. [*T*{136}]. 1B{1005,1274,1285}. **v**: Bison{1285}; Kaw{1285}; Nebred{1285}; Omaha{1285}; Oveson{1235}; Tres {heterogeneous}{023}; Turkey 1558{137}; Turkey 2578{137}. **v2**: Hyslop *Bt1*{733}; McDermid *Bt1*{734}; Oro *Bt7*{137}; Turkey 3055 *Bt7*{137}; Tyee *Bt1*{022}.

Bt5. 1B{1001}. **v**: Hohenheimer{397}; Selection R60-3432{551}.

Bt6. Since *Bt4* and *Bt6* are very similar, as well as closely linked, only Turkey 3055 should be used as a definite source of *Bt4*, and Rio should be used as the source of *Bt6*. [*R*{1418}]. 1B{1005}. **v**: Rio{1418}; Turkey 10095 & 10097{053}. **v2**: Columbia *Bt1*{1005}.

Bt7. [*M2*{1275}]. 2D{1000}. **s**: CS*7/Cheyenne 2D{1000}. **v**: Baart{1275}; Cheyenne{1000}; Federation{1275}; Gallipoli{1000}; Onas{1275}; Rane{1000}; Selection 1833{556}. **v2**: CI 7090 *Bt9*{1000}; Martin *Bt1*{137}; Odessa *Bt1*{137}; Oro *Bt4*{1000}; Turkey 3055 *Bt4*{1000}.

Bt8{1558}. **v**: PI 178210{1558}; Yayla 305{1558}.

Bt9{1006}. **v**: PI 166910{1006}; PI 166921{1006}; PI 167822{1006}; Selection M69-2073{551}. **v2**: CI 7090 *Bt7*{1000}; Jeff *Bt10*{1436}; PI 178383 *Bt10*{1006}; Ranger *Bt10*{1438}.

Bt10{1004}. **v**: Fairview{1183}; PI 116301{1004}; PI 116306{1004}; Selection M69-2094{551}; Jeff Bt9{1436}. **v2**: PI 178383 *Bt9*{1000}; Ranger *Bt9*{1438}; Others{239,0128}. **ma**: *Bt10* was completely linked with a 590 bp fragment produced by UBC primer 196{239}; RAPD - 1.5cM - *Bt10*{763}.
The RAPD fragment was sequenced and converted to a diagnostic PCR marker for *Bt10* in {0151}.

95.Reaction to *Tilletia indica* Mitra

Disease: Karnal bunt.

Kb1{394}. **v**: Chris{394}; CMH77.308 *Kb2*{394}.
Kb2{394}. **v**: PF7 113{394}; CMH77. 308 *Kb1*{394}; Shanghai #8 *Kb4*{394}.
Kb3{394}. **v**: Amsel{394}.
Kb4{394}. **v**: Shanghai #8 *Kb2*{394}.
Kb5{394}. Recessive {394} **v**: Pigeon *Kb6*{394}.
Kb6{394}. Recessive {394} **v**: Pigeon *Kb5*{394}.
Qkb.cnl-3B{9956}. **ma**: Located in the interval *XATPase-3B* - *Xcdo1164-3B*.
Qkb.cnl-5A.1{9956}. **ma**: Located in the interval *Xmwig2112-5A* - *Xcdo20-5A*.
Qkb.cnl-5A.2{9956}. **ma**: Located in the interval *Xabg391-5A* - *Xfba351-5A*.

96.Reaction to *Ustilago tritici* (Pers.) Rostrup

Disease: Loose smut.

Ut1{1073}. **v**: Florence/Aurore{1073}; Renfrew{1073}; Red Bobs{1074}.
Ut2{1073}. **v**: Kota{1073}; Little Club{1073}.
Ut3{1074}. **v**: Carma{1074}.
Ut4{1074}. **v**: Thatcher/Regent{1074}.
Ut-x{1164}. **v**: Biggar BSR{1164}. **ma**: *Xcrc4-2B* - 14 cM - *Ut-x* - 10 cM - *Xabc153-2B.2*{1164}; *Xcrc4-2B.2* (Syn. *Xcrc4.2*) is a SCAR.
Resistance to race 19 was associated with chromosome 6A of Cadet, Kota, Thatcher and TD18 {0208}. In the case of Cadet, resistance was localized to 6AS {0208}.

97.Reaction to Wheat Spindle Streak Mosaic Bymovirus (WSSMV)

QTL : 79% of the variation between Geneva (resistant) and Augusta (susceptible) was associated with markers *Xbcd1095-2D* and *Xcdo373-2D* located 12.4cM apart in chromosome 2DL {0131}.

98.Reaction to Wheat Streak Mosaic Virus

Wsm1{379,440}. Derived from *Thin. intermedium*. 4A {800} = T4AL.4Ai#2S{391}.4D = T4DL.4Ai#2S{391,389}.T6AS.4Ai#2L + T6AL.4Ai#2S{389}. **i**: Karl*4/CI 17884 = PI 583794 = KS93WGRC27{440}. **v**: CI 17766 = B-6-37-1{391,800,1543}; CI 17884{391}; KS90H445{391}; KS90H450{391}; CI17883{389}. **ad**: CI 17881; CI 17886{391}. **su**: 4Ai#2(4A):CI 15092{391}; 4Ai#2(4D):CI 17882 CI 17885{391}. **ma**: *Wsm1* cosegregated with a STS amplified by the primer set STSJ15{1456}.
. *Wsm1* is located in 4Ai#2S. CI 17882, CI 17884, CI 17885 and KS90H445 also carry a 7S chromosome substituting for 7A (See Reaction to *Schizaphis graminum*)

99.Reaction to *Xanthomonas campestris* pv. *undulosa*

Disease: Bacterial leaf streak

Bls1{244}. **v:** Pavon **Bls2**{244}; Mochis T88 **Bls3** **Bls4**{244}; Angostura F88 **Bls5**{244}.

Bls2{244}. **v:** Pavon **Bls1**{244}.

Bls3{244}. **v:** Mochis T88 **Bls1** **Bls4**{244}.

Bls4{244}. **v:** Mochis T88 **Bls1** **Bls3**{244}.

Bls5{244}. **v:** Turnco F88{244}; Angostura F88 **Bls1**{244}.

bls1 bls2 bls3 bls4 bls5: Alondra {244}.

100.Resistance to Colonization by *Eriophyes tulipae* (*Aceria tulipae*)

Mite pest: Wheat curl mite.

Eriophyes tulipae is the vector of wheat streak mosaic virus (WSMV) and the wheat spot mosaic agent (WSpM).

Cmc1{1467}. 6DS{1576}. **v:** *Ae. squarrosa* CI4/Novamichurinka (= AC PGR 16635){1467}; Norstar derivative{0222}.

Cmc2{1573}. Derived from *Thin. elongatum*. 6A = T6AS.6Ae#2S{389}.5B = T5BL.6Ae#2S{389}.6D {1575} = T6DL.6Ae#2S{1575,389}. **v:** 875-94-2{389}. **tr:** Rescue Derivative. **su:** Cadet 6Ae#2(6A){1575}; Cadet 6Ae#2(6D){1574}; Rescue 6Ae#2(6A){1574}; Rescue 6Ae#2(6B){1574}; Rescue 6Ae#2(6D). **ad:** Cadet + mono-6Ae#2{1574}; Rescue + 6Ae#2{1574}.

Cmc3{0222}. 1A = 1AL.1RS. **v:** Amigo; TAM107{0222}. **v2:** KS96GRC40 **Cmc4**{0222}.

Cmc4{0222}. 6DS{0222}. **v2:** KS96WRC40 **Cmc3**{0222}. **dv:** *Ae. tauschii* accession{0222}.