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Research article

Screening of wheat genotypes against toxin and pathogen of *Helminthosporium sativum*

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Summary

Wheat cultivars were screened against pathogen of *Helminthosporium sativum* and its crude toxin preparation. The pathogen produced helminthosporal toxic metabolite substance(s) and two pathostrains varied in their toxin producing ability. Bioassays using intact and detached leaves of 21-day-old plants inoculated with pathogen and crude toxin(s) revealed a similar reaction, thus suggesting that wheat genotypes can be effectively screened against culture filtrate/crude toxin(s) as pathogen inoculation.

Introduction

The fungus *Helminthosporium sativum* is the causal agent of seedling blight, root rot, head blight and leaf spot of cereals and grasses. This disease causes major losses in wheat production. Plant pathogens usually express several virulence mechanisms that increase their ability to colonize host plant tissues. Some of the general virulence mechanisms are the production of enzymes, plant growth regulators or toxins. These agents damage plant cells and cause the leakage of nutrients, providing an optimal environment for the pathogen and reducing the capacity of plant cells for defense (Keen 1992). Toxins have been implicated in virulence and are the products of pathogens and cause damage to plant tissues (Scheffer 1983). Tinline et al. (1960) reported that leaf spot lesions caused by *H. sativum* are highly variable. *H. sativum* grown in liquid synthetic medium produces a helminthosporal toxin (De Mayo et al. 1961). The production of toxic materials must be related to disease susceptibility of the host and virulence of the pathogen producing them. Hanneke et al. (1988) emphasized that prerequisites for the use of toxins as selective

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agents in *in vitro* selection are that they play an important role in pathogenesis and they act on the level where selection will be carried out. The work reported here relates to the extraction of toxic substances containing helminthosporal from two different pathostrains of *H. sativum* and screening of wheat cultivars against pathogen and a crude toxin preparation using intact and detached leaves.

Materials and methods

Biological material

The plant material of wheat (*Triticum aestivum*) comprised four early sown cvs. CPAN 3004, WH 542, PBW 154 and UP 2003 and 4 late sown cvs. Sonalika, HD 2285, PBW 226 and UP 2121. Plants were grown in a glasshouse for screening against pathogen and crude toxin(s). Two pathostrains of *Helminthosporium sativum* named as 'G' from Gurdaspur (Punjab Agricultural University Regional Station, Gurdaspur) and 'I' from Delhi (Indian Agricultural Research Institute, Delhi) were used.

Isolation of toxin(s)

The G and I isolates were maintained by periodic transfer in Potato Dextrose Agar (PDA). For isolation of toxin(s), seeding production flasks containing 50 ml of modified Fries medium were inoculated with fungal mycelium grown on PDA plates and cultured for 7 days at 21°C under fluorescent lights. The flasks were vigorously shaken to break the mycelium clump and 1 ml of mycelial suspension was transferred to production flasks containing 50 ml of Fries medium and cultured for 28 days at 21°C in stationary conditions under fluorescent lights. The culture filtrate was obtained by successive filtration through two layers of muslin/cheesecloth, Whatman No. 1 filter paper and 0.2 μm nylon membrane filter. The culture filtrate was used for toxin isolation by the procedure of Ward et al. (1975) with little modifications. To the filtrate an equal volume of solvent (chloroform: ethyl acetate = 9 : 1) was added and vigorously shaken. The lower chloroform phase was collected and the extraction procedure was repeated 3 times. To the chloroform extract, anhydrous sodium sulphate (100 g/l) was added for breaking the emulsion. The settled salts were filtered out and the filtrate was evaporated at 38°C *in vacuo*. The browny residue was dissolved in water (20 ml for 1 litre of culture filtrate). *H. sativum* is known to produce helminthosporal toxic substance with an optimum absorbance at 266 nm (Ludwig 1957). The toxin concentrations from the two pathostrains were calculated based on 1 litre of culture filtrate obtained after inoculation of 1 ml of mycelial suspension. The toxin content in moles/l of culture filtrate was quantified by applying Lambert and Bear formula as: $A = E\ b\ c$;
where A = absorbance; E = molar absorptivity (=11,000); b = path length (=1 cm); and c = concentration in moles /l.

Bioassay using intact leaves

50 µl of spore suspension (10^6/ml) and a crude toxin preparation of the two pathostrains were inoculated on leaves of 21-day-old potted plants. Distilled water was used as control. The plants were kept under high humidity for symptom development. After a week, data were recorded based on leaf necrosis using 2 plants of each cultivar.

Bioassay using detached leaves

1% agar medium containing 50 mg/l benzimidazole was prepared and poured in petri dishes.

Benzimidazole was added for its cytokinin like effect in prolonging the retention of chlorophyll in the leaves (Pringle 1977). Leaves of 21-day-old plants were detached and surface sterilized in sodium hypochlorite (1% active chlorine) followed by 3 - 4 rinses in sterile distilled water. Tip and basal portion of the leaves were removed and the central portion was placed in petri dishes. The detached leaves were pricked with a needle or a ballpoint pen and inoculated with 50 µl of spore suspension or crude toxin(s). Petri dishes were sealed and kept at 25°C for 3 day under fluorescent lights.

Data scoring

The data were recorded based on the degree of necrosis in the detached/ intact leaves and arbitrarily scored; 0: no infection, 1: very little necrosis, 2: little necrosis, 3: moderate necrosis, 4: high necrosis, 5: very high necrosis. The data were taken from two samples from each cultivar and analyzed statistically for comparison of pathogen and toxin reactions of each pathostrain using paired 't' test.

Results and discussion

The concentration of the helminthosporal toxin in the crude culture filtrate for both the pathostrains were calculated based on the absorbance. The culture filtrate containing helminthosporal showed a maximum absorbance at 264 nm for G strain and 260 nm for I strain. This shift of wavelength by 2 to 6 nm from the standard 266 nm was likely due to impurity of the toxin preparation. Thus, our measurements were biased to some extent. In addition, unknown toxins might have been contained in our samples. Nevertheless based on the absorbance measurements, strain G had more toxin(s) with value of 1.6×10^{-4} moles/l in culture filtrate as compared to strain I with 1.1×10^{-4} moles/l. Pringle (1979) reported in barley plants that toxin

Table 1. Screening of wheat cultivars against pathogen and toxin(s) of two strains of *Helminthosporium sativum* using intact leaves.

Cultivar	G pathostrain		I pathostrain		Control
	Pathogen	Toxin	Pathogen	Toxin	
CPAN 3004	1.0	1.0	0	0	0
PBW 226	4.0	4.0	0	0	0
WH 542	4.0	5.0	1.0	1.0	0
PBW 154	3.0	3.0	0	0	0
HD 2285	2.0	1.5	1.0	1.0	0
Sonalika	2.5	1.0	0	0	0
UP 2003	1.0	1.0	0	0	0
UP 2121	0	0	0	0	0
t-value		0.05		0.00	

Data are averages of two plants for each cultivar. Control: water inoculation

Fig. 1. Reaction of pathogen (left) and crude toxin (right) of Gurdaspur strain of *Helminthosporium sativum* on WH 542 cultivar of wheat.

production ability of *H. sativum* isolates varies widely and also varies in their disease development.

Screening by using intact leaves.

The reaction of pathogen and toxin(s) is shown in Table 1 and Fig. 1. WH 542 and PBW 226 showed high to very high intensity of necrosis to pathogen and toxin of G strain but little or no necrosis to both pathogen and toxin(s) of I strain. PBW 154 showed moderate reaction and HD 2285 and Sonalika moderate to little necrosis for G strain and little or no reaction for I strain. Very little to no necrosis was seen for CPAN 3004, UP 2003 and UP 2121 for both G and I strains. Control treatment of water did not show necrosis in any of the genotypes. Statistical comparison of pathogen and toxin reactions for G and I strains were both found to be non-significant, indicating that pathogen and toxin(s) can be equally used for screening.

Screening with detached leaves.

WH 542 and PBW 226 showed very high intensity of necrosis for both pathogen and toxin(s) of G strain and very high to moderate intensity of necrosis for I strain (Table 2). PBW 154 and Sonalika showed very high to high intensity of necrosis for G strain and moderate to low intensity of necrosis for toxin(s) of G strain, while no necrosis was seen for I strain. In the other genotypes if intensity of necrosis was low for pathogen or toxin(s) from G strain there was either little or no necrosis from I strain. With control inoculations no necrosis was seen. Paired t-test revealed nonsignificant differences between the pathogen and toxin reactions for each pathostrain thus indicating similarity of reaction.

Pathostrain G always showed more necrosis than I strain, indicating the variability in different strains for causing the virulent reaction. The production of toxic principles in culture filtrate of G strain was also higher than I strain. Vidhyasekaran et al. (1986) used detached leaf bioassay technique for comparison of pathogen and toxin reaction of *H. oryzae* against rice genotypes and found comparable reaction. They showed that toxin preparation obtained from diseased leaves induced characteristic brown spots surrounded by yellow halo symptoms. In tomato necrosis was never seen in resistant genotypes against AAL toxin of *Alternaria*, whereas very low concentration of toxin was sufficient to induce necrosis in leaves of susceptible genotypes (Hanneke et al. 1988).

Table 2. Screening of wheat cultivars against pathogen and toxin(s) of two strains of *Helminthosporium sativum* using detached leaves.

Cultivar	G pathostrain		I pathostrain		Control
	Pathogen	Toxin	Pathogen	Toxin	
CPAN 3004	2.0	2.0	0	0	0
PBW 226	5.0	5.0	5.0	4.0	0
WH 542	5.0	5.0	4.0	3.0	0
PBW 154	5.0	3.0	0	0	0
HD 2285	2.0	2.0	1.0	1.0	0
Sonalika	4.0	2.0	0	0	0
UP 2003	2.0	2.0	0	0	0
UP 2121	1.0	1.0	0	0	0
t-value		1.52		1.52	

Data are averages of two leaf samples for each cultivar. Control: water inoculation

They reported that intact leaves and detached leaves of plants exhibited the same sensitivity to toxin. These studies suggest that toxin production ability varies in different pathostrains. In the present study one unit higher degree of necrosis was observed in the tests using detached leaves than in the test using intact leaves. But, generally these two tests exhibited similar levels of sensitivity. These intact and detached leaf bioassays can be performed for screening of genotypes against isolated toxin(s) from culture filtrate as effectively as pathogen inoculation.

References

De Mayo P, Spencer EY and White RW (1961) Helminthosporal, the toxin from *H. sativum*. 1. Isolation and characterization. Can J Chem 39: 1608-1612.

Hanneke MAW, Carla EVC, Raoul JB, Loffler HJM, Nijkamp HJJ and Jacques H (1988) Effects of *Alternaria alternata* f. sp. *lycopersici* toxins at different levels of tomato plant cell development. Plant Sci 56: 253-260.

Keen NT (1992) The molecular biology of disease resistance. Plant Mol Biol 19: 109-122.

Ludwig RA (1957) Toxin production by *Helminthosporium sativum* P.K. and B. and its significance in disease development. Can J Bot 35: 291-301.

Pringle RB (1977) Role of toxins in etiology of root rot disease of wheat. Can J Bot 55: 1801-1806

Pringle RB (1979) Role of toxins in etiology of spot blotch disease of barley. Can J Plant Dis Surv 59: 74-79.

Scheffer RP (1983) A chemical determinant of disease. Ann Rev Plant Physiol 39: 1-68.

Tinline RD, Stauffer JF and Dickson JG (1960) *Cochliobolus sativus*. III. Effect of ultraviolet radiation. Can J Bot 38: 275-282.

Vidhyasekaran P, Borromeo ES and Mew TW (1986) Host specific toxin production by *Helminthosporium oryzae*. Phytopathol 76: 261-266.

Ward E, Unwin JH and Stoessel A (1975) Sesquiterpenoid phytoalexins from fruits of eggplants. Phytopathol 65: 859-863.

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Research article

C-band polymorphism and chromosomal rearrangements in tetraploid wheat (*Triticum turgidum* L.) landraces from Ethiopia

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Summary

We studied C-band polymorphism in seven representative Ethiopian tetraploid (2n=4x=28) wheat (*Triticum turgidum* L.) landrace morphotypes (=genotypes), and attempted to localize chromosomal breakpoints in five of them that are known to carry one reciprocal translocation each, relative to the variety Senatore Cappelli (SC). No difference for chromosomal arm-ratios was observed except that 7B was inconsistent. All chromosomes showed different levels of C-banding variation except 1A and 4A. No two morphotypes were identical. However, the variation was not associated with spike morphology or collection locality. None of the morphotypes showed a similar C-banding pattern to SC for chromosome arms 3BL, 5AL and 5BL. Unusual bands and banding patterns were observed on chromosome arms 2AS, 7AL and 5BL. Chromosome 7B in one of the morphotypes (B-3-11) was conspicuously different. The landrace variety, DZ-04-118, might have carried a 2B/4B translocation or a terminal deletion on 2BS. Generally, unequivocal localization of translocation breakpoints by C-banding alone proved difficult. Nevertheless, it is plausible that most of the translocations in these landraces have non-centromeric breakpoints. Structural rearrangements within the AB genome alone do not account for the observed C-banding variation, therefore, other possibilities such as "multiple lineage" and/or D genome introgression may need to be pursued.

Key words: *Triticum turgidum*, Wheat, Karyotype, C-banding polymorphism, Chromosomal rearrangements

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Introduction

Wheat (*Triticum* spp.) consists of diploid (2n=2x=14), tetraploid (2n=4x=28) and hexaploid (2n=6x=42) species. The tetraploids (*T. turgidum* L.) and hexaploids (*T. aestivum* L. em. Thell.) share two genomes (AB) in common. Intervarietal C-band polymorphism is well documented in the diploid progenitors and near relatives (Friebe and Gill 1996), in the wild tetraploid wheat, *T. araraticum* Jakubz. (A^tG) (Badaeva, Badaev et al. 1994), and hexaploid wheat (ABD) (Friebe and Gill 1994). However, there is no comparable study in the cultivated tetraploid forms (AB genomes) except that of Landgeva et al. (1995) who reported the N-banding patterns of four varieties.

Band polymorphism could be due to (excluding banding protocols) the differential staining of GC:AT rich regions, somatic crossing-over, deletion/amplification of DNA sequences and structural rearrangements (Sumner 1990). Polymorphism is revealed as presence/absence of a band, in staining intensity and band size. Initially, it was argued that because of multiple origin and extensive introgression there could be no 'standard' banding pattern for many of the wheat chromosomes (Zurabishvili et al. 1978), but it did not gain support from other studies (Endo and Gill 1984). It is now possible to identify all wheat chromosomes by C-banding (Gill et al. 1991), which, among other things, has been used to localize translocation breakpoints (e.g. Friebe and Gill 1994; Taketa and Kawahara 1996).

The cultivation of wheat landraces in the Ethiopian highlands dates back *ca.* 5000 years (Feldman 1976). Conceivably, such wheats represent one isolated group of the earliest cultivated forms after the formation of the amphiploid(s). Although they showed little variation for gross karyomorphology (based on arm ratio), meiotic studies have revealed the presence of reciprocal translocations. Moreover, a remarkably high sterility was observed in some intervarietal/ intraspecific hybrids (Belay et al. 1994; Belay and Merker 1997).

The main objectives of the present study were; (1) to investigate C-band polymorphism in seven tetraploid wheat landrace morphotypes (=genotypes) of Ethiopian origin and, (2) to identify translocation breakpoints in five of them that are known to carry one reciprocal translocation each, relative to the standard Italian durum wheat variety, Senatore Capplelli (Belay and Merker 1997). We also compared our previous karyomorphology studies in non-banded chromosomes (Belay et al. 1994) with the results from C-banded ones.

Materials and methods

Plant material

Seven tetraploid wheat morphotypes, namely K-1-1, B-3-33, B-3-11, CD-7, A-4-34, A-1-116 and DZ-04-118 (an improved landrace variety through mass selection) were used. Their collection history and some of their morphological characteristics are given in Belay et al. (1994). Except for A-4-34 and A-1-116, all differed by one translocation each from Senatore Cappelli (SC) (Belay and Merker 1997), which was also included here for comparison purposes. The AB genome chromosomes of SC are structurally similar to those of the hexaploid cytogenetic reference, Chinese Spring (Perera et al. 1983). Seeds of SC were kindly supplied by Prof. Carla Ceoloni, Viterbo, Italy.

Cytology

The C-banding procedure employed was that of Gill et al. (1991) with minor changes. Band

nomenclature followed that of the same authors. For each morphotype, a minimum of five metaphase plates from, at least, four plants each were analyzed. The karyotypes were compared mainly with those of the AB-genome chromosomes of hexaploid wheat varieties reported by Friebe and Gill (1994). Arm ratio (long/short) was calculated based on the mean of six homologous pairs of each chromosome as measured from enlarged photomicrographs. The results were compared with those reported by Endo and Gill (1994) and Landgeva et al. (1995). Whenever the mean arm ratio of a certain chromosome lied out of the range reported by these authors, Student's t-test was performed with its counterpart chromosome in SC.

Results

Chromosome morphology

The mean arm-ratio values for most chromosomes (data not shown) in all morphotypes were similar to those of SC, and lay within the range reported previously for tetraploid wheats (Langdeva et al. 1995) and the AB genome chromosomes of hexaploid wheat (Endo and Gill 1984). However, 7B (within median type) showed varying arm-ratio values ranging from 1.14 in B-3-11 and A-1-116 to 1.57 in DZ-04-118 and B-3-33. Compared to 7B of SC, only the mean arm ratio values of B-3-11 and A-1-116 (no chromosomal rearrangement was expected) were significantly different (Table 1).

C-banding

For all chromosomes, within-genotype C-band polymorphism was almost absent. The possibility that differences in banding procedures could account for the variation was ruled out since we have recovered almost all the landmark bands for the AB-genome chromosomes of Chinese Spring (Gill et al. 1991) in at least one landrace morphotype. Furthermore, the banding patterns of SC were nearly the same as that reported by Simeone et al. (1988) who used a different technique.

Table 1. Comparison (*t*-test) of the mean arm-ratio values for chromosome 7B of the landraces with that of Senatore Cappelli.

Variety/Landrace	Arm ratio mean ± SE	t-value (df =10)
S. Cappelli	1.45 ± 0.08	—
K-1-1	1.40 ± 0.07	0.05ns
B-3-33	1.57 ± 0.06	1.34ns
B-3-11	1.14 ± 0.05	3.70**
CD-7	1.34 ± 0.07	1.07ns
DZ-04-118	1.57 ± 0.04	1.42ns
A-4-34	1.44 ± 0.07	0.15ns
A-1-116	1.22 ± 0.04	3.28**

SE: standard error, df: degrees of freedom, **p<0.01, ns:non-significant

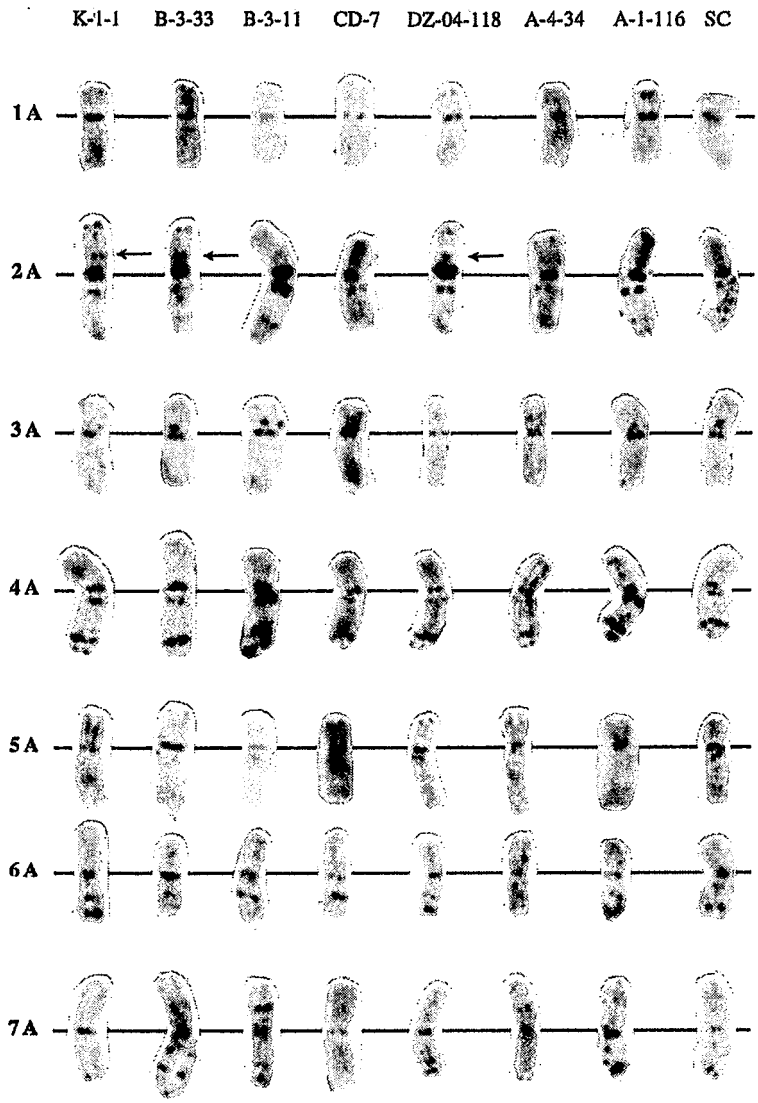

Fig. 1. C-banded A genome chromosomes of seven tetraploid wheat landraces of Ethiopian origin and *T. durum* cv. Senatore Cappelli. Arrows indicate one of the unusual bands on 2AS. (Chromosome sizes are not necessarily to the same scale).

C-banded chromosomes of each landrace morphotype, together with SC, are depicted in Figs. 1 and 2. C-banding polymorphism was observed for all chromosomes with possible exceptions of 1A and 4A. For each chromosome, polymorphism was mostly due to the presence/absence of bands and differing band positions. Satellite regions of chromosomes 1B and 6B also showed variation. Within the landraces, no two morphotypes were identical for all chromosomes, including those from the same population (B-3-11 and B-3-33). In addition, C-band polymorphism was not

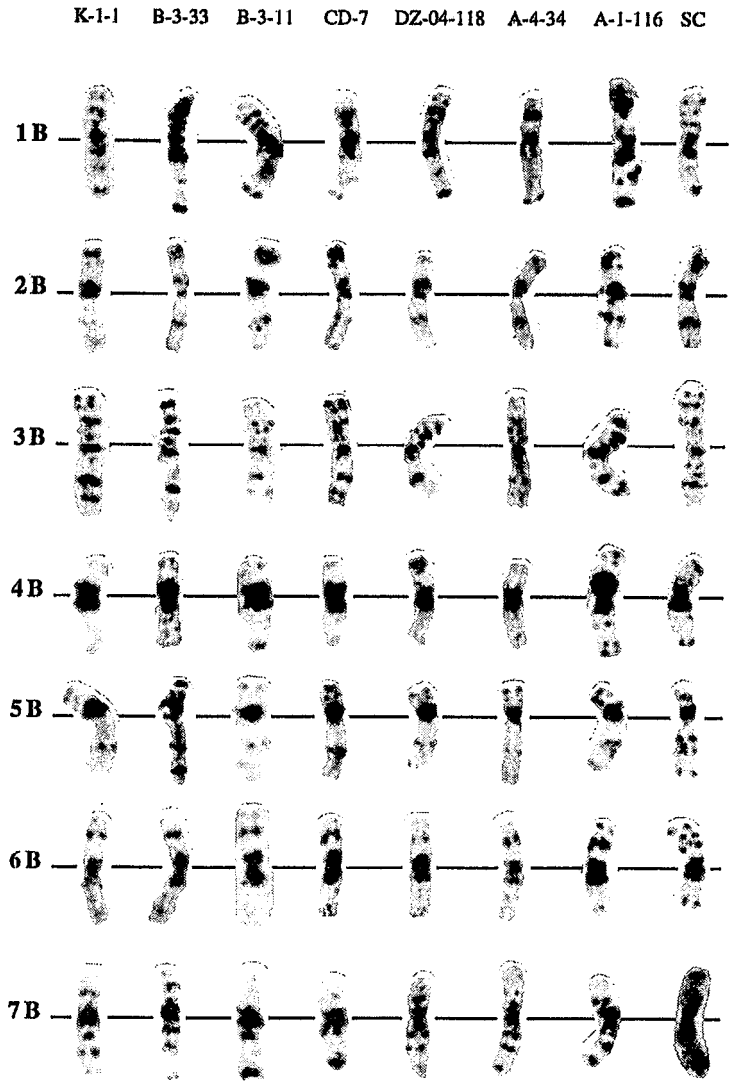

Fig. 2. C-banded B genome chromosomes of seven tetraploid wheat landraces of Ethiopian origin and *T. durum* cv. Senatore Cappelli. (Chromosome sizes are not necessarily to the same scale).

associated with spike morphology. The notable findings from the present study are summarized as follows: (1) None of the morphotypes showed a similar C-banding pattern to SC for chromosome arms 3BL, 5AL and 5BL. (2) Banding patterns not included in the polymorphic types of the AB genomes of hexaploid wheat varieties (Friebe and Gill 1994) were observed on chromosomes 2AS, 6AL, 7A, 3BL, 5BL, 7BS and, possibly, 1B. (3) Compared to previous other studies, the prominent band near the proximal region of 2AS in K-1-1, B-3-33 and DZ-04-118 (less clear) and, the band

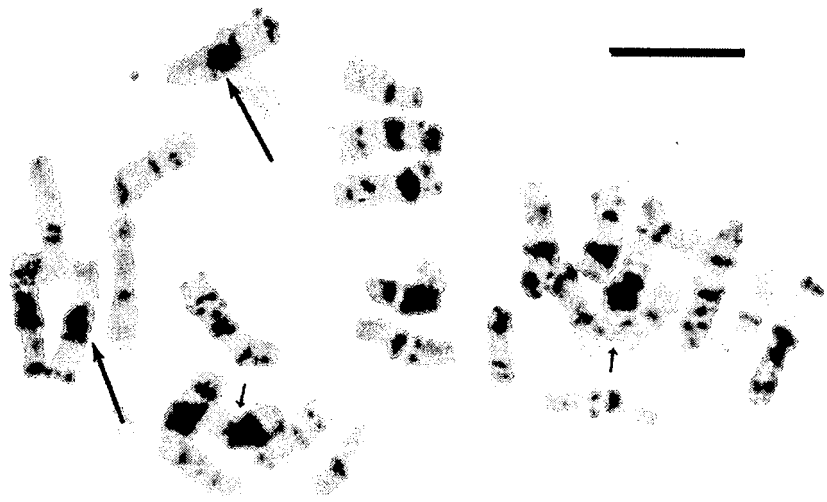

Fig. 3. C-banded metaphase chromosomes of B-3-11. Arrows indicate chromosomes 7B (long) and 4B (short). Scale bar=10μm.

positions on 7AL and 5BL in B-3-33 were unusual. Only B-3-11 showed three band positions on 5BL, but this was previously observed in one other landrace morphotype (Belay and Merker 1998). (4) Chromosome 7B of B-3-11, which was easily confused with 4B, was conspicuously different from the others because the interstitial bands on the short arm were absent and band 7BL2.5 was rarely observed (Fig. 3). Further, 7A of this morphotype was rather similar to $7A^t$ of *T. timopheevi* Zhuk. (Badaeva, Filatenko et al. 1994), although the interstitial band on 7AS was previously observed in the wild tetraploid wheat progenitor, *T. dicoccoides* Körn. by N-banding (Landgeva et al. 1995).

Detection of translocation breakpoints

Generally, the chances of localizing translocation breakpoints by C-banding alone proved difficult, presumably because of the lack of enough bands accompanied by conserved centromeric positions. However, DZ-04-118 might have carried a 2B/4B translocation with the breakpoints located in the distal regions of 2BS and 4BS (Fig. 2). This was considered equivocal because similar bands were observed on 4BS of A-1-116, which was not expected to carry a translocation. That means, if the subtelomeric bands on 4BS are variant forms, then 2BS in DZ-04-118 may be carrying a terminal deletion.

Discussion

The present results from the karyomorphological studies are consistent with our previous results on non-banded chromosomes of several landrace genotypes (Belay et al. 1994). This indicates that, despite the overwhelming morphological diversity of the Ethiopian tetraploid wheat

landraces, chromosome arm-ratios are highly conserved. Except for chromosome 7B (see below), the other minor discrepancies could be attributed to differential chromosome contraction and measurement error.

Generally, a considerable degree of C-band polymorphism occurs in these landraces. For the uniqueness of chromosome 7B in B-3-11, it may be difficult to conceive anything other than a structural divergence, which might also explain why its hybrids with the other landraces are highly sterile (Belay and Merker 1997). However, we have discounted the deletion of interstitial bands on 7BS, because otherwise, a higher arm ratio would have been expected.

Meiotic studies in F_1 hybrids of K-1-1 and B-3-33 did not indicate the presence of structural differences (Belay and Merker 1997), but the parental morphotypes showed marked C-band variation for chromosomes 5A, 6A, 7A, 3B and 5B. Furthermore, the banding patterns of 2AS (K-1-1, B-3-33 and DZ-04-118), 7AL (B-3-33), and the variations observed for 5BL are difficult to account for by structural rearrangements within the AB genome alone. For instance, deletion is less likely to explain the occurrence of only one interstitial band on 5BL (CD-7, DZ-04-118 and A-4-34) since it was observed in *T. dicoccoides* (Shang et al. 1988). Therefore, two conclusions emerge from the above analysis; (1) it is possible that some of the C-band variations resulted from cytologically (meiotically) undetectable rearrangements. (2) It may be that these variant forms have been maintained by chance in these primitive wheats that have been cultivated in isolation for millennia. In the latter case, "multiple lineage" (see Soltis and Soltis 1995) of the Ethiopian tetraploid wheat landraces may be assumed, which is in line with the results from analysis of Restriction Fragment Length Polymorphisms (Mori et al. 1997).

Because tetraploid wheats in Ethiopia have been grown in mixture with hexaploid wheat for centuries, we have also considered the possibility that D-genome introgression might have contributed to the observed C-band variation. In order to test this possibility, we have PCR-tested for the presence of D-genome chromatin in B-3-11, K-1-1 and DZ-04-118 using primers developed from the published sequence of the Dgas44, a repetitive element which is highly represented in, and is widely dispersed throughout the D-genome (McNeil et al. 1994). These genotypes were chosen because their 2AS was rather similar to 2DS (Friebe and Gill 1994). All three samples gave a negative result, making it very unlikely that these lines carry any A/D or B/D translocation. Given the non-sterility of the pentaploid hybrids and the possibilities of homoeologous pairing involving D genome chromosomes (Perera et al. 1983), the existence of such translocations in the landrace populations cannot be ruled out, and the PCR assay is seen as an effective and efficient mass screening method to identify rare carriers among the Ethiopian tetraploid wheats (Koebner R: pers commun). The nature of the translocation in positive selections could further be characterized by means of *in situ* hybridization with D genome-specific probes, or by GISH with total DNA of the D-genome donor (Mukai et al. 1993).

In these landraces, estimating translocation frequencies at the population level (e.g. Joppa et al. 1995), and determining the nature of breakpoints (centromeric vs. noncentromeric) would be of great evolutionary and breeding interest. For example, in *T. araraticum*, most translocations were of centric-break-fusion types (Badaeva, Badaev et al. 1994), but not those from *T. dicoccoides* (Nishikawa et al. 1986; Taketa and Kawahara 1996). Given that centromeric positions were altered in a few cases (Belay et al. 1994), it is plausible that most interchanges occurred outside of the centromeric regions that are devoid of C-bands. Alternatively, if their origin was through the centric-break-fusion mechanism, the interchanges were between chromosome arms of similar

sizes, which is particularly possible for some of the A genome chromosomes. These two hypotheses may be tested by systematically screening a larger number of genotypes. However, C-banding needs to be complemented by additional information from crossing analysis and other advanced molecular cytogenetic techniques.

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References

Badaeva ED, Badaev NS, Gill BS and Filatenko AA (1994) Intraspecific karyotype divergence in *Triticum araraticum* (Poaceae). Pl Syst Evol 192: 117-145.

Badaeva ED, Filatenko AA and Badaev NS (1994) Cytogenetic investigation of *Triticum Timopheevi* (Zhuk.) Zhuk. and related species using the C-banding technique. Theor Appl Genet 89: 622-628.

Belay G and Merker A (1997) Cytogenetic studies in Ethiopian landraces of tetraploid wheat (*Triticum turgidum* L.). II. Spontaneous chromosome translocations and fertility. Hereditas 126: 35-43.

Belay G and Merker A (1998) Cytogenetic analysis of a spontaneous 5B/6B translocation in tetraploid wheat landraces from Ethiopia and implications for breeding. Plant Breed 117: 537-542.

Belay G, Merker A and Tesemma T (1994) Cytogenetic studies in Ethiopian landraces of tetraploid wheat (*Triticum turgidum* L.). I. Spike morphology vs ploidy level and karyomorphology. Hereditas 121: 45-52.

Endo TR and Gill BS (1984) Somatic karyotype, heterochromatin distribution, and nature of chromosome differentiation in common wheat, *Triticum aestivum* L. em. Thell. Chromosoma 89: 361-369.

Feldman M (1976) Wheats. In: Simmonds NW (ed) Evolution of Crop Plants. Longman Group Ltd, London: 120-126.

Friebe B and Gill BS (1996) Chromosome banding and genome analysis in diploid and cultivated polyploid wheats. In: Jauhar PP (ed) Methods of Genome Analysis in Plants. CRC Press Inc, Boca Raton, FL: 39-60.

Friebe B and Gill BS (1994) C-band polymorphism and structural rearrangements detected in common wheat (*Triticum aestivum*). Euphytica 78: 1-5.

Gill BS, Friebe B and Endo TR (1991) Standard karyotype and nomenclature system for description of chromosome bands and structural aberrations in wheat. Genome 34: 830-839.

Joppa LR, Nevo E and Beiles A (1995) Chromosome translocations in wild populations of tetraploid emmer wheat in Israel and Turkey. Theor Appl Genet 91: 713-719.

Landgeva S, Ganeva G and Georgieva V (1995) Somatic karyotypes and N-banding patterns of tetraploid wheat. Biol Zentralbl 114: 253-265.

McNeil D, Lagudah ES, Hohmann U and Appels R (1994) Amplification of DNA sequences in wheat and its relatives: The Dgas44 and R350 families of repetitive sequences. Genome 37: 320-327.

Mori N, Moriguchi T and Nakamura C (1997) RFLP analysis of DNA for study of phylogeny and domestication of tetraploid wheat. Genes Genet Syst 72: 153-161.

Mukai Y, Nakahara Y and Yamamoto M (1993) Simultaneous discrimination of the three genomes in hexaploid wheat by multicolor fluorescence *in situ* hybridization using total genomic and highly repetitive DNA sequences. Genome 36: 489-494.

Nishikawa K, Mizuno S and Furuta Y (1986) Identification of chromosomes involved in translocations in wild emmer. Jpn J Genet 69: 371-376.

Perera E, Lacadena JR and Sendino AM (1983) Cytogenetic structure of durum wheat cultivars from, or introduced into Spain. Z Pflanzenzüchtg 91: 36-45.

Shang XM, Jackson RC and Nguyen RT (1988) Heterochromatin diversity and chromosome morphology in wheats analyzed by the HKG banding technique. Genome 30: 956-965.
Simeone R, Perrone V and Blanco A (1988) C-banding of tetraploid wheat trisomics. Proc 7th Int Wheat Genet Symp, Cambridge: 443-448.
Soltis DE and Soltis PS (1995) The dynamic nature of polyploid genomes. Proc Natl Acad Sci USA 92: 8089-8091.
Sumner AT (1990) Chromosome Banding. Unwin Hyman, London.
Taketa S and Kawahara T (1996) C-banding analysis on wild emmer (*Triticum dicoccoides* Körn) strains with and without spontaneous reciprocal translocations. Theor Appl Genet 92: 173-178.
Zurabishvili TB, Iordansky AB and Badaev NS (1978) Linear differentiation of cereal chromosomes. II. Polyploid wheats. Theor Appl Genet 51: 201-210.

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Research article

Identification of tetraploid *Aegilops* species from different altitudes of Turkey by gliadin electrophoresis

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Summary

The objective of the present study is to determine specific differences of some *Aegilops* species, by means of protein pattern structure characteristics. Twenty-one samples belonging to seven wild wheat species, collected from different altitudes and regions of Turkey were studied. Gliadin protein patterns, relative density and mobility of protein bands were compared by means of polyacrylamide gel electrophoresis (PAGE) method. As a result of the research, it was observed that the gliadin band pattern of the identical species had homogenous structure and there were significant differences between species.

Key words: *Aegilops* spp., Electrophoresis, Gliadin proteins, Tetraploid wild wheat

Introduction

Morphological, cytological and biochemical traits are used as markers in breeding studies. Since proteins can be used as one of the biochemical markers, the storage proteins can be also analyzed for identifying the wheat species. The quality of wheat depends on storage proteins. Structural or functional properties of storage proteins are identified by means of electrophoresis techniques. Hence, this technique can be used in identifying the species by their protein bands that can be considered as fingerprints.

Most widely used and effective technique of electrophoretic analysis for wheat gliadin proteins is the PAGE method (Khan 1982). Proteins are easily separated and examined. They are also the most stable genetic substance against diseases, freezing damages, environmental factors such as soil type, growing season and locational differences (Lee and Ronald 1967). Electrophoresis

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studies in plant breeding are divided in two categories, namely storage proteins and enzymes. The studies on storage proteins are related with heritage and identification of species. Electrophoresis for identification of species uses the principle of electrophoregrams. For this reason several researchers suggest that those bands can be used for identification of cultivated species (Khan et al. 1983; Sapirstein and Bushuk 1985a, b).

As an example for the utilization of gliadin proteins in plant breeding, the families with undesired banding pattern are eliminated at the early stage of bulking. Possibility of having more than one genotype in a cultivar is also eliminated. Genetic structure of hybrid wheat, uniformity of newly developed cultivars, testing of promising breeder lines for registration, determination of biochemical differences of morphologically identical species, purity test of wheat cultivars at the market are all enabled by means of the method. The aim of this research was to determine specific differences in tetraploid *Aegilops* species of Turkey by means of PAGE method.

Material and methods

In the study, 21 accessions of 7 different *Aegilops* species, from 3 different altitudes were collected throughout Turkey. The species, regions and altitudes from which the samples were collected, were given in Table 1 and Fig. 1.

The seeds were germinated at the greenhouse and transplanted into the field when they were at tillering stage to provide seeds needed for analysis of protein patterns. Electrophoresis methods suggested by Bushuk and Zillman (1978) and Tkachuk and Metlish (1980) were applied. Some modifications were done (Khan et al. 1985; Lookhart et al. 1982) for increasing the strength and decreasing the stickiness of the gel. After dying the gel, 70% alcohol was added in varying amounts depending on the species to get a clear vision of the bands. The amount of gliadin

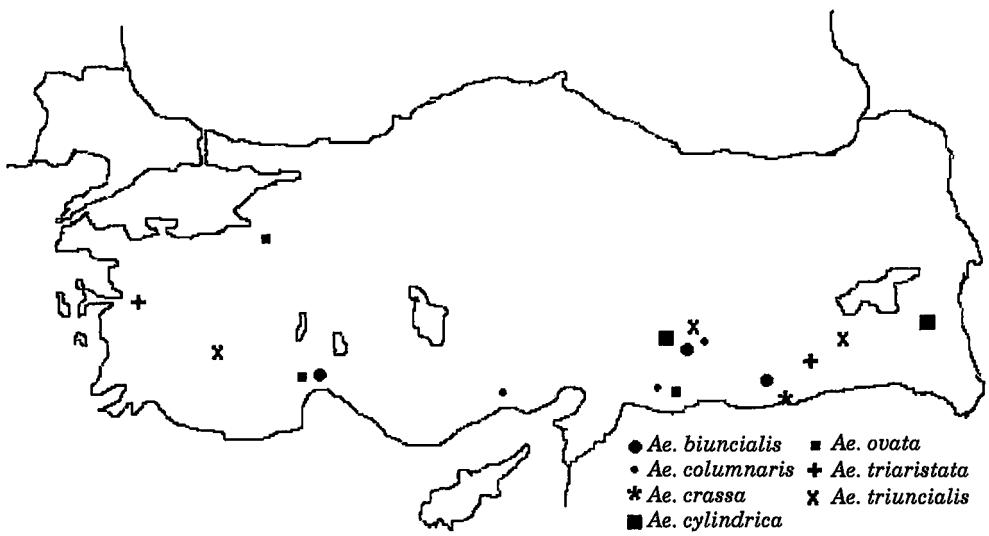

Fig. 1. Collection sites of *Aegilops* in Turkey

sample solution taken, varied among 8-10μl.

Seeds were ground, 70% alcohol was added and centrifuged. Extraction solution was added to the supernatant-gliadin solution (Burgoon et al. 1985; Metakovsky and Baboev 1992). Electrophoresis buffer solution (Maier and Wagner 1980; Metakovsky and Novaselskaya 1991), extract dilution solution, gel solution (Khan 1982), dying solution (Ewart 1973; Zillman and Bushuk 1979) and dye-removal solution were prepared and applied on a one dimensional electrophoresis apparatus with double gel cassettes, and a dual vertical slab gel mechanism.

Results were evaluated on 9 x 13 cm size photographs (Kosmolak et al. 1980). Relative mobility (Rm) values were calculated using Marquis species as a standard (Bushuk and Zillman 1978). A well-separated band of the electrophoregram was marked as the Rm reference values of 50 and the Rm values of the other bands were calculated according to the reference. To calculate the Rm value of a specific band, the distance of this band from the origin was divided into the distance of the Marquis reference band and then the value obtained was multiplied by the factor of 50. Intensity readings of the bands were taken and assessed on a 1-5 scale, 1 being the lightest and 5 the darkest (Draper and Craig 1981). Relative mobility and relative intensity (Ri) values of

Table 1. Distribution of gliadin bands from wild tetraploid wheats and the regions from where the samples were collected

Species	Altitude (m)	Site	Distribution of gliadin bands ($\alpha,\beta,\gamma,\omega$)
Ae. biuncialis Vis.	400	Adiyaman, Hayaz Vil.	2;2;3;13
"	750	Sanliurfa, 16 km SW of Hilvan	2;1;4;13
"	1140	Antalya, Elmali, Ozdemir Vil.	1;1;2;17
Ae. columnaris Zhuk.	150	Içel, 39 km E of Anamur	0;1;4;13
"	530	Adiyaman, 5 km E of Kahta	0;0;2;12
"	750	Gaziantep, 2 km NW Oguzeli	0;1;3;12
Ae. crassa Boiss.	375	Sanliurfa, 32 km NE Akcakale	0;1;4;10
"	550	Sanliurfa, 2 km S Altinbasak	1;2;2;12
"	625	Sanliurfa, Bozova, Igdeli, 2 km S	1;1;2;10
Ae. cylindrica Hast.	455	Adiyaman, 0.5 km W of Balcilar	1;0;3;13
"	1720	Van, 3 kmW	1;0;3;11
"	2100	Van, 74 kmW	1;0;3;11
Ae. ovata L.	150	Bursa, 19 W of Iznik	1;2;4;13
"	700	Gaziantep, 2 km SE of Oguzeli	1;2;5;10
"	1140	Antalya, Elmali, Özdemir Vil.	1;2;4;7
Ae. triaristata Wild.	0	Izmir, Bornova	0;0;5;10
"	575	Diyarbakir, 25 km W of Batman	0;0;4;9
"	1150	Diyarbakir, 15 km W of Silvan	0;0;4;10
Ae. triuncialis L.	410	Adiyaman, 2 km Hayaz Vil.	1;2;3;13
"	1120	Denizli, 1 km NW of Kovanoluk	0;2;2;13
"	1720	Bitlis, 5 km SW of Adilcevaz	2;3;4;13

each sample were listed and formulas of species were obtained. By using Rm values on species list (French system used by Bushuk and Zillman 1978) Rm values were classified between 0-59 for omega (ω) gliadin region, between 59-74 for gamma (γ) gliadin region, 74-85 for beta (β) gliadin region and 85-100 for alpha (α) gliadin regions (Motel and Mayer 1981; Lookhart et al. 1983).

Results and discussion

In this research, *Aegilops* species were collected from the region of Adiyaman, Sanliurfa, Antalya, Içel, Gaziantep, Van, Bursa, Izmir, Bitlis, Denizli, Diyarbakir and especially from Southern-east Anatolia from the various altitudes with collection programs throughout Turkey. Selection of the collected material was done depending on the maximum, minimum and average altitude of origin.

Samples of *Ae. biuncialis* were collected from 400m, 750m and 1140m altitudes. As a result of tests the distribution of bands for the samples from 400m altitude were 2;2;3;13 for α,β,γ,ω respectively, for the samples from 750m were 2;1;4;13 and for the samples from 1140m were 1;1 ;2;17. The maximum number of bands of samples of *Ae. biuncialis* were on ω gliadin region. In *Ae. columnaris*, samples of this group were collected from 530m, 150m and 750 m altitudes. The maximum number of bands was in ω gliadin region. For the sample from 530m, the distributions of bands were 0;0;2;12 for α,β,γ,ω regions respectively, for 150m were 0;1;4;13 and for 750m were 0;1;3;12. Samples from *Ae. crassa* were collected from 550m, 375m and 625m altitudes. The distribution of bands was 1;2;2;12 for the sample from 550m for α,β,γ,ω gliadin regions respectively, 0;1;4;10 for 375m and 1;1;2;10 for 625 m. Three samples examined of *Ae. cylindrica* were collected from 455m, 1720m and 2100m altitudes. The distribution of bands was 1;0;3;13 for the sample from 455m, 1;0;3;11 for the one from 1720m and 1;0;3;11 for the sample from 2100m for α,β,γ,ω gliadin regions. Samples examined of *Ae. ovata* were collected from 150m, 700m and 1140m. In three of all samples of this species, shared relative mobility was determined. The distribution of bands for the sample from 150m was 1;2;4;13, from 700 was 1;2;5;10 and from 1140m was 1;2;4;7 in α,β,γ,ω gliadin regions, respectively. The maximum number of bands was in ω gliadin regions in all samples. Three samples of *Ae. triaristata* were collected from 0m, 575m and 1150m altitudes. The distribution of bands was 0;0;5;10 for the sample from 0m, 0;0;4;9 for the sample from 575m and 0;0;4;10 for the sample from 1150m in α,β,γ,ω gliadin regions. The maximum number of bands was in ω gliadin region. In *Ae. triuncialis*, samples were collected from 410m, 1120m and 1720m altitudes. The distribution of bands was 1;2;3;13 for the sample from 410m, 0;2;2;13 for the sample from 1120m and 2;3;4;13 for the sample from 1720m in α,β,γ,ω gliadin regions, respectively. The maximum number of bands was also in for ω gliadin region (Table 1).

Electrophoregrams of tetraploid species indicated that gliadin band patterns of each sample were homogenous. Additionally it was determined that gliadin bands of the samples belonging to the same species showed similarity in distribution. However, complex band structure was observed in some columns of the samples of *Ae. triuncialis*, *Ae. triaristata* and *Ae. crassa*. This is due to the reason that the samples were collected as populations. This can be assumed as an indication of genetic diversity. Gliadin band distribution figures showed that distribution area got special values for individual species. For all species (*Aegilops* spp.) ω gliadin region had the maximum number of bands, whereas there was no band on α region for the species of *Ae. columnaris* and *Ae. triaristata*, and there was no band on β region for the species of *Ae. cylindrica* and *Ae. triaristata*. Relative mobility values and the number of bands obtained were similar within the species but

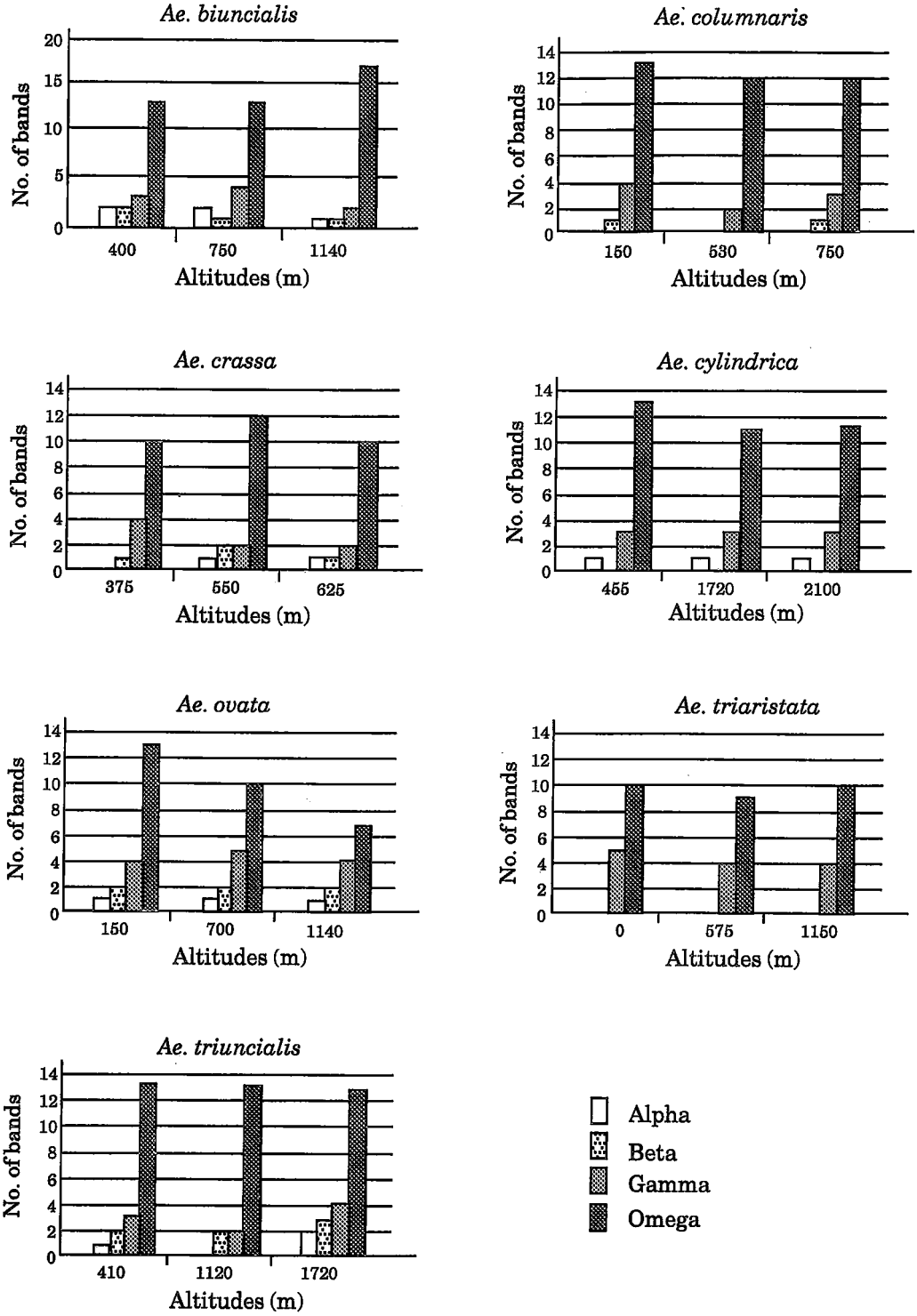

Fig. 2. Gliadin band patterns of *Aegilops* species from different altitudes

different between the species (Fig. 2). After determination of band numbers related to quality characteristics of wheat, relative mobility values will be used in selection in further studies.

Plant breeders and scientists dealing with biotechnology need evaluation information together with passport information of the genetic resources material with their studies. For this purpose, some wild tetraploid wheat species have been examined for their banding pattern by means of PAGE method. Some basic information has been provided for identification of the species and for breeding programs. In future gliadin compositions of internationally known species will be compared by using computer and automatic gel evaluation system will be used by means of densitometric scanning.

References

Burgoon A, Ikeda HS and Tanner SN (1985) A method for detecting adulteration in durum wheat pasta by polyacrylamide gel electrophoresis. Cereal Chem 62: 72-74.

Bushuk W and Zillman RR (1978) Wheat cultivar identification by gliadin electrophoregrams. I. Apparatus, method and nomenclature. Can J Plant Sci 58: 505-515.

Draper SR and Craig EA (1981) A phenotypic classification of wheat gliadin electrophoregrams. J Natn Inst Agric Bot 15: 390-398.

Ewart JAD (1973) Sodium dodecyl sulfate electrophoresis of wheat gliadins. J Sci Fd Agric 24: 685-689.

Khan K (1982) Polyacrylamide gel electrophoresis of wheat gluten proteins. Bakers Digest October: 56: 5.

Khan K, McDonald CE and Banasik OJ (1983) Polyacrylamide gel electrophoresis of gliadin proteins for wheat variety identification —— Procedural modifications and observations. Cereal Chem 60: 178-181.

Khan K, Hamada A and Patek J (1985) Polyacrylamide gel electrophoresis for wheat variety identification: Effect of variables on gel properties. Cereal Chem 62: 310-313.

Kosmolak FG, Dexter JE, Matsuo RR, Leisle D and Marchylo BA (1980) A relationship between durum wheat quality and gliadin electrophoregrams. Can J Plant Sci 60: 427-432.

Lee JW and Ronald JA (1967) Effect of environment on wheat gliadin. Nature 213: 844-846.

Lookhart GL, Jones BL, Hall SB and Finney KF (1982) An improved method for standardizing polyacrylamide gel electrophoresis of wheat gliadin proteins. Cereal Chem 59: 178-181.

Lookhart GL, Jones BL, Walker DE and Hall SB (1983) Computer-assisted method for identifying wheat cultivars from their gliadin electrophoregrams. Cereal Chem 60: 111-115.

Maier G and Wagner K (1980) Routine method for identification of wheat varieties by polyacrylamide gel electrophoresis. Z Lebensm Unters Forsch 170: 343-345.

Metakosky EV and Baboev SK (1992) Polymorphism and inheritance of gliadin polypeptides in *T. monococcum* L. Theor Appl Genet 84: 971-978.

Metakosky EV and Novoselskaya AY (1991) Gliadin allele identification in common wheat I. Methodological aspects of the analysis of gliadin patterns by one dimensional polyacrylamide gel electrophoresis. J Genet Breed 45: 317-324.

Motel JS and Meyer D (1981) Numerical taxonomic studies in the genera *Triticum* L. and *Pisum* L. Kulturpflanze 29: 241-250.

Sapirstein HD and Bushuk W (1985a) Computer-aided analysis of gliadin electrophoregrams. II. Wheat cultivar identification and class comparisons. Cereals Chem 62: 377-392.

Sapirstein HD and Bushuk W (1985b) Computer-aided analysis of gliadin electrophoregrams. III. Characterization of the heterogeneity in gliadin composition for a population of 98 common wheats. Cereal Chem 62: 392-398.

Tkachuk R and Metlish VJ (1980) Wheat cultivar identification by high voltage gel electrophoresis. Ann Technology Agric 29: 207-212.

Zilmann RR and Bushuk W (1979) Wheat cultivar identification by gliadin electrophoregrams II. Effects of environmental and experimental factors on the gliadin electrophoregram. Can J Plant Sci 59: 281-286.

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Research article

Transfer of alien genes *Lr9*, *Lr24* and *Lr28* to bread wheat cultivars susceptible to leaf rust

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Summary

Twelve wheat lines (VA92-10, CR7, CLRP-6, DW876, DW880, CPAN4166, CPAN4167, CPAN4168, Veery 's', HW741, HD2329 and HD2285) possessing good agronomic traits but susceptible to leaf rusts under natural epiphytotic conditions at Wellington were chosen from different nurseries grown under All India Coordinated Wheat Improvement Program. They were crossed with HW 2005 (carrying *Lr24+Sr24*), PH 127 (carrying *Lr9*) and HW 2037 (carrying *Lr28*) which were conferring high degree of resistance at Wellington, to obtain specific crosses. The resistant progenies to stem, leaf and stripe rusts were constituted at BC_3F_5 stage. The constituted lines were evaluated for three seasons under natural epiphytotic conditions (The predominant races of leaf rust pathotypes include 11, 77A, 77-1, 77-2, 77-5, 104B and 16, stem rust pathotypes are 11, 40, 40A, 40-1, 117, 117A and 117-1 and stripe rust pathotype I). The seedling tests were also carried out under glasshouse conditions against the individual races of stem, leaf and stripe rusts, predominantly prevalent in the Nilgiris, South India. The resistant lines to all the three rusts will be useful in combating the rust at foci of rust.

Introduction

Leaf rust caused by *Puccinia recondita* f. sp. *tritici* is the most important and destructive disease on wheat in India (Joshi et al. 1986; Anand et al. 1969; Evermeyer and Browder 1974; Sawhney et al. 1977). In the past several successful attempts were made to develope resistant wheat lines to leaf rust but time to time the varieties became susceptible due to occurrence of new virulence. Hence, the exploitation of specific rust resistance genes to combat the rust gains paramount importance.

Transferring these genes into different genetic background will offer a useful solution by way of durable resistance in the new lines. Though Van der Plank (1963) advocated development of rust resistant lines with horizontal resistance to have durable resistance, Johnson (1981) opined that the horizontal resistance which are apparently non specific to pathogenic races it may be

difficult to identify, evaluate and recover in breeding programs and still there is no guarantee that the resistance so introduced would be permanent. Considering these factors the practical approach would be to deploy the known rust specific genes under different genetic background and it will act as a mosaic to combat the rust in an environment favoring the disease. Therefore, we have to depend mainly on the alien sources of resistance genes and exploiting its interculture nature under different genetic background.

Over 30 key rusts resistance genes (*Lr* genes) have been identified from different sources and designated as *Lr1* through *Lr35* (McIntosh 1988). Out of which none of the specific genes from *Triticum aestivum* was found to offer complete resistance and only alien source of rust resistance genes viz. *Lr9*, *Lr19*, *Lr24*, *Lr28*, *Lr31* and *Lr32* are found to offer excellent resistance (Gupta 1985). In the present study an attempt was made to transfer the alien genes *Lr9*, *Lr24* and *Lr28* to different genetic background to develope resistant lines.

Materials and methods

From various nurseries grown at Wellington, Tamilnadu, India, through All India Coordinated Wheat Improvement Program, the wheat lines possessing good agronomic traits but susceptible to leaf rusts viz. VA92-10, CR7, CLRP-6, DW 876, DW 880, CPAN 4166, CPAN 4167, CPAN 4168, Veery 's', HW 741, HD 2329 and HD 2285 were selected. Specific set of crosses were obtained by crossing these lines (recurrent parents) with HW 2005 (carrying *Agropyron elongatum* derived gene *Sr24+Lr24*), HW 2037 (carrying *Aegilops speltoides* derived gene *Lr28*) and PH 127 (carrying *Aegilops umbellulata* derived gene *Lr9*) as donor parents.

F_1 hybrids resistant to leaf rust were backcrossed to respective recurrent parents followed by two backcrosses. The resistant lines at BC_3F_2 stage for stem, leaf and stripe rusts were selfed and the new lines were constituted at BC_3F_5 stage. The constituted lines were further screened against all the three rusts (1995-97) for three seasons under natural epiphytotic conditions at Wellington. The predominant races of leaf rust pathotypes include 11, 77A, 77-1, 77-2, 77-5, 104B and 16, stem rust pathotypes are 11, 40, 40A, 40-1, 117, 117A and 117-1 and stripe rust pathotype I. The seedling tests were also carried out under glasshouse conditions against individual races of stem, leaf and stripe rusts predominantly prevalent in Nilgiri hills, India.

Results

All the constituted lines were free to stem, leaf and stripe rusts except showing low susceptibility (TS) for stripe rusts in one of the derivatives (CLRP 6 X HW 2005) under natural epiphytotic conditions (Table 1). The seedlings of the individual constituted lines when tested under glasshouse condition showed resistant reactions to all the predominant races of leaf rust indicating the transfer of dominant genes *Lr9*, *Lr24* and *Lr28* into the constituted lines.

In the crosses involving HW 2005 (carrying *A. elongatum* derived gene *Sr24 + Lr24*) as donor parent the derivatives were resistant to stem and stripe rusts in addition to leaf rust resistance, though the donor parent was susceptible to stem and stripe rusts.

The lines obtained using PH 127 (carrying *Ae. umbellulata* derived gene *Lr9*) as donor parent also gave complete resistance to leaf rust, under both natural epiphytotic condition and glasshouse

Table 1. Adult plant response of newly constituted lines against stem, leaf and stripe rusts under natural epiphytotic conditions at Wellington during 1995-97

Recurrent parents/ crosses obtained	Genes transferred	Rust response		
		Stem	Leaf	Stripe
1. VA 92-10		TR	20S	F
VA 92-10 x HW 2005	*Lr 24*	TR	F	F
2. CR-7		TR	20S	F
CR-7 x HW 2005	*Lr 24*	TR	F	F
3. CLRP-6		TR	40S	TR
CLRP-6 x HW 2005	*Lr 24*	TR	F	TS
4. DW 876		TR	40S	F
DW 876 x HW 2005	*Lr 24*	TR	F	F
5. DW 880		TR	40S	F
DW 880 x HW 2005	*Lr 24*	TR	F	F
6. HD 2329		40S	80S	40S
HD 2329 x PH 127	*Lr 9*	TR	F	F
7. HD 2285		20S	60S	10S
HD 2285 x PH 127	*Lr 9*	TR	F	F
8. Veery 's'		F	20S	F
Veery 's' x PH 127	*Lr 9*	F	F	F
9. HW 741		F	50S	40S
HW 741 x PH 127	*Lr 9*	F	F	F
10. CPAN 4166		TR	20S	F
CPAN 4166 x HW 2037	*Lr 28*	TR	F	F
11. CPAN 4167		TR	20S	F
CPAN 4167 x HW 2037	*Lr 28*	TR	F	F
12. CPAN 4168		TR	20S	F
CPAN 4168 x HW 2037	*Lr 28*	TR	F	F
HW2005	*Lr 24*	20S	F	40S
PH 127	*Lr 9*	TR	F	F
HW2037	*Lr 28*	40S	F	40S

TR:trace resistant, TS:trace susceptible, F:free, S:susceptible

study (Table 1). Among recurrent parents HD 2329 and HD 2285 were susceptible to all the three rusts but the crosses obtained were resistant to all the three rusts.

The recurrent parents CPAN 4166, CPAN 4167 and CPAN 4168 when crossed to HW 2037 (carrying *Ae. speltoides* derived gene *Lr28*) the resultant progenies were resistant to stem, leaf and stripe rusts, indicating the transfer of *Lr28* gene.

Discussion

The resistance obtained to stem and stripe rusts in the constituted line in the crosses involving

HW 2005 may be due to the resistance already present in the recurrent parents. However, the cross involving CLRP 6 x HW 2005 resulted in the low susceptibility to stripe rust with the rust severity of TS. The res-gene *Lr24* is known to be very effective against all the leaf rust virulences prevalent in India (Sawhney 1985a; Kochumadhavan et al. 1988). The constituted lines may also carry the stem rust res-gene *Sr24*, since *Sr24* and *Lr24* are tightly linked (McIntosh et al. 1977). The res-gene *Sr24* also has been reported to be effective against all the virulence of stem rusts prevalent in India (Sawhney 1985a) except against the virulence 40-1 (Bhardwaj et al. 1990). However, *Sr24* might provide only additional resistance to other stem rust virulence than the virulence 40-1. Several workers have developed lines carrying *Sr24+Lr24* (Sears 1973; McIntosh 1976; Kochumadhavan et al. 1988; Brahma et al. 1996) and this gene continued to offer good resistance to leaf rust.

Recently several near isogenic lines of popular Indian cultivars carrying *A. elongatum* derived resistance gene *Sr24* + *Lr24* viz. Kalyansona, Sonalika, WH 147, WH 542, C 306, Lok-1, HD 2329, HUW 234, PBW 226, NI 5439, HD 2285, HD 2402, HI 1077, HD 2009, UP 262, VL 421, WL 711 and HS 240 has been developed (Kochumadhavan pers commun) at IARI-Regional Station, Wellington and they are resistant against all the leaf rust races prevalent at Wellington. Though some of the alien genes possess undesirable traits including *Lr24* (Gupta 1985), the lines which carries this specific gene gave superior yields when compared to non carriers (Brahma et al. 1996).

The yield tests of a number of backcross derivatives revealed that with suitable selection procedure it was possible to achieve superior or equal yield in comparison to the recurrent parent combined with alien derived resistances to rusts without any undesirable effects (Sawhney 1994).

The cross obtained with Veery 's' x PH 127 was resistant to all the three rusts and it was supposed to carry two alien source derived genes (*Secale cereale* derived linked gene *Sr31*, *Lr26* and *Yr9* and *Ae. umbellulata* derived *Lr9*). Further study on the yield parameter and interactive nature of two alien segments needed. Presence of these gene combination is expected to give durable rust resistance. Durable resistance due to a single gene such as *Sr31* in the IB/IR translocation, for resistance to stem rust are known but many cultivars that gave prolonged resistance to stem rust were found to have a combination of genes (McIntosh and Watson 1982). Van der Plank (1963) stated that resistance derived through certain gene interaction is likely to be more stable as compared to resistance determined by single gene pair.

The effectiveness of *Lr9* has already been reported by several earlier workers. The successful transfer of *Lr9* into Kalyansona gave excellent resistance to leaf rust (Sawhney 1985b,1987). Kochumadhavan (1996, pers commun) transferred *Ae. umbellulata* derived gene *Lr9* and developed near isogenic lines of several popular Indian bread wheat cultivars which are conferring good resistance against all the prevailing leaf rust races at Wellington.

The recurrent parents CPAN 4166, CPAN 4167 and CPAN 4168 when crossed to HW 2037 (carrying *Ae. speltoides* derived gene *Lr28*) the resultant progenies were resistant to stem, leaf and stripe rusts. The donor parent is susceptible to both stem and stripe rusts and hence the resistance to these rusts in the constituted line must be due to the resistance already present in the recurrent parents to stem and stripe rusts. The alien gene *Lr28* was found to offer high degree of field resistance (Kochumadhavan pers commun) and it is reported to confer seedling resistance against ten important leaf rust races (Sawhney and Goel 1983; Sawhney 1985a).

Though the alien genes *Lr*9, *Lr*24 and *Lr*28 offered excellent resistance, many of these genes

are highly influenced by environmental factors as well as age, genetic background of the host plants (Browder 1981; McGregor and Manners 1985). The alien genes *Lr9*, *Lr19*, *Lr24*, *Lr28*, *Lr31* and *Lr32* were highly resistant and the disease severity on the lines carrying these genes never exceeded 10 MR (Gupta 1985). Person (1959) extended a concept by suggesting that if a cultivar possesses two or more race specific resistance genes, its pathogen could possess genes for pathogenecity / virulence, each one corresponding to a particular resistance genes. The existence of gene to gene interactions therefore suggests that breeding for disease resistance must be a continuous process. Hence, control of diseases through maintenance of genetic diversity between cultivars for their resistance characters constitutes another strategy that will reduce the possibilities of major epidemics due to rapid spread of matching pathogenic races. This is possible by improved breeding stocks with unexploited resistance genes, particularly from alien sources, in agronomically desirable backgrounds for easy recovery of resistance without associated undesirable effects (Sawhney 1994). Hence, the developed lines are quite useful by way of offering not only wheat lines with genetic diversity and resistance to combat the rust but also will act as genetic source for future breeding programs.

References

Anand SC, Tyagi PD and Saxena VK (1969) The effect of rust on yield and other characters in wheat. J Res (PAU) 6: 912-916.

Bhardwaj SC, Nayar SK, Prashar M, Kumar J, Menon MK and Singh SB (1990) A pathotype of *Puccinia graminis* f. sp. *tritici* on *Sr24* in India. Cereal Rusts and Powdery Mildew Bull 18: 35-38.

Brahma RN, Sivasamy M and Saikia Aloka (1996) Development of wheat lines with resistance to stem, leaf and stripe rust. Cereal Rust and Powdery Mildew Bull 24: 82-84.

Browder LE (1981) A compendium of information about named genes for low reaction to *Puccinia recondita* f. sp. *tritici*. Crop Sci 13: 203-206.

Evermeyer MG and Browder LE (1974) Effect of leaf rust and stem rust in 1973 Kansas wheat yields. Pl Dis Reprt 58: 469-471.

Gupta AK (1985) Effectiveness and nature of leaf rust resistance genes in hexaploid and tetraploid wheats. In: Gupta AK, Nagarajan S and Rana RS (ed) Genetics and wheat improvement. Proc 3rd Natil Sem Genet Wheat Improv, Shimla, India. 33-56.

Johnson R (1981) Durable resistance. Definition of genetic control and attainment in plant breeding. Phytopathol 71: 567-568.

Joshi LM, Singh DV and Srivastava KD (1986) Wheat and wheat diseases in India. In: Joshi LM, Singh DV and Srivastava KD (ed) Problems and progress of wheat pathology in South Asia. 1-19.

Kochumadhavan M, Tomar SMS and Nambisan PNN (1988) Transfer of rust resistance genes into commercial cultivars of wheat. Ann Wheat Newsletter 34: 54-55.

McGregor AJ and Manners JG (1985) The effect of temperature and light intensity on growth and sporulation of *Puccinia striiformis* on wheat. Plant Pathol 34: 263-271.

McIntosh RA (1976) Genetics of wheat and wheat rusts since Farrer. Farrer Memorial Oration 1976. J Aust Inst Agr Sci 42: 203-216.

McIntosh RA (1988) Catalogue of gene symbols of wheat. Proc 7th Int Wheat Genet Symp: 1225-1323.

McIntosh RA, Dyck PL and Green GJ (1977) Inheritance of leaf rust and stem rust resistance in wheat cultivars Agent and Agatha. Aust J Agr Res 28: 37-45.

McIntosh RA and Watson (1982) Genetics of host pathogen interactions in rusts. In: Scott KJ and Chakravorty AK (ed) The rust fungi. Academic Press, Oxford. 122-148.

Person CO (1959) Gene-for-gene relationships in host-parasite systems. Can J Bot 37: 1101-1130.

Sawhney RN (1985a) Genetic study of *Triticum- Puccinia* interactions and its value in breeding strategies. In: Gupta AK, Nagarajan S and Rana RS (ed) Genetics and wheat improvement. Proc 3rd Natil Sem Genet Wheat Improv, Shimla, India. 6-21.

Sawhney RN (1985b) Identification and exploitation of diverse variability for disease resistance and yield

components to improve and stabilize wheat yields. Rachis 4: 21-25.
Sawhney RN (1987) Genetics of variation for resistance to rusts in wheat and its exploitation in resistance breeding. In: Gill KS, Khera AS and Verma MM (ed) Keynote presentation. Proc First Symp Crop Improv 1, Ludhiana: 147-166.
Sawhney RN (1994) Leaf rust resistance studies. In: Breeding for durable resistance to wheat rusts. Public Inform Direct IARI New Delhi: 8-14.
Sawhney RN and Goel LB (1983) Effectiveness of newly described leaf rust resistance genes against Indian culture of standard races and biotypes of leaf rust in wheat. Wheat Inf Serv 56: 34-36.
Sawhney RN, Nayar SK, Singh SD and Chopra VL (1977) Virulence pattern of the Indian leaf rust races on lines and varieties of wheat with known *Lr* genes. SABRAO J 9: 13-20.
Sears ER (1973) *Agropyron*-wheat transfers induced by homoeologous pairing. Proc 4th Int Wheat Genet Symp Univ Missouri. 191-199.
Van der Plank JE (1963) Plant diseases epidemics and control. Academic Press, New York and London.

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Research article

Transfer of *Triticum urartu* cytoplasm to emmer wheat is difficult, if not impossible

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Summary

Although the transfer of *Triticum boeoticum* cytoplasm to emmer wheat by successive backcrosses of the F_1 hybrid, *T. boeoticum* x emmer wheat, with emmer wheat as recurrent pollen parent was easy, no viable F_1 hybrid was obtained between *T. urartu* as female and emmer wheat, even with the aid of embryo rescue technique. *T. urartu* when used as female showed strong cross incompatibility to emmer wheat; a newly revealed aspect of the genetic differentiation between *T. urartu* and *T. boeoticum*.

Key words: *T. urartu*, *T. boeoticum*, Emmer wheat, Cytoplasm transfer, Cross incompatibility

Introduction

There is a general agreement in the opinion that *Triticum urartu* (2n=2x=14, genome constitution AA) provided the A genome to both groups of tetraploid wheat, Emmer and Timopheevi (Konarev 1983; Nishikawa 1983; Dvorak et al. 1988; Galili et al. 1991; Takumi et al. 1993). We have studied plasmon diversity among *Triticum* and *Aegilops* species, including two einkorn species, *T. boeoticum* and *T. monococcum*, by producing alloplasmic lines of common wheat having their cytoplasms (see Tsunewaki 1996 for review). Similar works have been carried out by many other researchers, such as Maan (1975) and Panayotov (1983). Those works revealed the plasmon differentiation among diploid species and the descent of plasmons in polyploid species. No people, however, has succeeded in producing alloplasmic lines of polyploid wheat having the cytoplasm of *T. urartu*, and no genetic characterization of its cytoplasm has been done so far. It is important to know whether the cytoplasm of *T. urartu* is similar to or very different from those of polyploid wheats in determination of their female parent, and clarification of the plasmon differentiation in diploid wheats.

Last three years we attempted to introduce the cytoplasm of *T. urartu* to emmer wheat, but

failed. In this article, the results of our attempt are presented and compared with those of our old, comparable investigation, in which cytoplasm of the other wild einkorn wheat, *T. boeoticum*, successfully was transferred to emmer wheat (Hori and Tsunewaki 1967).

Materials and methods

Plant materials

Two species of einkorn wheat (2n = 2x = 14, genome constitution AA), and three species of emmer wheat (2n = 4x = 28, AABB) were used. Einkorn species used were *T. boeoticum* (ssp. *aegilopoides*) and *T. urartu* var. *albonigrum* (accession KU 199-6), and those of emmer wheat were *T. dicoccum* (two cultivars, Vernal and Hokudai), *T. durum* (two varieties, *melanopus and rechenbachii*, and cv. Langdon) and *T. turgidum* (var. *nigrobarbatum*). Both einkorn species were crossed as female to emmer wheat. Viable F_1 hybrids obtained from the cross, *T. boeoticum* x emmer wheat, were backcrossed two times with emmer wheat as the recurrent pollen parent.

Embryo culture

Because crosses made in 1997 between *T. urartu* as female and emmer wheat did not produce any viable F_1 seeds, embryo culture was employed for the same cross in 1998. In this case, ovaries of 13-17 days after pollination were dissected and sterilized with 70% ethanol for 2 min, then embryos were excised from them and cultured on the N6 medium that was supplemented with casein hydrolysate (400 mg/l), GA_3 (0.5 mg/l), IBA (0.5 mg/l), and sucrose (50 g/l), keeping the cultures at 26 ˚C under artificial illumination of a 16-hour photoperiod, after Koba et al. (1991). Culture was carried out for about 50 days, then the cultures were discarded because they all withered.

Results

Transfer of *T. boeoticum* cytoplasm to emmer wheat

Table 1 shows the results of the crosses, *T. boeoticum* x emmer wheats, and two successive backcrosses of the F_1 and B_1 hybrids to emmer wheats as recurrent pollen parent (Hori and Tsunewaki 1967, unpubl). One hundred and fifty florets of *T. boeoticum* pollinated with *T. dicoccum* cv. Hokudai produced 93 F_1 seeds, the seed setting rate being 62%. From those seeds 73 F_1 hybrids were obtained, of which germination rate was 78.5%. Some of the F_1's were backcrossed as female to four accessions of emmer wheat. Crossed seed fertility was only 0.5% when all F_1's data were pooled. Germination rate of the B_1 seeds was very high (70% in total). The B_1 hybrids were backcrossed further to three accessions of emmer wheat. Seed setting rate (61%) was improved greatly. The B_2 seeds obtained germinated well at the overall frequency of 93%. Almost all B_2 plants cytologically checked had 2n = 28 chromosomes, with an exceptional plant that had 2n = 29 (Hori and Tsunewaki 1967). Thus, transfer of the *T. boeoticum* cytoplasm to emmer wheat was achieved rather easily.

Transfer of *T. urartu* cytoplasm to emmer wheat

Crosses between *T. urartu* (♀) and an emmer wheat (♂) did not set any viable F_1 seeds, as shown in the last line of Table 1. To overcome this cross incompatibility, embryo culture was

Table 1. Results of the crosses and backcrosses to transfer the cytoplasms of einkorn wheat to emmer wheat

Cross	No. florets pollinated	No. seeds set	Seed setting rate (%)	No. seeds germ.	Germination rate (%)
T. boeoticum x *T. dicoccum* cv. Hokudai	150	93	62.0	73	78.5
F_1 x *T. dicoccum* cv. Hokudai	390	0	0.0	–	–
F_1 x *T. dicoccum* cv. Vernal	360	3	0.8	3	100.0
F_1 x *T. durum* var. *melanopus*	600	2	0.3	0	0.0
F_1 x *T. turgidum* var. *nigrobarbatum*	720	5	0.7	4	80.0
Total (F_1 x emmer)	2,070	10	0.5	7	70.0
B_1 x *T. dicoccum* cv. Hokudai	40	26	65.0	25	96.2
B_1 x *T. dicoccum* cv. Vernal	124	80	64.5	73	91.3
B_1 x *T. durum* var. *reichenbachii*	40	18	45.0	17	94.4
Total (B_1 x emmer)	204	124	60.8	115	92.7
T. urartu x *T. durum* cv. Langdon	230	50[1)]	21.7	0	0.0

[1)] All seeds apparently were empty.

Table 2. Results of artificial culture of the F_1 embryos from the cross, *T. urartu* x *T. durum* cv. Langdon

No. days after pollination[1)]	No. florets poll.	No. embryos obtained	No.embryos forming			No. embryos showing no change
			Aberrant shoot & roots	Aberrant shoot only	Callus	
13	36	23	10	4	1	8
14	24	10	3	3	0	4
15	24	17	2	6	0	9
16	24	12	0	0	0	12
17	12	4	0	1	0	3
Total[2)]	84	50	15	13	1	21

[1)] Date when embryo was excised.

[2)] Data of the days 13-15 were totaled.

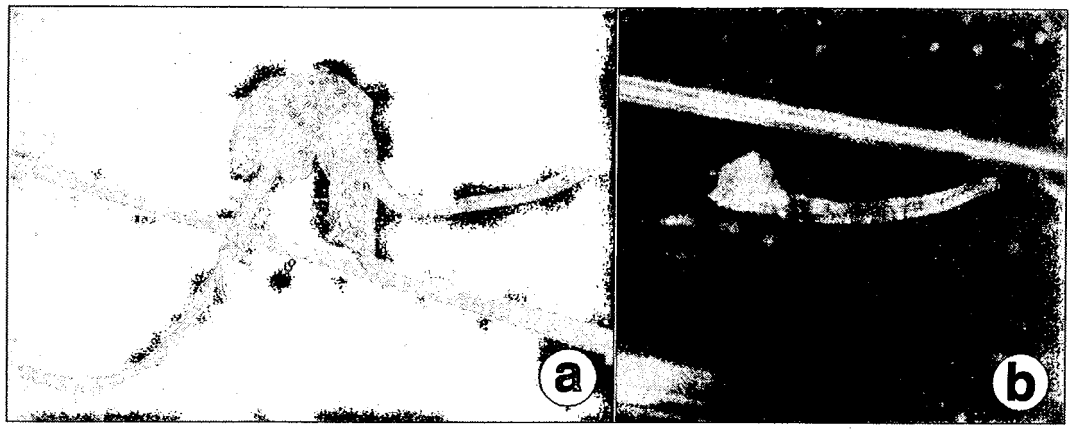

Fig. 1. Embryos from the cross, *T. urartu* x *T. durum* cv. Langdon, that were cultured for about 30 days on the N6 medium supplemented with casein hydrolysate, GA_3, IBA and sucrose (see text for details). a: Embryo differentiating a shoot and root. Shoot is abnormal in shape and albinotic, never recovering chlorophyll. b: Embryo forming a root, but not shoot.

performed (Table 2). Ovaries of *T. urartu*, which were pollinated with the pollen of *T. durum*, were excised on the 13th to 17th day after pollination, and the embryos dissected were cultured as described above.

The embryos dissected from the ovaries of 16 or 17 days after pollination rarely showed any sign of development, with one exception. About 60% of ovaries which were on the 13th to 15th day after pollination contained embryo. When cultured, about 55% of those embryos showed some growth, differentiating shoot and/or roots. Most of the remainders showed no sign of development. However, all shoots developed were abnormal (Fig. 1), and sooner or later they stopped growing and finally withered out. Thus, even with the aid of embryo culture, we could not get any F_1 hybrid from the cross, *T. urartu* (♀) x emmer wheat. It appears very difficult, if not impossible, to transfer the *T. urartu* cytoplasm to polyploid wheat.

Discussion

Yamagishi (1987) made a large number of crosses between different accessions of *T. boeoticum* and *T. urartu*. He demonstrated that these two species have the identical genome A, although their reciprocal F_1 hybrids showed deep sterility, indicating that the sterility barrier has developed between the two species in the course of their speciation. Dvorak et al. (1988) and Takumi et al. (1993) showed that their nuclear genomes have greatly been differentiated to each other, based on the magnitude of RFLP between their nuclear genomes. They used repeated DNA and genomic DNA sequences as probes, respectively. On the other hand, *T. boeoticum* and *T. urartu* have identical chloroplast genome so far as the restriction fragment patterns of their chloroplast DNAs obtained by the use of 13 restriction endonucleases were concerned (Ogihara and Tsunewaki 1988).

We may say from all these informations, including the present results, that the nuclear genomes of *T. urartu* and emmer wheat are incompatible, whereas that between the genomes of *T. boeoticum* and emmer wheat are compatible. We then fall in a paradox between two generally accepted hypotheses, i. e., *T. urartu* provided the A genome (ref. Introduction), and *Ae. speltoides* donated the B genome to emmer wheat (Sarkar and Stebbins 1956; Tsunewaki 1988; Dvorak and Zhang 1990). Based on these two hypotheses, we may assume that the A genomes of *T. urartu* and emmer wheat are compatible, and, similarly, that the A genome of *T. urartu* and the B of emmer wheat are compatible, because the F_1 hybrid between *T. urartu* and *Ae. speltoides* had been produced in the past to give rise to the present-day emmer wheat. Then, we can deduce logically that the nuclear genomes of *T. urartu* and emmer wheat should be compatible, but actually they were not. Of course, we may postulate different events that might have occurred during evolution of all those species. An approach to solve this enigma is to cross the F_1 hybrid between *T. urartu* and *T. boeoticum* to emmer wheat, and investigate the progeny of this cross.

References

Dvorak J and Zhang HB (1990) Variation in repeated nucleotide sequences sheds light on the phylogeny of the wheat B and G genomes. Proc Natl Acad Sci USA 87: 9640-9644.

Dvorak J, McGuire PE and Cassidy B (1988) Apparent sources of the A genomes of wheats inferred from polymorphism in abundance and restriction fragment length of repeated nucleotide sequences. Genome 30: 680-689.

Galili S, Galili G and Feldman M (1991) Chromosomal location of genes for Rubisco small subunit and Rubisco-binding protein in common wheat. Theor Appl Genet 81: 98-104.

Hori T and Tsunewaki K (1967) Study on substitution lines of several emmer wheats having the cytoplasm of *Triticum boeoticum*. Seiken Zihô 19: 55-59.

Koba T, Handa T and Shimada T (1991) Efficient production of wheat-barley hybrids and preferential elimination of barley chromosomes. Theor Appl Genet 81: 285-292.

Konarev VG (1983) The nature and origin of wheat genomes on the data of grain protein immunochemistry of grain proteins. Cereal Chem 56: 272-278.

Maan SS (1975) Cytoplasmic variability and speciation in Triticinae. In: Wali MK (ed.) Prairie: A Multiple View. North Dakota State University Press Fargo ND. 255-281.

Nishikawa K (1983) Species relationship of wheat and its putative ancestors as viewed from isozyme variation. Proc 6th Int Wheat Genet Symp Kyoto: 59-63.

Ogihara Y and Tsunewaki K (1988) Diversity and evolution of chloroplast DNA in *Triticum* and *Aegilops* as revealed by restriction fragment analysis. Theor Appl Genet 76: 321-332.

Panayotov I (1983) The cytoplasm in Triticinae. Proc. 6th Int Wheat Genet Symp Kyoto: 481-497.

Sarkar P and Stebbins GL (1956) Morphological evidence concerning the origin of the B genome in wheat. Amer J Bot 43: 297-304.

Takumi S, Nasuda S, Liu YG and Tsunewaki K (1993) Wheat phylogeny determined by RFLP analysis of nuclear DNA. 1. Einkorn wheat. Jpn J Genet 68: 73-79.

Tsunewaki K (1988) Cytoplasmic variation in *Triticum* and *Aegilops*. Proc. 7th Int Wheat Genet Symp Cambridge 1: 53-62.

Tsunewaki K (1996) Plasmon analysis as the counterpart of genome analysis. In: Jauhar PP (ed.) Methods of genome analysis in plants. CRC Press Inc New York. 271-299.

Yamagishi Y (1987) Phylogenetic differentiation between two species of the wild diploid wheats. Genbunsha Kyoto. pp 170.

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Research article

Fast rusting to stem rust in Indian bread wheat cultivars carrying the genes *Lr28* and *Lr32*

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Summary

Nine Indian bread wheat (*Triticum aestivum* L.) cultivars susceptible to leaf rust (*Puccinia recondita* Rob. ex Desm. f. sp. *tritici*) were chosen for incorporating resistance genes *Lr28* and *Lr32*. Five to nine backcrosses were given. Out of 18, fourteen backcross lines of leaf rust susceptible cultivars, namely, C306, HD2329, J24, Kalyansona, NI5439, Sonalika and WH147 carrying *Lr28* and *Lr32* showed fast rusting as compared to their recurrent parents under natural incidence of stem rust infection at Wellington. Fast rusting phenomenon seems to be associated with leaf rust resistance genes *Lr28* and *Lr32*. Evaluation of two backcross lines carrying *Lr28* indicate that there is distinct yield advantage in backcross lines over susceptible recurrent parents under high incidence of leaf rust infection.

Key words: Fast rusting, Backcross lines, Stem rust, Resistance, Susceptibility

Introduction

Wellington, situated in the Nilgiri hills, South India at an altitude of 1850 m. (above msl.) is a hot spot for rusts, powdery mildew and other foliar diseases of wheat. All the three wheat rusts, *Puccinia graminis* Pers. f. sp. *tritici*, *P. recondita* Rob. ex Desm. f. sp. *tritici* and *P. striiformis* f. sp. *tritici* with a wide spectrum of pathotypes occur throughout the year in Wellington. Rusts begin to appear on highly susceptible genotypes on seedling after 4th week of planting under natural conditions and thus are highly destructive.

Alien specific genes, namely, *Lr9* (*Aegilops umbellulata*), *Lr19*, *Lr24* (both from *Agropyron elongatum*), *Lr28* (*Ae. speltoides*), *Lr32* (*Ae. squarrosa*) and *Lr37* (*Ae. ventricosa*) confer high degree of adult plant resistance to leaf rust at Wellington (Tomar and Menon 1998). A backcross program was initiated during 1988 to introgress these genes into popular Indian bread wheat cultivars which were susceptible to leaf rust. While transferring these genes by repeated backcrossing authors observed the improved cultivars (backcross lines) to be highly susceptible

to stem rust as compared to their recurrent parents. Investigations were, therefore, carried out to screen the backcross lines carrying *Lr28* and *Lr32* against stem rust at different plant growth stages to know whether high susceptibility to stem rust is closely associated with leaf rust resistance as compared with their respective recurrent parents.

Materials and methods

The material used in the present study comprised of (a) two donor parents viz., CS 2A/2M 4/2 carrying *Lr28* and C86-8/Kalyansona F_4 having *Lr32*, (b) recurrent parents, namely, C306, HD2329, J24, Kalyansona, NI5439, Sonalika, WH147, WH542 and HS240 and (c) backcross lines carrying *Lr28* and *Lr32*. Since *Lr28* and *Lr32* are dominant genes, five to nine backcrosses were given in quick succession and backcross lines were constituted after three generations of selfing at F_3 generation. Backcross lines were similar to their recurrent parents in all respect like height, heading, maturity and seed characteristics except that they carried genes *Lr28* and *Lr32* conferring resistance to leaf rust. The backcross lines along with the recurrent parents were planted in paired rows. Stem rust inoculum collected from local and farmer's field was sprayed after 40 days of planting. Observations on susceptibility/resistance to stem rust and its progress was recorded at regular intervals at different stages of plant growth. The rust reactions were scored according to the modified Cobb's scale. The experiment was conducted for two seasons. A trial to assess yield potential of two backcross lines carrying *Lr28* was also conducted during 1997-98 season in RBD with four replications under optimal growing conditions.

Results and discussion

The results obtained in the study are presented in Tables 1, 2 and 3. About 32 pathotypes of stem rust have been reported from the Nilgiri hills over the last four decades. However, prevalent pathotypes are about 20 with major and minor fluctuations periodically. The line CS 2A/2M 4/2 carries the *Ae. speltoides* derived gene *Lr28* and *Ae. comosa* derived genes *Sr34* and *Yr8* (both tightly linked). Both *Lr28* and *Yr8* are highly effective at Wellington whereas *Sr34* is totally ineffective. Selections were done only for leaf rust resistance in all the backcross generations, thus eliminating the linked genes *Sr34* and *Yr8*. *Sr34* is reported to be ineffective to 19 Indian stem rust pathotypes in the seedling stage (Patil and Deokar 1996). Backcross lines carrying *Lr28* and *Lr32* when tested with a mixture of stem rust pathotypes including 40-1, a new virulence on *Sr24*, were found susceptible in adult plant stage (Tables 1 and 2). The high level of resistance to stem rust in backcross lines WH542*6//CS 2A/2M 4/2, WH542*6//C86-8/Kalyansona F_4, HS240*6//CS 2A/2M 4/2 and HS240*6//C86-8/Kalyansona F_4 is due to the presence of Petkus rye derived dominant gene *Sr31* (Nayar 1996).

In crosses with respective parents as well as with a stock carrying specific gene *Sr26* conferring resistance to stem rust, the factor for fast rusting to stem rust in the backcross lines carrying *Lr28* and *Lr32* was observed as recessive in nature. Therefore it is suggested that an undesignated recessive factor (*sr*) for fast rusting is tightly linked with *Lr28* and *Lr32*. The gene *Sr26* is located on chromosome 6AL while *Lr28* and *Lr32* are present on 4AL and 3DS chromosomes respectively. Therefore, the gene(s) for fast rusting (undesignated) is non-allelic to *Sr26*, hence the use of term

Table 1. Adult plant response to rusts in donor, recurrent parents and backcross lines carrying *Lr28* and *Lr32*

Parents/backcross lines	Gene(s)	Reaction to rusts		
		Stem	Leaf	Stripe
CS 2A/2M 4/2	*Lr28 Sr34 Yr8*	90S	F	F
C86-8/Kalyansona(KS) F_4	*Lr32*	80S	F	90S
C306		90S	90S	F
C306*9/CS 2A/2M 4/2	*Lr28*	90S	F	F
C306*5/C86-8/KS F_4	*Lr32*	90S	F	F
HD2329		70S	90S	90S
HD2329*7/CS 2A/2M 4/2	*Lr28*	90S	F	90S
HD2329*5/C86-8/KS F_4	*Lr32*	90S	F	90S
J24		90S	100S	100S
J24*7/CS 2A/2M 4/2	*Lr28*	90S	F	100S
J24*5/C86-8/KS F_4	*Lr32*	90S	F	100S
Kalyansona		80S	80S	90S
KS*9/CS 2A/2M 4/2	*Lr28*	90S	F	90S
KS*5/C86-8/KS F_4	*Lr32*	90S	F	90S
NI5439		90S	90S	100S
NI5439*7/CS 2A/2M 4/2	*Lr28*	90S	F	100S
NI5439*5/C86-8/KS F_4	*Lr32*	90S	F	100S
Sonalika		60S	80S	60S
Sonalika*8/CS 2A/2M 4/2	*Lr28*	80S	F	70S
Sonalika*5/C86-8/KS F_4	*Lr32*	80S	F	70S
WH147		90S	90S	90S
WH147*7/CS 2A/2M 4/2	*Lr28*	100S	F	90S
WH147*5/C86-8/KS F_4	*Lr32*	100S	F	100S
WH542	*Lr26 Sr31 Yr9*	10R, MR	80S	F
WH542*6/CS 2A/2M 4/2	*Lr28 Lr26 Sr31 Yr9*	15R, MR	F	F
WH542*5/C86-8/KS F_4	*Lr32 Lr26 Sr31 Yr9*	10R, MR	F	F
HS240	*Lr26 Sr31 Yr9*	10R, MR	70S	F
HS240*6/CS 2A/2M 4/2	*Lr28 Lr26 Sr31 Yr9*	5R, MR	F	F
HS240*/C86-8/KS F_4	*Lr32 Lr26 Sr31 Yr9*	5R, MR	F	F

Lr26 is not effective while *Yr9* is effective at Wellington, India

dominance is inappropriate. The gene *Sr26*, in particular, is present in hemizygous condition in F_1 hybrid, its allelic form is absent because of its alien origin. However, the fast rusting has been observed in the hybrids involving backcross lines with respective recurrent parents, the nature of the gene(s) can be called as recessive.

Fast rusting in the above cases is characterized by very short latent period, increased frequency of penetration, very large pustule size and increased pustule expression, increased number of uredinia per unit area of host surface and sporulation, appearance of stem rust pathogen in early vegetative phase and rapid progress and higher intensity even before maturity. Short latent

Table 2. Response, severinty, and progress of stem rust in Indian bread wheat cultivars carrying the gene *Lr28* and *Lr32* at different stages of plant growth

Variety/backcross line	Gene(s)	Early tiller-ing	Late tiller-ing	Early boot leaf	Late boot leaf	Flower-ing	Milk	Dough	Maturity
CS 2A/2M 4/2 (donor)	*Lr28*	15MS	30S	40S	50S	80S	90S	90S	90S
C86.8/Kalyansona(KS) F_4 (donor)	*Lr32*	10S	20S	40S	60S	70S	80S	80S	80S
C306		F	F	5S	20S	40S	60S	80S	90S
C306*9/CS 2A/2M 4/2	*Lr28*	15S	30S	50S	80S	80S	90S	90S	90S
C306*5/C86.8/KS F_4	*Lr32*	5S	20S	40S	70S	80S	80S	90S	90S
HD2329		F	F	5S	10S	15S	70S	70S	80S
HD2329*7/CS 2A/2M 4/2	*Lr28*	10S	30S	50S	80S	80S	90S	90S	90S
HDS2329*5/C86.8/KS F_4	*Lr32*	5S	40S	50S	70S	70S	80S	90S	90S
J24		F	F	5S	20S	60S	80S	80S	90S
J24*7/CS 2A/2M 4/2	*Lr28*	20S	30S	60S	80S	90S	90S	90S	90S
J24*/C86.8/KS F_4	*Lr32*	10S	20S	50S	70S	80S	90S	90S	90S
Kalyansona		F	F	5S	10S	20S	40S	60S	80S
KS*9/CS 2A/2M 4/2	*Lr28*	10S	15S	20S	40S	60S	80S	90S	90S
KS*5/C86.8/KS F_4	*Lr32*	15S	15S	30S	40S	60S	80S	90S	90S
NI5439		F	F	5S	10S	15S	60S	70S	90S
NI5439*7/CS 2A/2M 4/2	*Lr28*	10S	20S	50S	80S	80S	90S	90S	90S
NI5439*5/C86.8/KS F_4	*Lr32*	10S	15S	40S	70S	80S	90S	90S	90S
Sonalika		F	F	F	TS	10S	30S	50S	60S
Sonalika*8/CS 2A/2M 4/2	*Lr28*	5S	10S	15S	30S	50S	60S	70S	80S
Sonalika*5/C86.8/KS F_4	*Lr32*	TS	5S	10S	30S	50S	60S	80S	80S
WH147		F	F	5S	10S	20S	80S	80S	90S
WH147*7/CS 2A/2M 4/2	*Lr28*	15S	30S	50S	70S	80S	90S	90S	100S
WH147*5/C86.8/KS F_4	*Lr32*	10S	30S	60S	70S	80S	90S	90S	100S
WH542	*Sr31 Lr26 Yr9*	F	F	F	F	F	5R, MR	10R, MR	10R, MR
WH542*6/CS 2A/2M 4/2	*Lr28 Sr31 Lr26 Yr9*	F	F	F	F	5R	10R, MR	15R, MR	15R, MR
WH542*5/C86.8/KS F_4	*Lr32 Sr31 Lr26 Yr9*	F	F	F	F	5R	5R, MR	10R, MR	10R, MR
HS240	*Sr31 Lr26 Yr9*	F	F	F	F	F	TR	5R, MR	5R, MR
HS240*6/C8 2A/2M 4/2	*Lr28 Sr31 Lr26 Yr9*	F	F	F	F	F	TR	5R, MR	5R, MR
HS240*5/C86.8/KS F.	*Lr32 Sr31 Lr26 Yr9*	F	F	F	F	F	TR	5R, MR	5R, MR

period and very large pustule size and early wide coalescence were prominent. Rapid progress led to broken stems at an early stage and resulted in highly shrivelled grains. Caution should therefore, be exercised in deploying cultivars carrying *Lr28* or *Lr32* in areas highly prone to stem

Table 3. Grain yield of backcross lines carrying *Lr28*

Backcoss lines/recurrent parents	Mean grain yield (q/ha)
HD2329*7/CS 2A/2M 42	49.83
HD2329	48.64
WH147*7/CS 2A/2M 42	41.12
WH147	39.48

rust and this is particularly true in the case of southern hills, peninsular and central regions of India. However, highly effective major dominant genes like *Sr26*, *Sr31*, *Sr32* and *Sr36* along with *Lr28* or *Lr32* protect the cultivars from stem rust and leaf rust pathogens.

Out of 18, two backcross lines carrying *Lr28* were evaluated for yield (Table 3) at New Delhi during 1997-98 season. Normally, stem rust does not appear in Delhi conditions because of low temperature during the crop growth period. No infection was noticed on the backcross lines as well as on the recurrent parents. However, leaf rust infection was observed on the recurrent parents with moderate intensity. The yield differences were not high as both the backcross lines yielded as good as the recurrent parents. Since HD2329 and WH147 showed susceptibility to leaf rust the real effect of *Lr28* on grain yield could not be assessed, however, it can be concluded that resistance incorporated in HD2329 and WH147 protected the genotypes in yield loss from leaf rust infection which is a distinct advantage. Cultivar Sunland was registered in New South Wales, Australia as prime hard cultivar in 1992. Although no detrimental effect appear associated with the presence of *Lr28*, the durability of resistance is likely to be low (McIntosh et al. 1995). In view of the effectiveness of *Lr28* and *Lr32* against a mixture of races of leaf rust, the use of both the gens in wheat improvement is advocated.

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References

McIntosh RA, Wellings CR and Park RF (1995) An atlas of resistance genes. In: Alexa Cloud-Guest (ed) Wheat Rusts. University of Sydney Australia. 1-200.

Nayar SK, Prashar M and Bhardwaj SC (1996) Resistance breeding for new virulent pathotypes of rust. 35th All India Wheat Workers Workshop IARI New Delhi.

Patil JV and Deokar AB (1996) Host parasite interactions between lines and varieties of wheat with known *Sr* genes and races of stem rust. Cereal Rusts and Powdery Mildews Bulletin 24: 91-97.

Tomar SMS and Menon MK (1998) Adult plant response of near-isogenic lines and stocks of wheat carrying specific *Lr* genes against leaf rust. Indian Phytopathol 51: 61-67.

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Research article

Near-isogenic lines of spring common wheat Novosibirskaya 67 marked with short and long glume

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Summary

Near-isogenic lines (BC_9) of common spring wheat (*Triticum aestivum* L.) Novosibirskaya 67 marked with short (ANK-29) and long (ANK-30) glume were studied. Recessive allele *s1*, located on chromosome 3D, was a marker trait of ANK-29. In addition to short glume, ANK-29 is characterized by shortened stem and spherical grain, that is, the entire set of distinguishing traits of the donor (*T. sphaerococcum*). ANK-30, a derivative of *T. polonicum*, exhibits long glume and lemma, whereas the lengths of palea and grain are similar to those of the recurrent parent (Novosibirskaya 67). Comparative study of the near-isogenic lines suggests that the grain length is influenced by the size of palea.

Key words: Wheat, Near-isogenic lines, Glume length, Lemma, Aneuploid analysis.

Introduction

Several wheat species with lengthened or shortened grain linear size and glumes (*Triticum polonicum*, *T. turanicum* and *T. petropavlovsky*) have been described (Zhukovskii 1964; Dorofeev 1976). Middle Asian *T. aestivum* cultivars of Surchak type exhibit increased length of kernels and glumes. Genetics of this trait remains scantily investigated. Short glume and spherical grain of *T. sphaerococcum* are known to be determined by a recessive allele *s1* located on the long arm of chromosome 3D (McIntosh 1988; Goncharov 1992). The gene *Eg1* responsible for long glume of *T. polonicum* was localized to the long arm of chromosome 7A by Arbuzova et al. (1996) using our hybrids.

Experts in plant resources and plant breeders believe that the grain length correlates with the glume length in common wheats of Surchak type, *T. polonicum*, *T. turgidum*, and *T. petropavlovsky*, and their use as donors of the latter trait will result in long-grained cultivars.

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However, the pleiotropic effects of glume and grain lengths have not been studied. Correlation analysis of these traits in various species gives ambiguous results due to differences in their genetic and ecological characteristics. This was also the reason for a failure of the relevant experiments with hybrids of these species and common wheat. Nevertheless, Zhukovskii (1964) suggested that the spherical grain trait was separatable from other undesirable characteristics of *T. sphaerococcum* (small grain, low yield, and unacceptably short stem).

Near-isogenic lines present a convenient model for studying this problem, as they possess near identity in all the characteristics except the selected marker traits and nearby chromosomal regions (Koval 1991, 1997).

The goal of this work was to study the genetics and pleiotropic effects of glume length in the near-isogenic lines marked with short and long glume and clarify the connection between the glume length, grain length, and plant productivity.

Materials and methods

Two near-isogenic lines (NILs) of spring common wheat Novosibirskaya 67 (Koval 1997) were used, ANK-29 possesses short glumes and spherical grains, and ANK-30 has long glumes. The pure line of *T. aestivum* var. *albidum* cv. Novosibirskaya 67 (N-67), used as a standard, exhibits medium glume length, resistance to lodging and loose smut, and susceptibility to leaf rust and powdery mildew. Its gliadins (according to Metakovsky) are 1A3, 1B4, 1D3, 6A16, 6B2, and 6D6; other alleles of importance for the present investigation include: response to vernalization, *Vrn1*, *Vrn2*, and *vrn3*; grain color, *r1*, *r2*, and *r3*; awnlessness, *B1*, *b2*, and *hd*; color and haired glume, *hg*, *bg*, and *rg*; hybrid necrosis, *ne1* and *ne2*; haired nodes, *Hn*; and purple stem color, *Pc*.

The marker trait *s1* was donated to ANK-29 by *T. sphaerococcum* (k-5498), and *Eg1* to ANK-30 by *T. polonicum* (k-19597). The numbers of donors are cited from the catalogue of the Vavilov Institute of Plant Industry (St. Petersburg, Russia). Growth habit and plant development of these NILs coincided with those of the recurrent parent (N-67). Development of our NILs and their complete list were described earlier (Koval 1997).

Genetic analysis of the marker traits involved aneuploids, monosomic 3D from Milturum 553 monosomic series (Tsilke and Zharkov 1981) and fertile nullisomic 7A isolated in the progeny of a monosomic from Saratovskaya 29 aneuploid series (Maystrenko and Troshina 1970). The aneuploids were kindly provided by Prof. R.A. Tsilke (Agricultural University, Novosibirsk, Russia) and Dr. O.I. Maystrenko (Institute of Cytology and Genetics, Novosibirsk, Russia). Both aneuploids and their recurrent parents, Milturum 553 and Saratovskaya 29, have medium length glumes similar to N-67 and other Siberian cultivars.

Productivity of the NILs was studied in a field experiment (1992-1993) in the experimental farm of the Institute of Cytology and Genetics (Novosibirsk). The plants were seeded in a three-row plots, row length 1 m. The experiment was made in triplicate. The plants from the middle row were assayed. The measurements made were used to calculate the weight per 1000 kernels and the harvest index, that is, the ratio of the grain weight to the total biomass of the plant. The spike density was calculated as a quotient of its length and the number of its spikelets (including the sterile ones).

In addition, 30 plants were used to measure the glume, lemma, and palea lengths in the middle part of the spike and the linear sizes (length and width) of the corresponding grains.

Results

The phenotype of ANK-29 plant is typical of *T. sphaerococcum* and it is maladapted to Siberian conditions. The F_1 hybrids with the recurrent parent were similar to Novosibirskaya 67 except for a more closely packed spike. Thus, the short glume trait proved to be recessive. ANK-30 differed from Novosibirskaya 67 by a lengthened glume, which was dominant.

The F_2 segregation of the hybrids with the recurrent parent was close to 3:1, corresponding to the monogenic mode of inheritance (Table 1). The F_2 generation of the cross mono 3D x ANK-29 contained 110 plants with shortened glumes and 2 nullisomics with medium-length glumes, typical of N-67. The set of sphaerococcoid traits was incompletely expressed in a hemizygous state. Therefore, the F_3 generation of all the 110 plants was raised (according to the F_2 families). The plants with ANK-29 phenotype were present in all the families of the third generation. Thus, the marker trait was present in all the 110 F_2 plants, and no segregation occurred in the second generation. All the F_1 plants of the cross nulli 7A x ANK-30 were monosomics. In the second generation, all the 132 monosomic and disomic plants had long glumes typical of ANK-30. This

Table 1. Chromosome location of the marker genes in the near-isogenic lines, ANK-29 and ANK-30

Cross combination	Total number of plants F_2	With marker	Without marker	χ^2 3:1*
N-67 x ANK-29	110	22	88	1.37
mono 3D x ANK-29	112	110	2	32.19*
N-67 x ANK-30	196	154	42	1.33
nulli 7A x ANK-30	132	132	0	44.00*

*Value for significance of P = 0.01 is 5.99.

Table 2. The lengths of glume and grain in Novosibirskaya 78 (N-67) and the near-isogenic lines, ANK-29 and ANK-30

Organ	Year	N-67	ANK-30	ANK-29
Glume (mm)	1992	8.9	12.7 *	7.5 *
	1993	9.6	11.9 *	7.4 *
Lemma (mm)	1992	10.6	12.3 *	8.2 *
	1993	10.8	12.7 *	8.4 *
Palea (mm)	1992	10.5	10.5	7.1 *
	1993	10.7	10.6	7.2 *
Grain (mm)	1992	6.9	7.0	5.5 *
	1993	6.9	7.1	5.6 *

Table 3. Productivity components of the near-isogenic lines compared to those of Novosibirskaya 67 over two years

Trait	Year	N-67	ANK-30	ANK-29
Plant height (cm)	1992	86.7	71.9 *	47.2 *
	1993	93.2	97.5	57.6 *
Plant weight (g)	1992	3.1	2.8	2.2 *
	1993	4.9	4.8	2.5 *
Harvest index	1992	38.7	40.1	29.5 *
	1993	29.0	29.2	19.6 *
Main spike				
Length (cm)	1992	7.0	6.3	5.1
	1993	9.8	10.7	5.9
Number of spikelets	1992	13.9	14.1	14.7
	1993	17.3	16.1	16.5
Weight (g)	1992	1.20	1.20	0.82 *
	1993	1.51	1.55	0.77 *
Spike density (cm/1 spikelet)	1992	0.51	0.45	0.35 *
	1993	0.57	0.66 *	0.36 *
Number of grains	1992	29.5	28.8	24.1
	1993	39.9	38.4	32.1 *
Grain weight (g/spike)	1992	0.94	0.94	0.58 *
	1993	1.06	1.08	0.45 *
Weight per 1000 kernels (g)	1992	31.5	32.1	22.7 *
	1993	26.4	27.5	20.1 *

*Difference from Novosibirskaya 69 significant at P = 0.05

contrasted with the N-67 x ANK-30 cross when the F_2 showed monogenic segregation.

The set of ANK-29 phenotypic traits (low stiff straw, weak tillering, vertical leaves, short and closely packed spike, and spherical grain) was inherited jointly by the progeny during both the NIL development (nine backcrosses) and hybrid segregation in test crosses. It is likely that this set of phenotypic traits is determined by either a single gene *s1* or a tightly linked group of genes.

ANK-29 differs considerably from Novosibirskaya 67 and ANK-30 in the lengths of glume, lemma, and palea. Pronounced differences between ANK-30 and Novosibirskaya 67 in the lengths of the glume and lemma were recorded in both years of observation, while the grain and palea were of similar lengths (Table 2). Therefore, the grain length is unconnected to the lengths of glume and lemma. On the contrary, the shortened palea of ANK-29 suggests that it is the size of palea that determines the grain length.

ANK-29 was inferior to the standard in all productivity constituents except for the number of spikelets in a spike. The decrease in the grain number per spike along with the equal number of spikelets indicates the decreased fertility of the florets of this genotype. ANK-30 did not differ from the recurrent parent in productivity (Table 3) during both years of observation, despite the

contrasting weather conditions.

Discussion

The absence of segregation in the F_2 generation of the hybrids of the NILs with the corresponding aneuploids confirms the known location (McIntosh 1988; Arbuzova et al. 1996) of the marker genes, *s1* (ANK-29) on chromosome 3D and *Eg1* (ANK-30) on 7A.

We have earlier recorded a regular decrease in plant biomass and grain size in reduced height genotypes marked with *Rht* genes (Koval and Koval 1997). The reason lay with an insufficient capacity of the intermediate metabolite depot in vegetative organs. Similarly, the shortened grain in ANK-29 is unable to utilize the metabolites transported from the plant, thus resulting in a decreased productivity. The low harvest index of ANK-29 indicates that metabolites have been utilized incompletely during grain filling and their considerable portion remained in vegetative organs.

One thousand kernel weight is known to correlate very well with the plant productivity and yield (Millet 1984), thus representing an important breeding trait. However, the NILs have almost reached the limits of grain filling with metabolites, since the linear size of the grain restricts the amount of nutritive substances. Further increase in the 1,000 kernel weight will be possible only with the increase in metabolite capacity of the grain, that is, with an increase in linear size.

Basing on the high ecological stability of the grain linear size (Afanas'ev 1985) compared with its weight (filling of the grain), several plant breeders have suggested selection for the maximal length of the grain aiming to obtain the biggest grain (Korobeinikov 1985). Therefore, the search for the wheat polymorphism in the palea length is an ongoing problem.

References

Afanas'ev PD (1985) Nasledovanie formy i krupnosti zerna (Inheritance of grain shape and bigness). In: *Sbornik nauchnykh trudov po prikladnoi botanike, genetike i selektsii* (Collection of research works on applied botany, genetics, and breeding) 98: 72-75.

Arbuzova VS, Efremova TT, Laikova LI, Maystrenko OI, Popova OM and Pshenichnikova TA (1996) The development of precise genetic stocks in two wheat cultivars and their use in genetic analysis. Euphytica 89: 11-15.

Dorofeev VF ed. (1976) Pshenitsy mira (Wheats of the world). Leningrad, Kolos.

Goncharov NP (1992) Lokalizatsiya genov u myagkoi pshenitsy (Location of common wheat genes). Novosibirsk, IC&G.

Korobeinikov NI (1985) Izmenchivost' i kharakter nasledovaniya lineinykh razmerov i massy zernovki u sortov i gibridov myagkoi pshenitsy (Variability and type of inheritance of kernel linear size and weight in cultivars and hybrids of soft wheat). Nauchn. Tekh. Byulleten' SO VASKhNIL, Novosibirsk 45: 19-24.

Koval SF (1991) Sozdanie i ispol'zovanie analogov, izogennykh i alloplazmaticheskikh linii (Development and use of analogues, near-isogenic, and alloplasmic lines). In: Izogennye linii cul'turnykh rastenii (Isogenic lines of cultivated plants). Novosibirsk, IC&G: 5-27.

Koval SF (1997) The catalogue of near-isogenic lines of Novosibirskaya 67 common wheat and principles of their use in experiments. Russ J Genet 33: 995-1000.

Koval SF and Koval VS (1997) Genetic and phenotypic characteristics of short-stem isogenic lines of spring common wheat cv. Novosibirskaya 67. Russ J Genet 33: 553-557.

Maystrenko OI and Troshina AV (1970) Chromosome location of the genes for time of jointing in the spring wheat variety Saratovskaya 29. EWAC Newsletter: 51-52.

McIntosh RA (1988) Catalog of gene symbols for wheat. Proc. 7th Int Wheat Genet Symp Cambridge 2: 1225-1323.

Millet E (1984) The association between grain weight and grain volume in wheat. J Cereal Sc 2:31-35.
Tsilke RA and Zharkov NA (1981) Sravnitel'noe izuchenie monosomikov i disomikov pshenitsy Mil'turum 553 po elementam produktivnosti (Comparative study of productivity components of monosomics and disomics of wheat Milturum 553). In: Nauchnometodicheskie voprosy povysheniya effektivnosti selektsii sel 'skokhozyaistvennykh rastenii (Scientific methodical questions of increasing breeding efficiency of commercial plants). Nauchn. Tekh. Byulleten' SO VASKhNIL, Novosibirsk, SO VASKhNIL 7: 44-48.
Zhukovskii PM (1964) Kul'turnye rasteniya i ikh sorodichi (Cultivated plants and their relatives). Leningrad, Kolos.

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Research article

Suppression of the crossability genes of Chinese Spring (CS) in amphiploids CS/*Lophopyrum elongatum* and CS/ *Thinopyrum bessarabicum*

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Summary

CS and two amphiploids, CS / *Lophopyrum elongatum* and CS / *Thinopyrum bessarabicum*, were hybridized with rye (*Secale cereale* L.) and *Aegilops variabilis* to determine the suppression of the crossability genes of CS in amphiploid backgrounds. The results indicated that the recessive crossability genes of CS were inhibited by a suppressor or suppressors located in the E^e genome of *L. elongatum* and the E^b genome of *T. bessarabicum* in CS/*L. elongatum* and CS / *T. bessarabicum*, respectively. The effect of suppressor(s) in the cross of the amphiploids with rye was significantly weaker than that in the cross with *Ae. variabilis*.

Key words: Suppression, Crossability, *Lophopyrum elongatum*, *Thinopyrum bessarabicum*, Wheat

Introduction

The crossability of wheat with rye and other wheat relative species is controlled by the *Kr* system (Riley and Chapman 1967; Snape et a1. 1979; Koba and Shimada 1993). It was known that the crossability was promoted by the recessive *kr* genes, but was suppressed by the dominant loci. Four recessive *kr* genes, *kr1*, *kr2*, *kr3* and *kr4*, were identified on chromosome 5B, 5A (Riley and Chapman 1967), 5D (Krowlow 1970) and 1A (Zheng et al. 1992), respectively. Since CS possesses three recessive *kr* alleles, *kr1*, *kr2*, and *kr3*, it has been usually used as a test parent in studies on crossability between wheat and relative species. Liu et al. (1998) suggested that chromosome $4E^e$ in *Lophopyrum elongatum* suppressed crossability of CS with rye by testing the crossability of CS (*L. elongatum*) addition and substitution lines provided by Dr. J. Dvorak.

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The objective of this study was to analyze the expression and suppression of the recessive crossability genes in CS under the background in amphiploids of CS/ *L. elongatum* and CS/ *T. bessarabicum*.

Materials and methods

The experimental materials used in the study are described in Table 1. Two inbred lines of rye and two accessions of *Ae. variabilis* were used as male testers, and CS was used as male control in the crosses. Spikes of CS and the two amphiploids, CS/ *L. elongatum* and CS/ *T. bessarabicum* (Mujeeb-Kazi and Hettel 1995) were emasculated and bagged to avoid pollination with other plants. After 2-3 days, the stigmas of emasculated florets were pollinated with fresh pollen of rye or *Ae. variabilis*, then bagged again. The crosses were made using two outermost florets of the middle spikelets in each spike in the field condition. To evaluate the self-pollination seeds set rates, the emasculated florets of CS and the two amphiploids were pollinated with their fresh pollen respectively. Thirty days after pollination, the number of florets with and without seeds were recorded for each spike. The data are expressed as the percentage of successful crosses over the total number of florets pollinated. CS was used as control to detect the expression and suppression of the recessive crossability genes of CS in amphiploids. The significance of differences between the crossability percentages were detected by Student's statistical t-test.

Results and discussion

The crossabilities of amphiploids CS / *L. elongatum* and CS / *T. bessarabicum* with rye and *Ae. variabilis* are compared with that of control, CS, in Table 2.

Table 1. Plant materials used in this study

Material	Genome	Original source
(*Triticum aestivum* L.)		
cv. Chinese Spring	AABBDD	
(Amphiploid)		
CS / *L. elongatum*	AABBDDE^{e}E^{e}	Dr.A. Mujeeb-Kazi, CIMMYT
CS / *T. bessarabicum*	AABBDDE^{b}E^{b}	Dr. A.Mujeeb-Kazi, CIMMYT
(*Secale cereale* L.)		
cv. Qinling	RR	TRISAU*
cv. Jingzhou	RR	TRISAU
(*Aegilops variabilis*)		
Ae. variabilis-1	UUSS	Dr. A.Mujeeb-Kazi,CIMMYT
Ae. variabilis-2	UUSS	TRISAU

*TRISAU: Triticeae Research Institute, Sichuan Agricultural University.

Table 2. Crossability of CS and amphiploids with rye and *Ae. variabilis*

Combination	No. of florets pollinated	No. of seed-sets	Crossability percentage	t-value
CS (CK1)	200	190	95.0	—
CS / *L. elongatum*	180	165	91.7	1.10
CS / *T. bessarabicum*	180	168	93.3	0.47
CS / *L. elongatum* x CS	180	162	90.0	1.64
CS / *T. bessarabicum* x CS	160	146	91.3	1.20
CS x Qinling rye (CK2)	120	87	72.5	—
CS / *L. elongatum* x Qinling rye	124	43	34.7	5.80**
CS / *T. bessarabicum* x Qinling rye	120	64	53.3	2.94**
CS x Jingzhou rye (CK3)	160	113	70.6	—
CS / *L. elongatum* x Jingzhou rye	148	49	33.1	6.44**
CS / *T. bessarabicum* x Jingzhou rye	132	72	54.6	2.71 **
CS x *Ae. variabilis*-1 (CK4)	106	85	80.2	—
CS / *L. elongatum* x *Ae. variabilis*-1	124	0	0	12.43**
CS / *T. bessarabicum* x *Ae. variabilis*-1	120	10	8.3	7.74**
CS x *Ae. variabilis*-2 (CK5)	120	98	81.7	—
CS / *L. elongatum* x *Ae. variabilis*-2	148	18	12.1	11.31**
CS / *T. bessarabicum* x *Ae. variabilis*-2	182	17	9.3	12.57**

**: significant at 0.1% level of probability.

Crossability percentages of CS with Qinling rye and Jingzhou rye were 72.5% and 70.6% respectively, and were similar to the results reported by Luo et al. (1992, 1993a, b). However, the crossabilities of amphiploids CS / *L. elongatum* and CS / *T. bessarabium* with rye were significantly lower than that of CS (Table 2). As seen in Table 2, crossability percentages of CS/ *L. elongatum* with Qinling rye and Jingzhou rye were 34.7% and 33.1%, and those of CS / *T. bessarabicum* were 53.3% and 54.6%, respectively. There were two possible reasons for explaining the lower crossability percentages between the two amphiploids and rye. The one, the gamete fertility of the two amphiploids may be lower than that of CS due to meiotic chromosome pairing abnormalities. The other, there may be genetic factors inhibiting the success of crosses of the two amphiploids and rye. The self-pollination seed set rates of the amphiploids and the crossability percentages of amphiploids with CS were similar to that of CS (Table 2). This result indicated that the gamete fertility of the two amphiploids were normal. Therefore, the present experimental results could be explained that the crossability of CS with rye was partly inhibited by a suppressor or suppressors in the genomes of *L. elongatum* and *T. bessarabicum* under amphiploid backgrounds. In fact, Liu et al. (1998) had revealed that chromosome $4E^e$ of *L. elongatum* suppressed crossability of wheat with rye by using chromosome substitution or addition lines. However, the present results revealed that suppressor(s) on the E^b genome of *T. bessarabicum* also involved in the crossability of wheat with rye. On the other hand, the average crossability percentages between CS/ *L. elongatum* and CS/ *T. bessarabicum* with rye were significantly different (t=4.55). This results also indicated that, the suppressor(s) on E^e genome of *L. elongatum* was (or were) stronger

than that on E^b genome of *T. bessarabicum*.

Similar results were also observed when amphiploids crossed with *Ae. variabilis*. The crossability percentages of CS with *Ae. variabilis*-1 and *Ae. variabilis*-2 were very high, and were 80.2% and 81.7% respectively. But the two amphiploids had significantly lower crossability (Table 2). These results indicated that the crossability of CS with *Ae. variabilis* was mostly inhibited by suppressor(s) on the E^e genome of *L. elongatum* and the E^b genome of *T. bessarabicum* in their amphiploids.

A consistent difference in crossability percentages between amphiploids crossed with rye and *Ae. variabilis* was also observed. As seen in Table 2, crossabilities of amphiploids with rye were 33.1-54.6%, but those of amphiploids with *Ae. variabilis* were only 0–12.1%. The average crossability percentages of amphiploids with rye was significantly higher than that of amphiploids with *Ae. variabilis* (t=13.65). This results indicated that the effect of suppressor(s) inhibiting the success of crosses of amphiploids with *Ae. variabilis* were stronger than that in the crosses of the amphiploids with rye.

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Reference:

Koba T and Shimada T (1993) Crossability of common wheat with *Aegilops squarrosa*. Wheat Inf Serv 77: 7-12.

Krowlow KD (1970) Untersuchungen über die Kreuzbarkeit zwischen Weizen und Roggen. Z Pflanzenzücht 64: 44-72.

Liu DC, Yen C, Yang JL and Zheng YL (1998) Chromosome distribution of genes in diploid *Lophopyrum elongatum* (Host) A. Löve that influences crossability of wheat with rye. Wheat Inf Serv 86: 13-18.

Luo MC, Yen C and Yang JL (1992) Crossability percentages of bread wheat landraces from Sichuan Province, China with rye. Euphytica 61: 1-7.

Luo MC, Yen C and Yang JL (1993a) Crossability percentages of bread wheat landraces from Shaanxi and Henan Provinces, China with rye. Euphytica 67:1-8.

Luo MC, Yen C and Yang JL (1993b) Crossability percentages of bread wheat collections from Tibet, China with rye. Euphytica 70:127-129.

Mujeeb-Kazi A and Hettel GP (1995) Utilizing wild grass biodiversity in wheat improvement: 15 years of wide cross research at CIMMYT. CIMMYT Res Rep 2 Mexico DF, CIMMYT. pp 129.

Riley R and Chapman V (1967) The inheritance in wheat of crossability with rye. Genet Res Cambridge 9: 259-267.

Snape JW, Chapman V, Moss J, Blanchard CL and Miller TL (1979) The crossability of wheat varieties with *Hordeum bulbosum*. Heredity 42: 291-298.

Zheng YL, Luo MC, Yen C and Yang JL (1992) Chromosome location of a new crossability gene in common wheat. Wheat Inf Serv 75: 36-40.

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Research article

Transfer of *Agropyron elongatum*-derived resistance genes *Sr25/ Lr19* into Indian bread wheat cultivars

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Summary

Alien genes *Lr19/Sr25* were transferred into fourteen well adapted Indian bread wheat cultivars by repeated backcrossing. All the backcross lines carrying the alien segment (*Lr19/Sr25*) exhibited a high degree of resistance to leaf rust and high to moderate resistance to stem rust. Backcross line WH542*6//Sunstar*6/C80-1 has however, showed TR to MR reaction to stem rust infection appearing at late maturity. The yield data recorded in three backcross lines indicated that the segment carrying resistance does not have detrimental effect on yield in certain backgrounds.

Key words: Leaf rust, Stem rust, Resistance, Backcross lines, Grain yield

Introduction

Rusts have been historically the most destructive of wheat diseases and cause substantial losses in grain yield world wide. Stem rust is highly destructive in the temperature range of 15 to 30°C, whereas leaf rust rapidly develops and causes considerable destruction in the temperature range of 10 to 30°C. Stripe rust is restricted to cooler regions (1 to 15°C). IARI Regional Station, Wellington is situated at an altitude of 1900 m above mean sea level in the Nilgiri hills of south India with an average annual maximum temperature of 25°C. All the three rusts are highly destructive throughout the year. A large number of pathotypes of *Puccinia graminis* f.sp. *tritici* and *P. recondita* have been reported from this place while *Puccinia striiformis* consists of only a few pathotypes. Genes of alien origin have more or less controlled the infection of stem rust and leaf rust in major wheat growing areas including India. This communication deals with the introgression of linked genes *Sr25/Lr19* derived from *Agropyron elongatum* into elite Indian bread wheat cultivars which are otherwise susceptible to both stem and leaf rusts.

Materials and methods

The materials used in the present study consist of rust resistant donor Sunstar*6/C80-1, a

derivative of *Lr19* with highly reduced yellow pigment in the endosperm and 14 well adapted but rust susceptible Indian bread wheat cultivars (recurrent parents), namely, C 306, HD 2285, HD 2329, HD 2402, HI 1077, HUW 234, J 24, Kalyansona, Lok-1, NI 5439, PBW 226, Sonalika, WH 147 and WH 542. Since *Sr25* and *Lr19* are tightly linked dominant genes, five to seven backcrosses were given during a span of two to three years (raising three crops in a calendar year) and the genotypes phenotypically similar to their respective recurrent parents with resistance to stem and leaf rusts were constituted after three generations of selfing at F_3 generation. Three backcross lines carrying *Sr25/Lr19* were evaluated for grain yield at New Delhi farm during 1997-98. Each plot consisted of 6 meter length spaced at 23 cm. Seed rate of 100kg/ha was used. Paired *t*-test was applied to test the significance of difference between the two means.

Results and discussion

The results obtained in the study are presented in the Tables 1 and 2. Sharma and Knott (1966) transferred the segment carrying *Sr25* and *Lr19* from the decaploid *Agropyron elongatum* to common wheat Agatha. These genes, however, could not be utilized in breeding because of their undesirable linkage with yellow flour color which was not commercially acceptable. Knott (1980) induced mutations through EMS and obtained two mutant lines having the normal flour color. The authors used a line Sunstar*6/C80-1 developed by McIntosh (pers commun) with highly reduced yellow pigment as a donor in the backcross program to introgress *Sr25/Lr19* into susceptible cultivars. Presently, many of these cultivars are in cultivation either in small pockets or in large areas. Leaf rust resistance gene *Lr19* (Agatha) confers total immunity to leaf rust at Wellington as well in other parts of the country. Sawhney et al. (1977) reported that *Lr19* conferred seedling resistance to all the leaf rust pathotypes prevalent in India. A wide spectrum of pathotypes of leaf rust prevalent in U.S.A., Canada, Australia, India and other countries are avirulent on *Lr19* (Agatha). However, Huerta-Espino and Singh (1994) detected a virulence (CBJ/QQ) on *Lr19* in Mexico. Sibikeev et al. (1997) have also identified a pathotype of leaf rust virulent on *Lr19* and *Lr19d* in Saratov and Qrenbhurg districts of Russia.

Since Agatha equals its parent Thatcher in yield, milling and baking quality, the authors do not expect any kind of yield reduction in the backcross lines carrying *Lr19* although yield reductions associated with alien genetic transfers have been reported in some cases in hexaploid wheats (The et al. 1988). All the backcross lines were screened under artificial epiphytotic conditions of stem rust and leaf rust infection at Wellington over two seasons. Maximum reactions to both stem and leaf rusts are given in Table 1. Reactions to stripe rust were also recorded and are presented in Table 1, which will benefit the users. The low reaction to stem rust observed in WH 542 carrying *Lr19* could be due to the presence of two major alien genes *Sr25* and *Sr31*. The cultivar WH 542 has been postulated to carry *Sr31* (Sharma et al. 1997).

McIntosh et al. (1977) reported that *Sr25* conferred effective resistance to all the races of stem rust prevalent in Australia. Similarly Roelfs and McVey (1979) reported that *Sr25* was effective to all the pathotypes of stem rust in U.S.A. *Sr25* is reported to be effective at seedling stage against 19 Indian culture of stem rust pathogen viz., 14, 15, 17, 21, 21A-1, 24, 34, 40, 40-1, 42, 42B, 117, 117A, 117A-1, 122, 184, 194, 222 and 295 (Sawhney and Goel 1981; Patil and Deokar 1996). Tomar and Menon (unpublished) in a detailed study found that *Sr25* appeared to be a major slow rusting gene and imparted a high level of resistance to a wide spectrum of stem

Table 1. Adult plant response to stem, leaf and stripe rusts of donor and recurrent parents and backcross lines carrying *Sr25 / Lr19* genes

Parents/backcross lines	Gene(s) present	Reaction to		
		Stem rust	Leaf rust	Stripe rust
Sunstar*6/C80-1	*Sr25 Lr19*	10R, MR-30R, MR	F	F
Cook*6/C80-1	*Sr6 Sr36 Sr25 Lr19*	F	F	F
C306		90S	90S	F
C306*4//Sunstar*6/C80-1	*Sr25 Lr19*	30MR, MS	F	F
HD2285		30MS	100S	30S
HD2285*6//Sunstar*6/C80-1	*Sr25 Lr19*	15R, MR	F	30S
HD2329		80S	90S	90S
HD2329*7//Sunstar*6/C80-1	*Sr25 Lr19*	20R, MR, MS	F	90S
HD2402		30S	100S	F
HD2402*5//Sunstar*6/C80-1	*Sr25 Lr19*	TR, MR	F	F
HI1077		30MS, S	100S	40MS
HI1077*5//Sunstar*6/C80-1	*Sr25 Lr19*	20R	F	40MS
HUW234		20MS, S	100S	F
HUW234*6//Sunstar*6/C80-1	*Sr25 Lr19*	TR, MR	F	F
J24		90S	100S	100S
J24*4//Sunstar*6/C80-1	*Sr25 Lr19*	40MS, S	F	100S
Kalyansona(K.sona)		80S	90S	90S
K.sona*5//Sunstar*6/C80-1	*Sr25 Lr19*	20R, MR, MS, S	F	90S
Lok-1		70S	80S	80S
Lok-1*7//Sunstar*6/C80-1	*Sr25 Lr19*	5R, MR, MS, S	F	90S
NI5439		90S	90S	100S
NI5439*//Sunstar*6/C80-1	*Sr25 Lr19*	30MR, MS, S	F	100S
PBW226		20S	90S	F
PBW226*5//Sunstar*6/C80-1	*Sr25 Lr19*	TR, MR	F	F
Sonalika		60S	80S	60S
Sonalika*5//Sunstar*6/C80-1	*Sr25 Lr19*	15R, MR	F	60S
WH147		90S	90S	90S
WI47*7//Sunstar*6/C80-1	*Sr25 Lr19*	30R, MR, MS,	F	90S
WH542	*Sr31 Lr26 Yr9*	TR, 10R, MR	80S	F
WH542*6//Sunstar*6/C80-1	*Sr31 Sr25 Lr19 Lr26 Yr9*	F-TR, MR	F	F

R: resistant (hypersensitive flecks and small uredia with necrosis), MR: moderately resistant (moderate size uredia with chlorosis), MS: moderately susceptible (moderate size of uredia with chlorosis), S: susceptible (large uredia with or without necrosis or chlorosis), F: no infection (immune), T: traces. *Sr31* and *Yr9* are highly effective while *Lr26* is ineffective at Wellington.

Table 2. Grain yield of backcross lines carrying *Agropyron elongatum* derived genes *Sr25/Lr19*

Backcross lines/recurrent parents	Mean grain yield in q/ha
HD 2329*7//Sunstar*6/C80-1	54.67
HD 2329	52.26
Lok-1*7//Sunstar*6/C80-1	45.52
Lok-1	42.35
WH 542*6//Sunstar*6/C80-1	57.82
WH 542	56.24

rust pathotypes prevalent in the Nilgiri hills. The adult plant reaction to stem rust on backcross lines (Table 1) indicated that the gene *Sr25* exhibited high to moderate resistance (moderately susceptible pustules appear towards maturity) except where *Sr31* was present.

Sunstar*6/C80-1 developed by McIntosh in white seeded background with reduced yellow pigment thus appears to be a elite donor to develop genotypes carrying resistance to stem and leaf rusts for deployment in the southern hills, peninsular and central regions of India where both the rusts occur prominently during the crop season. We evaluated Cook*6/C80-1, another *Lr19* derivative with reduced yellow pigment developed by McIntosh and found it totally immune to stem rust probably due to the presence of three slow rusting genes *Sr6*, *Sr25* and *Sr36* as Cook carries *Sr6* and *Sr36*. The presence of *Sr36* in the line was further confirmed by its high resistance to powdery mildew (Score 0-1). The powdery mildew resistance gene *Pm6* is thought to have been derived from *Triticum timopheevi* along with *Sr36* and is located on 2B chromosome (Nyquist 1963). The authors did not use this line in the backcross program as it is late maturing genotype; however, this line will prove useful as an alternative nonrecurrent parent.

The difference in grain yield between backcross lines and their recurrent parents were not significant. However, numerical differences in yield observed among the backcross lines and their recurrent parents were due to rust infection on recurrent parents.

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References

Huerta-Espino J and Singh RP (1994) First report on virulence in wheat with leaf rust resistance gene *Lr19* in Mexico. Plant Dis 78.

Knott DR (1980) Mutation of a gene for yellow pigment linked to *Lr19* in wheat. Can J Genet Cytol 22: 651-654.

McIntosh RA, Dyck PL and Green GJ (1977) Inheritance of leaf rust and stem rust resistance in wheat cultivars Agent and Agatha. Aust J Agric Res 28: 37-45.

Nyquist WE (1963) Inheritance of powdery mildew resistance in hybrids involving common wheat strain derived from *Triticum timopheevi*. Crop Sci 3: 40-43.

Patil VV and Deokar AB (1996) Host parasite interactions between lines and varieties of wheat with known *Sr* genes and races of stem rust. Cereal Rusts and Powdery Mildew Bull 24: 91-97.

Roelfs AP and McVey DV (1979) Low infection types produced by *Puccinia graminis tritici* and wheat lines with designated genes for resistance. Phytopathol 69: 722-730.

Sawhney RN and Goel LB (1981) Race specific interaction between wheat genotypes and Indian cultures of stem rust. Theor Appl Genet 60:61-66.

Sawhney RN, Nayar SK, Singh SD and Chopra VL (1977) Virulence pattern of the Indian leaf rust races on lines and varieties of wheat with known *Lr* genes. SABRAO J 9: 13-20.

Sharma AK, Kumar J and Nagarajan S (1997) DWR Progress Report of the Coordinated Experiments 1997. Crop Protection Vol. V: 16.

Sharma D and Knott DR (1966) The transfer of leaf rust resistance from *Agropyron* to *Triticum* by irradiation. Can J Genet Cytol 8: 137-143.

Sibikeev SN, Krupnov VA, Voronina SA and Elisin VA (1996) First report of leaf rust pathotypes virulent to highly effective *Lr* genes transferred from *Agropyron* species to bread wheat. Plant Breed 115: 276-278.

The TT, Latter BDH, McIntosh RA, Ellison FW, Brennen PS, Fisher J, Hollamby GJ, Rathjen A and Wilson RE (1988) Grain yield of near isogenic lines with added genes for stem rust resistance. Proc 7th Int Wheat Genet Symp Cambridge: 901-906.

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Report

GrainTax Synonymy Tables Project: June 1999 Progress Report

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This progress report presents the accomplishments to date for the *GrainTax* Synonymy Project which was initiated on the recommendation of participants in the Taxonomy Workshop held at the 9th International Wheat Genetics Symposium (2-7 August 1998) in Saskatoon, Canada (See Appendix below). The project, now underway, is developing an interactive database system that will contain classification and synonymy tables of all modern taxonomic treatments of the wheats dating from 1921 to present. Consistent with the recommendations of the Taxonomy Workshop, this report is being published concurrently in the June 1999 issue of the *Annual Wheat Newsletter* and also will be posted on the *GrainTax* website (http://wheat.pw.usda.gov/ggpages/GrainTax).

Classification Tables

Tables for all current and relevant historical classifications of the wheats are now under construction on the Kansas State University Wheat Genetics Resource Center (WGRC) web site (http://www.ksu.edu/wgrc/Germplasm/Taxonomy). As each classification is prepared for the WGRC site, it has been reviewed for errors in species names and authority citations. Additionally, notations have been made where species names are illegitimate, invalid, or ambiguous according to the rules of the International Code of Botanical Nomenclature (ICBN, Greuter et al. 1994). As of this writing, tables for 24 classifications have been constructed. Eleven of these classifications are historical; the other 13 are current treatments followed variously by genebanks, researchers, and botanists.

Although it was the original intention of the *GrainTax* Synonymy Project to limit the Classification Tables to only 12 treatments (See Appendix), this task has expanded for the following reasons. Names from older taxonomic treatments can still be encountered in modern literature.

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Historical classifications have value either because they illustrate changing treatment concepts or they laid the foundation for the more current treatments that followed them. All generic concepts are covered by these tables -- the traditional concept of two separate genera, *Triticum* L. and *Aegilops* L.; the enlarged concept of one genus, *Triticum* L. *sensu lato*; the move of the T-genome species from *Aegilops* into *Amblyopyrum* (Jaub. & Spach) Eig; the move of the S-genome species of *Aegilops* into *Triticum*; and the genomic concept of many genera defined by distinctive diploid or polyploid genomic combinations.

Classification Tables for *Triticum* include Percival (1921), Flaksberger (1935), Schiemann (1948), Jakubziner (1958), Bowden (1959), Mac Key (1966, 1988), Morris and Sears (1967), Gandilyan (1972), Dorofeev et al. (1979), Löve (1984), the *Flora of Turkey* (Tan 1985), Kimber and Sears (1987), Kimber and Feldman (1987), Mac Key (1988) and van Slageren (1994) will be printed. Classification Tables for *Aegilops* include Zhukovsky (1928), Eig (1929), Kihara (1954), Chennaveeraiah (1960), Hammer (1980), Witcombe (1983), Löve (1984), the *Flora of Turkey* (Davis 1985), and van Slageren (1994). There is also a Comparative Classification Table which is organized by genome and contrasts the commonly encountered *Triticum* and *Aegilops* treatments of Dorofeev et al. (1979), Hammer (1980), Kimber and Sears (1987), Mac Key (1988), and van Slageren (1994).

Correct Names and Authority Citations

Unfortunately, many of the wheat classifications have nomenclatural errors, spelling mistakes, and incorrect authority citations. Each of the current treatments of Gandilyan (1972), Dorofeev et al. (1979), Hammer (1980), Witcombe (1983), Löve (1984), *Flora of Turkey* (1985), Kimber and Sears (1987), Kimber and Feldman (1987), Mac Key (1988), and van Slageren (1994) will be presented in a corrected version. When species names are known to be incorrect or misspelled, they will be changed or indicated as such. The historical treatments of Percival (1921), Zhukovsky (1928), Eig (1929), Flaksberger (1935), Kihara (1954), Schiemann (1948), Jakubziner (1958), Bowden (1959), Chennaveeraiah (1960), Mac Key (1966), and Morris and Sears (1967) will be left in their original forms except for corrections of authority citations and notations of invalid, illegitimate, and ambiguous names.

In the case of authority citations, the spelling and abbreviation of the names of authorities will follow Brummitt and Powell (1992), the publication that sets the current standard throughout the international botanical community. A Table of Authorities, including names and abbreviations found in wheat taxonomy, is also available on the WGRC web site. A Nomenclatural Errors Table lists names known to be invalid (names not effectively published according to the ICBN), illegitimate (names incorrectly applied according to the ICBN), and ambiguous (names which are in doubt because identity of the associated type specimen is ambiguous). There also is an Orphan Names Table which will list names, typically for domesticated forms, that have been dropped or are not treated in most current classifications due to changing treatment concepts.

Internet Access

Tables are formatted for direct viewing or downloading and are accessible directly on the WGRC site or by link from the *GrainTax* site. *GrainTax*, which is located on *GrainGenes* (http://wheat.pw.usda.gov), was established to serve the project. In addition to its link to the WGRC Tables, *GrainTax* contains a bulletin board for postings and a mailgroup (to join, contact Dave

Matthews, matthews@greengenes.cit.cornell.edu). This internet compilation of current and historical classifications provides a central location where names and treatment concepts of the wheats can be viewed and checked. The tables are an authoritative source for verifying correct taxonomic usage. It is hoped that their availability over the internet will encourage a more consistent usage of taxonomic names in wheat research.

Project Status

All 24 Classification Tables are available for access although users are advised that they are not yet in their fully corrected forms. For the next step, the Project will develop a cross-referencing system with two different components -- (1) linking names to classifications and (2) linking a name to all of its synonyms. Included in this system will be a Table of Synonyms containing an alphabetical listing of all taxonomic names by which the wheats are known. Projected operation for these components is in 2000.

Postings concerning the project will appear on the *GrainTax* web site and will be emailed to *GrainTax* mailgroup subscribers. Written or email comments on the operation and design of the Classification and Synonymy Tables are invited from the wheat research community.

References

Bowden WM (1959) The taxonomy and nomenclature of the wheats, barleys, and ryes and their wild relatives. Can J Bot 37: 657-684.

Brummit RK and Powell CE (ed) (1992) Authors of Plant Names. Kew.

Chennaveeraiah MA (1960) Karyomorphologic and cytotaxonomic studies in *Aegilops*. Acta Horti Gotob 23 (4): 85-178.

Davis PH (1985) 13. *Aegilops* L. In: Davis PH (ed) *Flora of Turkey* and the East Aegean Islands Vol 9 Edinburgh at the University Press Scotland pp 232-245.

Dorofeev VF, Filatenko AA, Migushova EF, Udaczin RA and Jakubziner MM (1979) Wheat. In: Dorofeev VF and Korovina ON (ed) Flora of Cultivated Plants. Vol 1 (Kolos, Leningrad [St. Petersburg] [in Russian].

Eig A (1929) Monographisch-kritische Übersicht der Gattung *Aegilops*. Feddes Repert spec nov reg veg Beih. 55: 1-228 [in German].

Flaksberger CA (1935) Cereals: Wheat. In: Wulf EW (ed) Flora of Cultivated Plants. Vol 1 Gos Izd Kolkh Sovkh Moscow and Leningrad [St. Petersburg] pp 17-435 [in Russian].

Gandilyan PA (1972) On the wild-growing species of *Triticum* of the Armenian SSR. Bot Zhurn 57: 173-181 [in Russian].

Greuter W et al. (ed) (1994) International code of botanical nomenclature (Tokyo Code) adopted by the Fifteenth International Botanical Congress Yokohama, August-September 1993 Regnum Veg 131.

Hammer K (1980) Vorarbeiten zur monograhischen Darstellung von Wildpflanzensortimenten: *Aegilops* L. Kulturpflanze 28: 33-180 [in German].

Jakubziner MM (1958) New wheat species. Proc 1st Int Wheat Genet Symp Winnipeg Canada: 207-220.

Kihara H (1954) Considerations on the evolution and distribution of *Aegilops* species based on the analyser-method. Cytologia 19: 336-357.

Kimber G and Feldman M (1987) Wild wheat: an introduction. Spec. Rpt. 353. Coll Agri Univ Mo Columbia.

Kimber G and Sears ER (1987) Evolution in the genus *Triticum* and the origin of cultivated wheat. In: Heyne EG (ed) Wheat and wheat improvement 2nd ed Madison pp 154-164.

Löve Á (1984) Conspectus of the Triticeae. Feddes Repert 95: 425-521.

Mac Key J (1966) Species relationships in the *Triticum*. Proc 2nd Int Wheat Genet Symp Hereditas Suppl 2: 237-276.

Mac Key J (1988) A plant breeder's perspective on taxonomy of cultivated plants. Bio Zentralbl 107: 369-379.

Morris R and Sears ER (1967) The cytogenetics of wheat and its relatives. In: Quisenberry KS and Reitz LP (ed) Wheat and wheat improvement. Am Soc Agron Madison pp 19-87.

Percival J (1921) The Wheat Plant. Duckworth & Co London.

Schiemann E (1948) Weizen, Roggen, Gerste: Systematik, Geschichte und Verwendung. G Fischer Verlag Jena [in German].
Slageren MW van (1994) Wild wheats: a monograph of *Aegilops* L. and *Amblyopyrum* (Jaub. & Spach) Eig. Wageningen Agric Univ Pap 1994 (7).
Tan K (1985) 14. *Triticum* L. In: Davis PH (ed) Flora of Turkey and the East Aegean Islands. Vol 9 Edinburgh at the University Press Scotland pp 245-255.
Witcombe JR (1983) A guide to the species of *Aegilops* L.: their taxonomy, morphology and distribution. IBPGR [IPGRI] Rome.
Zhukovsky PM (1928) A critical systematic survey of the species of the genus *Aegilops* L. Bull Appl Bot Genet Pl Breed 18: 417-609 [in Russian with English summary].

Appendix

The *GrainGenes* Synonymy Tables Database Project--Design and Goals According to Recommendations of the 9th International Wheat Genetics Symposium Taxonomy Workshop (Saskatoon, Canada; 2-7 August 1998).

1. The Synonymy Tables database will have three components that will enable users to associate names with synonyms and names with classifications:

(a) A Classification Table listing the species names with authorities (and where relevant, lower ranking taxa at subspecific and botanical varietal levels) will be constructed for each of the 12 principal classifications currently in use. For *Triticum*: van Slageren (1994), Kimber and Sears/ Kimber and Feldman (1987), *Flora of Turkey* (Tan 1985), Löve (1984), Dorofeev et al. (1979), Mac Key (1988). For *Aegilops* and *Amblyopyrum*: van Slageren (1994), *Flora of Turkey* (Davis 1985), Witcombe (1983), Hammer (1980), Kihara (1954), Eig (1929).

(b) Each taxon name in a Classification Table will link to its synonyms. For example, in the table for the van Slageren classification, the diploid D-genome species *Ae. tauschii* Coss. will link to its synonyms--*Ae. squarrosa* L., *T. tauschii* (Coss.) Schmalh., *T. aegilops* P. Beauvois ex Roem. & Schult., *Patropyrum tauschii* (Coss.) Á Löve.

(c) Each synonym will link to its associated classification(s). Following the above example with *Ae. tauschii*, its four synonyms will link to their respective classifications--*Ae. squarrosa* L. [name in the Eig, Kihara, and Witcombe classifications], *T. tauschii* (Coss.) Schmalh. [name in the Kimber and Sears/Kimber and Feldman classification], *T. aegilops* P. Beauvois ex Roem. & Schult. [correct name with priority in *Triticum sensu lato*], *Patropyrum tauschii* (Coss.) Á Löve [Löve 1984].

(d) Each name also will link to itself when treated by the same name in other classifications. For example, *Ae. tauschii* Coss. in the van Slageren classification table will link to *Ae. tauschii* Coss. in the tables for the Hammer and *Flora of Turkey* classifications.

2. Project coordinators include: Synonymy Table construction--Laura Morrison (Oregon State University) and John Raupp (Kansas State University); *GrainGenes* database implementation--Dave Matthews and Gerry Lazo (USDA-ARS); Triticeae taxonomy liaison--Mary Barkworth (Utah State University); wheat genetics liaisons--Giles Waines (University California-Riverside) and Jan Dvorak (University of California-Davis).

3. Notices of the progress and eventual availability of the Synonymy Tables database will appear in the *Wheat Information Service* (published January and June) and the *Annual Wheat Newsletter* (published June).

4. *GrainTax*, an internet mailgroup and bulletin board, has been set up as a discussion forum and an information exchange service for issues associated with wheat taxonomy. Notices published in the *Wheat Information Service* and the Annual Wheat Newsletter also will be posted here.

5. To join the *GrainTax* mailgroup, contact Dave Matthews, matthews@greengenes.cit.cornell.edu. The *GrainTax* bulletin board can be reached at http://wheat.pw.usda.gov:8000/cgi-bin/mboard/graintax/list.cgi.

6. Recipients of this notice are encouraged to pass it on to their fellow wheat researchers.

Wheat Information Service
Number 88: 57-59 (1999)
Report

A Record from the Business Meeting of the 9th IWGS

J. W. Snape[1] and P. Hucl[2]

[1]Jone Innes Centre, Colney Lane, Norwich NR4 7UH, UK
[2]Department of Crop Science, University of Saskatchewan, Saskatoon, Saskatchewan S7N 5C8, Canada

The Business Meeting of the 9th IWGS was held on Friday, 7th August 1998.

Co-Chairmen: Dr. J.W. Snape (IOC), Dr. P. Hucl (LOC)

1. Report of Meeting of IOC/LOC, Thursday 6th August 1998

Dr. J.W. Snape had chaired this meeting and the IOC had thanked Dr. Hucl and his colleagues on the LOC on the excellent organization of the 9th IWGS. The organization of the 9th IWGS and recommendations for the 10th IWGS were discussed, and the following recommendations were made which would be transmitted to the organizers of the 10th IWGS, including:

1) No concurrent sessions.
2) More time should be made for posters in the body of the meeting.
3) Sessions should, as at the 9th IWGS, consist of Keynote speakers and contributed papers.
4) Keynote speakers should concentrate on state-of-the-art information, and not on a general review of the field.
5) Workshops, as far as possible, should be put into one full day.
6) The Proceedings, as here, should be produced before the Symposium, and possibly, in electronic form.

2. Proceeding of 9th IWGS

Dr. Hucl reported to the meeting that extra copies of the proceedings would be available for purchase by libraries and individuals at the cost of 100 Canadian dollars excluding postage. No reprints would be available, but the reports of the Workshops, Business Meeting and other information would be prepared electronically and posted on the 9th IWGS Web site and on GrainGenes through the kind offices of Dave Matthews.

3. Proposal for the creation of the Ernie Sears Memorial Lecture

At the instigation of Prof. Bob McIntosh, a proposal was put to the Symposium: 'That the LOC of the 10th and subsequent IWGS creates the Ernie Sears Memorial Lecture which will be given as an invited Keynote lecture by a person distinguished in wheat genetics' This was accepted by

acclamation.

4. Organization of the 10th IWGS

The Chairmen invited suggestions from the floor of the meeting concerning the structure of the 10th IWGS and the following comments were made:

1) The precedent of producing the Proceedings before the meeting was endorsed with the possibility of producing an electronic version of additional information, such as Workshops and Business Meetings, presented at the meeting.

2) The possibility of producing the Proceedings on CD-ROM should be investigated.

3) More time for poster sessions is necessary.

4) Speakers should be asked to present their talks in a slower, clearer way for the benefit of non-native English participants.

5) All announcements should be displayed on OHs for the benefit of non-English speaking participants.

6) All posters should remain up for the period of the meeting.

5. International Organizing Committee for the 10th IWGS

Professors Li Zhensheng (China), Bikram Gill (USA), Eric Kerber (Canada), A. Damania (India) were retiring from the Committee and the Conference thanked them for their contributions to the organization of the current Symposium. A nominations committee chaired by Professor Bob McIntosh (Australia) and comprising Profs. Moshe Feldman (Israel), Gary Hart (USA) and Koichiro Tsuenwaki (Japan) made the following recommendations for new members.

Pierre Hucl (Canada)
Olin Anderson (USA)
Lui Dajun (China)
Enrique Suarez (Argentina)
These were accepted by acclamation.

The full IOC for the 10th IWGS consists of:
Pierre Hucl (Canada): Chairman
John Snape (UK)
Peter Sharp (Australia)
Takashi Endo (Japan)
Noberto Pogna (Italy)
Olin Anderson (USA)
Lui Dajun (China)
Enrique Suarez (Argentina)

6. Venue of Next Meeting

Four nominations were received for the venue of the 10th IWGS and short presentations were made on behalf of each venue concerning the timing, facilities available, relevance to wheat genetics research and financial support :

University of Sydney, Sydney, Australia: Dr. Peter Sharp
University of Missouri, Columbia, Missouri, USA: Dr. Perry Gustafson

Institute for Cereals Research, Rome, Italy: Dr. Noberto Pogna
Ministry of Agriculture, Ankara, Turkey: Mr. Vehbi Eser
Following a free vote, the majority of votes cast recommended to the IOC that the venue of the 10th IWGS should be in Italy.

7. Catalogue of Gene Symbols for Wheat

Prof. Bob McIntosh presented his report as Editor-in-Chief of the gene catalogue. He thanked his co-editors Dr. Mike Gale, Dr. Gary Hart, Dr. Katrien Devos and Dr. John Rogers for their hard work in compiling the catalogue. Prof. McIntosh outlined the very large increase in the catalogue since the inclusion of molecular marker data, and progress in further development of the catalogue. He informed the meeting that Dr. Jorge Dubovsky had been invited to become a new co-editor. Prof. McIntosh indicated his willingness to serve for a further five years, if the Symposium so wished.
The Chairmen thanked and congratulated Prof. McIntosh for his enormous contribution to wheat genetics in compiling the catalogue and the Symposium unanimously invited him to continue the work.

8. Wheat Information Service

Dr. T. Sasakuma presented information on the Wheat Information Service.

9. Reports from the Workshop Sessions

Brief presentations were given which summarized the presentations, discussions and conclusions of the Workshop Sessions held during the Symposium. Full transcripts to be posted electronically.
1) Taxonomy of the wheats: Dr. Laura Morrison
2) Abiotic Stress: Dr. M. Tahir
3) Genetic Resources Network: Drs. T. Endo/B. Skovmand
4) Hybrid wheat: Dr. Ian Edwards
5) Starch: Dr. Peter Sharp
6) Gene symbols in *Triticum* and *Aegilops*: Dr. Richard Wang
7) Wheat transformation: Drs. Monica Baga/Ann Blechl
8) Under-Utilized wheats: Dr. Sakti Jana

10. Any Other Business

There was no other business.

Wheat Information Service
Number 88: 60-75 (1999)
Recent publications

Recent publications on wheat genetics

Following references are selected from the original database, Life Science Collection of Cambridge Scientific Abstracts, using key words, WHEAT and GENETICS. The present list is continued from that in the last issue of WIS. The editor thanks CSA for authorizing WIS to publish the database.

1998

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(23)
ACCN:001968981 CTLN:4318697
ABSJ:G (Genetics Abstracts)
AUTH:Luo, M.;Yang, Z.;Dvorak, J.
AFFN:Department of Agronomy and Range Science, University of California, Davis, CA 95616
TITL:Position effects of ribosomal RNA multigene loci on meiotic recombination in wheat
HTIL:Genetics
HSSN:0016-6731
HYER:19980600
HCOL:vol. 149, no. 2, pp. 1105-1113

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(24)
ACCN:001969934 CTLN:4324031
ABSJ:G (Genetics Abstracts)
AUTH:Yang, T.;Lev-Yadun, S.;Feldman, M.;Fromm, H.
AFFN:Department of Plant Sciences, Weizmann Institute of Science, Rehovot 76100, Israel
TITL:Developmentally regulated organ-, tissue-, and cell-specific expression of calmodulin genes in common wheat
HTIL:Plant Mol. Biol.
HSSN:0167-4412
HYER:19980501
HCOL:vol. 37, no. 1, pp. 109-120

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(25)
ACCN:001976970 CTLN:4347955
ABSJ:G (Genetics Abstracts)
AUTH:Dragavtsev, V.A.;Barashkova, E.A.;Surkova, L.I.;Rybakova, M.I.
AFFN:N.I. Vavilov All-Russian Institute of Plant Genetic Resources (VIR), St. Petersburg, Russia
TITL:Revealing the donors of the systems of adaptability, attraction and micro-distribution in winter wheat varieties
HTIL:Genet. Resour. Crop Evol.
HSSN:0925-9864
HYER:19980600
HCOL:vol. 45, no. 3, pp. 187-196

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(26)
ACCN:001981417 CTLN:4307884
ABSJ:G (Genetics Abstracts)
AUTH:Vazquez-Tello, A.;Ouellet, F.;Sarhan, F.
AFFN:Departement des Sciences Biologiques, Universite du Quebec a Montreal, C.P. 8888, Succursale Centre-Ville, Montreal, Quebec, Canada H3C 3P8
TITL:Low temperature-stimulated phosphorylation regulates the binding of nuclear factors to the promoter of Wcs120, a cold-specific gene in wheat
HTIL:Mol. Gen. Genet.
HSSN:0026-8925
HYER:19980100
HCOL:vol. 257, no. 2, pp. 157-166

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(27)
ACCN:001981455 CTLN:4308142
ABSJ:G (Genetics Abstracts)
AUTH:Kato, K.;Tanizoe, C.;Beiles, A.;Nevo, E.
AFFN:Faculty of Agriculture, Okayama University, Okayama 700, Japan
TITL:Geographical variation in heading traits in wild emmer wheat, Triticum dicoccoides. II. Variation in heading date and adaptation to diverse eco-geographical conditions
HTIL:Hereditas
HSSN:0018-0661
HYER:19980000
HCOL:vol. 128, no. 1, pp. 33-39

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(28)
ACCN:001981457 CTLN:4308145
ABSJ:G (Genetics Abstracts)
AUTH:Bosakova, M.;Gregova, E.;Kraic, J.
AFFN:Research Institute of Plant Production, Bratislavska cesta 122, 92168 Piest'any, Slovak Republic
TITL:Identification of wheat (Triticum aestivum L.) aneuploids by protein markers
HTIL:Hereditas
HSSN:0018-0661
HYER:19980000

HCOL:vol. 128, no. 1, pp. 53-58

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(29)
ACCN:001981519 CTLN:4312178
ABSJ:G (Genetics Abstracts); K (Microbiology Abstracts C: Algology, Mycology & Protozoology)
AUTH:Yildirim, A.;Jones, S.S.*;Murray, T.D.
AFFN:Department of Crop and Soil Sciences, Washington State University, Pullman, WA 99164-6420, USA
TITL:Mapping a gene conferring resistance to Pseudocercosporella herpotrichoides on chromosome 4V of Dasypyrum villosum in a wheat background
HTIL:Genome
HSSN:0831-2796
HYER:19980200
HCOL:vol. 41, no. 1, pp. 1-6

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(30)
ACCN:001981889 CTLN:4318698
ABSJ:G (Genetics Abstracts)
AUTH:Nasuda, S.;Friebe, B.;Gill, B.S.
AFFN:Wheat Genetics Resource Center, Department of Plant Pathology, Throckmorton Plant Sciences Center, Kansas State University, Manhattan, KS 66506-5502
TITL:Gametocidal genes induce chromosome breakage in the interphase prior to the first mitotic cell division of the male gametophyte in wheat
HTIL:Genetics
HSSN:0016-6731
HYER:19980600
HCOL:vol. 149, no. 2, pp. 1115-1124

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(31)
ACCN:001984010 CTLN:4331700
ABSJ:G (Genetics Abstracts)
AUTH:Tomar, S.M.S.;Singh, B.
AFFN:Division of Genetics, Indian Agricultural Research Institute, New Delhi 110 012, India
TITL:Hybrid chlorosis in wheat x rye crosses
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 99, no. 1, pp. 1-4

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(32)
ACCN:001984012 CTLN:4331702
ABSJ:G (Genetics Abstracts)
AUTH:Pecetti, L.;Annicchiarico, P.
AFFN:International Center for Agricultural Research in the Dry Areas, P.O. Box 5466, Aleppo, Syria
TITL:Agronomic value and plant type of Italian durum wheat cultivars from different eras of breeding
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 99, no. 1, pp. 9-15

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(33)
ACCN:001984013 CTLN:4331703
ABSJ:G (Genetics Abstracts); J (Microbiology Abstracts B: Bacteriology)
AUTH:McCormac, A.C.;Wu, Huixia;Bao, Manzhu;Wang, Yibing;Xu, Ruiji;Elliott, M.C.;Chen, Dong-Fang
AFFN:Norman Borlaug Institute for Plant Science Research, De Montfort University, Scraptoft, Leicester, LE7 9SU, UK
TITL:The use of visual marker genes as cell-specific reporters of Agrobacterium-mediated T-DNA delivery to wheat (Triticum aestivum L.) and barley (Hordeum vulgare L.)
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 99, no. 1, pp. 17-25

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(34)
ACCN:001984315 CTLN:4332986
ABSJ:G (Genetics Abstracts)
AUTH:Anderson, O.D.;Abraham-Pierce, F.A.;Tam, A.
AFFN:1215 Santa Fe Avenue, Berkeley, CA 94706, USA
TITL:Conservation in wheat high-molecular-weight glutenin gene promoter sequences: comparisons among loci and among alleles of the GLU-B1-1 locus
HTIL:Theor. Appl. Genet.
HSSN:0040-5752
HYER:19980500
HCOL:vol. 96, no. 5, pp. 568-576

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(35)
ACCN:001985059 CTLN:4341483
ABSJ:G (Genetics Abstracts)
AUTH:Schubert, I.;Shi, Fang;Fuchs, J.;Endo, T.R.
AFFN:Institute of Plant Genetics and Crop Plant Research, D-06466 Gatersleben, Germany
TITL:An efficient screening for terminal deletions and translocations of barley chromosomes added to common wheat
HTIL:Plant J.
HSSN:0960-7412
HYER:19980500
HCOL:vol. 14, no. 4, pp. 489-495

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(36)
ACCN:001985232 CTLN:4342425
ABSJ:G (Genetics Abstracts)
AUTH:Singh, R.P.;Huerta-Espino, J.;Rajaram, S.;Crossa, J.
AFFN:International Maize and Wheat Improvement

Center (CIMMYT), Lisboa 27, Apdo. Postal 6-641, 06600, Mexico, D.F., Mexico
TITL:Agronomic Effects from Chromosome Translocations 7DL.7Ag and 1BL.1RS in Spring Wheat
HTIL:Crop Sci.
HSSN:1679-2020
HYER:19980200
HCOL:vol. 38, no. 1, pp. 27-33

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(37)
ACCN:001985241 CTLN:4342446
ABSJ:G (Genetics Abstracts)
AUTH:Burkhamer, R.L.;Lanning, S.P.;Martens, R.J.;Martin, J.M.;Talbert, L.E.
AFFN:Dep. Plant Soil and Environmental Sciences, PO Box 173120, Montana State Univ., Bozeman, MT 59717-3120, USA
TITL:Predicting Progeny Variance from Parental Divergence in Hard Red Spring Wheat
HTIL:Crop Sci.
HSSN:1679-2020
HYER:19980200
HCOL:vol. 38, no. 1, pp. 243-248

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(38)
ACCN:001985242 CTLN:4342447
ABSJ:G (Genetics Abstracts)
AUTH:Hess, J.R.;Carman, J.G.
AFFN:Dep. of Plants, Soils and Biometeorology, Utah State Univ., Logan, UT 84322-4820, USA
TITL:Embryogenic Competence of Immature Wheat Embryos: Genotype, Donor Plant Environment, and Endogenous Hormone Levels
HTIL:Crop Sci.
HSSN:1679-2020
HYER:19980200
HCOL:vol. 38, no. 1, pp. 249-253

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(39)
ACCN:001993414 CTLN:4308143
ABSJ:G (Genetics Abstracts)
AUTH:Sourdille, P.;Charmet, G.;Trottet, M.;Tixier, M.H.;Boeuf, C.;Negre, S.; Barloy, D.;Bernard, M.
AFFN:INRA Station d'Amelioration des Plantes, Domaine de Croueel, 63039 Clermont-Ferrand Cedex, France
TITL:Linkage between RFLP molecular markers and the dwarfing genes Rht-B1 and Rht-D1 in wheat
HTIL:Hereditas
HSSN:0018-0661
HYER:19980000
HCOL:vol. 128, no. 1, pp. 41-46

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(40)
ACCN:001994740 CTLN:4334817
ABSJ:G (Genetics Abstracts)
AUTH:Bruns, R.;Peterson, C.J.
AFFN:Agripro Seeds Inc., P.O. Box 30, Berthoud, CO, 80513, USA
TITL:Yield and stability factors associated with hybrid wheat
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 1-5

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(41)
ACCN:001994741 CTLN:4334818
ABSJ:G (Genetics Abstracts)
AUTH:Litvinenko, N.A.
AFFN:Plant Breeding & Genetics Institute, UAAN, Ovidiopolskaya doroga, 3, 270036, Odessa, Ukraine
TITL:Breeding intensive winter bread wheat varieties for Southern Ukraine
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 7-14

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(42)
ACCN:001994742 CTLN:4334819
ABSJ:G (Genetics Abstracts)
AUTH:Verma, S.R.;Yunus, M.;Sethi, S.K.
AFFN:Department of Plant Breeding, CCS Harvana Agricultural University, Hisar 125004, India
TITL:Breeding for yield and quality in durum wheat
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 15-18

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(43)
ACCN:001994743 CTLN:4334820
ABSJ:G (Genetics Abstracts)
AUTH:McIntosh, R.A.
AFFN:University of Sydney, Plant Breeding Institute Cobbitty, Private Bag 11, Camden, NSW 2570, Australia
TITL:Breeding wheat for resistance to biotic stresses
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 19-34

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(44)
ACCN:001994744 CTLN:4334824
ABSJ:G (Genetics Abstracts)
AUTH:Rathjen, A.J.;Eastwood, R.F.;Lewis, J.G.;Dube, A.J.
AFFN:Waite Agricultural Research Institute, University of Adelaide, Adelaide, South Australia, Australia
TITL:Breeding wheat for resistance to Heterodera avenae in Southeastern Australia

HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 55-62

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(45)
ACCN:001994745 CTLN:4334825
ABSJ:G (Genetics Abstracts); Z (Entomology Abstracts)
AUTH:Kinaci, E.;Kinaci, G.;Yildirim, A.F.;Atli, A.
AFFN:Bahri Dagdas International Winter Cereals Research Center, P.K. 325, Konya, Turkey
TITL:Sunn pest problems in Central Anatolia and the role of wheat varieties in integrated control
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 63-67

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(46)
ACCN:001994746 CTLN:4334826
ABSJ:G (Genetics Abstracts); Z (Entomology Abstracts)
AUTH:Elmali, M.
AFFN:Plant Protection Department, Faculty of Agriculture, Selcuk University, 42031 Konya, Turkey
TITL:Russian wheat aphid in Konya province
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 69-76

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(47)
ACCN:001994747 CTLN:4334827
ABSJ:G (Genetics Abstracts)
AUTH:Blum, A.
AFFN:Volcani Centre, P.O. Box 6, Bet Dagan, Israel
TITL:Improving wheat grain filling under stress by stem reserve mobilisation
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 77-83

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(48)
ACCN:001994748 CTLN:4334828
ABSJ:G (Genetics Abstracts)
AUTH:Reynolds, M.P.;Singh, R.P.;Ibrahim, A.;Ageeb, O.A.A.;Larque-Saavedra, A.;Quick, J.S.
AFFN:CIMMYT, Lisboa 27, Apdo. Postal 6-641, 06600 Mexico, D.F., Mexico
TITL:Evaluating physiological traits to complement empirical selection for wheat in warm environments
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 85-94

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(49)
ACCN:001994749 CTLN:4334829
ABSJ:G (Genetics Abstracts)
AUTH:El Bassam, N.
AFFN:Institute of Crop Science, Federal Agricultural Research Centre (FAL), Bundesallee 50, D-38116 Braunschweig, Germany
TITL:A concept of selection for 'low input' wheat varieties
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 95-100

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(50)
ACCN:001994750 CTLN:4334830
ABSJ:G (Genetics Abstracts)
AUTH:Fedoulov, Y.P.
AFFN:Plant Resistance Physiology Laboratory, Krasnodar Lukyanenko Research Institute of Agriculture, 350012, Krasnodar, Russia
TITL:System analysis of frost resistance in winter wheat and its use in breeding
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 101-108

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(51)
ACCN:001994751 CTLN:4334831
ABSJ:G (Genetics Abstracts)
AUTH:Van Ginkel, M.;Calhoun, D.S.;Gebeyehu, G.;Miranda, A.;Tian-you, C.; Lara, R.P.;Trethowan, R.M.;Sayre, K.;Crossa, J.;Rajaram, S.
AFFN:CIMMYT, Lisboa 27, Apdo. Postal 6-641, 06600 Mexico D.F., Mexico
TITL:Plant traits related to yield of wheat in early, late, or continuous drought conditions
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 109-121

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(52)
ACCN:001994752 CTLN:4334832
ABSJ:G (Genetics Abstracts)
AUTH:Kalayci, M.;Alkan, A.;Cakmak, I.;Bayramoglu, O.;Yilmaz, A.;Aydin, M.; Ozbek, V.;Ekiz, H.;Ozberisoy, F.
AFFN:Transitional Region Agricultural Research Institute, Eskisehir, Turkey
TITL:Studies on differential response of wheat cultivars to boron toxicity
HTIL:Euphytica
HSSN:0014-2336

HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 123-129

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(53)
ACCN:001994753 CTLN:4334833
ABSJ:G (Genetics Abstracts)
AUTH:Campbell, T.A.;Rathjen, A.J.;Paull, J.G.;Islam, A.K.M.R.
AFFN:Waite Agricultural Research Institute, University of Adelaide, Private Bag 1, Glen Osmond, SA 5064, Australia
TITL:Method for screening bread wheat for tolerance to boron
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 131-135

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(54)
ACCN:001994754 CTLN:4334834
ABSJ:G (Genetics Abstracts)
AUTH:Bushuk, W.
AFFN:Department of Food Science, University of Manitoba, Winnipeg, MB, R3T 2N2, Canada
TITL:Wheat breeding for end-product use
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 137-145

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(55)
ACCN:001994755 CTLN:4334835
ABSJ:G (Genetics Abstracts)
AUTH:Corbellini, M.;Mazza, L.;Ciaffi, M.;Lafiandra, D.;Borghi, B.
AFFN:Istituto Sperimentale per la Cerealicoltura, Via Mulino, 3, 20079 S. Angelo Lodigiano, Italy
TITL:Effect of heat shock during grain filling on protein composition and technological quality of wheats
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 147-154

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(56)
ACCN:001994756 CTLN:4334836
ABSJ:G (Genetics Abstracts)
AUTH:Crosbie, G.B.;Huang, S.;Barclay, I.R.
AFFN:Agriculture Western Australia, Baron-Hay Court, South Perth, WA 6151, Australia
TITL:Wheat quality requirements of Asian foods
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 155-156

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(57)
ACCN:001994757 CTLN:4334837
ABSJ:G (Genetics Abstracts)
AUTH:Peterson, C.J.;Graybosch, R.A.;Shelton, D.R.;Baenziger, P.S.
AFFN:USDA-ARS, Department of Agronomy, University of Nebraska, Lincoln, NE 68583, USA
TITL:Baking quality of hard winter wheat: Response of cultivars to environment in the Great Plains
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 157-162

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(58)
ACCN:001994758 CTLN:4334838
ABSJ:G (Genetics Abstracts)
AUTH:Clarke, J.M.;Marchylo, B.A.;Kovacs, M.I.P.;Noll, J.S.;McCaig, T.N.; Howes, N.K.
AFFN:Agriculture and Agri-Food Canada, Semiarid Prairie Agricultural Research Centre, Swift Current, Saskatchewan, Canada
TITL:Breeding durum wheat for pasta quality in Canada
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 163-170

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(59)
ACCN:001994759 CTLN:4334839
ABSJ:G (Genetics Abstracts)
AUTH:Utku, H.;Koksel, H.;Kayhan, S.
AFFN:Department of Physics Engineering, Hacettepe University, 06532 Beytepe, Ankara, Turkey
TITL:Classification of wheat grains by digital image analysis using statistical filters
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 171-178

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(60)
ACCN:001994760 CTLN:4334840
ABSJ:G (Genetics Abstracts)
AUTH:Bedo, Z.;Vida, G.;Lang, L.;Karsai, I.
AFFN:Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvasar, Hungary
TITL:Breeding for breadmaking quality using old Hungarian wheat varieties
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 179-182

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(61)
ACCN:001994762 CTLN:4334842
ABSJ:G (Genetics Abstracts)
AUTH:Ekiz, H.;Safi Kiral, A.;Akcin, A.;Simsek, L.
AFFN:Bahri Dagdas International Winter Cereals Research Centre, P.O. Box 325, Konya, Turkey
TITL:Cytoplasmic effects on quality traits of bread wheat (Triticum aestivum L.)
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 189-196

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(62)
ACCN:001994763 CTLN:4334843
ABSJ:G (Genetics Abstracts)
AUTH:Porceddu, E.;Turchetta, T.;Masci, S.;D'Ovidio, R.;Lafiandra, D.; Kasarda, D.D.;Impiglia, A.;Nachit, M.M.
AFFN:Department of Agrobiology and Agrochemistry, University of Tuscia, Viterbo, Italy
TITL:Variation in endosperm protein composition and technological quality properties in durum wheat
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 197-205

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(63)
ACCN:001994764 CTLN:4334844
ABSJ:G (Genetics Abstracts); W2(Agricultural and Environmental Biotechnology Abstracts)
AUTH:Snape, J.W.
AFFN:John Innes Centre, Norwich Research Park, Colney, Norwich, UK
TITL:Golden calves or white elephants? Biotechnologies for wheat improvement
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 207-217

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(64)
ACCN:001994765 CTLN:4334845
ABSJ:G (Genetics Abstracts); W2(Agricultural and Environmental Biotechnology Abstracts)
AUTH:Loerz, H.;Becker, D.;Luetticke, S.
AFFN:Institut fuer Allgemeine Botanik, AMP II, Universitaet Hamburg, Ohnhorststr. 18, D-22609 Hamburg, Germany
TITL:Molecular wheat breeding by direct gene transfer
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 219-223

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(65)
ACCN:001994766 CTLN:4334846
ABSJ:G (Genetics Abstracts)
AUTH:Howes, N.K.;Woods, S.M.;Townley-Smith, T.F.
AFFN:Agriculture & Agri-Food Canada, Cereal Research Centre, Winnipeg, Manitoba, Canada
TITL:Simulations and practical problems of applying multiple marker assisted selection and doubled haploids to wheat breeding programs
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 225-230

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(66)
ACCN:001994768 CTLN:4334848
ABSJ:G (Genetics Abstracts); W2(Agricultural and Environmental Biotechnology Abstracts)
AUTH:Pershina, L.A.;Numerova, O.M.;Belova, L.I.;Devyatkina, E.P.
AFFN:Institute of Cytology and Genetics, Siberian Department of the Russian Academy of Sciences, Lavrentiev Ave. 10, Novosibirsk 630090, Russia
TITL:Biotechnological and cytogenetic aspects of producing new wheat genotypes using hybrids
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 239-244

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(67)
ACCN:001994770 CTLN:4334850
ABSJ:G (Genetics Abstracts)
AUTH:Karsai, I.;Bedoe, Z.
AFFN:Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvasar, H-2462, Hungary
TITL:Relationship between anther culture response and aluminium tolerance in wheat (Triticum aestivum L.)
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 249-252

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(68)
ACCN:001994771 CTLN:4334851
ABSJ:G (Genetics Abstracts)
AUTH:Inagaki, M.N.;Mujeeb-Kazi, A.
AFFN:CIMMYT, Lisboa 27, Apdo. Postal 6-641, 06600 Mexico, D.F., Mexico
TITL:Production of polyhaploids of hexaploid wheat using stored pearl millet pollen
HTIL:Euphytica
HSSN:0014-2336

HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 253-259

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(69)
ACCN:001994772 CTLN:4334852
ABSJ:G (Genetics Abstracts)
AUTH:Thomas, J.;Chen, Q.;Talbert, L.
AFFN:Lethbridge Research Centre Agriculture and Agri-Food Canada Box 3000, Lethbridge, Alberta, T1J 4B1, Canada
TITL:Genetic segregation and the detection of spontaneous wheat-alien translocations
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 261-267

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(70)
ACCN:001994773 CTLN:4334854
ABSJ:G (Genetics Abstracts)
AUTH:Perenzin, M.;Corbellini, M.;Accerbi, M.;Vaccino, P.;Borghi, B.
AFFN:Istituto Sperimentale per la Cerealicoltura, Via Mulino No. 3 20079 S. Angelo Lodigiano, Italy
TITL:Bread wheat: F sub(1) hybrid performance and parental diversity estimates using molecular markers
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 273-279

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(71)
ACCN:001994774 CTLN:4334855
ABSJ:G (Genetics Abstracts)
AUTH:Schlegel, R.;Cakmak, I.;Torun, B.;Eker, S.;Tolay, I.;Ekiz, H.;Kalayci, M.;Braun, H.J.
AFFN:Institute of Wheat & Sunflower Research, BG-9520 General Toshevo/Varna, Bulgaria
TITL:Screening for zinc efficiency among wheat relatives and their utilisation for alien gene transfer
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 281-286

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(72)
ACCN:001994775 CTLN:4334856
ABSJ:G (Genetics Abstracts)
AUTH:Al Hakimi, A.;Monneveaux, P.;Nachit, M.M.
AFFN:Faculty of Agriculture, Sana'a University, Yemen
TITL:Direct and indirect selection for drought tolerance in alien tetraploid wheat x durum wheat crosses
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 287-294

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(73)
ACCN:001994776 CTLN:4334857
ABSJ:G (Genetics Abstracts)
AUTH:Merezhko, A.F.
AFFN:N.I. Vavilov All-Russian Institute of Plant Industry, 44 Bolshaya Morskaya Street, St. Petersburg 190000, Russia
TITL:Impact of plant genetic resources on wheat breeding
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 295-303

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(74)
ACCN:001994777 CTLN:4334858
ABSJ:G (Genetics Abstracts)
AUTH:Martynov, S.P.
AFFN:Information and Computation Centre, Russian Academy of Agricultural Science, P.O. Emmaus, 171330 Tver, Russia
TITL:Analysis of genetic profiles of winter wheats from Russia
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 305-311

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(75)
ACCN:001994778 CTLN:4334859
ABSJ:G (Genetics Abstracts); W2(Agricultural and Environmental Biotechnology Abstracts)
AUTH:Simonenko, V.K.;Motsny, I.I.;Sechnyak, A.L.;Kulbida, M.P.
AFFN:Department of Genetics and Biotechnology, Plant Breeding and Genetics Institute, 270036 Odessa, Ukraine
TITL:The use of wheat-alien and Aegilops-rye amphiploids for introgression of genetic material to wheat
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 313-321

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(76)
ACCN:001994779 CTLN:4334860
ABSJ:G (Genetics Abstracts)
AUTH:Rabinovich, S.V.
AFFN:National Centre for Plant Genetic Resources of Ukraine, Yurj'ev Institute for Plant Production, Kharkov, Ukraine
TITL:Importance of wheat-rye translocations for breeding modern cultivars of Triticum aestivum

L.
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 323-340

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(77)
ACCN:001994780 CTLN:4334861
ABSJ:G (Genetics Abstracts)
AUTH:Klepper, B.;Rickman, R.W.;Waldman, S.;Chevalier, P.
AFFN:USDA-ARS, Pendleton, OR, USA
TITL:The physiological life cycle of wheat: Its use in breeding and crop management
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 341-347

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(78)
ACCN:001994782 CTLN:4334863
ABSJ:G (Genetics Abstracts)
AUTH:Stelmakh, A.F.
AFFN:Plant Breeding and Genetics Institute, Ovidiopolskaya Road 3, Odessa 270036, Ukraine
TITL:Genetic systems regulating flowering response in wheat
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 359-369

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(79)
ACCN:001994783 CTLN:4334864
ABSJ:G (Genetics Abstracts)
AUTH:Goncharov, N.P.
AFFN:Institute of Cytology and Genetics, 630090 Novosibirsk, Russia
TITL:Genetic resources of wheat related species: The Vrn genes controlling growth habit (spring vs. winter)
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 371-376

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(80)
ACCN:001994784 CTLN:4334865
ABSJ:G (Genetics Abstracts)
AUTH:Ortiz Ferrara, G.;Mosaad, M.G.;Mahalakshmi, V.;Rajaram, S.
AFFN:CIMMYT/ICARDA, P.O. Box 5466, Aleppo, Syria
TITL:Photoperiod and vernalisation response of Mediterranean wheats, and implications for adaptation
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 377-384

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(81)
ACCN:001994785 CTLN:4334866
ABSJ:G (Genetics Abstracts)
AUTH:Worland, A.J.;Boerner, A.;Korzun, V.;Li, W.M.;Petrovic, S.;Sayers, E.J.
AFFN:John Innes Centre, Colney, Norwich NR4 7UH, UK
TITL:The influence of photoperiod genes on the adaptability of European winter wheats
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 385-394

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(82)
ACCN:001994786 CTLN:4334867
ABSJ:G (Genetics Abstracts)
AUTH:Morgounov, A.I.;Alborran, M.;Rajaram, S.
AFFN:CIMMYT, P.K. 39 Emek, 06511, Ankara, Turkey
TITL:Selecting winter/facultative wheat genotypes from spring x spring crosses
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 395-400

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(83)
ACCN:001995522 CTLN:4340773
ABSJ:G (Genetics Abstracts)
AUTH:Horiguchi, G.;Kawakami, N.;Kusumi, K.;Kodama, H.;Iba, K.
AFFN:Department of Biology, Faculty of Science, Kyushu University 33, Hakozaki, Higashi-ku, Fukuoka, 812-8581 Japan
TITL:Developmental regulation of genes for microsome and plastid omega -3 fatty acid desaturases in wheat (Triticum aestivum L.)
TIL:Plant Cell Physiol.
HSSN:0032-0781
HYER:19980000
HCOL:vol. 39, no. 5, pp. 540-544

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(84)
ACCN:001997213 CTLN:4353006
ABSJ:G (Genetics Abstracts)
AUTH:Roeder, M.S.;Korzun, V.;Wendehake, K.;Plaschke, J.;Tixier, M.;Leroy, P.;Ganal, M.W.
AFFN:Marion S. Roeder, Institute for Plant Genetics and Crop Research, Corrensstr. 3, 06466 Gatersleben, Germany.
TITL:A microsatellite map of wheat
HTIL:Genetics
HSSN:0016-6731
HYER:19980800

HCOL:vol. 149, no. 4, pp. 2007-2023

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(85)
ACCN:001997760 CTLN:4356455
ABSJ:G (Genetics Abstracts)
AUTH:Cassidy, B.G.;Dvorak, J.;Anderson, O.D.
AFFN:Samuel Roberts Noble Foundation, P.O. Box 2180, Ardmore, OK 73402, USA
TITL:The wheat low-molecular-weight glutenin genes: characterization of six new genes and progress in understanding gene family structure
HTIL:Theor. Appl. Genet.
HSSN:0040-5752
HYER:19980500
HCOL:vol. 96, no. 6-7, pp. 743-750

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(86)
ACCN:001997773 CTLN:4356481
ABSJ:G (Genetics Abstracts)
AUTH:Cadalen, T.;Sourdille, P.;Charmet, G.;Tixier, M.H.;Gay, G.;Boeuf, C.; Bernard, S.;Leroy, P.;Bernard, M.
AFFN:INRA Station d'Amelioration des Plantes, Domaine de Crouel, 63039 Clermont-Ferrand Cedex, France
TITL:Molecular markers linked to genes affecting plant height in wheat using a doubled-haploid population
HTIL:Theor. Appl. Genet.
HSSN:0040-5752
HYER:19980500
HCOL:vol. 96, no. 6-7, pp. 933-940

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(87)
ACCN:001998476 CTLN:4372387
ABSJ:G (Genetics Abstracts)
AUTH:Feuillet, C.;Reuzeau, C.;Kjellbom, P.;Keller, B.
AFFN:Institute of Plant Biology, University of Zuerich, Zollikerstr. 107, 8008 Zuerich, Switzerland
TITL:Molecular characterization of a new type of receptor-like kinase (wlrk) gene family in wheat
HTIL:Plant Mol. Biol.
HSSN:0167-4412
HYER:19980700
HCOL:vol. 37, no. 6, pp. 943-953

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(88)
ACCN:001999577 CTLN:4383163
ABSJ:G (Genetics Abstracts)
AUTH:Chun, J.U.;Yu, X.M.;Griffith, M.
AFFN:Department of Agronomy, Sunchon National University, Sunchon, Korea 540-742
TITL:Genetic studies of antifreeze proteins and their correlation with winter survival in wheat
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 102, no. 2, pp. 219-226

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(89)
ACCN:001999588 CTLN:4383183
ABSJ:G (Genetics Abstracts)
AUTH:Hansen, N.J.P.;Andersen, S.B.
AFFN:Royal Veterinary and Agricultural University, Department of Agricultural Sciences, Section Plant Breeding and Crop Science, Thorvaldsensvej 40, 1871 Frederiksberg C, Denmark
TITL:In vitro chromosome doubling with colchicine during microspore culture in wheat (Triticum aestivum L.)
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 102, no. 1, pp. 101-108

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(90)
ACCN:002008081 CTLN:4356460
ABSJ:G (Genetics Abstracts)
AUTH:Nasuda, S.;Friebe, B.;Busch, W.;Kynast, R.G.;Gill, B.S.
AFFN:Laboratory of Plant Genetics, Graduate School of Agriculture, Kyoto University, Sakyo-ku, Kyoto 606-01 Japan
TITL:Structural rearrangement in chromosome 2M of Aegilops comosa has prevented the utilization of the Compair and related wheat-Ae. comosa translocations in wheat improvement
HTIL:Theor. Appl. Genet.
HSSN:0040-5752
HYER:19980500
HCOL:vol. 96, no. 6-7, pp. 780-785

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(91)
ACCN:002009750 CTLN:4376289
ABSJ:Z (Entomology Abstracts); G (Genetics Abstracts)
AUTH:Ma, Z.-Q.;Saidi, A.;Quick, J.S.;Lapitan, N.L.V.
AFFN:Soil and Crop Sciences Department, Colorado State University, Fort Collins, CO 80523, USA
TITL:Genetic mapping of Russian wheat aphid resistance genes Dn2 and Dn4 in wheat
HTIL:Evolution
HSSN:0014-3820
HYER:19980600
HCOL:vol. 52, no. 3, pp. 303-306

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(92)
ACCN:002011689 CTLN:4390148
ABSJ:G (Genetics Abstracts)
AUTH:Morawala-Patell, V.;Gualberto, J.M.;Lamattina, L.;Grienenberger, J.-M.; Bonnard, G.
AFFN:Institut de Biologie Moleculaire des Plantes

du CNRS, Universite Louis Pasteur, 12 rue du General Zimmer, 67084 Strasbourg Cedex, France
TITL:Cis- and trans-splicing and RNA editing are required for the expression of nad2 in wheat mitochondria
HTIL:Mol. Gen. Genet.
HSSN:0026-8925
HYER:19980601
HCOL:vol. 258, no. 5, pp. 503-511

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(93)
ACCN:002011727 CTLN:4390320
ABSJ:G (Genetics Abstracts)
AUTH:Kosner, J.;Pankova, K.
AFFN:Research Institute of Crop Production, Drnovska 507, 161 06 Praha 6 - Ruzyne, Czech Republic
TITL:The detection of allelic variants at the recessive vrn loci of winter wheat
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 101, no. 1, pp. 9-16

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(94)
ACCN:002011732 CTLN:4390327
ABSJ:G (Genetics Abstracts)
AUTH:Kato, K.;Miura, H.;Akiyama, M.;Kuroshima, M.;Sawada, S.
AFFN:Department of Crop Science, Obihiro University of Agriculture and Veterinary Medicine, Obihiro, 080, Japan
TITL:RFLP mapping of the three major genes, Vrn1, Q and B1, on the long arm of chromosome 5A of wheat
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 101, no. 1, pp. 91-95

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(95)
ACCN:002011736 CTLN:4390332
ABSJ:G (Genetics Abstracts)
AUTH:Hussien, T.;Bowden, R.L.;Gill, B.S.;Cox, T.S.
AFFN:Department of Plant Pathology, Kansas State University, Manhattan, KS 66506-5502, USA
TITL:Chromosomal locations in common wheat of three new leaf rust resistance genes from Triticum monococcum
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 101, no. 1, pp. 127-131

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(96)
ACCN:002011742 CTLN:4390340
ABSJ:G (Genetics Abstracts)
AUTH:Sun, Q.;Ni, Z.;Liu, Z.;Gao, J.;Huang, T.
AFFN:Department of Plant Genetics & Breeding, China Agricultural University, Beijing 100094, P.R. China
TITL:Genetic relationships and diversity among Tibetan wheat, common wheat and European spelt wheat revealed by RAPD markers
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 99, no. 3, pp. 205-211

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(97)
ACCN:002011753 CTLN:4391936
ABSJ:G (Genetics Abstracts)
AUTH:Ali, A.M.;Tomita, M.*;Nakata, N.;Yasumuro, Y.
AFFN:Laboratory of Plant Genetics and Breeding, Faculty of Agriculture, Tottori University, Tottori 680, Japan
TITL:Cytogenetic and molecular markers mapping of translocations in the wheat cultivar Shirodaruma and its ancestor Daruma
HTIL:Cytologia
HSSN:0011-4545
HYER:19980600
HCOL:vol. 63, no. 2, pp. 115-124

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(98)
ACCN:002011773 CTLN:4392097
ABSJ:W2(Agricultural and Environmental Biotechnology Abstracts); G (Genetics Abstracts)
AUTH:Bizimungu, B.;Collin, J.;Comeau, A.;St.-Pierre, C.-A.
AFFN:Department de Phytologie, Universite Laval, Quebec G1K 7P4, Canada
TITL:Hybrid necrosis as a barrier to gene transfer in hexaploid winter wheat x triticale crosses
HTIL:Can. J. Plant Sci./Rev. Can. Phytotech.
HSSN:0008-4220
HYER:19980400
HCOL:vol. 78, no. 2, pp. 239-244

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(99)
ACCN:002013049 CTLN:4402674
ABSJ:W2(Agricultural and Environmental Biotechnology Abstracts); G (Genetics Abstracts)
AUTH:Eckardt, N.A.;McHenry, L.;Guiltinan, M.J.*
AFFN:Department of Horticulture and The Life Sciences Consortium, Penn State University, University Park, PA 16802, USA
TITL:Overexpression of Delta EmBP, a truncated dominant negative version of the wheat G-box binding protein EmBP-1, alters vegetative development in transgenic tobacco
HTIL:Plant Mol. Biol.
HSSN:0167-4412
HYER:19981101

HCOL:vol. 38, no. 4, pp. 539-549

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(100)
ACCN:002013227 CTLN:4403469
ABSJ:G (Genetics Abstracts); V (Virology & AIDS Abstracts)
AUTH:Savenkov, E.I.;Solovyev, A.G.*;Morozov, S.Y.
AFFN:A. N. Belozersky Institute of Physico-Chemical Biology, Moscow State University, Moscow 11 9899, Russia
TITL:Genome sequences of poa semilatent and lychnis ringspot hordeiviruses
HTIL:Arch. Virol.
HSSN:0304-8608
HYER:19980000
HCOL:vol. 143, no. 7, pp. 1379-1393

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(101)
ACCN:002013425 CTLN:4405264
ABSJ:G (Genetics Abstracts)
AUTH:Sarma, R.N.;Gill, B.S.;Sasaki, T.;Galiba, G.;Sutka, J.;Laurie, D.A.; Snape, J.W.
AFFN:John Innes Centre, Norwich Research Park, Colney, Norwich, NR4 7UH, UK
TITL:Comparative mapping of the wheat chromosome 5A Vrn-A1 region with rice and its relationship to QTL for flowering time
HTIL:Theor. Appl. Genet.
HSSN:0040-5752
HYER:19980700
HCOL:vol. 97, no. 1-2, pp. 103-109

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(102)
ACCN:002013445 CTLN:4405296
ABSJ:W2(Agricultural and Environmental Biotechnology Abstracts); G (Genetics Abstracts); K (Microbiology Abstracts C: Algology, Mycology & Protozoology)
AUTH:Leckband, G.;Loerz, H.
AFFN:Institut fuer Allgemeine Botanik, Angewandte Molekularbiologie der Pflanzen (AMP II), Universitaet Hamburg, Ohnhorststrasse 18, D-22609 Hamburg, Germany
TITL:Transformation and expression of a stilbene synthase gene of Vitis vinifera L. in barley and wheat for increased fungal resistance
HTIL:Theor. Appl. Genet.
HSSN:0040-5752
HYER:19980600
HCOL:vol. 96, no. 8, pp. 1004-1012

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(103)
ACCN:002013455 CTLN:4405309
ABSJ:G (Genetics Abstracts)
AUTH:Korzun, V.;Roeder, M.S.;Ganal, M.W.;Worland, A.J.;Law, C.N.
AFFN:Institut fuer Pflanzengenetik und Kulturpflanzenforschung (IPK), Correnssstr. 3, D-06466, Gatersleben, Germany
TITL:Genetic analysis of the dwarfing gene (Rht8) in wheat. Part I. Molecular mapping of Rht8 on the short arm of chromosome 2D of bread wheat (Triticum aestivum L.)
HTIL:Theor. Appl. Genet.
HSSN:0040-5752
HYER:19980600
HCOL:vol. 96, no. 8, pp. 1104-1109

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(104)
ACCN:002013457 CTLN:4405312
ABSJ:G (Genetics Abstracts); K (Microbiology Abstracts C: Algology, Mycology & Protozoology)
AUTH:Hsam, S.L.K.;Huang, X.Q.;Ernst, F.;Hartl, L.;Zeller, F.J.
AFFN:Technische Universitaet Muenchen, Institut fr Pflanzenbau und Pflanzenzuechtung, D-85350 Freising-Weihenstephan, Germany
TITL:Chromosomal location of genes for resistance to powdery mildew in common wheat (Triticum aestivum L. em Thell.). 5. Alleles at the Pm1 locus
HTIL:Theor. Appl. Genet.
HSSN:0040-5752
HYER:19980600
HCOL:vol. 96, no. 8, pp. 1129-1134

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(105)
ACCN:002013461 CTLN:4405321
ABSJ:G (Genetics Abstracts)
AUTH:Benavente, E.;Orellana, J.;Fernandez-Calvin, B.
AFFN:Unidad de Genetica, E. T. S. I. Agronomos, Universidad Politecnica, Ciudad Universitaria, 28040-Madrid, Spain
TITL:Comparative analysis of the meiotic effects of wheat ph1b and ph2b mutations in wheatxrye hybrids
HTIL:Theor. Appl. Genet.
HSSN:0040-5752
HYER:19980600
HCOL:vol. 96, no. 8, pp. 1200-1204

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(106)
ACCN:002013478 CTLN:4405349
ABSJ:G (Genetics Abstracts)
AUTH:Dominguez, F.;Cejudo, F.J.*
AFFN:Instituto de Bioquimica Vegetal y Fotosintesis, Centro de Investigaciones Cientificas Isla de la Cartuja, Avda Americo Vespucio s/n. 41092-Sevilla, Spain
TITL:Germination-related genes encoding proteolytic enzymes are expressed in the nucellus of developing wheat grains
HTIL:Plant J.
HSSN:0960-7412
HYER:19980800

HCOL:vol. 15, no. 4, pp. 569-574

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(107)
ACCN:002017056 CTLN:4334821
ABSJ:G (Genetics Abstracts); K (Microbiology Abstracts C: Algology, Mycology & Protozoology)
AUTH:Singh, R.P.;Rajaram, S.;Miranda, A.;Huerta-Espino, J.;Autrique, E.
AFFN:CIMMYT, Lisboa 27, Apdo. Postal 6-641, 06600 Mexico, D.F., Mexico
TITL:Comparison of two crossing and four selection schemes for yield, yield traits, and slow rusting resistance to leaf rust in wheat
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 35-43

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(108)
ACCN:002017057 CTLN:4334822
ABSJ:G (Genetics Abstracts); K (Microbiology Abstracts C: Algology, Mycology & Protozoology)
AUTH:Mamluk, O.F.
AFFN:ICARDA, P.O. Box 5466, Aleppo, Syria
TITL:Bunts and smuts of wheat in North Africa and the Near East
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 45-50

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(109)
ACCN:002017058 CTLN:4334823
ABSJ:G (Genetics Abstracts); K (Microbiology Abstracts C: Algology, Mycology & Protozoology)
AUTH:Torabi, M.;Nazari, K.
AFFN:Seed and Plant Improvement Institute, Karaj, Iran
TITL:Seedling and adult plant resistance to yellow rust in Iranian bread wheats
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 100, no. 1-3, pp. 51-54

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(110)
ACCN:002017348 CTLN:4342444
ABSJ:A (Microbiology Abstracts A: Industrial & Applied Microbiology); G (Genetics Abstracts); K (Microbiology Abstracts C: Algology, Mycology & Protozoology)
AUTH:Nelson, J.C.;Autrique, A.E.;Fuentes-Davila, G.;Sorrells, M.E.
AFFN:Dep. of Plant Breeding and Biometry, 252 Emerson Hall, Cornell Univ., Ithaca, NY 14853, USA
TITL:Chromosomal location of genes for resistance to karnal bunt in wheat
HTIL:Crop Sci.
HSSN:1679-2020
HYER:19980200
HCOL:vol. 38, no. 1, pp. 231-236

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(111)
ACCN:002018775 CTLN:4383162
ABSJ:G (Genetics Abstracts)
AUTH:Efremova, T.T.;Maystrenko, O.I.;Arbuzova, V.S.;Laikova, L.I.
AFFN:Institute of Cytology and Genetics, Siberian Division of the Russian Academy of Sciences, Novosibirsk, 630090, Russia
TITL:Genetic analysis of glume colour in common wheat cultivars from the former USSR
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 102, no. 2, pp. 211-218

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(112)
ACCN:002019629 CTLN:4394606
ABSJ:G (Genetics Abstracts)
AUTH:El Hafid, R.;Smith, D.H.;Karrou, M.;Samir, K.
AFFN:National Institute of Agricultural Research, P.O. Box 589, Settat, Morocco
TITL:Morphological attributes associated with early-season drought tolerance in spring durum wheat in a mediterranean environment
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 101, no. 3, pp. 273-282

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(113)
ACCN:002020610 CTLN:4402900
ABSJ:G (Genetics Abstracts)
AUTH:Law, J.R.;Donini, P.;Koebner, R.M.D.;Reeves, J.C.;Cooke, R.J.
AFFN:National Institute of Agricultural Botany, Cambridge CB3 0LE, UK
TITL:DNA profiling and plant variety registration. III: The statistical assessment of distinctness in wheat using amplified fragment length polymorphisms
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 102, no. 3, pp. 335-342

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(114)
ACCN:002021352 CTLN:4410143
ABSJ:G (Genetics Abstracts); K (Microbiology Abstracts C: Algology, Mycology & Protozoology)
AUTH:Gallego, F.;Feuillet, C.;Messmer, M.;Penger, A.;Graner, A.;Yano, M.; Sasaki, T.;Keller, B.*
AFFN:Department of Resistance and Quality

Breeding, Swiss Federal Research Station for Agroecology and Agriculture, Reckenholzstrasse 191, CH-8046 Zuerich, Switzerland
TITL:Comparative mapping of the two wheat leaf rust resistance loci Lr1 and Lr10 in rice and barley
HTIL:Genome
HSSN:0831-2796
HYER:19980600
HCOL:vol. 41, no. 3, pp. 328-336

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(115)
ACCN:002021358 CTLN:4410152
ABSJ:G (Genetics Abstracts)
AUTH:Talbert, L.E.;Smith, L.Y.;Blake, N.K.
AFFN:Department of Plant Sciences, Montana State University, Bozeman, MT 59717, USA
TITL:More than one origin of hexaploid wheat is indicated by sequence comparison of low-copy DNA
HTIL:Genome
HSSN:0831-2796
HYER:19980600
HCOL:vol. 41, no. 3, pp. 402-407

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(116)
ACCN:002034703 CTLN:4402895
ABSJ:G (Genetics Abstracts)
AUTH:Tesemma, T.;Tsegaye, S.;Belay, G.;Bechere, E.;Mitiku, D.
AFFN:Department of Plant Breeding Research, Swedish University of Agricultural Sciences, S-26831 Svaloev, Sweden
TITL:Stability of performance of tetraploid wheat landraces in the Ethiopian highland
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 102, no. 3, pp. 301-308

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(117)
ACCN:002035163 CTLN:4405275
ABSJ:G (Genetics Abstracts)
AUTH:Maestra, B.;Naranjo, T.
AFFN:Departamento de Genetica, Facultad de Biologia, Universidad Complutense, 28040 Madrid, Spain
TITL:Homoeologous relationships of Aegilops speltoides chromosomes to bread wheat
HTIL:Theor. Appl. Genet.
HSSN:0040-5752
HYER:19980700
HCOL:vol. 97, no. 1-2, pp. 181-186

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(118)
ACCN:002035166 CTLN:4405283
ABSJ:G (Genetics Abstracts)
AUTH:Parker, G.D.;Chalmers, K.J.;Rathjen, A.J.;Langridge, P.
AFFN:ARC Special Research Centre for Basic and Applied Plant Molecular Biology, Department of Plant Science, Waite Campus, University of Adelaide, South Australia 5064, Australia
TITL:Mapping loci associated with flour colour in wheat (Triticum aestivum L.)
HTIL:Theor. Appl. Genet.
HSSN:0040-5752
HYER:19980700
HCOL:vol. 97, no. 1-2, pp. 238-245

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(119)
ACCN:002035174 CTLN:4405310
ABSJ:G (Genetics Abstracts)
AUTH:Worland, A.J.;Korzun, V.;Roeder, M.S.;Ganal, M.W.;Law, C.N.
AFFN:John Innes Centre, Cereals Research Department, Norwich, NR4 7UJ, UK
TITL:Genetic analysis of the dwarfing gene Rht8 in wheat. Part II. The distribution and adaptive significance of allelic variants at the Rht8 locus of wheat as revealed by microsatellite screening
HTIL:Theor. Appl. Genet.
HSSN:0040-5752
HYER:19980600
HCOL:vol. 96, no. 8, pp. 1110-1120

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(120)
ACCN:002035175 CTLN:4405313
ABSJ:G (Genetics Abstracts)
AUTH:Romero, M.D.;Montes, M.J.;Sin, E.;Lopez-Brana, I.;Duce, A.;Martin- Sanchez, J.A.;Andres, M.F.;Delibes, A.
AFFN:Centro de Ciencias Medioambientales, C.S.I.C. Serrano 115, Madrid, E-28006, Spain
TITL:A cereal cyst nematode (Heterodera avenae Woll.) resistance gene transferred from Aegilops triuncialis to hexaploid wheat
HTIL:Theor. Appl. Genet.
HSSN:0040-5752
HYER:19980600
HCOL:vol. 96, no. 8, pp. 1135-1140

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(121)
ACCN:002036678 CTLN:4417216
ABSJ:G (Genetics Abstracts)
AUTH:Vega, J.M.;Feldman, M.
AFFN:Department of Plant Sciences, The Weizmann Institute of Science, Rehovot 76100, Israel
TITL:Effect of the pairing gene ph1 and premeiotic colchicine treatment on intra- and interchromosome pairing of isochromosomes in common wheat
HTIL:Genetics
HSSN:0016-6731
HYER:19981100
HCOL:vol. 150, no. 3, pp. 1199-1208

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(122)
ACCN:002036773 CTLN:4417514
ABSJ:G (Genetics Abstracts)
AUTH:Peng, Z.S.;Yen, C.;Yang, J.L.
AFFN:Triticeae Research Institute, Sichuan Agricultural University, Dujiangyan, Sichuan 611830, P.R. China
TITL:Chromosomal location of genes for supernumerary spikelet in bread wheat
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 103, no. 1, pp. 109-114

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(123)
ACCN:002036778 CTLN:4417521
ABSJ:G (Genetics Abstracts)
AUTH:Fokar, M.;Nguyen, H.T.*;Blum, A.
AFFN:Department of Plant and Soil Science, Texas Tech University, Lubbock, TX 79409-2122, USA
TITL:Heat tolerance in spring wheat. I. Estimating cellular thermotolerance and its heritability
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 104, no. 1, pp. 1-8

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(124)
ACCN:002036779 CTLN:4417522
ABSJ:G (Genetics Abstracts)
AUTH:Fokar, M.;Blum, A.;Nguyen, H.T.
AFFN:Department of Plant and Soil Science, Texas Tech University, Lubbock, TX 79409-2122, USA
TITL:Heat tolerance in spring wheat. II. Grain filling
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 104, no. 1, pp. 9-15

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(125)
ACCN:002036780 CTLN:4417523
ABSJ:G (Genetics Abstracts)
AUTH:Inagaki, M.N.;Pfeiffer, W.H.;Mergoum, M.;Mujeeb-Kazi, A.
AFFN:International Maize and Wheat Improvement Center (CIMMYT), Lisboa 27, Colonia Juarez, Apartado Postal 6-641, 06600, Mexico, D.F., Mexico
TITL:Variation of the crossability of durum wheat with maize
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 104, no. 1, pp. 17-23

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(126)
ACCN:002036782 CTLN:4417526
ABSJ:G (Genetics Abstracts)
AUTH:Dhanda, S.S.;Sethi, G.S.
AFFN:Department of Plant Breeding, CCS Haryana Agricultural University, Hisar 125 004, India
TITL:Inheritance of excised-leaf water loss and relative water content in bread wheat (Triticum aestivum)
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 104, no. 1, pp. 39-47

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(127)
ACCN:002036786 CTLN:4417534
ABSJ:G (Genetics Abstracts)
AUTH:Taketa, S.;Takahashi, H.;Takeda, K.
AFFN:Research Institute for Bioresources, Okayama University, Chuo 2-20-1, Kurashiki, Okayama 710, Japan
TITL:Genetic variation in barley of crossability with wheat and its quantitative trait loci analysis
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 103, no. 2, pp. 187-193

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(128)
ACCN:002036787 CTLN:4417535
ABSJ:G (Genetics Abstracts)
AUTH:Villareal, R.L.;Banuelos, O.;Mujeeb-Kazi, A.;Rajaram, S.
AFFN:International Maize and Wheat Improvement Center (CIMMYT), Lisboa 27, Apartado Postal 6-641, Delegacion Cuauhtemoc, 06600 Mexico, D.F., Mexico
TITL:Agronomic performance of chromosomes 1B and T1BL.1RS near-isolines in the spring bread wheat Seri M82
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 103, no. 2, pp. 195-202

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(129)
ACCN:002036804 CTLN:4417554
ABSJ:G (Genetics Abstracts)
AUTH:Araghi, S.G.;Assad, M.T.
AFFN:Department of Agronomy, College of Agriculture, Shiraz University Shiraz, Iran
TITL:Evaluation of four screening techniques for drought resistance and their relationship to yield reduction ratio in wheat
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 103, no. 3, pp. 293-299

(130)
ACCN:002036807 CTLN:4417557
ABSJ:G (Genetics Abstracts)
AUTH:Bitsch, C.;Groeger, S.;Lelley, T.
AFFN:Department of Biotechnology in Plant Production, Agrobiotechnology Institute Tulln, Konrad Lorenz Str. 20, A-3430 Tulln, Austria
TITL:Effect of parental genotypes on haploid embryo and plantlet formation in wheat x maize crosses
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 103, no. 3, pp. 319-323

(131)
ACCN:002043243 CTLN:4392448
ABSJ:G (Genetics Abstracts); Z (Entomology Abstracts)
AUTH:Lou, K.F.;Weiss, M.J.;Bruckner, P.L.*;Morrill, W.L.;Talbert, L.E.; Martin, J.M.
AFFN:Department of Plant Science (Lou, Bruckner, Talbert, and Martin) (Morrill), Montana State University, Bozeman, MT 59717, USA; E-mail: bruckner@montana.edu
TITL:RAPD variation within and among geographic populations of wheat stem sawfly (Cephus cinctus Norton)
HTIL:Journal of Heredity
HSSN:0022-1503
HYER:19980800
HCOL:vol. 89, no. 4, pp. 329-335

(132)
ACCN:002043550 CTLN:4394600
ABSJ:G (Genetics Abstracts); K (Microbiology Abstracts C: Algology, Mycology & Protozoology)
AUTH:Yang, Z.;Yang, X.;Huang, D.
AFFN:Agro-Biotechnology Research Center and Institute of Plant Protection, Shanghai Academy of Agricultural Sciences, Shanghai 201106, P.R. China
TITL:Studies on somaclonal variants for resistance to scab in bread wheat (Triticum aestivum L.) through in vitro selection for tolerance to deoxynivalenol
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 101, no. 2, pp. 213-219

(133)
ACCN:002044685 CTLN:4402847
ABSJ:G (Genetics Abstracts); Q1(ASFA 1: Biological Sciences & Living Resources)
AUTH:Waples, R.S.
AFFN:Conservation Biology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, 2725 Montlake Boulevard East, Seattle, WA 98112, USA; E-mail: robin.waples@noaa.gov
TITL:Separating the Wheat From the Chaff: Patterns of Genetic Differentiation in High Gene Flow Species
HTIL:Journal of Heredity
HSSN:0022-1503
HYER:19981000
HCOL:vol. 89, no. 5, pp. 438-450

(134)
ACCN:002044689 CTLN:4402898
ABSJ:G (Genetics Abstracts)
AUTH:Tesemma, T.;Bechere, E.
AFFN:Seeds of Survival/Ethiopia, USC-Canada, P.O. Box 5760, Addis Ababa, Ethiopia
TITL:Developing elite durum wheat landrace selections (composites) for Ethiopian peasant farm use: Raising productivity while keeping diversity alive
HTIL:Euphytica
HSSN:0014-2336
HYER:19980000
HCOL:vol. 102, no. 3, pp. 323-328

(135)
ACCN:002044939 CTLN:4405252
ABSJ:G (Genetics Abstracts); V (Virology & AIDS Abstracts); Z (Entomology Abstracts)
AUTH:Chen, Q.;Conner, R.L.;Ahmad, F.;Laroche, A.;Fedak, G.;Thomas, J.B.
AFFN:Research Centre, Agriculture and Agri-Food Canada, PO Box 3000, Lethbridge, AB T1J 4B1, Canada; E-mail: chenqi@em.agr.ca
TITL:Molecular characterization of the genome composition of partial amphiploids derived from Triticum aestivum X Thinopyrum ponticum and T. aestivum X Th. intermedium as sources of resistance to wheat streak mosaic virus and its vector, Aceria tosichella
HTIL:Theoretical and Applied Genetics
HSSN:0040-5752
HYER:19980700
HCOL:vol. 97, no. 1-2, pp. 1-8

(136)
ACCN:002052371 CTLN:4434508
ABSJ:G (Genetics Abstracts); K (Microbiology Abstracts C: Algology, Mycology & Protozoology)
AUTH:Sacco, F.;Suarez, E.Y.;Naranjo, T.
AFFN:Instituto de Genetica "Ewald A. Favret," Centro de Investigacion en Ciencias Agronomicas, Instituto Nacional de Tecnologia Agropecuaria, CC 25 Castelar 1712, Argentina; E-mail: fsacco@cica.inta.gov.ar
TITL:Mapping of the leaf rust resistance gene Lr3 on chromosome 6B of Sinvalocho MA wheat

HTIL:Genome
HSSN:0831-2796
HYER:19981000
HCOL:vol. 41, no. 5, pp. 686-690

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(137)
ACCN:002053474 CTLN:4437252
ABSJ:G (Genetics Abstracts)
AUTH:Nagaki, K.;Tsujimoto, H.;Sasakuma, T.
AFFN:Kihara Institute Biological Research, Yokohama City University, 641-12 Maioka-cho, Totsuka-ku, Yokohama 244, Japan; E-mail: nagaki@yokohama-cu.ac.jp
TITL:Dynamics of tandem repetitive Afa-family sequences in Triticeae, wheat-related species
HTIL:Journal of Molecular Evolution
HSSN:0022-2844
HYER:19980800
HCOL:vol. 47, no. 2, pp. 183-189

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(138)
ACCN:002053549 CTLN:4437352
ABSJ:G (Genetics Abstracts)
AUTH:Chen, Q.-F.;Yen, C.;Yang, J.-L.
AFFN:Triticeae Research Institute, Sichuan Agricultural University, Dujiangyan City 611830, Sichuan, P.R. China
TITL:Chromosome location of the gene for brittle rachis in the Tibetan weedrace of common wheat
HTIL:Genetic Resources and Crop Evolution
HSSN:0925-9864
HYER:19981000
HCOL:vol. 45, no. 5, pp. 407-410

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(139)
ACCN:002053551 CTLN:4437354
ABSJ:G (Genetics Abstracts)
AUTH:Donini, P.;Stephenson, P.;Bryan, G.J.;Koebner, R.M.D.
AFFN:Plant Breeding Unit, IAEA Seibersdorf Laboratory, A-2444 Seibersdorf, Austria
TITL:The potential of microsatellites for high throughput genetic diversity assessment in wheat and barley
HTIL:Genetic Resources and Crop Evolution
HSSN:0925-9864
HYER:19981000
HCOL:vol. 45, no. 5, pp. 415-421

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(140)
ACCN:002053567 CTLN:4437396
ABSJ:G (Genetics Abstracts)
AUTH:Gordei, S.I.;Hsam, S.L.K.;Zeller, F.J.
AFFN:Institute of Genetics and Cytology, National Academy of Sciences of Belarus, Skorina Str. 27, 220072 Minsk, Belarus
TITL:Identification of powdery mildew resistance genes in common wheat (Triticum aestivum L. em. Thell.). X. Cultivars grown in Belarus and neighbouring countries
HTIL:Journal of Applied Genetics
HSSN:1234-1983
HYER:19980000
HCOL:vol. 39, no. 1, pp. 1-8

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(141)
ACCN:002053569 CTLN:4437401
ABSJ:G (Genetics Abstracts)
AUTH:Flintham, J.E.;Gale, M.D.
AFFN:Cambridge Laboratory Colney Lane, Norwich, Norfolk NR4 7UJ, United Kingdom
TITL:Plant height and yield components of inbred isogenic and F sub(1) hybrid Rht dwarf wheats
HTIL:Journal of Applied Genetics
HSSN:1234-1983
HYER:19980000
HCOL:vol. 39, no. 1, pp. 73-83

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(142)
ACCN:002053729 CTLN:4437718
ABSJ:G (Genetics Abstracts); W2(Agricultural and Environmental Biotechnology Abstracts)
AUTH:Briney, A.;Wilson, R.;Potter, R.H.;Barclay, I.;Crosbie, G.;Appels, R.; Jones, M.G.K.
AFFN:Western Australian State Agricultural Biotechnology Centre, Murdoch University, Perth, Western Australia 6150, Australia
TITL:A PCR-based marker for selection of starch and potential noodle quality in wheat
HTIL:Molecular Breeding
HSSN:1380-3743
HYER:19980000
HCOL:vol. 4, no. 5, pp. 427-433

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(143)
ACCN:002054356 CTLN:4439839
ABSJ:G (Genetics Abstracts); N (Biochemistry Abstracts 2: Nucleic Acids)
AUTH:Mena, M.;Vicente-Carbajosa, J.;Schmidt, R.J.;Carbonero, P.*
AFFN:Laboratorio de Bioquimica y Biologia Molecular, Departamento Biotecnologia-UPM, ETS Ingenieros Agronomos, 28040 Madrid, Spain; E- mail: pcarbonero@bit.etsia.upm.es
TITL:An endosperm-specific DOF protein from barley, highly conserved in wheat, binds to and activates transcription from the prolamin-box of a native B-hordein promoter in barley endosperm
HTIL:Plant Journal
HSSN:0960-7412
HYER:19981000
HCOL:vol. 16, no. 1, pp. 53-62

Editorial remarks

The present issue of WIS includes of nine articles of original research, and two important reports from international organizations. As described in the notice on the inside of cover, "Research article" are ones with judging by reviewers, and proportion of acceptance among contributed papers is about 60%. We welcome to receive informative articles in progress or of short communication without reviewer's revise, which will appear as "Research information".

Along the previous issue, we have asked members for continuation of subscription. Some of you have not responded by April, 1999, so that we include a questionnaire again to whom have not answered. This is important for saving energy and economy on continuous publication of this type of nonprofit academic journal.

During the last fiscal year, WIS acknowledged money donation from 73 subscribers. Thanks for their contribution, but it covered only the mailing cost. Kihara Memorial Foundation supports the publication cost, and the editorial business is on the voluntary of the committee members. We would like to encourage all subscribers and wheat lovers to support WIS with donation, sending information and suggestion.

The report from Drs. Morrison and Raupp on *GrainTax* Synonymy Tables Project, and Drs. Snape and Hucl on the Business Meeting of the 9th IWGS should be important for all of us. Thanks for their works.

WIS wishes for beautiful crop season as well as great research advances.

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