Published online May 18, 2006

Geographic Distribution of Common and Dwarf Bunt Resistance in Landraces of *Triticum aestivum* subsp. *aestivum*

J. Michael Bonman,* Harold E. Bockelman, Blair J. Goates, Don E. Obert, Patrick E. McGuire, Calvin O. Qualset, and Robert J. Hijmans

ABSTRACT

Landrace accessions of wheat (*Triticum aestivum* L. subsp. *aestivum*) from the USDA-ARS National Small Grains Collection (NSGC) have been tested systematically for the past 25 yr for disease resistance. We analyzed the resistance of 10 759 common wheat accessions to common bunt (CB) caused by *Tilletia tritici* (Bjerk.) Wint. and *T. laevis* Kühn, and 8167 to dwarf bunt (DB) caused by *T. controversa* Kühn with respect to geographic origin, relationship to color of awn, glume, and kernel of accessions, and phenotypic variation within areas of high frequency of resistance. A clear center of concentration was evident for CB resistance extending from Serbia and Montenegro through Macedonia, Turkey, and Iran with the highest frequency of resistance occurring in Kosovo province in Serbia and Montenegro (36%) and Bakhtaran province in Iran (40.8%). Compared to CB resistance (5.5% of total tested), DB resistance was more rare (1.3% of total tested). DB resistance was concentrated in accessions from Iran, Turkey, and Serbia and Montenegro with the highest frequency (58%) occurring in Hakkari province in southeastern Turkey. CB resistance was positively associated with lightly pigmented kernels and negatively associated with lightly pigmented awns and glumes. Analysis of accessions from areas with unusually high frequency of resistance suggested that DB resistant accessions from Hakkari are genetically diverse, whereas CB resistant accessions from Bakhtaran may be much less so.

Bunt and other smut diseases have probably been associated with wheat cultivation since the crop's domestication (Fischer and Holton, 1957). Common bunt occurs on both spring and winter wheat worldwide and DB is found on winter wheat in regions with persistent snow cover (Goates and Peterson, 1999). Although chemical seed treatments can effectively control these diseases, especially CB, resistant cultivars remain desirable for bunt management in developing countries (Saari et al., 1996), for organic production of wheat, and as a lower-cost alternative to chemical treatment. The fungi causing DB and CB are closely related and resistance to both diseases is conferred by the same 15 major resistance genes (Goates, 1996).

During the past 100 yr the USDA has acquired more than 54 454 accessions of cultivated wheat and wild relatives of wheat, including 19 615 landrace accessions of common wheat. Systematic characterization of the collection began about 25 yr ago and some disease and insect resistance evaluations began even earlier. Also, many of the accessions have been characterized for various agronomic, spike, kernel, and quality traits. Since the evaluation program began, many of the common wheat accessions in the NSGC have been tested for resistance to CB and DB, including 97% of the landrace accessions present in the collection. This compilation represents one of the most complete sets of disease evaluation data collected by the NSGC. The data can be accessed through the USDA-ARS Germplasm Resources Information Network (GRIN) database at www.ars-grin.gov/npgs. The purposes of the present research were to (i) analyze the NSGC data for CB and DB resistance among common wheat landrace accessions to elucidate relationships between resistance and other characteristics, including geographic origin and awn, glume, and kernel color and (ii) generate information to guide future wheat acquisition, evaluation, and utilization.

MATERIALS AND METHODS

Disease Resistance Assessment

Landrace accessions of common wheat from the NSGC were tested for CB reaction at Pendleton, OR from 1981 to 1986 by R.J. Metzger and at Aberdeen, ID from 1992 to 2004 by B.J. Goates. A total of 4478 accessions were tested at Pendelton and 9177 were tested at Aberdeen. Several thousand accessions were tested in more than one experiment and for these the highest disease score was used, resulting in 10 759 accessions in the analysis of CB resistance. Seeds were heavily surface-inoculated with teliospores of the CB pathogens before planting 4 to 7 cm deep in single 1.5 m rows when soil temperatures were 5 to 10° C (Goates, 1996). In the tests in Pendleton during 1982 and 1984 specific accessions were inoculated with one of three pathogenic races, and in 1985 and 1986 specific accessions were inoculated with a single race or a race composite. In Aberdeen during 1992 to 2004 one of three different race composites were used separately in different years to represent a broad spectrum of virulence. Specific information on the pathogenic race, race composite, the virulence genes contained in each race, and the inoculum used in each experiment is available on GRIN.

For DB, 8167 landrace accessions were tested near Logan, UT, from 1978 to 2005. Seeds were sown about 2 cm deep in a furrow 8 to 10 cm deep, timed so that plants were at the 2- to 3-leaf stage before the onset of dormancy in late fall (Goates, 1996). Inoculum was applied onto the soil after planting as a water suspension at a rate of about 0.25 g of teliospores per row. The inoculum was prepared by suspending ground bunted spikes in water and filtering the resulting teliospores suspen-

J.M. Bonman, H.E. Bockelman, B.J. Goates, and D.E. Obert, USDA-ARS, Small Grains and Potato Germplasm Research Unit, 1691 South 2700 West, Aberdeen, ID 83210; P.E. McGuire and C.O. Qualset, Genetic Resources Conservation Program, University of California, One Shields Avenue, Davis CA 95616; R.J. Hijmans, International Rice Research Institute, DAPO Box 7777, Metro Manila, Philippines. Received 9 Dec. 2005. *Corresponding author (mbonman@uidaho.edu).

Published in Crop Sci. 46:1622–1629 (2006).
Plant Genetic Resources
doi:10.2135/cropsci2005.12-0463

677 S. Segoe Rd., Madison, WI 53711 USA

Abbreviations: CB, common bunt; DB, dwarf bunt; GRIN, Germplasm Resources Information Network; NSGC, National Small Grains Collection.

sion through cheesecloth. The inoculum was a composite of all named *T. controversa* races and other isolates from throughout the western US. The composite is maintained by periodically adding races to inoculum for the nursery, and then harvesting smutted spikes from both resistant and susceptible genotypes.

For both diseases the number of bunted and healthy spikes per row was scored after physiologic maturity, growth stage 92 (Zadoks et al., 1974), then recorded in GRIN as a percentage relative to the susceptible checks, cultivars Red Bobs for CB, and Cheyenne for DB, which were sown every 20 rows throughout the nurseries. Trials where the susceptible checks showed less than 70% infection were not used. These data and other accession level data were extracted from the GRIN for this report.

Agronomic Descriptor Data

Nearly all of the landrace accessions in the NSGC have been scored for growth habit based on spring-sown evaluations at Aberdeen, ID (43°2′ N, 112°49′ W, 1331 m elevation). Accessions flowering normally were designated as having spring habit, those that did not flower as having winter habit, and those that flowered very late as facultative. Most of the accessions tested in the CB nurseries had spring habit and most of those tested in the DB nurseries were classified as winter habit. Using color charts and standard rating codes, about 6000 landrace accessions have been scored for awn and glume color and more than 8000 have been scored for kernel color. Landrace classification was determined by the NSGC curator (H.E. Bockelman) based on information available in the passport data and is somewhat subjective.

In addition to the information from the GRIN database, we used information for most of the Iranian accessions from field experiments done at the University of California Davis Agronomy Research Farm (38° 32′ N, 121° 46′ W, 16 m elevation) from 1991 to 1996. These accessions were received by C.O. Qualset from the University of Tehran from 1986 to 1989 and represent 90% of the Iranian landrace accessions within the NSGC. Plantings were made in November or December each year. Irrigation was applied when needed, usually two times each year during pre- and post-heading. Accessions were sown in single 2.5-m rows spaced 60 cm apart laid out 20 rows wide in a serpentine pattern with spring habit check cultivars Yecora Rojo and Anza repeated throughout the experiment. Data were obtained for: days to heading and maturity (expressed as days past 31 March); flag leaf blade length and width (cm, two leaves for each accession); mature plant height (cm); spike length (mm) measured as the distance from the tip of the apical spike to the collar; awn length (mm); number of spikelets per spike; and kernel weight (mg kernel^{-1}) based on 50 kernels. Awn, glume, and kernel color were also recorded.

Data Analysis

Accessions were classified as resistant if 5% or less disease incidence relative to the susceptible check was recorded. Countries of origin were classified into regions based on the United Nations designations for World Macroregions (United Nations, 2000). Nonoverlap of the 95 or 99% binomial confidence intervals was used as a basis for determining significant differences between accessions from various geographic groupings.

Sites of collection for individual wheat accessions were georeferenced by one of the following methods based on the level of detail available in the locality data: (1) collector notes indicating geographic coordinates (latitude and longitude) based on maps or GPS instruments; (2) gazetteers either from the GEOnet Names Server (National Geospatial-Intelligence Agency, 2004) or the Getty Thesaurus of Geographic Names Online (J. Paul Getty Trust, 2000) when the collection site was named; or (3) ArcView 8.2 (ESRI, 2002) software when collector's notes indicated distance and direction from a city or village or other landmark. We obtained coordinates for a total of 7727 accessions tested for CB resistance and 6094 accessions tested for DB resistance. Accessions that lacked specific locality or coordinates were mapped either to state/province or to country level only and these data were used in analyses that did not require identification of the specific collection site. Elevation data were derived from either collector notes indicating elevation or the GTOPO30 dataset on the Global GIS Global Coverage DVD developed by the U.S. Geological Survey and the American Geological Society (Hearn et al., 2003). DIVA-GIS 5.2 was used to determine the fraction of the accessions that were resistant in 100- by 100-km grid cells (Hijmans et al., 2005b). DIVA-GIS was also used to extract climate data for all accessions from the WorldClim database (Hijmans et al., 2005a).

Not all disease resistance and other descriptor data were available in GRIN for each accession, so associations of CB or DB resistance to awn, glume, and kernel color were assessed on subsets where data for both traits were available. Because few NSGC descriptor data were available within GRIN for Iranian landraces, data collected from UC Davis were used to test for associations between disease resistance with awn, glume, and kernel color. To simplify the analysis color data were classified as either lightly pigmented (white, amber, or yellow) or pigmented (brown, bronze, tan, or red). Data from 1932 to 4797 accessions were available for analysis for each disease-trait combination. Fisher's Exact Test was used to ascertain if there was a relationship between pairs of variables (Langsrud, 2004).

Accessions from certain geographic locations showed unusually high frequencies of resistance. To compare the morphological variation among resistant accessions from these locations with that of other accessions, NSGC data were used for DB and 1991 UC Davis data were used for CB. The NSGC data consisted of images of spikes and kernels captured with a color flat-bed scanner and accessible via GRIN. The 1991 field planting at UC Davis included 248 accessions from Bakhtaran province in Iran and 1858 accessions from other areas of Iran. Values for the quantitative traits measured in the trial were adjusted with Agrobase software (Agronomix Software, 2004) using the quadratic method of moving means. This method adjusts entry values based on the check means and two adjacent rows on either side of the entry. In the case of unbordered end rows, the adjacent four rows on the existing side were used to adjust the entry value. A one-tailed *F*-test was used to compare variances for the measured traits of the CB-susceptible and resistant accessions from Bakhtaran and other common wheat accessions from throughout Iran that were included in the trial.

RESULTS AND DISCUSSION

Relationship to Geographic Origin

General Distribution

Three macroregions, Southern Europe, Western Asia, and South-central Asia, had a significantly higher ($P < 0.01$) frequency of both CB- and DB-resistant landrace accessions compared to the total for all other regions (Table 1). The frequencies of CB-resistant accessions from South-central Asia, Southern Europe, and Western

Table 1. Numbers of accessions of common wheat tested and resistant† to common and dwarf bunt from nine geographic regions‡.

	Common bunt			Dwarf bunt		
Geographic region	Resistant (*n*)	Total (*n*)	Resistant (%)	Resistant (*n*)	Total (*n*)	Resistant (%)
Eastern Africa	1	811	0.1	0	169	0
Eastern Asia	0	657	0	0	485	0
Eastern Europe	2	176	1.1	0	114	0
Northern Africa	0	166	0	0	31	0
South America	0	369	0	0	268	0
South-central Asia	367	5320	6.9**	57	4627	1.2**
Southern Europe	80	1189	6.7**	10	1367	0.7*
Western Asia	139	1765	7.9**	37	701	5.3**
Western Europe	7	282	2.5	0	392	0
Total sample	597	10759	5.5	104	8167	1.3

* Significantly greater by nonoverlap of binomial confidence intervals than regions not representing centers of concentration for resistance at $P < 0.5$.
** Significantly greater by nonoverlap of binomial confidence intervals than regions not representing centers of concentration for resistance at $P < 0.01$.
† Accessions were classified as resistant if they had less than 5% infection relative to susceptible checks.
‡ Macroregions with fewer than 17 accessions omitted, but data included in total sample.

Asia were 6.9, 6.7, and 7.9%, respectively. The frequency of CB-resistant accessions from elsewhere (0.4%, n = 2485) was significantly less ($P < 0.01$). Similarly, the frequencies of DB-resistant accessions from South-central Asia, Southern Europe, and Western Asia were 1.2, 0.7, and 5.3%, respectively. No DB-resistant accessions from elsewhere were found (n = 1472). Accessions from South-central Asia, Southern Europe, and Western Asia accounted for 97.8% of the CB-resistant accessions and all of the DB-resistant accessions identified within the collection. Table 2 shows that four of the 40 countries within these three regions (Serbia and Montenegro, Macedonia, Turkey, and Iran) accounted for 92% of the CB-resistant accessions identified, while Serbia and Montenegro, Turkey, and Iran accounted for all of the identified DB-resistant accessions. Serbia and Montenegro had the highest frequency of CB resistance and Turkey had the highest frequency of DB resistance.

Common Bunt Resistance

There is a nearly contiguous geographic band with high frequency of CB resistance from southern Serbia and Montenegro through Iran (Fig. 1A) and this area represents a "center of concentration" sensu Ward (1962) for CB resistance. Most of Bulgaria and a small part of northeastern Greece lie between Macedonia and Turkey (Fig. 1B), but only 76 spring-habit landrace accessions from Bulgaria and Greece were available in the NSGC. Sixty-five of these accessions were tested for CB resistance, none were resistant and few of the accessions had sufficient information to map their origin to a specific geographic point (Fig. 1B). At least one landrace from Greece, PI 116301, is reported to have CB resistance gene *Bt10* (Metzger and Silbaugh, 1971), but was susceptible to the races used in NSGC testing and to race X-1 from the Pacific Northwest of the USA (Metzger and Kendrick, 1967). Landrace accessions identified within the GRIN database are generally accessions from farmers' fields or markets collected either before the era of modern plant breeding or in less favorable environments where modern cultivars are not grown. The status of certain other accessions is ambiguous, because the passport data are limited. Seven of 49 such ambiguous accessions from Greece and five of 16 such accessions from Bulgaria were resistant to CB. This frequency of resistance is significantly higher ($P < 0.01$) than that found within the remainder of the 2167 common wheat accessions in the NSGC that have limited passport data (n = 2167, 1.9% resistant). Based on these observations and on the geographic distribution of resistant landrace accessions, we hypothesize that Bulgaria and northeastern Greece are likely within the center of concentration for CB resistance. The European Wheat Database lists 162 landraces of common wheat from Bulgaria and 137 from Greece (Faberova et al., 2005), and additional sources of CB resistance might be present among these accessions.

Over the four-country center of concentration for CB resistance the frequency of resistant accessions was approximately 11% and within this center there are regions where the frequency of CB resistant accessions is much higher than the average. In Iran the frequency of CB resistance among accessions originating from Bakhtaran province is 40.8% (n = 341) (Fig. 1B) and the adjacent province of Hamadan also has a high frequency of CB resistant accessions (25%, n = 100). In fact, there appears to be a gradient of CB resistant accessions

Table 2. Numbers of accessions of common wheat tested and resistant† to common and dwarf bunt from four countries and from all other countries.

	Common bunt			Dwarf bunt		
Country	Resistant (n)	Total (n)	Resistant (%)	Resistant (n)	Total (n)	Resistant (%)
Iran	351	2785	12.6*	57	3325	1.7*
Turkey	133	1551	8.6*	37	637	5.8*
Serbia and Montenegro	57	388	14.7*	10	700	1.4*
Macedonia	16	392	4.1*	0	413	0
All others	40	5664	0.7	0	3102	0

* Significantly greater by non-overlap of binomial confidence intervals ($P < 0.01$) than frequency of resistance from the all others category.
† Accessions were classified as resistant if they had less than 5% infection relative to susceptible checks.

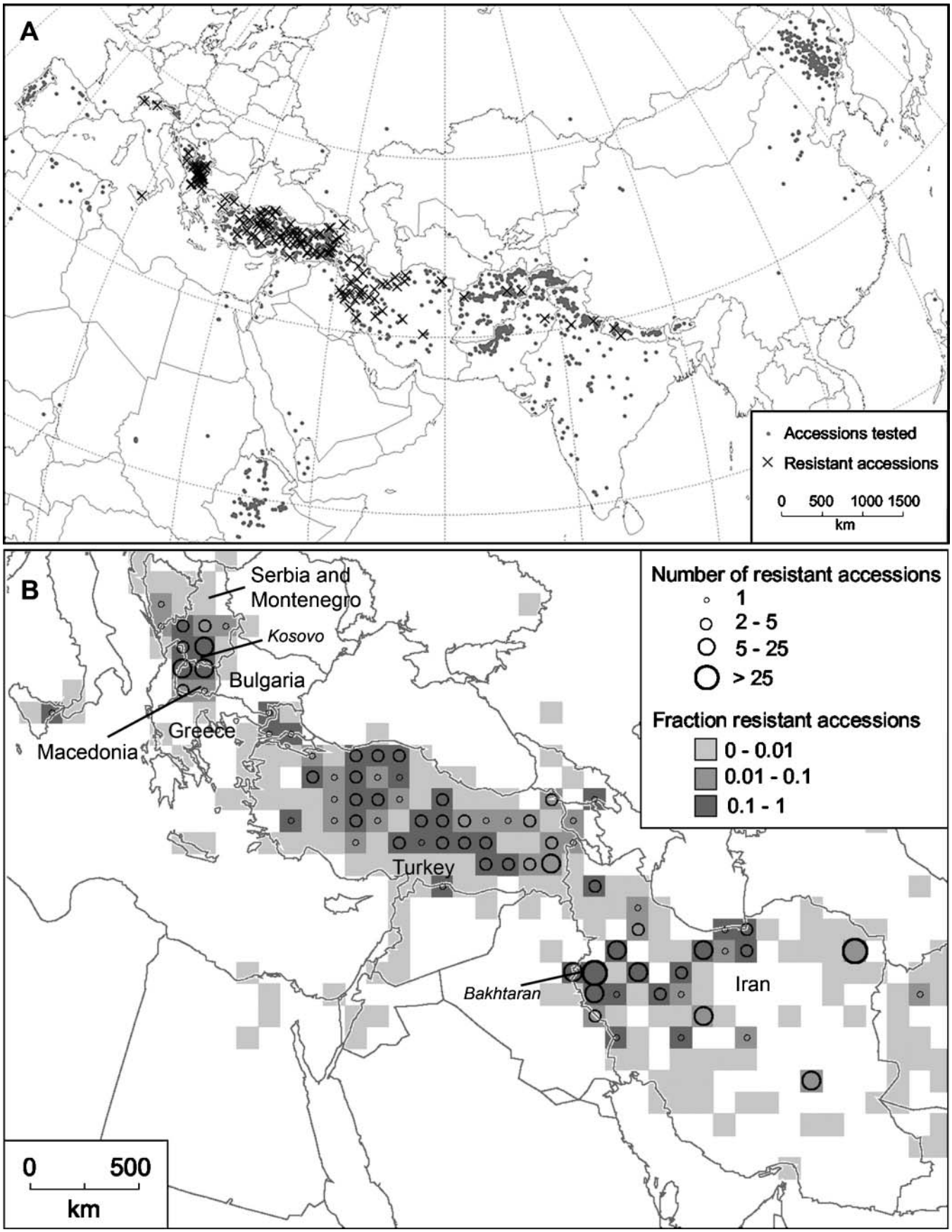

Fig. 1. Specific geographic locations where CB resistant and susceptible wheat landrace accessions were collected: A) pattern of occurrence from Europe through Eastern Asia and B) number of resistant accessions and frequency of resistance per 100 km by 100 km grid cell in the four country region where the most resistant accessions were found.

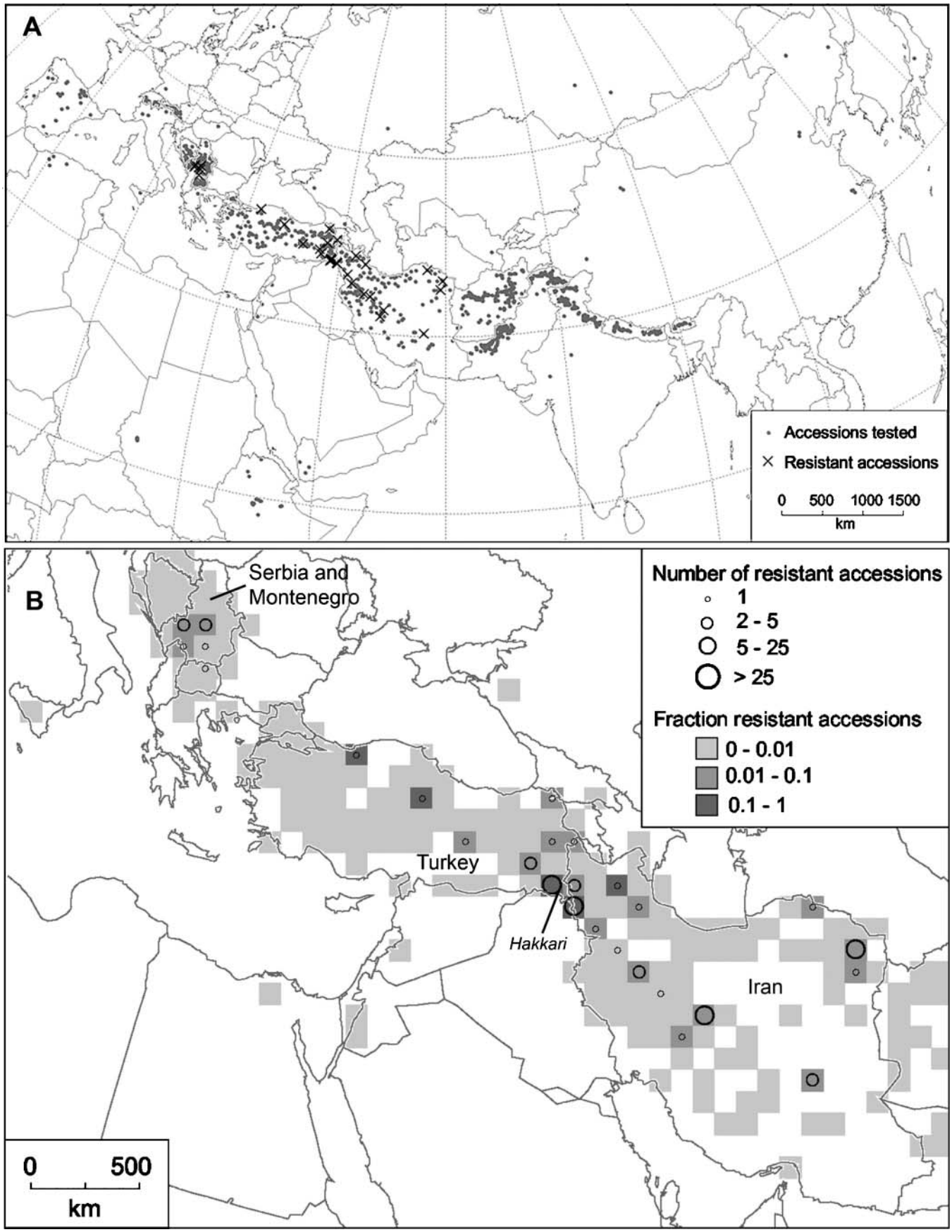

Fig. 2. Specific geographic locations where DB resistant and susceptible wheat landrace accessions were collected: A) pattern of occurrence from Europe through Eastern Asia and B) number of resistant accessions and frequency of resistance per 100 km by 100 km grid cell in the four country region where the most resistant accessions were found.

centering on Bakhtaran province with lower frequency as distance from the province increased (Fig. 1B). In Turkey and Macedonia there do not appear to be any subcenters of concentration such as Bakhtaran in Iran. However, in Serbia and Montenegro, the province of Kosovo had a high frequency of CB resistant accessions (36%, $n = 100$) (Fig. 1B), and in one locality in the south of the province 15 of 19 accessions collected from three specific locations within approximately 16 km of one another were resistant.

Dwarf Bunt Resistance

Resistance to DB occurs in the same general area as CB resistance (Fig. 2A), but DB resistance is less common. Two centers of concentration for DB resistance are apparent, one in Serbia and Montenegro and the other in eastern Turkey and Iran (Fig. 2B). The highest frequency of DB resistance occurred among accessions from the province of Hakkari in southeastern Turkey where 58% of the 48 accessions tested were resistant. Resistant accessions from Hakkari represent 76% (28 of 37) of the resistant accessions identified from Turkey. DB resistance in accessions from eastern Turkey is known to bunt researchers (Bruehl, 1990), but neither the high frequency of resistance within accessions from Hakkari province nor the occurrence of DB resistance in accessions from Iran and Serbia and Montenegro has been described previously.

Of 132 landrace accessions from Hakkari present in the NSGC, 85 have either spring or facultative growth habit. Few of these accessions were tested for DB resistance, yet some were reported to be DB resistant by others (Bruehl, 1990). Currently, DB data are available for five accessions from Hakkari classified as spring habit and of these four were resistant. Thus, it is likely that more DB resistant accessions could be identified from Turkey within the materials classified as spring and facultative habit and these will be tested in the future.

Within Turkey, data from the WorldClim database showed the mean precipitation for the coldest quarter of the year was 237 mm for the locations where DB resistant accessions originated compared to 155 mm for locations where susceptible accessions originated. Similarly, DB resistance was related to elevation of origin of the accession. Across the three countries where DB resistance was found, elevation at origin was available for 3958 accessions. Within this sample the frequency of DB resistance is significantly lower (1.5 vs. 2.9%, $P < 0.05$) for accessions from less than 1250 m than for accessions from higher elevations. These differences in precipitation and elevation are likely correlated with long-lasting snow cover that is required for infection by the DB pathogen (Goates, 1996).

Relationship to Awn, Glume, and Kernel Pigmentation

In both sets of data examined the occurrence of lightly pigmented kernels was positively associated with the occurrence of CB resistance, whereas lightly pigmented awn and glumes were associated with CB susceptibility (Table 3). The positive association between lightly pigmented kernels and CB resistance in the NSGC data was not due to accessions with white/amber kernels being overrepresented and accessions with more darkly pigmented kernels being underrepresented in the four countries that had the high frequency of CB resistance. For example, within Turkey, Serbia and Montenegro, and Macedonia 1375 accessions were classified with respect to kernel color and among these there was a negative association between resistance and red kernels ($P = 10^{-6}$) and a positive association between resistance and white/amber kernels ($P = 10^{-6}$). There was a weak, but significant ($P < 0.01$), association of dark kernel color with DB resistance.

Phenotypic Diversity within and among Accessions from Subcenters of Resistance

The subcenters where the frequency of resistant accessions was exceptionally high, such as Hakkari province in Turkey for DB and Bakhtaran province in Iran for CB, could be due to the consequence of highly disease-conducive environments resulting in farmer-selection for resistant landraces over time, or stochastically, because of recurrent mutations for resistance that remained in the landrace populations (Qualset, 1975). For these two locations we examined the phenotypic diversity among the resistant accessions using data from the NSGC for Hakkari and from the 1991 UC Davis trial for Bakhtaran.

Many of the resistant accessions from Hakkari were collected by C. Sperling, H. Gecit, and D. Eser in the mid 1980s and a few were collected by J. Harlan in 1948 and by J. Hoffmann, M. Kanbertay, R.J. Metzger, and H. Sencer in 1979. Little morphoagronomic data are available for the resistant accessions, but based on the seed and spike images available in GRIN it is clear that the materials are morphologically diverse. Furthermore, there appears to be diversity within the accessions as

Table 3. Associations and the frequencies of accessions with lightly pigmented awns, glumes, and kernels with the frequency of common bunt resistance in landrace accessions of *Triticum aestivum* subsp. *aestivum* from the USDA National Small Grains Collection (NSGC) in two data sets.†

		NSGC		UC Davis	
Trait	**Trait combination**	**n**	**Association**	**n**	**Association**
Awn color	**Light/CB resistant**	**53**	**$-(10^{-4})$‡**	**166**	**$-(10^{-25})$**
	Light/CB susceptible	**2576**		**1409**	
	Dark/CB resistant	**54**		**122**	
	Dark/CB susceptible	**1287**		**235**	
Glume color	**Light/CB resistant**	**56**	**$-(10^{-2})$**	**46**	**$-(10^{-4})$**
	Light/CB susceptible	**2446**		**439**	
	Dark/CB resistant	**53**		**288**	
	Dark/CB susceptible	**1430**		**1642**	
Kernel color	**Light/CB resistant**	**114**	**$+(10^{-13})$**	**220**	**$+(10^{-9})$**
	Light/CB susceptible	**1552**		**114**	
	Dark/CB resistant	**76**		**1016**	
	Dark/CB susceptible	**3055**		**1057**	

† NSGC data primarily from non-Iranian wheat accessions; UC Davis data from 1991–1996 with Iranian accessions.

‡ Numbers in parenthesis are probability of independence of the two variables based on Fisher's Exact Test.

Table 4. Mean ($\bar{x}$), variance (s^2), coefficient of variation (cv), and ratio of variances (*F*-value) for quantitative traits in 106 accessions resistant to common bunt from Bakhtaran province, Iran compared to 142 susceptible accessions from the same province and to 1858 other accessions from Iran.

	Resistant			Susceptible			Other accessions			F-value (*P*)	
Trait†	$\bar{x}$	s^2	cv	$\bar{x}$	s^2	cv	$\bar{x}$	s^2	cv	Susceptible/resistant	Other accessions/resistant
Awn length	72.0	336.6	25.5	70.0	328.3	25.9	87.5	487.7	25.2	0.98 (>0.05)	1.45 (0.01)
Flag leaf length	24.6	5.5	9.5	25.3	7.8	11.0	25.8	8.0	11.0	1.42 (0.03)	1.46 (0.01)
Flag leaf width	1.9	0.04	10.5	1.8	0.12	19.2	1.9	0.07	13.9	3.19 (10^{-11})	1.91 (10^{-5})
Heading date	39.4	5.6	6.0	37.5	17.5	11.2	39.2	13.0	9.2	3.12 (10^{-9})	2.31 (10^{-9})
Height	134.4	60.1	5.8	133.1	58.8	5.8	133.8	85.7	6.9	0.98 (>0.05)	1.43 (0.01)
Kernel weight	43.4	8.4	6.7	42.5	24.0	11.5	45.7	23.2	10.5	2.85 (10^{-8})	2.75 (10^{-10})
Maturity	89.9	4.1	2.3	89.3	13.1	4.0	89.4	7.9	3.1	3.16 (10^{-9})	1.90 (10^{-5})
Spike length	140.7	289.0	12.1	142.0	249.5	11.1	128.3	208.1	11.2	0.86 (>0.05)	0.72 (>0.05)
Spikelets/spike	22.4	1.6	5.6	22.3	2.3	6.8	22.7	2.7	7.2	1.43 (0.03)	1.67 (10^{-4})

† See Materials and Methods for measurement units.

expected for landraces. The NSGC has attempted to maintain the diversity within landraces, but population size bottlenecks have rendered many of them as uniform as single-plant derivatives. Some marketplace grain collections, such as those collected from Hakkari province, show diversity within the NSGC accessions. For example, seven DB resistant genotypes were selected from within PI 560603 which are morphologically diverse with respect to spike type, glume and kernel color. These selections were recently given new PI designations (PI 636145–PI 636151), as were several other resistant accessions selected from Hakkari collections. The environmental conditions in the southeastern Turkey province of Hakkari are probably highly conducive to the DB disease, resulting in farmer-selection of disease resistant landraces over time.

The variability in quantitative traits among CB-resistant accessions from the Bakhtaran province, Iran, was lower than the variability among CB-susceptible accessions for six of the nine traits assessed (Table 4). Similarly, for the quantitative traits except spike and awn length, the resistant accessions from Bakhtaran were significantly less variable than the other common wheat accessions tested in the 1991 Davis planting. The differences in variance were small, but as expected if the resistant Bakhtaran accessions were derived from the same or closely related landraces. The high frequency of resistant accessions from this area may be the result of selection pressure for resistance induced in highly disease-conducive environments. Genes and phenotypes occurring at high frequencies would have been taken by collectors repeatedly by chance because the CB disease will not be apparent in most instances of field, farm stores, or market sources. Investigations with molecular markers (Driesigaker et al., 2004, 2005) may shed light on this unusual observation.

In summary, we have identified geographic centers of concentration for both CB and DB in common wheat landrace accessions from the NSGC and have found that lightly pigmented kernels are associated with CB resistance. In addition, geographic subcenters of concentration were revealed in Kosovo province in Serbia and Montenegro and in Bakhtaran province in Iran for CB resistance, and in Hakkari province in Turkey for DB resistance. This information will be useful in guiding further exploration for sources of genes for bunt resistance and for the study of resistance gene diversity within the centers. Such information can also be used to target further collection efforts aimed at finding new resistance gene sources for these two diseases. Based on the analysis of variability of accessions from Bakhtaran province, where CB resistance was exceptionally frequent, genetic analyses would be useful to determine if these accessions were mono- or polymorphic for specific CB resistance genes.

ACKNOWLEDGMENTS

The authors are grateful to Jamshid Jafari-Shabestari for data collection on the Iranian wheat accessions at UC Davis, to Glenda Rutger for assistance in extracting data from GRIN, and for financial support for introducing and evaluating the Iranian wheats from the USDA-ARS, the Wallace Genetic Fund, the California Crop Improvement Association, CIMMYT, and ICARDA.

REFERENCES

Agronomix Software. 2004. Agrobase Generation II users manual. Agronomix Software. Winnipeg, MB.

Bruehl, G.W. 1990. History of the Department of Plant Pathology. Washington State University. www.getty.edu/research/conducting_research/vocabularies/tgn/index.html (verified 14 March 2006).

Driesigaker, S., P. Zhang, M.L. Warburton, B. Skovmand, D. Hoisington, and A.E. Melchinger. 2005. Genetic diversity among and within CIMMYT wheat landrace accessions investigated with SSRs and implications for plant genetic resources management. Crop Sci. 45:653–661.

Driesigaker, S., P. Zhang, M.L. Warburton, M. Van Ginkel, D. Hoisington, M. Bohn, and A.E. Melchinger. 2004. SSR and pedigree analyses of genetic diversity among CIMMYT wheat lines targeted to different megaenvironments. Crop Sci. 44:381–388.

ESRI. 2002. ArcMap. version 8.2 ESRI. Redlands, CA.

Faberova, I., I. Hon, A. Le Blanc, and J. Koenig. 2005. European Wheat Database. http://genbank.vurv.cz/ewdb/ (verified 9 March 2006).

Fischer, G.W., and C.S. Holton. 1957. Biology and control of the smut fungi. The Ronald Press. New York.

Goates, B.J. 1996. Common bunt and dwarf bunt. p. 12–25. *In* R.D. Wilcoxson, and E.E. Saari (ed.) Bunt and smut diseases of wheat: Concepts and methods of disease management. CIMMYT. Mexico, D.F.

Goates, B.J., and G.L. Peterson. 1999. Relationship between soilborne and seedborne inoculum density and the incidence of dwarf bunt of wheat. Plant Dis. 83:819–824.

Hearn, P., T. Hare, P. Schruben, D. Sherrill, C. LaMar, and P. Tsushima. 2003. Global GIS Global Coverage DVD. version 6.4.2. American Geological Institute. Alexandria, VA.

Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones, and A. Jarvis.

2005a. Very high resolution interpolated climate surfaces for global land areas. Int. J. Climatol. 25:1965–1978.

Hijmans, R.J., L. Guarino, A. Jarvis, R. O'Brien, P. Mathur, C. Bussink, M. Cruz, I. Barrantes, and E. Rojas. 2005b. DIVA-GIS. www.diva-gis.org/.

J. Paul Getty Trust. 2000. Getty Thesaurus of Geographic Names Online [Online]. www.getty.edu/research/conducting_research/vocabularies/tgn/index.html (verified 14 March 2004).

Langsrud, O. 2004. Fisher's Exact Test. /www.matforsk.no/ola/fisher.htm (verified 28 November 2005).

Metzger, R.J., and E.L. Kendrick. 1967. A new race of *Tilletia caries*. Plant Dis. Rep. 52:287–288.

Metzger, R.J., and B.A. Silbaugh. 1971. A new factor for resistance to common bunt in hexaploid wheat. Crop Sci. 11:66–69.

National Geospatial-Intelligence Agency. 2004. GEOnet Names Server (GNS) [Online]. http://earth-info.nga.mil/gns/html/index.html (verified 14 March 2006).

Qualset, C.O. 1975. Sampling germplasm in a center of diversity: An example of disease resistance in Ethiopian barley. p. 81–96. *In* O.H. Frankel, and J.G. Hawkes (ed.) Crop genetic resources for today and tomorrow. Cambridge Univ. Press. Cambridge.

Saari, E.E., O.F. Mamluk, and P.A. Burnett. 1996. Bunts and smuts of wheat p. 1–11. *In* R.D. Wilcoxson and E.E. Saari (ed.) Bunt and smut diseases of wheat: Concepts and methods of disease management. CIMMYT. Mexico, D.F.

United Nations. 2000. World Macroregions and Components [Online]. http://www.un.org/depts/dhl/maplib/worldregions.htm (verified 14 March 2006).

Ward, D.J. 1962. Some evolutionary aspects of certain morphologic characters in a world collection of barleys. Technical Bulletin 1276. U.S. Dep. Agric.

Zadoks, J.C., T.T. Chang, and C.F. Zonzak. 1974. A decimal code for the growth stages of cereals. Weed Res. 14:415–421.

Supplemental Table 1. Accesssions of *Triticum aestivum* var. *aestivum* from the National Small Grains Collection resistant to common bunt disease. Only data for the landrace accessions were included in the analysis presented in the paper.

Accession Prefix	Accession number	Name	Status	Origin
CItr	4306	8	LANDRACE	Iran
CItr	7368	G 334	BREEDING	United States
CItr	11432	A-2–59–14	BREEDING	United States
CItr	11438	27461C-2–6-1	BREEDING	United States
CItr	11471	2421–7.19.32	BREEDING	United States
CItr	11473	McFadden 1280	BREEDING	United States
CItr	11491	White Russian	CULTIVATED	China
CItr	11532	G2343-A-4–28	BREEDING	United States
CItr	11543	Utah Q231–17	BREEDING	United States
CItr	11576	TURKEY SELECTION	BREEDING	United States
CItr	11617		BREEDING	United States
CItr	11635	RENOWN	CULTIVAR	Canada
CItr	11650	RL 716	BREEDING	Canada
CItr	11713	Ns. 2594	BREEDING	United States
CItr	11721	RL 1114	BREEDING	Canada
CItr	11723	N 1264	BREEDING	United States
CItr	11775	Ns. 2590	BREEDING	United States
CItr	11779	Ns. 2687	BREEDING	United States
CItr	11786	N 1250	BREEDING	United States
CItr	11787	N 1249	BREEDING	United States
CItr	11789	II-28–16	BREEDING	United States
CItr	11790	II-28–68	BREEDING	United States
CItr	11869	REGENT	CULTIVAR	Canada
CItr	11871	II-28–102	BREEDING	United States
CItr	11882	N 1349	BREEDING	United States
CItr	11884	N 1330	BREEDING	United States
CItr	11885	N 1098–28	BREEDING	United States
CItr	11891	II-29–53	BREEDING	United States
CItr	11892	II-28–27	BREEDING	United States
CItr	11898	II-29–60	BREEDING	United States
CItr	11931	N 1466	BREEDING	United States
CItr	11937	GREAT NORTHERN	CULTIVAR	Canada
CItr	11940	PREMIER	CULTIVAR	United States
CItr	11968	Nebr. Sel. 363452	BREEDING	United States
CItr	12005	Ns. No. 2747	BREEDING	United States
CItr	12006	Ns. 2800	BREEDING	United States
CItr	12012	RL 1333	BREEDING	Canada
CItr	12040	II-29–57	BREEDING	United States
CItr	12042	I-38–3	BREEDING	United States
CItr	12056	N 1637	BREEDING	United States
CItr	12058	SD 1463–26	BREEDING	United States
CItr	12187	KENYA 117C	CULTIVAR	Kenya
CItr	12309	II-36–13	BREEDING	United States
CItr	12317	N 1753	BREEDING	United States
CItr	12318	NEWTHATCH	CULTIVAR	United States
CItr	12324	N 1769	BREEDING	United States
CItr	12354	N 1609	BREEDING	United States
CItr	12358	Ns. 3111	BREEDING	United States
CItr	12360	Ns. 3096	BREEDING	United States
CItr	12367	N 1535	BREEDING	United States
CItr	12431	N. 1840	BREEDING	United States
CItr	12432	II-38–19	BREEDING	United States
CItr	12433	II-38–14	BREEDING	United States
CItr	12437	Ns. 3129	BREEDING	United States
CItr	12492	N 2035	BREEDING	United States
CItr	12493	N 2012	BREEDING	United States
CItr	12521	Huntley 4a	BREEDING	United States
CItr	12542	N 1843–41	BREEDING	United States
CItr	12547	II-39–57	BREEDING	United States
CItr	12548	N 3264	BREEDING	United States
CItr	12549	N 2092	BREEDING	United States
CItr	12634	II-42–22	BREEDING	United States
CItr	12637	N 2232	BREEDING	United States
CItr	12642	Ns. 3269	BREEDING	United States
CItr	12643	Ns. 3274	BREEDING	United States
CItr	12644	Ns. 3282	BREEDING	United States
CItr	12645	Ns. 3284	BREEDING	United States
CItr	12680	BUNT RES ELGIN 1	BREEDING	United States
CItr	12724	Kansas No. 47B121	BREEDING	United States
CItr	12732	1416 A-1–8-3–2	BREEDING	United States
CItr	12735	1416 A-1–2-3–2	BREEDING	United States
CItr	12737	1465 A-1–5-4–1	BREEDING	United States
CItr	12738	1464 A-1–24–1-1	BREEDING	United States
CItr	12741	Ns. 3291	BREEDING	United States
CItr	12742	Ns. 3684	BREEDING	United States
CItr	12746	N. 1924.44	BREEDING	United States
CItr	12785	N. 2223	BREEDING	United States

Continued next page.

Supplemental Table 1. Continued.

Accession Prefix	Accession number	Name	Status	Origin
CItr	12786	Ns. 3679	BREEDING	United States
CItr	12822	III-47–36	BREEDING	United States
CItr	12839	RL 2632	BREEDING	Canada
CItr	12849	RL 2667	BREEDING	Canada
CItr	12850	RL 2709	BREEDING	Canada
CItr	12851	Kansas No. 462666	BREEDING	United States
CItr	12852	Kansas No. 44767	BREEDING	United States
CItr	12853	Kansas No. 431413	BREEDING	United States
CItr	12867	Colo. F.C. 1197	BREEDING	United States
CItr	13043	Ns. 3880.227	BREEDING	United States
CItr	13092	II-40–107	BREEDING	United States
CItr	13100	SELKIRK	CULTIVAR	Canada
CItr	13152	Ns. 3880.127	BREEDING	United States
CItr	13199	SD Sel. 56–45	BREEDING	United States
CItr	13266	AWNED ELGIN 2	BREEDING	United States
CItr	13332	PEMBINA	CULTIVAR	Canada
CItr	13451	ND 152	BREEDING	United States
CItr	13691	Sel. 18–5	BREEDING	United States
CItr	13729	LUFT	CULTIVAR	United States
CItr	13738	Sel. 6	BREEDING	United States
CItr	13824	II-58–14	BREEDING	United States
CItr	13837	Sel. C61–9	BREEDING	United States
CItr	13958	WALDRON	CULTIVAR	United States
CItr	14107	SNOW MOLD TOLERANT SELECTION 2	BREEDING	United States
CItr	14127	NORDMAN	CULTIVAR	United States
CItr	14128	PLAINSMAN	CULTIVAR	United States
CItr	14267	DT 183	BREEDING	Canada
CItr	14275	Q 2331–34	BREEDING	Canada
CItr	14290	LA 1491	BREEDING	Mexico
CItr	15001	57–349	LANDRACE	Nepal
CItr	17576	6720–10	BREEDING	United States
CItr	17725	GREER	CULTIVAR	United States
CItr	17730	ID 77–53–23-B	BREEDING	United States
CItr	17731	ID 75–53–7	BREEDING	United States
CItr	17734	ID 75–55–19	BREEDING	United States
CItr	17755	RL 6043	BREEDING	Canada
CItr	17838	ID 72–5059	BREEDING	United States
CItr	17841	ID 74–53/18	BREEDING	United States
CItr	17842	ID 77–53/23-B	BREEDING	United States
PI	8818	Koola	LANDRACE	Iraq
PI	40946	Type No. 8A	LANDRACE	Pakistan
PI	40956	Graecum	LANDRACE	Pakistan
PI	41020	Kizil Bogara	LANDRACE	Uzbekistan
PI	68096	BELOKOLOSKA	CULTIVAR	Russian Federation
PI	68176	CItr 8523	CULTIVATED	Russian Federation
PI	71106	BELOKOLOSKA	CULTIVAR	Russian Federation
PI	74084	BELOKOLOSKA	CULTIVAR	Russian Federation
PI	74492	CItr 9319	BREEDING	Russian Federation
PI	78814	CItr 10112	LANDRACE	Georgia
PI	94359	52ASW	LANDRACE	Ukraine
PI	94364	59BSW	LANDRACE	Armenia
PI	94593	573	LANDRACE	Russian Federation
PI	106163	G 1–6-0	BREEDING	Australia
PI	106177	G 1–0	BREEDING	Australia
PI	106197	G 316–0-0	BREEDING	Australia
PI	106208	G 240–85–0	BREEDING	Australia
PI	106210	G 271–1-2	BREEDING	Australia
PI	106217		BREEDING	Australia
PI	117727	2716	BREEDING	Australia
PI	117762	2716	BREEDING	Australia
PI	124900	E-29-G-3-LO	BREEDING	Australia
PI	131276	C 10535	BREEDING	Australia
PI	131376		BREEDING	Australia
PI	131384	C 10534	BREEDING	Australia
PI	131391	0–7-4–0	BREEDING	Australia
PI	131393	0–19–4-0	BREEDING	Australia
PI	133291	EUREKA 2	CULTIVAR	Australia
PI	133292	EUREKA	CULTIVAR	Australia
PI	133293	3781	BREEDING	Australia
PI	133299	9010	BREEDING	Australia
PI	142222	QUADRAT	CULTIVAR	Australia
PI	142379	364–5G-40	BREEDING	Australia
PI	142380	366–7-G-40	BREEDING	Australia
PI	142381	388–9-G-40	BREEDING	Australia
PI	142382	393–4-G-40	BREEDING	Australia
PI	142397	755-G-40	BREEDING	Australia
PI	164362	Kanak	LANDRACE	India
PI	165141	Sivas	LANDRACE	Turkey

Continued next page.

Supplemental Table 1. Continued.

Accession Prefix	Accession number	Name	Status	Origin
PI	165163	Yumusak	LANDRACE	Turkey
PI	165175	Ak	LANDRACE	Turkey
PI	166219	Ak	LANDRACE	Turkey
PI	166252	Yumusak	LANDRACE	Turkey
PI	166258	Haci Yusuf	LANDRACE	Turkey
PI	166260	Germir	LANDRACE	Turkey
PI	166261	Zerun	LANDRACE	Turkey
PI	166267	Zerin	LANDRACE	Turkey
PI	166278	Guzluk Yillik	LANDRACE	Turkey
PI	166282	Zeran	LANDRACE	Turkey
PI	166283	Yillik	LANDRACE	Turkey
PI	166293	Erik Kislik	LANDRACE	Turkey
PI	166296	Saritopbas	LANDRACE	Turkey
PI	166299	Ak	LANDRACE	Turkey
PI	166310	Yumusak	LANDRACE	Turkey
PI	166477	Cakirli	LANDRACE	Turkey
PI	166481	Sumdar	LANDRACE	Turkey
PI	166494	Ak	LANDRACE	Turkey
PI	166562	Yumusak	LANDRACE	Turkey
PI	166622	Sari Bursa	LANDRACE	Turkey
PI	166703	Kurt	LANDRACE	Turkey
PI	166748	Yazlik	LANDRACE	Turkey
PI	166927	Sam	LANDRACE	Turkey
PI	167508	2141	LANDRACE	Turkey
PI	167551	2721	LANDRACE	Turkey
PI	167694	3888	LANDRACE	Turkey
PI	167712	3944	LANDRACE	Turkey
PI	167731	3988	LANDRACE	Turkey
PI	167772	4091	LANDRACE	Turkey
PI	167773	4093	LANDRACE	Turkey
PI	167780	4104	LANDRACE	Turkey
PI	167814	4197	LANDRACE	Turkey
PI	167817	4204	LANDRACE	Turkey
PI	167818	4208	LANDRACE	Turkey
PI	167824	4219	LANDRACE	Turkey
PI	167857	4298	LANDRACE	Turkey
PI	167868	4318	LANDRACE	Turkey
PI	168486	9368a	LANDRACE	India
PI	170996	6615	LANDRACE	Turkey
PI	171006	3918	LANDRACE	Turkey
PI	171007	3920	LANDRACE	Turkey
PI	171018	3935	LANDRACE	Turkey
PI	171023	4066	LANDRACE	Turkey
PI	171029	4076	LANDRACE	Turkey
PI	171033	4109	LANDRACE	Turkey
PI	171052	4263	LANDRACE	Turkey
PI	172201	186	BREEDING	Australia
PI	172533	7698	LANDRACE	Turkey
PI	172534	Kirik	LANDRACE	Turkey
PI	172554	8355	LANDRACE	Turkey
PI	172561	Sertak	LANDRACE	Turkey
PI	172565	Menceki	LANDRACE	Turkey
PI	173384	6517	LANDRACE	Turkey
PI	173388	6535	LANDRACE	Turkey
PI	173395	6627	LANDRACE	Turkey
PI	173399	Sumeder Cakerlisi	LANDRACE	Turkey
PI	173444	Kirik	LANDRACE	Turkey
PI	173450	Kirik	LANDRACE	Turkey
PI	173471	Kose	LANDRACE	Turkey
PI	173474	Kose	LANDRACE	Turkey
PI	173477	8032	LANDRACE	Turkey
PI	173478	8038	LANDRACE	Turkey
PI	177977	184/2	BREEDING	Turkey
PI	178000	165/5	BREEDING	Turkey
PI	178007	193/2	BREEDING	Turkey
PI	178101	Rus	LANDRACE	Turkey
PI	178172	141/3	BREEDING	Turkey
PI	178175	144/10	BREEDING	Turkey
PI	178182	7607	LANDRACE	Turkey
PI	178193	8818	LANDRACE	Turkey
PI	178194	8820	LANDRACE	Turkey
PI	178206	Saribas	LANDRACE	Turkey
PI	178210	YAYLA 305	CULTIVAR	Turkey
PI	178224	10227	LANDRACE	Turkey
PI	178687	Dimcuit	LANDRACE	Turkey
PI	178689	184/5	BREEDING	Turkey
PI	178692	182/3	BREEDING	Turkey
PI	178694	146/6	BREEDING	Turkey

Continued next page.

Supplemental Table 1. Continued.

Accession Prefix	Accession number	Name	Status	Origin
PI	178695	145/2	BREEDING	Turkey
PI	178697	140/3	BREEDING	Turkey
PI	178705	175/2	BREEDING	Turkey
PI	178713	142/5	BREEDING	Turkey
PI	178723	142/6	BREEDING	Turkey
PI	178726	193/5	BREEDING	Turkey
PI	178737	165/6	BREEDING	Turkey
PI	178748	6499	BREEDING	Turkey
PI	178750	9735	LANDRACE	Syria
PI	178767	62/2	LANDRACE	Turkey
PI	178776	YAYLA 305	CULTIVAR	Turkey
PI	178777	73/1	LANDRACE	Turkey
PI	178784	Ruto	LANDRACE	Turkey
PI	178793	Beleke	LANDRACE	Turkey
PI	178801	10325	LANDRACE	Turkey
PI	178804	10341	LANDRACE	Turkey
PI	180636	Strain No. 3524/38	BREEDING	Germany
PI	180638	Strain No. 1179/42	BREEDING	Germany
PI	181256	14	LANDRACE	Afghanistan
PI	185275	H912 SEL 47 933	BREEDING	Argentina
PI	185298	H 1092 47–683	BREEDING	Argentina
PI	185867	II-116–2C-5C-(1–3C)-16C	BREEDING	Mexico
PI	189780	BLE DUR D 115	BREEDING	Tunisia
PI	189786	Sel. 49–4796 H544	BREEDING	Argentina
PI	189804	Sel. 49–4809 H653	BREEDING	Argentina
PI	189821	Sel. 49–4831 H1035	BREEDING	Argentina
PI	189840	Sel. 49–2854 H1168	BREEDING	Argentina
PI	190154	HOHENHEIMER BASTARD	CULTIVAR	Germany
PI	190490	ELLA	CULTIVAR	Sweden
PI	191122	Jeja de Barcelona	LANDRACE	Spain
PI	191135	Marceno de Lerida	LANDRACE	Spain
PI	191363	Russie 062	CULTIVATED	Italy
PI	191391	Tricoccum	CULTIVATED	Ethiopia
PI	191496	H 2 B 13326	CULTIVATED	Portugal
PI	191559	H 15 N 13356	CULTIVATED	Portugal
PI	191584	HNAD 12228	CULTIVATED	Portugal
PI	191706	Bladette de Besplas	LANDRACE	France
PI	191872	Arrancada	CULTIVATED	Portugal
PI	192249	Bohom Vaxelv Seleta	CULTIVATED	Czech Republic
PI	192393	SELECTY PRESIVKA	CULTIVAR	Czechoslovakia
PI	192433	Egipcio	CULTIVATED	Portugal
PI	192569	Forma Vinda de Varmland	LANDRACE	Sweden
PI	192576	BON FERMIER	CULTIVAR	France
PI	202786		BREEDING	Peru
PI	204035	Santa Marta	LANDRACE	Portugal
PI	211645	220–39	CULTIVATED	Turkey
PI	211667	1467	CULTIVATED	Turkey
PI	212820	1	CULTIVATED	Uruguay
PI	213570	AQUILA	CULTIVAR	Italy
PI	213572	Gzal. Mitre	CULTIVATED	Argentina
PI	213582	D.I.V. 6703	BREEDING	Argentina
PI	213591	D.I.V. 6712	BREEDING	Argentina
PI	213594	D.I.V. 6715	BREEDING	Argentina
PI	213602	D.I.V. 6723	BREEDING	Argentina
PI	213682	BUCK 62/52	BREEDING	Argentina
PI	220433	Line 1167–68	BREEDING	Egypt
PI	221368	NOVI SAD 1439	CULTIVAR	Yugoslavia
PI	221397	Icterinum	CULTIVATED	Yugoslavia
PI	221701		CULTIVATED	Indonesia
PI	222669	1660	LANDRACE	Iran
PI	222683	1674	LANDRACE	Iran
PI	223186	ATAHUALPA NO. 1	BREEDING	Ecuador
PI	223542	Gandom-i-Sorkh	LANDRACE	Afghanistan
PI	225290	104	LANDRACE	Iran
PI	225311	125	LANDRACE	Iran
PI	227877	15203	LANDRACE	Iran
PI	227963	Line 1342–2651	BREEDING	Egypt
PI	228069	TAICHUNG NO. 29	CULTIVAR	Taiwan
PI	231357	RUSSELLO S.G. 7	CULTIVAR	Italy
PI	234176		BREEDING	Peru
PI	234384	KARAKI HAMRA	CULTIVAR	Jordan
PI	235160	Hoiti	CULTIVATED	Australia
PI	243636	5339	LANDRACE	Iran
PI	243655	5363	LANDRACE	Iran
PI	245380	3017	LANDRACE	Afghanistan
PI	245632	k3267	LANDRACE	Afghanistan
PI	249821	PIF-57	CULTIVAR	Israel
PI	254034		CULTIVATED	Europe

Continued next page.

Supplemental Table 1. Continued.

Accession Prefix	Accession number	Name	Status	Origin
PI	254077		CULTIVATED	Europe
PI	254142		LANDRACE	Ethiopia
PI	254219	349	LANDRACE	Georgia
PI	259894	P603n318.A.T.	BREEDING	Croatia
PI	263153	Zincirli 126	CULTIVATED	Turkey
PI	264254	Pseudo Rubriceps	CULTIVATED	Turkey
PI	264941	22	LANDRACE	Italy
PI	267150	SARATOVSKAJA 210	CULTIVAR	Russian Federation
PI	268305	86	LANDRACE	Iran
PI	268309	90	LANDRACE	Iran
PI	272483	I-1–1157	BREEDING	Hungary
PI	278471	254	CULTIVATED	Russian Federation
PI	278532	Beyrouth 1	LANDRACE	Lebanon
PI	278654	SARROSA	CULTIVAR	Former Soviet Union
PI	280446	LUTESCENS 62	CULTIVAR	Russian Federation
PI	280450	AL'BIDUM 3700	CULTIVAR	Russian Federation
PI	282910	Iblocskai 7	CULTIVATED	Argentina
PI	282918	CANDEAL DURUMBUCK	CULTIVAR	Argentina
PI	282921		BREEDING	Argentina
PI	283151	Italian	CULTIVATED	Jordan
PI	283814	BINYA	CULTIVAR	Australia
PI	284669	NOVOSADSKA 1439	CULTIVAR	Yugoslavia
PI	285933	Chudoskaja	CULTIVATED	Poland
PI	285945	GORZOWSKA WCZEANA	CULTIVAR	Poland
PI	285973	LUTESCENS 62	CULTIVAR	Russian Federation
PI	286066		CULTIVATED	Poland
PI	290744	CATCHER	CULTIVAR	Kenya
PI	292938	53–3	CULTIVATED	Pakistan
PI	294578	111/33	CULTIVATED	United States
PI	294899	Botewgrad	CULTIVATED	Bulgaria
PI	294900	Breznik	CULTIVATED	Bulgaria
PI	294903	DIOZEG WINTERWEIZEN NO. 200	CULTIVAR	Hungary
PI	294910	Karapalzi	CULTIVATED	Bulgaria
PI	294925	Sadowka	CULTIVATED	Bulgaria
PI	294932	Ubileina III	CULTIVATED	Bulgaria
PI	294970	KRASNAJA ZVEZDA	CULTIVAR	Kazakhstan
PI	306500	2870	CULTIVATED	Romania
PI	315987	HEURTEBISE	CULTIVAR	France
PI	315993	MAGALI	CULTIVAR	France
PI	316005	REX VILMORIN	CULTIVAR	France
PI	320104	Pitcher	CULTIVATED	Kenya
PI	321876	B-840	LANDRACE	Turkey
PI	321932	B-903	LANDRACE	Turkey
PI	321953	B-925	LANDRACE	Turkey
PI	321978	B-953	LANDRACE	Turkey
PI	321980	B-955	LANDRACE	Turkey
PI	321982	B-957	LANDRACE	Turkey
PI	321986	B-961	LANDRACE	Turkey
PI	321991	B-966	LANDRACE	Turkey
PI	322009	B-987	LANDRACE	Turkey
PI	322014	B-992	LANDRACE	Turkey
PI	322030	B-1008	LANDRACE	Turkey
PI	322195	WC 541	CULTIVATED	India
PI	322199	WC 545	CULTIVATED	India
PI	341270	AK 702	CULTIVAR	Turkey
PI	341289	Evli	LANDRACE	Turkey
PI	341317	Yumusak	LANDRACE	Turkey
PI	341322	Bugday	LANDRACE	Turkey
PI	341326	Bugday	LANDRACE	Turkey
PI	341327	Yerli Kirik	LANDRACE	Turkey
PI	341348	Beyaz Kose	LANDRACE	Turkey
PI	341363	Bugday	LANDRACE	Turkey
PI	341383	Beyaz	LANDRACE	Turkey
PI	341395	Kose Camak	LANDRACE	Turkey
PI	341397	Bugday	LANDRACE	Turkey
PI	341409	Kirik	LANDRACE	Turkey
PI	341427	MIDA	CULTIVAR	Italy
PI	341435	B-240	LANDRACE	Turkey
PI	341452	Kose Eskisehir	LANDRACE	Turkey
PI	341457	Kose Topbas	LANDRACE	Turkey
PI	341464	Kirik	LANDRACE	Turkey
PI	341465	Kirik	LANDRACE	Turkey
PI	341618	Zerun	LANDRACE	Turkey
PI	341623	1137/50	CULTIVATED	Turkey
PI	341626	Sunter	LANDRACE	Turkey
PI	341630	Kirmizi Basak	LANDRACE	Turkey
PI	341658	Kirmizi	LANDRACE	Turkey
PI	341676	Beyaz Tir	LANDRACE	Turkey

Continued next page.

Supplemental Table 1. Continued.

Accession Prefix	Accession number	Name	Status	Origin
PI	341695	Sunter	LANDRACE	Turkey
PI	345056	54-II/8-C	LANDRACE	Yugoslavia
PI	345246	245-VII/6	LANDRACE	Macedonia
PI	345251	250-VII/7	LANDRACE	Macedonia
PI	345255	254-VII/10	LANDRACE	Macedonia
PI	345258	257-VII/11	LANDRACE	Macedonia
PI	345280	279-VII/19	LANDRACE	Macedonia
PI	345281	280-VII/19	LANDRACE	Macedonia
PI	345285	284-VII/21	LANDRACE	Macedonia
PI	345323	323-VII/40	LANDRACE	Macedonia
PI	347220	FAO 26.203	LANDRACE	Iran
PI	349458	1890B	LANDRACE	Switzerland
PI	349485	1247A	LANDRACE	Switzerland
PI	349487	1092C	LANDRACE	Switzerland
PI	351021	69Z2.153/2074A	LANDRACE	Switzerland
PI	351195	Austral 14	CULTIVATED	Australia
PI	351257	NOVI SAD 1439	CULTIVAR	Yugoslavia
PI	351405	Bladette	LANDRACE	Switzerland
PI	351406	P.L.M.	CULTIVAR	France
PI	351493	EXTRA KOLBEN I	CULTIVAR	Sweden
PI	351536	Ottawa 2780 E	CULTIVATED	Canada
PI	351539	REDMAN	CULTIVAR	Canada
PI	351587	ROBERT FORLANI	CULTIVAR	Italy
PI	351595	Chitral	LANDRACE	India
PI	351596	Konya 8 1	CULTIVATED	Turkey
PI	351795	B 20	BREEDING	Switzerland
PI	351813	Ellar	CULTIVATED	Switzerland
PI	351937	CAREST	CULTIVAR	France
PI	351974	LERA	CULTIVAR	Germany
PI	352133	SVALOF 57157	BREEDING	Sweden
PI	352163	St Johann 1376C	LANDRACE	Austria
PI	352188	Mex 21	BREEDING	Mexico
PI	352198	63 R 3154	BREEDING	United States
PI	361850	I BO 1828	BREEDING	Italy
PI	362220	GERMINAL	CULTIVAR	France
PI	362446	III/17-A	LANDRACE	Yugoslavia
PI	362456	III/22-B	LANDRACE	Yugoslavia
PI	362530	V/3-C	LANDRACE	Yugoslavia
PI	362537	V/6-B	LANDRACE	Yugoslavia
PI	362542	VI/1-G	LANDRACE	Yugoslavia
PI	362543	VI/2-A	LANDRACE	Yugoslavia
PI	362545	VI/2-G	LANDRACE	Yugoslavia
PI	362546	VI/3-A	LANDRACE	Yugoslavia
PI	362547	VI/3-B	LANDRACE	Yugoslavia
PI	362548	VI/3-G	LANDRACE	Yugoslavia
PI	362550	VI/4-B	LANDRACE	Yugoslavia
PI	362551	VI/4-C	LANDRACE	Yugoslavia
PI	362552	VI/4-G	LANDRACE	Yugoslavia
PI	362555	VI/6-A	LANDRACE	Yugoslavia
PI	362556	VI/6-B	LANDRACE	Yugoslavia
PI	362557	VI/6-E	LANDRACE	Yugoslavia
PI	362558	VI/6-F	LANDRACE	Yugoslavia
PI	362559	VI/6-G	LANDRACE	Yugoslavia
PI	362561	VI/7-A	LANDRACE	Yugoslavia
PI	362562	VI/7-B	LANDRACE	Yugoslavia
PI	362564	VI/8-A	LANDRACE	Yugoslavia
PI	362566	VI/8-C	LANDRACE	Yugoslavia
PI	362567	VI/8-E	LANDRACE	Yugoslavia
PI	362568	VI/8-F	LANDRACE	Yugoslavia
PI	362569	VI/8-G	LANDRACE	Yugoslavia
PI	362570	VI/8-L	LANDRACE	Yugoslavia
PI	362571	VI/8-X7	LANDRACE	Yugoslavia
PI	362572	VI/9-A	LANDRACE	Yugoslavia
PI	362573	VI/9-B	LANDRACE	Yugoslavia
PI	362576	VI/10-B	LANDRACE	Yugoslavia
PI	362578	VI/10-G	LANDRACE	Yugoslavia
PI	362580	VI/10-X6	LANDRACE	Yugoslavia
PI	362581	VI/11-A	LANDRACE	Yugoslavia
PI	362582	VI/11-B	LANDRACE	Yugoslavia
PI	362583	VI/11-D	LANDRACE	Yugoslavia
PI	362584	VI/11-F	LANDRACE	Yugoslavia
PI	362585	VI/11-G	LANDRACE	Yugoslavia
PI	362595	VII/4-A	LANDRACE	Macedonia
PI	362600	VII/5-B	LANDRACE	Macedonia
PI	362606	VII/6-C	LANDRACE	Macedonia
PI	362687	VIII/17-A	LANDRACE	Bosnia and Herzegovina
PI	362689	VIII/18-A	LANDRACE	Yugoslavia
PI	362693	VIII/21-A	LANDRACE	Yugoslavia

Continued next page.

Supplemental Table 1. Continued.

Accession Prefix	Accession number	Name	Status	Origin
PI	362695	VIII/25-A	LANDRACE	Yugoslavia
PI	362702	VIII/33-B	LANDRACE	Yugoslavia
PI	362706	VIII/37-B	LANDRACE	Yugoslavia
PI	366027	OUEST DESPREZ	CULTIVAR	France
PI	366566	419	LANDRACE	Afghanistan
PI	366971	1378	LANDRACE	Afghanistan
PI	367109	1776	LANDRACE	Afghanistan
PI	368019	651-VI/6	CULTIVATED	Former Yugoslavia
PI	371991	32633–71	LANDRACE	Turkey
PI	371993	32646–71	LANDRACE	Turkey
PI	371994	32648–71	LANDRACE	Turkey
PI	372028	32848–71	LANDRACE	Turkey
PI	372123	AL'BIDUM 3700	CULTIVAR	Russian Federation
PI	372128	SURHAK 5688	CULTIVAR	Tajikistan
PI	372131	SURHAN KOIN	CULTIVAR	Tajikistan
PI	372134	KRASNAJA ZVEZDA	CULTIVAR	Kazakhstan
PI	372145	AMURSKAJA 75	CULTIVAR	Russian Federation
PI	372465	FAO 29.940	LANDRACE	Greece
PI	374540	78/71	LANDRACE	Yugoslavia
PI	374555	93/71	LANDRACE	Yugoslavia
PI	374565	103/71	LANDRACE	Yugoslavia
PI	374567	105/71	LANDRACE	Yugoslavia
PI	374568	106/71	LANDRACE	Yugoslavia
PI	374570	108/71	LANDRACE	Yugoslavia
PI	374576	114/71	LANDRACE	Yugoslavia
PI	374644	182/71	LANDRACE	Macedonia
PI	374670	208/71	LANDRACE	Bosnia and Herzegovina
PI	378298	1570	LANDRACE	Yugoslavia
PI	378315	1588	LANDRACE	Yugoslavia
PI	378316	1589	LANDRACE	Yugoslavia
PI	378322	1595	LANDRACE	Yugoslavia
PI	378324	1597	LANDRACE	Yugoslavia
PI	378329	1602	LANDRACE	Yugoslavia
PI	378338	1612	LANDRACE	Yugoslavia
PI	378350	1624	LANDRACE	Macedonia
PI	378450	1725	LANDRACE	Macedonia
PI	378519	1794	LANDRACE	Macedonia
PI	381952	4	LANDRACE	Iran
PI	382040	117	LANDRACE	Iran
PI	382051	128	LANDRACE	Iran
PI	382059	136	LANDRACE	Iran
PI	386162	KITE	CULTIVAR	Australia
PI	405871	I/37	LANDRACE	Macedonia
PI	413761	JABIRU	CULTIVAR	Australia
PI	414570	FENG JIANG 2	CULTIVAR	China
PI	422432	KIRAC 66	CULTIVAR	Turkey
PI	445712	FAO 51.851	LANDRACE	Nepal
PI	468996	MG 27049	CULTIVATED	Greece
PI	469014	MG 27070	CULTIVATED	Greece
PI	469017	MG 27073	CULTIVATED	Greece
PI	469064	MG 27950	CULTIVATED	Greece
PI	469069	MG 27955	CULTIVATED	Greece
PI	469072	MG 27959	CULTIVATED	Greece
PI	469078	MG 27965	CULTIVATED	Greece
PI	470529	79TK103–543A	LANDRACE	Turkey
PI	470552	79TK108–572E	LANDRACE	Turkey
PI	470553	79TK108–573A	LANDRACE	Turkey
PI	470554	79TK108–573B	LANDRACE	Turkey
PI	470556	79TK108–575B	LANDRACE	Turkey
PI	470560	79TK109–58	LANDRACE	Turkey
PI	470599	79TK113–1080	LANDRACE	Turkey
PI	470677	79TK130–682A	LANDRACE	Turkey
PI	470690	79TK131–705A	LANDRACE	Turkey
PI	476212	SM SELECTION 4	BREEDING	United States
PI	476213	SM SELECTION 11	BREEDING	United States
PI	476214	SM SELECTION 22	BREEDING	United States
PI	483058	TAKARI	CULTIVAR	Australia
PI	483063	QUARRION	CULTIVAR	Australia
PI	491569	SD 2968	BREEDING	United States
PI	502966	CELTIC	CULTIVAR	United States
PI	518595	Datouhuang	CULTIVATED	China
PI	518616	ISOLINE: Rht1 Rht2	BREEDING	United States
PI	518618	ISOLINE: Rht1 rht2	BREEDING	United States
PI	518619	ISOLINE: Rht1 rht2	BREEDING	United States
PI	518620	ISOLINE: Rht1 rht2	BREEDING	United States
PI	518623	ISOLINE: rht1 Rht2	BREEDING	United States
PI	518628	ISOLINE: rht1 rht2	BREEDING	United States
PI	518889	CO 701976	BREEDING	United States

Continued next page.

Supplemental Table 1. Continued.

Accession Prefix	Accession number	Name	Status	Origin
PI	519286	MON 753787	BREEDING	United States
PI	519426	ND 12–21	BREEDING	United States
PI	519470	ND 602	BREEDING	United States
PI	520010	T 5059–4T-1V-1T	BREEDING	Chile
PI	520195	WA 6511	BREEDING	United States
PI	520269	LEAF RUST MONOGENE LINE LR 19 (THATCHER)	GENETIC	Canada
PI	520492	RL 5045	BREEDING	Canada
PI	520536	PF 83142	BREEDING	Brazil
PI	525277	1118	CULTIVATED	Morocco
PI	532902	79TK108–573A-hd1	CULTIVATED	Turkey
PI	532903	79TK108–572–3-hd1	CULTIVATED	Turkey
PI	532908	79TK123–645	CULTIVATED	Turkey
PI	534449	MG 18238	CULTIVATED	Algeria
PI	542586	79TK125–1107, HD7	LANDRACE	Turkey
PI	554114	M83–1591	GENETIC	United States
PI	554142	SC8021V2	BREEDING	Canada
PI	554441	79TK069–387-hd7	LANDRACE	Turkey
PI	554442	79TK069–387-hd8	LANDRACE	Turkey
PI	554456	79TK126–655-hd1	LANDRACE	Turkey
PI	554462	79TK131–702-hd1	LANDRACE	Turkey
PI	554579	79TK130–684-hd15	LANDRACE	Turkey
PI	559531	KM 704–1-90	BREEDING	Czech Republic
PI	559616	84TK601–001.0	LANDRACE	Turkey
PI	559660	ERGET	CULTIVAR	Yugoslavia
PI	559965	Sert	LANDRACE	Turkey
PI	560807	TU86–14–03	LANDRACE	Turkey
PI	560814	Istanbul	LANDRACE	Turkey
PI	560826	TU86–29–02–1	LANDRACE	Turkey
PI	564255	MTRWA 92–149	BREEDING	United States
PI	564256	MTRWA 92–150	BREEDING	United States
PI	564257	MTRWA 92–158	BREEDING	United States
PI	572634	HAR'KOVSKAJA 6	CULTIVAR	Ukraine
PI	572650	GALLIAARAL'SKAJA 3	CULTIVAR	Uzbekistan
PI	572718	I-842	LANDRACE	Nepal
PI	574171	82WTR-14	BREEDING	United States
PI	574173	83SEB61SN	BREEDING	United States
PI	574191	85SEB135ST	BREEDING	United States
PI	574197	83SEB255SN	BREEDING	United States
PI	574218	85SEB196	BREEDING	United States
PI	574232	83SEB255ST	BREEDING	United States
PI	574237	83SEB252SN	BREEDING	United States
PI	574253	90SW-25ST	BREEDING	United States
PI	574257	90SW-34SN	BREEDING	United States
PI	583795	KS93WGRC28	BREEDING	United States
PI	585179	3068	LANDRACE	Turkey
PI	585184	2532	LANDRACE	Turkey
PI	585193	NSGC 5579	CULTIVATED	Turkey
PI	591777	CLEOPATRA 74	CULTIVAR	Mexico
PI	591820	N94L7846	GENETIC	United States
PI	592033	ERITROSPERMUM 5	CULTIVAR	Russian Federation
PI	592039	DIAS 2	CULTIVAR	Russian Federation
PI	592070	YUZHNAYA 12	CULTIVAR	Kazakhstan
PI	620683	3950865	BREEDING	United States
PI	620706	3950727	BREEDING	United States
PI	620707	3950728	BREEDING	United States
PI	620708	3950730	BREEDING	United States
PI	623179	IWA8600743	LANDRACE	Iran
PI	623243	IWA8600988	LANDRACE	Iran
PI	623392	IWA8603209	LANDRACE	Iran
PI	623487	IWA8606101	LANDRACE	Iran
PI	623505	IWA8606148	LANDRACE	Iran
PI	623508	IWA8606151	LANDRACE	Iran
PI	623513	IWA8606183	LANDRACE	Iran
PI	623672	IWA8606623	LANDRACE	Iran
PI	623701	IWA8606686	LANDRACE	Iran
PI	623703	IWA8606704	LANDRACE	Iran
PI	623712	IWA8606739	LANDRACE	Iran
PI	623781	IWA8606949	LANDRACE	Iran
PI	623893	IWA8607353	LANDRACE	Iran
PI	623896	IWA8607357	LANDRACE	Iran
PI	623900	IWA8607370	LANDRACE	Iran
PI	623911	IWA8607386	LANDRACE	Iran
PI	623915	IWA8607391	LANDRACE	Iran
PI	623940	IWA8607428	LANDRACE	Iran
PI	623946	IWA8607438	LANDRACE	Iran
PI	623952	IWA8607445	LANDRACE	Iran
PI	623976	IWA8607473	LANDRACE	Iran
PI	623977	IWA8607483	LANDRACE	Iran

Continued next page.

Supplemental Table 1. Continued.

Accession Prefix	Accession number	Name	Status	Origin
PI	623978	IWA8607485	LANDRACE	Iran
PI	623980	IWA8607499	LANDRACE	Iran
PI	623981	IWA8607502	LANDRACE	Iran
PI	623985	IWA8607510	LANDRACE	Iran
PI	623986	IWA8607511	LANDRACE	Iran
PI	623991	IWA8607517	LANDRACE	Iran
PI	624004	IWA8607537	LANDRACE	Iran
PI	624008	IWA8607545	LANDRACE	Iran
PI	624009	IWA8607547	LANDRACE	Iran
PI	624012	IWA8607554	LANDRACE	Iran
PI	624013	IWA8607556	LANDRACE	Iran
PI	624022	IWA8607569	LANDRACE	Iran
PI	624024	IWA8607572	LANDRACE	Iran
PI	624026	IWA8607575	LANDRACE	Iran
PI	624027	IWA8607576	LANDRACE	Iran
PI	624029	IWA8607579	LANDRACE	Iran
PI	624034	IWA8607586	LANDRACE	Iran
PI	624036	IWA8607588	LANDRACE	Iran
PI	624037	IWA8607589	LANDRACE	Iran
PI	624038	IWA8607592	LANDRACE	Iran
PI	624039	IWA8607594	LANDRACE	Iran
PI	624044	IWA8607601	LANDRACE	Iran
PI	624046	IWA8607603	LANDRACE	Iran
PI	624047	IWA8607604	LANDRACE	Iran
PI	624054	IWA8607616	LANDRACE	Iran
PI	624055	IWA8607618	LANDRACE	Iran
PI	624062	IWA8607627	LANDRACE	Iran
PI	624066	IWA8607631	LANDRACE	Iran
PI	624067	IWA8607632	LANDRACE	Iran
PI	624075	IWA8607647	LANDRACE	Iran
PI	624077	IWA8607650	LANDRACE	Iran
PI	624084	IWA8607659	LANDRACE	Iran
PI	624092	IWA8607671	LANDRACE	Iran
PI	624093	IWA8607672	LANDRACE	Iran
PI	624094	IWA8607673	LANDRACE	Iran
PI	624095	IWA8607674	LANDRACE	Iran
PI	624097	IWA8607680	LANDRACE	Iran
PI	624098	IWA8607681	LANDRACE	Iran
PI	624114	IWA8607700	LANDRACE	Iran
PI	624121	IWA8607710	LANDRACE	Iran
PI	624122	IWA8607711	LANDRACE	Iran
PI	624124	IWA8607715	LANDRACE	Iran
PI	624131	IWA8607730	LANDRACE	Iran
PI	624132	IWA8607731	LANDRACE	Iran
PI	624133	IWA8607733	LANDRACE	Iran
PI	624140	IWA8607746	LANDRACE	Iran
PI	624144	IWA8607766	LANDRACE	Iran
PI	624147	IWA8607778	LANDRACE	Iran
PI	624177	IWA8607842	LANDRACE	Iran
PI	624183	IWA8607849	LANDRACE	Iran
PI	624184	IWA8607850	LANDRACE	Iran
PI	624189	IWA8607855	LANDRACE	Iran
PI	624190	IWA8607856	LANDRACE	Iran
PI	624193	IWA8607865	LANDRACE	Iran
PI	624199	IWA8607872	LANDRACE	Iran
PI	624201	IWA8607876	LANDRACE	Iran
PI	624204	IWA8607882	LANDRACE	Iran
PI	624205	IWA8607883	LANDRACE	Iran
PI	624214	IWA8607894	LANDRACE	Iran
PI	624216	IWA8607901	LANDRACE	Iran
PI	624225	IWA8607918	LANDRACE	Iran
PI	624227	IWA8607920	LANDRACE	Iran
PI	624231	IWA8607933	LANDRACE	Iran
PI	624232	IWA8607934	LANDRACE	Iran
PI	624235	IWA8607940	LANDRACE	Iran
PI	624239	IWA8607948	LANDRACE	Iran
PI	624245	IWA8607954	LANDRACE	Iran
PI	624255	IWA8607964	LANDRACE	Iran
PI	624260	IWA8607978	LANDRACE	Iran
PI	624267	IWA8607986	LANDRACE	Iran
PI	624273	IWA8607994	LANDRACE	Iran
PI	624275	IWA8608002	LANDRACE	Iran
PI	624278	IWA8608006	LANDRACE	Iran
PI	624282	IWA8608010	LANDRACE	Iran
PI	624284	IWA8608012	LANDRACE	Iran
PI	624286	IWA8608014	LANDRACE	Iran
PI	624289	IWA8608029	LANDRACE	Iran
PI	624290	IWA8608030	LANDRACE	Iran

Continued next page.

Supplemental Table 1. Continued.

Accession Prefix	Accession number	Name	Status	Origin
PI	624315	IWA8608123	LANDRACE	Iran
PI	624319	IWA8608130	LANDRACE	Iran
PI	624322	IWA8608135	LANDRACE	Iran
PI	624333	IWA8608172	LANDRACE	Iran
PI	624339	IWA8608192	LANDRACE	Iran
PI	624350	IWA8608222	LANDRACE	Iran
PI	624357	IWA8608230	LANDRACE	Iran
PI	624363	IWA8608238	LANDRACE	Iran
PI	624366	IWA8608242	LANDRACE	Iran
PI	624368	IWA8608245	LANDRACE	Iran
PI	624380	IWA8608265	LANDRACE	Iran
PI	624385	IWA8608271	LANDRACE	Iran
PI	624386	IWA8608274	LANDRACE	Iran
PI	624395	IWA8608286	LANDRACE	Iran
PI	624398	IWA8608293	LANDRACE	Iran
PI	624409	IWA8608307	LANDRACE	Iran
PI	624417	IWA8608317	LANDRACE	Iran
PI	624418	IWA8608318	LANDRACE	Iran
PI	624419	IWA8608321	LANDRACE	Iran
PI	624427	IWA8608330	LANDRACE	Iran
PI	624438	IWA8608354	LANDRACE	Iran
PI	624439	IWA8608355	LANDRACE	Iran
PI	624450	IWA8608375	LANDRACE	Iran
PI	624455	IWA8608382	LANDRACE	Iran
PI	624461	IWA8608395	LANDRACE	Iran
PI	624466	IWA8608404	LANDRACE	Iran
PI	624470	IWA8608411	LANDRACE	Iran
PI	624471	IWA8608412	LANDRACE	Iran
PI	624481	IWA8608426	LANDRACE	Iran
PI	624487	IWA8608435	LANDRACE	Iran
PI	624490	IWA8608438	LANDRACE	Iran
PI	624498	IWA8608447	LANDRACE	Iran
PI	624499	IWA8608448	LANDRACE	Iran
PI	624508	IWA8608460	LANDRACE	Iran
PI	624517	IWA8608470	LANDRACE	Iran
PI	624525	IWA8608481	LANDRACE	Iran
PI	624532	IWA8608489	LANDRACE	Iran
PI	624533	IWA8608491	LANDRACE	Iran
PI	624535	IWA8608498	LANDRACE	Iran
PI	624536	IWA8608499	LANDRACE	Iran
PI	624539	IWA8608502	LANDRACE	Iran
PI	624541	IWA8608506	LANDRACE	Iran
PI	624548	IWA8608515	LANDRACE	Iran
PI	624550	IWA8608520	LANDRACE	Iran
PI	624551	IWA8608521	LANDRACE	Iran
PI	624556	IWA8608532	LANDRACE	Iran
PI	624572	IWA8608550	LANDRACE	Iran
PI	624573	IWA8608551	LANDRACE	Iran
PI	624574	IWA8608554	LANDRACE	Iran
PI	624579	IWA8608570	LANDRACE	Iran
PI	624589	IWA8608593	LANDRACE	Iran
PI	624604	IWA8608650	LANDRACE	Iran
PI	624611	IWA8608670	LANDRACE	Iran
PI	624612	IWA8608672	LANDRACE	Iran
PI	624627	IWA8608703	LANDRACE	Iran
PI	624628	IWA8608706	LANDRACE	Iran
PI	624643	IWA8608728	LANDRACE	Iran
PI	624645	IWA8608734	LANDRACE	Iran
PI	624646	IWA8608737	LANDRACE	Iran
PI	624647	IWA8608742	LANDRACE	Iran
PI	624648	IWA8608743	LANDRACE	Iran
PI	624650	IWA8608745	LANDRACE	Iran
PI	624660	IWA8608762	LANDRACE	Iran
PI	624661	IWA8608763	LANDRACE	Iran
PI	624671	IWA8608778	LANDRACE	Iran
PI	624686	IWA8608802	LANDRACE	Iran
PI	624692	IWA8608810	LANDRACE	Iran
PI	624699	IWA8608819	LANDRACE	Iran
PI	624708	IWA8608830	LANDRACE	Iran
PI	624709	IWA8608831	LANDRACE	Iran
PI	624712	IWA8608837	LANDRACE	Iran
PI	624713	IWA8608838	LANDRACE	Iran
PI	624714	IWA8608839	LANDRACE	Iran
PI	624715	IWA8608840	LANDRACE	Iran
PI	624717	IWA8608845	LANDRACE	Iran
PI	624718	IWA8608846	LANDRACE	Iran
PI	624719	IWA8608847	LANDRACE	Iran
PI	624733	IWA8608867	LANDRACE	Iran

Continued next page.

Supplemental Table 1. Continued.

Accession Prefix	Accession number	Name	Status	Origin
PI	624737	IWA8608871	LANDRACE	Iran
PI	624741	IWA8608876	LANDRACE	Iran
PI	624742	IWA8608877	LANDRACE	Iran
PI	624749	IWA8608887	LANDRACE	Iran
PI	624760	IWA8608904	LANDRACE	Iran
PI	624763	IWA8608909	LANDRACE	Iran
PI	624765	IWA8608911	LANDRACE	Iran
PI	624767	IWA8608915	LANDRACE	Iran
PI	624773	IWA8608923	LANDRACE	Iran
PI	624782	IWA8608938	LANDRACE	Iran
PI	624823	IWA8608992	LANDRACE	Iran
PI	624825	IWA8608994	LANDRACE	Iran
PI	624838	IWA8609012	LANDRACE	Iran
PI	624842	IWA8609016	LANDRACE	Iran
PI	624845	IWA8609019	LANDRACE	Iran
PI	624847	IWA8609021	LANDRACE	Iran
PI	624849	IWA8609023	LANDRACE	Iran
PI	624856	IWA8609030	LANDRACE	Iran
PI	624857	IWA8609031	LANDRACE	Iran
PI	624862	IWA8609037	LANDRACE	Iran
PI	624865	IWA8609040	LANDRACE	Iran
PI	624874	IWA8609053	LANDRACE	Iran
PI	624875	IWA8609055	LANDRACE	Iran
PI	624910	IWA8609110	LANDRACE	Iran
PI	624917	IWA8609127	LANDRACE	Iran
PI	624918	IWA8609128	LANDRACE	Iran
PI	624919	IWA8609130	LANDRACE	Iran
PI	624920	IWA8609142	LANDRACE	Iran
PI	624924	IWA8609151	LANDRACE	Iran
PI	624925	IWA8609153	LANDRACE	Iran
PI	624930	IWA8609159	LANDRACE	Iran
PI	624937	IWA8609192	LANDRACE	Iran
PI	624941	IWA8609200	LANDRACE	Iran
PI	624944	IWA8609206	LANDRACE	Iran
PI	624945	IWA8609207	LANDRACE	Iran
PI	624947	IWA8609213	LANDRACE	Iran
PI	624948	IWA8609219	LANDRACE	Iran
PI	624950	IWA8609223	LANDRACE	Iran
PI	624954	IWA8609227	LANDRACE	Iran
PI	624974	IWA8609292	LANDRACE	Iran
PI	624975	IWA8609294	LANDRACE	Iran
PI	624981	IWA8609320	LANDRACE	Iran
PI	624982	IWA8609321	LANDRACE	Iran
PI	624985	IWA8609327	LANDRACE	Iran
PI	624986	IWA8609330	LANDRACE	Iran
PI	624994	IWA8609377	LANDRACE	Iran
PI	624997	IWA8609382	LANDRACE	Iran
PI	625001	IWA8609408	LANDRACE	Iran
PI	625011	IWA8609428	LANDRACE	Iran
PI	625013	IWA8609430	LANDRACE	Iran
PI	625014	IWA8609431	LANDRACE	Iran
PI	625015	IWA8609434	LANDRACE	Iran
PI	625061	IWA8609564	LANDRACE	Iran
PI	625073	IWA8609596	LANDRACE	Iran
PI	625074	IWA8609598	LANDRACE	Iran
PI	625078	IWA8609603	LANDRACE	Iran
PI	625089	IWA8609634	LANDRACE	Iran
PI	625099	IWA8609651	LANDRACE	Iran
PI	625101	IWA8609654	LANDRACE	Iran
PI	625102	IWA8609655	LANDRACE	Iran
PI	625104	IWA8609658	LANDRACE	Iran
PI	625110	IWA8609669	LANDRACE	Iran
PI	625115	IWA8609678	LANDRACE	Iran
PI	625155	IWA8609841	LANDRACE	Iran
PI	625161	IWA8609892	LANDRACE	Iran
PI	625167	IWA8609949	LANDRACE	Iran
PI	625177	IWA8610135	LANDRACE	Iran
PI	625190	IWA8610305	LANDRACE	Iran
PI	625201	IWA8610375	LANDRACE	Iran
PI	625235	IWA8610470	LANDRACE	Iran
PI	625236	IWA8610477	LANDRACE	Iran
PI	625285	IWA8610627	LANDRACE	Iran
PI	625286	IWA8610628	LANDRACE	Iran
PI	625319	IWA8610799	LANDRACE	Iran
PI	625331	IWA8610830	LANDRACE	Iran
PI	625355	IWA8610937	LANDRACE	Iran
PI	625373	IWA8611014	LANDRACE	Iran
PI	625386	IWA8611037	LANDRACE	Iran

Continued next page.

Supplemental Table 1. Continued.

Accession Prefix	Accession number	Name	Status	Origin
PI	625393	IWA8611071	LANDRACE	Iran
PI	625394	IWA8611077	LANDRACE	Iran
PI	625406	IWA8611100	LANDRACE	Iran
PI	625409	IWA8611104	LANDRACE	Iran
PI	625410	IWA8611105	LANDRACE	Iran
PI	625412	IWA8611108	LANDRACE	Iran
PI	625414	IWA8611111	LANDRACE	Iran
PI	625417	IWA8611114	LANDRACE	Iran
PI	625431	IWA8611143	LANDRACE	Iran
PI	625439	IWA8611166	LANDRACE	Iran
PI	625441	IWA8611172	LANDRACE	Iran
PI	625448	IWA8611222	LANDRACE	Iran
PI	625469	IWA8611309	LANDRACE	Iran
PI	625470	IWA8611325	LANDRACE	Iran
PI	625471	IWA8611326	LANDRACE	Iran
PI	625474	IWA8611333	LANDRACE	Iran
PI	625475	IWA8611334	LANDRACE	Iran
PI	625482	IWA8611365	LANDRACE	Iran
PI	625499	IWA8611439	LANDRACE	Iran
PI	625518	IWA8611518	LANDRACE	Iran
PI	625524	IWA8611542	LANDRACE	Iran
PI	625532	IWA8611582	LANDRACE	Iran
PI	625584	IWA8611788	LANDRACE	Iran
PI	625601	IWA8611834	LANDRACE	Iran
PI	625604	IWA8611839	LANDRACE	Iran
PI	625616	IWA8611863	LANDRACE	Iran
PI	625626	IWA8611896	LANDRACE	Iran
PI	625637	IWA8611956	LANDRACE	Iran
PI	625651	IWA8612006	LANDRACE	Iran
PI	625668	IWA8612062	LANDRACE	Iran
PI	625669	IWA8612064	LANDRACE	Iran
PI	625711	IWA8612167	LANDRACE	Iran
PI	625717	IWA8612175	LANDRACE	Iran
PI	625733	IWA8612213	LANDRACE	Iran
PI	625757	IWA8612278	LANDRACE	Iran
PI	625782	IWA8612378	LANDRACE	Iran
PI	625784	IWA8612380	LANDRACE	Iran
PI	625795	IWA8612417	LANDRACE	Iran
PI	625806	IWA8612431	LANDRACE	Iran
PI	625839	IWA8612071	LANDRACE	Iran
PI	625849	IWA8612568	LANDRACE	Iran
PI	625862	IWA8612605	LANDRACE	Iran
PI	625882	IWA8612663	LANDRACE	Iran
PI	625909	IWA8612777	LANDRACE	Iran
PI	625922	IWA8612822	LANDRACE	Iran
PI	625925	IWA8612829	LANDRACE	Iran
PI	625941	IWA8612919	LANDRACE	Iran
PI	625970	IWA8612990	LANDRACE	Iran
PI	625975	IWA8612997	LANDRACE	Iran
PI	625976	IWA8612998	LANDRACE	Iran
PI	625995	IWA8613036	LANDRACE	Iran
PI	626018	IWA8613079	LANDRACE	Iran
PI	626020	IWA8613086	LANDRACE	Iran
PI	626036	IWA8613117	LANDRACE	Iran
PI	626045	IWA8613136	LANDRACE	Iran
PI	626047	IWA8613138	LANDRACE	Iran
PI	626049	IWA8613143	LANDRACE	Iran
PI	626074	IWA8613183	LANDRACE	Iran
PI	626085	IWA8613197	LANDRACE	Iran
PI	626086	IWA8613198	LANDRACE	Iran
PI	626097	IWA8613214	LANDRACE	Iran
PI	626098	IWA8613215	LANDRACE	Iran
PI	626370	IWA8613682	LANDRACE	Iran
PI	626433	IWA8613912	LANDRACE	Iran
PI	626434	IWA8613913	LANDRACE	Iran
PI	626436	IWA8613933	LANDRACE	Iran
PI	626441	IWA8613955	LANDRACE	Iran
PI	626445	IWA8613964	LANDRACE	Iran
PI	626463	IWA8614005	LANDRACE	Iran
PI	626473	IWA8614054	LANDRACE	Iran
PI	626484	IWA8614083	LANDRACE	Iran
PI	626492	IWA8614119	LANDRACE	Iran
PI	626494	IWA8614122	LANDRACE	Iran
PI	626495	IWA8614123	LANDRACE	Iran
PI	626496	IWA8614124	LANDRACE	Iran
PI	626534	IWA8614208	LANDRACE	Iran
PI	626543	IWA8614253	LANDRACE	Iran
PI	626552	IWA8614281	LANDRACE	Iran
PI	626558	IWA8614289	LANDRACE	Iran
PI	626622	IWA8614463	LANDRACE	Iran

Supplemental Table 2. Accesssions of *Triticum aestivum* var. *aestivum* from the National Small Grains Collection resistant to dwarf bunt disease. Only data for the landrace accessions were included in the analysis presented in the paper.

Accession Prefix	Accession number	Name	Status	Origin
CItr	12249	Sel. 27–11	BREEDING	United States
CItr	15317	FRANKLIN	CULTIVAR	United States
CItr	17247	ID 711004	BREEDING	United States
CItr	17271	WA 5911	BREEDING	United States
CItr	17727	WESTON	CULTIVAR	United States
CItr	17730	ID 77–53–23-B	BREEDING	United States
CItr	17733	ID 74–7/47	BREEDING	United States
CItr	17734	ID 75–55–19	BREEDING	United States
CItr	17838	ID 72–5059	BREEDING	United States
CItr	17841	ID 74–53/18	BREEDING	United States
CItr	17902	WINRIDGE	CULTIVAR	United States
PI	119333	1696	LANDRACE	Turkey
PI	166910	Dimenit	LANDRACE	Turkey
PI	173390	6555	LANDRACE	Turkey
PI	173437	7838	LANDRACE	Turkey
PI	173438	7845	LANDRACE	Turkey
PI	178044	4464	LANDRACE	Turkey
PI	178210	YAYLA 305	CULTIVAR	Turkey
PI	181463	THULE III	CULTIVAR	Sweden
PI	192412	DROTT	CULTIVAR	Sweden
PI	211657	1167	CULTIVATED	Turkey
PI	345099	98-II/25-A	LANDRACE	Yugoslavia
PI	345102	101-II/25-D	LANDRACE	Yugoslavia
PI	345106	105-II/27-A	LANDRACE	Yugoslavia
PI	345222	221-VI/16-A	LANDRACE	Yugoslavia
PI	345426	425-VII/78	LANDRACE	Yugoslavia
PI	345428	427-VII/80	LANDRACE	Yugoslavia
PI	362566	VI/8-C	LANDRACE	Yugoslavia
PI	362572	VI/9-A	LANDRACE	Yugoslavia
PI	362675	VIII/1-A	LANDRACE	Yugoslavia
PI	378329	1602	LANDRACE	Yugoslavia
PI	470390	79TK054–309	LANDRACE	Turkey
PI	470395	79TK058–330	LANDRACE	Turkey
PI	470452	79TK080–219	LANDRACE	Turkey
PI	470464	79TK082–428	LANDRACE	Turkey
PI	470547	79TK107–567	LANDRACE	Turkey
PI	476212	SM SELECTION 4	BREEDING	United States
PI	476213	SM SELECTION 11	BREEDING	United States
PI	476214	SM SELECTION 22	BREEDING	United States
PI	518907	A6324-B-1–39–2-3	BREEDING	United States
PI	518911	A6258-G-5–35–10	BREEDING	United States
PI	518914	A6258-G-8–35–10	BREEDING	United States
PI	518916	A6258-F-9–22–15	BREEDING	United States
PI	518964	M70–1428	BREEDING	United States
PI	542575	M85–22	BREEDING	United States
PI	542576	M85–25	BREEDING	United States
PI	557012	IDAHO 352	BREEDING	United States
PI	560595	TU85–020–01–1	LANDRACE	Turkey
PI	560596	TU85–020–01–2	LANDRACE	Turkey
PI	560599	TU85–024–03–1	LANDRACE	Turkey
PI	560601	TU85–025–04	LANDRACE	Turkey
PI	560602	TU85–025–06–1	LANDRACE	Turkey
PI	560603	TU85–025–06–2	LANDRACE	Turkey
PI	560605	TU85–027–01–2	LANDRACE	Turkey
PI	560685	TU85–078–02–2	LANDRACE	Turkey
PI	560792	TU86–07–01–1	LANDRACE	Turkey
PI	560793	TU86–07–01–2	LANDRACE	Turkey
PI	560795	TU86–07–01–4	LANDRACE	Turkey
PI	560804	TU86–13–08–4	LANDRACE	Turkey
PI	560829	Kislik	LANDRACE	Turkey
PI	560830	TU86–32–02	LANDRACE	Turkey
PI	560831	TU86–33–01	LANDRACE	Turkey
PI	560832	TU86–33–02	LANDRACE	Turkey
PI	560835	Poize	LANDRACE	Turkey
PI	560836	Poize	LANDRACE	Turkey
PI	560838	TU86–41–01–1	LANDRACE	Turkey
PI	560842	TU86–41–01–5	LANDRACE	Turkey
PI	560843	TU86–41–01–6	LANDRACE	Turkey
PI	560844	TU86–42–01–1	LANDRACE	Turkey
PI	560845	TU86–42–01–3	LANDRACE	Turkey
PI	560846	TU86–42–01–4	LANDRACE	Turkey
PI	560847	TU86–42–01–5	LANDRACE	Turkey
PI	560848	TU86–42–01–6	LANDRACE	Turkey
PI	564550	PI192339HF	BREEDING	United States
PI	574234	86WTR-8	BREEDING	United States
PI	586753	WA 7759	BREEDING	United States
PI	620895	IWA8606142	LANDRACE	Iran

Continued next page.

Supplemental Table 2. Continued.

Accession Prefix	Accession number	Name	Status	Origin
PI	620897	IWA8606144	LANDRACE	Iran
PI	620911	IWA8606182	LANDRACE	Iran
PI	620927	IWA8606245	LANDRACE	Iran
PI	620928	IWA8606246	LANDRACE	Iran
PI	620933	IWA8606319	LANDRACE	Iran
PI	620940	IWA8606367	LANDRACE	Iran
PI	620949	IWA8606388	LANDRACE	Iran
PI	620954	IWA8606408	LANDRACE	Iran
PI	620959	IWA8606418	LANDRACE	Iran
PI	621003	IWA8606525	LANDRACE	Iran
PI	621004	IWA8606527	LANDRACE	Iran
PI	621036	IWA8606574	LANDRACE	Iran
PI	621049	IWA8606600	LANDRACE	Iran
PI	621058	IWA8606642	LANDRACE	Iran
PI	621106	IWA8606814	LANDRACE	Iran
PI	621586	IWA8608765	LANDRACE	Iran
PI	621623	IWA8609107	LANDRACE	Iran
PI	621961	IWA8610108	LANDRACE	Iran
PI	622068	IWA8610516	LANDRACE	Iran
PI	622080	IWA8610551	LANDRACE	Iran
PI	622279	IWA8611034	LANDRACE	Iran
PI	622296	IWA8611066	LANDRACE	Iran
PI	622371	IWA8611283	LANDRACE	Iran
PI	622386	IWA8611329	LANDRACE	Iran
PI	622411	IWA8611408	LANDRACE	Iran
PI	622470	IWA8611575	LANDRACE	Iran
PI	622496	IWA8611635	LANDRACE	Iran
PI	622497	IWA8611636	LANDRACE	Iran
PI	622500	IWA8611641	LANDRACE	Iran
PI	622515	IWA8611666	LANDRACE	Iran
PI	622547	IWA8611825	LANDRACE	Iran
PI	622596	IWA8612028	LANDRACE	Iran
PI	622677	IWA8612389	LANDRACE	Iran
PI	622769	IWA8612735	LANDRACE	Iran
PI	622785	IWA8612947	LANDRACE	Iran
PI	622823	IWA8613181	LANDRACE	Iran
PI	622824	IWA8613188	LANDRACE	Iran
PI	622852	IWA8613394	LANDRACE	Iran
PI	622853	IWA8613399	LANDRACE	Iran
PI	622854	IWA8613401	LANDRACE	Iran
PI	622879	IWA8613569	LANDRACE	Iran
PI	622888	IWA8613616	LANDRACE	Iran
PI	622938	IWA8613905	LANDRACE	Iran
PI	622941	IWA8613916	LANDRACE	Iran
PI	622953	IWA8613936	LANDRACE	Iran
PI	622956	IWA8613941	LANDRACE	Iran
PI	622968	IWA8613976	LANDRACE	Iran
PI	622995	IWA8614069	LANDRACE	Iran
PI	622997	IWA8614072	LANDRACE	Iran
PI	623047	IWA8614225	LANDRACE	Iran
PI	623066	IWA8614314	LANDRACE	Iran
PI	626778	IWA8600207	LANDRACE	Iran
PI	626784	IWA8600214	LANDRACE	Iran
PI	626830	IWA8600282	LANDRACE	Iran
PI	627677	IWA8603110	LANDRACE	Iran
PI	627757	IWA8603225	LANDRACE	Iran
PI	636145	PI560603-sel-bco	BREEDING	Turkey
PI	636146	PI560603-sel-bcl	BREEDING	Turkey
PI	636147	PI560603-sel-wclws	BREEDING	Turkey
PI	636148	PI560603-sel-wclrs	BREEDING	Turkey
PI	636149	PI560603-sel-wcors	BREEDING	Turkey
PI	636150	PI560603-sel-wcows	BREEDING	Turkey
PI	636151	PI560603-sel-blaw	BREEDING	Turkey