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Advancing Resilient Agricultural Systems: Adapting to and Mitigating Climate Change

Content will focus on resilience to climate change in agricultural systems, exploring the latest research investigating strategies to adapt to and mitigate climate change. Innovation and imagination backed by good science, as well as diverse voices and perspectives are encouraged. Where are we now and how can we address those challenges? Abstracts must reflect original research, reviews and analyses, datasets, or issues and perspectives related to objectives in the topics below. Authors are expected to review papers in their subject area that are submitted to this virtual issue.

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- Emissions and Sequestration
  - » Strategies for reducing greenhouse gas emissions, sequestering carbon
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  - » Prediction of climate change impacts
  - » Physiological changes
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  - » Threats to soil sustainability (salinization, contamination, degradation, etc.)
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- Strategies for Water and Nutrient Management
  - » Improved cropping systems
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  - » Protecting germplasm and crop wild relatives
  - » Breeding for climate adaptations
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Registration of 'Leduc' Barley

'Leduc' spring barley (*Hordeum vulgare* L.) (Reg. no. CV-260, PI 592799) (CI*Ho* 15852; CN2363) was developed at the Research Station, Agriculture and Agri-Food Canada, Brandon, MB, and registered for sale in Canada in 1982, where the registration number was 2277. It was tested at Brandon as Br.DS4-1 and in the Canadian Western Cooperative Six-Row Barley Registration Trials as BT337.

Leduc was selected at Brandon, MB, in 1974 as an F_4 plant from the cross 'Steptoe'/'Klondike', made in the fall of 1972. A modified bulk breeding method was used. F_3 and F_4 seeds of the cross were carefully selected for size, shape, and freedom from staining due to disease and weathering. F_4 plants were selected for a high level of tillering and absence of leaf disease symptoms. The F_5 nonreplicated plots were selected for yield, uniformity, and clean leaves. Breeder seed was developed from 311 F_7 head selections made in 1977. A true-to-type bulk of head row progeny was sent to the Experimental Farm, Agriculture and Agri-Food Canada, Indian Head, SK, Canada, to continue seed increase of the cultivar. Leduc is a six-rowed spring feed barley with midseason maturity. The spikes are fairly short and moderately dense. The lateral kernels do not overlap at the tip. Kernels are covered, fairly large, wide, and of medium length. The aleurone is yellow. The lemma is not wrinkled but the palea is, slightly. Rachilla hairs are short. There are numerous barbs on lateral veins. The basal marking of the kernel is an incomplete horseshoe depression. Both glume and lemma awns are rough and green tipped. The glume awn is short, about equal to the length of the glume. The dorsal surface of the glume is covered with short hairs. The rachis edge is tapered and glabrous. The lowest internode of the spike is slightly curved.

Leduc is widely adapted across the Canadian prairies (1). During the years 1985 through 1992, between 4.3 and 7.3% of the area sown to barley in Western Canada was in Leduc (205 000 to 313 000 ha yr^{-1}) (2). In spite of its wide adaptation, the major concentration of hectarage has been within about 200 km of Edmonton, AB.

Leduc was tested in replicated trials beginning in 1976. In the 1978–1981 Western Cooperative Six-Row Barley Registration Tests, consisting of 72 yield trials across western Canada, it yielded 97% of the feed check 'Johnston' and matured 2.8 d earlier (51 station years). In these same trials, it had somewhat stronger straw, 3.5 vs. 3.9 on a scale of 1 to 9, where 1 = erect (34 station years). Its test weight was less and its mean kernel weight was greater than those of Johnston, 61.7 vs. 62.3 kg hL^{-1} (57 comparisons) and 42.0 vs. 37.3 mg (56 comparisons), respectively. In these tests, Leduc averaged 74.2 cm in height, 6.7 cm shorter than Johnston (55 station years).

Leduc shows variable reactions to relevant pathogens. It is susceptible to loose smut [caused by *Ustilago tritici* (Pers.) Rostr.; syn. *U. nuda* (Jens.) Rostr.], and moderately resistant to covered smut [caused by *U. hordei* (Pers.) Lagerh.] and false loose smut [caused by *U. avenae* (Pers.) Rostr.; syn. *U. nigra* Tapke]. Leduc is also moderately resistant to barley leaf scald [caused by *Rhynchosporium secalis* (Oudem.) J.J. Davis] and to composite race samples of stem rust (caused by *Puccinia graminis* Pers.: Pers. f. sp. *tritici* Eriks. & E. Henn.) (non Pgt-QCC); it is resistant to stem rust Race R56. Leduc is susceptible to the Winnipeg culture 102 of net blotch (caused by *Pyrenophora teres* Drechs.), resistant to the culture 857 of the same pathogen, and moderately resistant to culture 858. It is susceptible to the Winnipeg culture 692 of septoria leaf blotch (caused by *Septoria passerinii* Sacc.), and, as evidenced by subcrown internode staining, it is moderately susceptible to common root rot [caused by *Cochliobolus sativus* (Ito & Kuribayashi) Drechs. ex Dastur and *Fusarium* spp.].

Breeder seed of Leduc is maintained at the Experimental Farm, Agriculture and Agri-Food Canada, Indian Head, SK S0G 2K0, Canada. Responsibility for distribution of pedigreed seed to growers was given to SeCan Association, 200-57 Auriga Dr., Nepean, ON K2E 8B2, Canada.

R. I. WOLFE,* R. B. IRVINE, AND K. W. CAMPBELL (3)

References and Notes

1. Wolfe, R.I., R.B. Irvine, and K.W. Campbell. 1988. Leduc barley. Can. J. Plant Sci. 68:221–223.
2. Anonymous. Annual. "Prairie Grain Variety Survey" of Prairie Pools Inc., Royal Bank Ctr., 90 Sparks St., Suite 724, Ottawa, ON K1P 5B4, Canada.
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Registration of 'Starling' Barley

Starling (Reg. no. CV-262, PI 591480) six-row winter feed barley (*Hordeum vulgare* L.) was developed by the Virginia Agricultural Experiment Station and released in June 1993. Starling, formerly designated VA 85-44-226, was derived as a selection from a composite of six populations in which CI*Ho* 11550 was used as a parent for tolerance to low pH and Al. Development of the initial populations was completed in 1977, and seed from F_1 plants of these six populations was composited to form a single bulk that was advanced using a modified bulk breeding method. The six populations were (i) CI*Ho* 11550/4/'Harrison'/3/'Cebada Capa'/'Wong'//Awnletted 'Hudson'/5/VA 77-42-35 ('Surry' selection), (ii) CI*Ho* 11550/4/Harrison/3/Cebada Capa/Wong//Awnletted Hudson/5/VA 77-42-37 (Surry selection), (iii) CI*Ho* 11550/Surry//'Monroe', (iv) CI*Ho* 11550/Surry//VA 77-12-39 (CI*Ho* numbers 9623, 9658, 9708, BYDV Res. 'Atlas', each crossed to a Cebada Capa/Wong//Awnletted Hudson selection), (v) CI*Ho* 11550/Surry//VA 76-44-72 ('Jefferson' and Harrison/3/Cebada Capa/Wong//Awnletted Hudson), and (vi) CI*Ho* 11550/5/Harrison/3/Cebada Capa/Wong/2/Awnletted Hudson/4/*3 CI*Ho* 3515 /6/'Henry'. Starling was selected as an F_7 headrow and was named in recognition of the contributions made by Thomas M. Starling to small grains breeding and genetics.

Starling is a medium tall, midseason, six-row barley with compact spikes. Early growth is semiprostrate. Penultimate leaves average 19 cm in length and 16 mm in width, and the distance from the flag leaf to the spike is greater than 10 cm. Starling has spikes that are slightly waxy, dense, and parallel and that frequently have overlapping lateral kernels. Spikes are usually awnless, but occasionally have short, semismooth awns on the central spikelets. At maturity, the neck is straight to gently curved, and the spikes are nodding rather than erect. The rachis is tough and covered with hair; the collar is closed. Glumes are one-third the length of the lemma and have hairs that generally are confined to the band, but occasionally extend to cover the glume. Starling has semismooth glume awns that are equal to the glume in length. Lemmas are yellow at maturity, with few teeth on lateral and marginal nerves, and have a slight crease at the base. Starling has long, covered, white, semiwrinkled kernels, with long-haired rachillas.

Seedlings of Starling are moderately susceptible to powdery mildew (caused by *Puccinia graminis* Pers.:Pers. f. sp. *hordei* Em. Marchal; syn. *Blumeria graminis*) and leaf rust (caused by *Puccinia hordei* G. Otth), while the adult plants are moderately resistant to both pathogens. Starling is resistant to the prevalent pathotypes of

the causal organisms of net blotch (*Pyrenophora teres* Drechs.), scald [*Rhynchosporium secalis* (Oudem.) J.J. Davis], spot blotch [*Cochliobolus sativus* (Ito & Kuribayashi) Drechs. ex Dastur], septoria leaf blotch (*Septoria passerinii* Sacc.), and barley yellow dwarf (BYDV).

Starling has better winter hardiness than 'Nomini', but is not as hardy as 'Wysor'. Spike emergence of Starling is 1 d later than Wysor and 2 d earlier than 'Boone'. Starling is similar to Wysor in plant height and straw strength. Grain yields of Starling in 49 trials conducted in Virginia from 1987 to 1995 averaged 5700 kg ha^{-1}, which is similar to that of Nomini and 10% higher than that of Wysor. Grain volume weight of Starling (595 kg m^{-3}) is similar to that of Nomini, but slightly less than that of Wysor (605 kg m^{-3}).

In the Uniform Winter Barley Yield Nursery consisting of 15 to 20 entries grown in 9 to 11 states, Starling ranked 7th for grain yield in 1989, 2nd in 1990, and 5th in 1991. Starling is adapted throughout Virginia, and generally should perform well in areas where Wysor and Boone have been grown. This cultivar also has performed well in tests conducted in the Coastal Plain and Piedmont regions of North Carolina.

Breeder seed of Starling will be maintained by the Virginia Agricultural Experiment Station under the auspices of the Department of Crop and Soil Environmental Sciences, Virginia Polytechnic Institute and State University, Blacksburg. Authorized seed classes are foundation, registered, and certified. Foundation seed will be produced and distributed by the Virginia Crop Improvement Association via the Foundation Seed Farm, Box 78, Mount Holly, VA 22524. U.S. plant variety protection has been granted for this cultivar.

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References and Notes

1. A.M. Price, C.A. Griffey, W.L. Sisson, and D.E. Brann, Crop and Soil Environmental Sciences Dep., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061. Registration by CSSA. Accepted 29 Feb. 1996. *Corresponding author.

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Registration of 'Callao' Barley

Callao (Reg. no. CV-267, PI 592800) six-row winter feed barley (*Hordeum vulgare* L.) was developed by the Virginia Agricultural Experiment Station and released in March 1994. Callao originated from the cross 'Boone'/'Henry'//'Sussex', which was completed in 1981. Callao was derived in 1987 as an F_7 headrow selection using a modified bulk breeding system.

Callao is a short, early-maturing, six-row winter feed barley with high grain volume weight. Early growth is prostrate, and similar to Boone in this respect. Stems of Callao have straight necks with closed collars. The rachis is covered with hairs, and its basal internode is short and curved. Spikes are nodding, dense, and parallel, with overlapping lateral kernels. Glumes are one-third the length of the lemmas in length, and have long hairs in wide bands. Glume awns are rough and slightly shorter than the glumes in length. Lemma awns are rough and intermediate in length, being longer than those of Boone but shorter than those of 'Pamunkey'. Lemmas have depressed bases and are yellow in color at maturity, with several teeth on lateral and marginal nerves and some hairs along the ventral surface. The covered kernels are white, midlong, and wrinkled, with long-haired rachillas.

In the mid-Atlantic region, Callao is moderately resistant to the prevalent pathotypes of the causal organisms of powdery mildew (*Puccinia graminis* DC. f. sp. *hordei* Em. Marchal; syn. *Blumeria graminis*), net blotch (*Pyrenophora teres* Drechs.), scald [*Rhynchosporium secalis* (Oudem.) J.J. Davis], spot blotch [*Cochliobolus sativus* (Ito & Kuribayashi) Drechs. ex Dastur], septoria leaf blotch (*Septoria passerinii* Sacc.), and barley yellow dwarf (BYDV). Callao is moderately susceptible to leaf rust (caused by *Puccinia hordei* G. Otth) in the seedling stage, but has a moderate level of adult-plant resistance in the field, based on comparisons with susceptible cultivars such as Wysor.

Winter hardiness of Callao is moderate, in that Callao is hardier than Pamunkey but slightly less hardy than Wysor. Winter survival of Callao was similar to the check 'Tennessee Winter' in the 1991–1992 and 1992–1993 USDA-ARS Uniform Barley Winter Hardiness Nurseries. Spike emergence of Callao is very early (Day of Year 105 d), similar to 'Barsoy' in the mid-Atlantic region. Callao heads about 2 d earlier than Nomini and Pamunkey, and 5 to 8 d earlier than 'Starling' and Boone. Plant height of Callao (81 cm) is 8 cm shorter than Barsoy, and 13 to 20 cm shorter than Pamunkey, Starling, Nomini, and Boone. Straw strength of Callao is similar to Boone, but less than that of Barsoy, Nomini, Pamunkey, and Starling. Grain yields of Callao in 27 trials conducted in Virginia from 1991 to 1995 averaged 6075 kg ha^{-1}, which was 11% higher than yields of Boone and 3% lower than Nomini. Callao has an average grain volume weight of 656 kg m^{-3}, which is 6% higher than those of Boone and Nomini.

Callao was evaluated for 3 yr (1992–1994) in the Uniform Winter Barley Yield Nursery. In all 3 yr, Callao ranked 2nd in grain yield, with average yields exceeding the test mean by 8 to 10%. Among the hulled barleys, Callao ranked 1st or 2nd in grain volume weight, with average test weights of 619 to 642 kg m^{-3}. Callao performed well in the mid-Atlantic and southeastern regions, particularly in Virginia, Georgia, North Carolina, South Carolina, Tennessee, and Texas.

Breeder seed of Callao will be maintained by the Virginia Agricultural Experiment Station under the auspices of the Department of Crop and Soil Environmental Sciences, Virginia Polytechnic Institute and State University, Blacksburg. Authorized seed classes are foundation, registered, and certified. Foundation seed will be produced and distributed by the Virginia Crop Improvement Association via the Foundation Seed Farm, Box 78, Mount Holly, VA 22524. Application for U.S. plant variety protection has been made for this cultivar.

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References and Notes

1. A.M. Price, C.A. Griffey, T.M. Starling, W.L. Sisson, and D.E. Brann, Crop and Soil Environmental Sciences Dep., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061. Registration by CSSA. Accepted 31 Mar. 1996. *Corresponding author.

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Registration of 'Pamunkey' Barley

'Pamunkey' (Reg. no. CV-261, PI 583865) six-row winter feed barley (*Hordeum vulgare* L.) was developed by the Virginia Agricultural Experiment Station and released in June 1993. Pamunkey originated from the three-way cross 'Boone'/'Henry'//VA 77-12-41, which was completed in 1977. The parental line VA 77-12-41 was derived from a composite of crosses that consisted of CI*Ho* 9623, CI*Ho* 9658, CI*Ho* 9708, and barley yellow dwarf resistant 'Atlas', each crossed to a 'Cebada Capa'/'Wong'//Awnletted 'Hudson' selection. From the three-way cross, VA 88-11-7 was derived as an F_6 headrow selection using a modified bulk breeding method. Pamunkey was derived as a reselection of VA 88-11-7, which was heterogeneous for awned and awnletted head types. Seed from 300 F_{13} headrows derived from VA 88-11-7 and selected for long awns were planted in 4.2-m^2 plots. Of these, seed from 114 plots that were homogeneous for long awns and similar morphologically and