Ninety years of perennial forage grass breeding for the Canadian prairie provinces

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Abstract. The majority of Canadian beef production takes place in the three prairie provinces of western Canada and seeded pasture and hay land provides a large proportion of the feed for these cattle. This region is characterized by low to moderate rainfall (300-500 mm annually) and extremely cold winters; thus, forage species grown must have high tolerance to cold and drought. Perennial grass breeding for the region began in 1922 and has continued for ninety years in two programs. Major seeded grass species were introduced into Canada from Eurasia. Significant developments from this program include: the development of Fairway crested wheatgrass (*Agropyron cristatum* L.) (1932) which was used to revegetate more than 0.5 million ha of eroded land; the introduction and development of improved cultivars of meadow bromegrass (*Bromus riparius* Rehm.) (1987) which were rapidly adopted by beef producers, making it the most popular grazing species in the prairie provinces; the development of hybrid bromegrass (*B. riparius* X *B. inermis* Leyss.) cultivars (2000) which have become popular dual purpose hay/pasture grasses; and the development of green wheatgrass (*Elymus hoffmanii* K.B. Jensen and K.H. Asay), which is highly tolerant to soil salinity. Recently, there has been increased demand for native Canadian grasses to be used for forage, conservation and reclamation purposes and cultivars or ecological varieties of several species have been released or are under development. Perennial grass cultivars developed in these programs occupy a large portion of the seeded hay and pasture area in the Northern Great Plains region of Canada.

Keywords: perennial grass breeding, cultivar development.

Introduction

Canada's major area of field crop production is found in the three provinces, Manitoba, Saskatchewan and Alberta, located in the Northern Great Plains region of Canada. This area is also where the majority of the country's beef production takes place. Native rangeland and large areas of seeded pasture and hay land provide the majority of feed for these cattle. Forage crops are planted in the Great Plains region either for hay production or grazing. Stands are generally maintained for a minimum of five years, with some stands for grazing in the driest areas being permanent. A small percentage of forage crops are seeded in rotation with annual crops, with the forage stand life being two or three years. The climate of this region is characterized by low to moderate rainfall (300-500 mm), hot, short growing seasons and extremely cold winters: thus, forage grass and legume species used must be winter hardy and drought tolerant. The purpose of this paper is to provide historical information, including major developments, on the two perennial grass breeding programs which have developed most of the cultivars used in this region.

The Programs

Saskatchewan is the central of the three provinces in the Great Plains agricultural area. Perennial forage crop breeding started in the central city of Saskatoon in 1922 with the appointment of L.E. Kirk as a professor at the University of Saskatchewan. In 1931, the Canada Department of Agriculture (now Agriculture and Agri-Food Canada - AAFC) assumed responsibility for forage crop breeding with the establishment of the Dominion Forage Crops Laboratory which, together with other Laboratories, became the Saskatoon Research Centre in the 1950s. Grass breeding was carried out by RP Knowles (1941-1985), S Wright (1986-1993) and B. Coulman (1993- present). In 2005, B Coulman transferred to the University of Saskatchewan, so the grass breeding is now a collaborative program between AAFC and the University. Swift Current is a city in the southwest part of Saskatchewan, the driest area of the province. Initial programs in forage crop breeding began in 1947 by DH Heinrichs and colleagues at the Experimental Farm of AAFC. T. Lawrence was hired in 1954 to work exclusively on grass breeding and his program continued until his retirement in 1989. A reduced introduced grass breeding program was directed by P Jefferson until 2006. More recently, development of ecological varieties of native Canadian grass species has been carried out at this centre by G McLeod and MP Schellenberg.

Species and Breeding Objectives

The majority of the effort in these two programs concentrated on winter hardy, drought tolerant grass species introduced from Europe and Asia. The major species were smooth bromegrass (*Bromus inermis* Leyss.), meadow bromegrass (*Bromus riparius* Rehm.), crested

Table 1. Significant cultivars released from the Saskatoon and Swift Current perennial grass breeding programs.

Species	Cultivar	Year of release	Characteristics or Use
Agropyron cristatum	Fairway	1932	First Canadian cultivar. Used to revegetate large area of eroded land in 1930s.
Bromus inermis	Carlton	1961	High forage and seed yields. Still a widely grown cultivar.
Thinopyrum intermedium	Chief	1961	Improved forage and seed yields. Still a popular cultivar.
Psathyrostachys juncea	Swift	1978	Improved seedling vigor and superior stand establishment.
Bromus riparius	Fleet	1987	Improved seed yield and quality. The most widely used cultivar.
B. riparius X B. inermis	Knowles	2000	First hybrid brome cultivar. High hay and pasture yields.
Elymus hoffmanii	Saltlander	2004	High salinity tolerance with high forage nutritive value.

wheatgrass (*Agropyron cristatum* (L.) Gaertn. and *A. desertorum* (Fisch. ex Link) Schult., intermediate wheatgrass (*Thinopyrum intermedium* (Host) Barkworth and D.R. Dewey), and Russian wildrye (*Psathyrostachys juncea* (Fisch.). Today, these are the major perennial grass species found in most seeded pasture and hay lands across the region. There is an increasing demand for seed of native Canadian grass species for conservation and reclamation plantings. Since the early 1990s, pre-variety germplasm or ecological varieties which are genetically diverse and adapted to the Great Plains region have been developed for seven grass species and more are under development (Coulman *et al.* 2008).

Early breeding involved the evaluation of plant introductions of these species for performance and adaptation. Improved forage yield has been a consistent goal of the programs. Seed yield was also identified as an important breeding goal to insure that there would be adequate seed availability of improved cultivars at a reasonable cost. Selection which resulted in substantially improved seed yield was carried out in intermediate wheatgrass (Knowles 1977), Russian wildrye (McLeod *et al.* 2003) and meadow bromegrass (Knowles 1990a). Although diseases have not been a major issue in perennial grasses in this climate, selection was done to reduce the incidence of leaf spotting diseases in smooth bromegrass (Smith and Knowles 1967, 1973). Slow establishment of stands due to poor seedling vigor has been a major constraint to wider use of Russian wildrye. Seedling vigor was substantially improved in diploid (Lawrence 1979) and tetraploid (Lawrence *et al.* 1990) cultivars of this species. Improved digestibility was a breeding goal in crested wheatgrass (Coulman and Knowles 1974); however, there have been no cultivars released with improved nutritive value. The Canadian prairie region has a large area of moderately to highly saline soils and tall wheatgrass (*Thinopyrum ponticum* (Podp.) Barkworth and D.R. Dewey) was introduced and selected for high salinity tolerance (Lawrence 1967). A cultivar of green wheatgrass, likely a hybrid between quackgrass (*Elytrigia repens* (L.) Desv. Ex Nevski) and bluebunch wheatgrass (*Pseudo-roegneria spicata* (Pursh) A. Love), was selected in the salt-tolerance testing laboratory at Swift Current (Steppuhn *et al.* 2006). This highly saline tolerant grass has superior forage quality to tall wheatgrass. Adaptation to water stress in field nurseries resulted in selection for visibly waxy (glaucous) trait in Altai wildrye (*Leymus angustus* (Trin.) Pilger) (Lawrence *et al.* 1991).

Breeding Methods

Initially, in the Saskatoon program, genotypic selection was used for improvement of smooth and meadow bromegrass and crested wheatgrass. Selection of superior plants was based on the performance of their open-pollinated progenies (Knowles 1955) or polycross progenies (Knowles 1990). Phenotypic selection was also used in the selection of a number of cultivars (Coulman 2006a), usually involving pollination control (*i.e.* only selected plants were interpollinated). Interspecific crosses of meadow and smooth bromegrass produced fertile progeny and following several generations of recurrent selection the first hybrid bromegrass cultivars were released (Coulman 2004, 2006b). These hybrids had high first cut yields like the smooth bromegrass parent, and relatively fast regrowth like the meadow bromegrass parent. DNA markers were used to study the genetic relationships of breeding lines, ecotypes and species of crested wheatgrass (Mellish *et al.* 2002) and smooth bromegrass (Ferdinandez and Coulman 2004); however, these markers have not been used in the selection of new cultivars.

Over the 90 years of perennial grass breeding in these two Saskatchewan programs, a total of 31 cultivars have been released. Some of the cultivars which represented new developments, and/or which have been widely used, are listed in Table 1.

The Future

Over the past 20 years, many Canadian public forage breeding programs have been terminated. Recent funding decisions suggest that the two programs in Saskatchewan will continue into the foreseeable future. With the advances in genomic information and methodology for a number of grass species, it is likely that these techniques will play an increasingly important role in the two breeding programs.

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