# Evolutionary Recurrent Selection Develops Adapted Annual Ryegrass

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# EVOLUTIONARY RECURRENT SELECTION DEVELOPS ADAPTED ANNUAL RYEGRASS

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## Abstract

Seed companies find having their own annual ryegrass breeding program in the southeastern USA, unprofitable. The annual ryegrass breeding program at the University of Florida provides new annual ryegrass (*Lolium multiflorum*) cultivars with disease resistance and adaption. The evolutionary recurrent selection breeding uses large nurseries, roguing of diseased and unthrifty plants and selection of best plants to provide seed for the next generation. Current commercial cultivars developed are named along with some of their characteristics.

**Keywords**: Annual ryegrass; *Lolium multiflorum*, recurrent selection, *Puccinia coronata*.

## Introduction

Over one million hectares of annual ryegrass (*Lolium multiflorum* L.) is grown annually in the southeastern USA. Seed companies need new cultivars to sell, but find breeding these cultivars unprofitable. Southeastern USA (see Figure 1) is a region of mild temperate to subtropical climate that allows growing of annual ryegrass during the cool season from fall through spring. The cool season may vary from September to July in the northern portion and mid October

to mid May in the southern portion. The annual ryegrass breeder is faced with developing cultivars adapted to a wide range of soils and various degrees of winter temperatures.

The seed of ryegrass sold in the Southeast are mostly produced in the Willamette Valley of Western Oregon. The most important diseases of annual ryegrass are crown rust (*Puccinia coronata*) in the Southeast, especially along the Gulf coast, and stem rust (*P. graminis*) in Oregon. Gray leaf spot (*Pyricularia grisea*) and *Helminthosporium* leaf spot (*Dreschslera* spp.) diseases are often present in the Southeast at damaging levels.

For an annual ryegrass cultivar to be successful it must be grown over much of the southeastern ryegrass belt (shown in Figure 1) and make seed successfully in Oregon. This paper has the objective to report the annual ryegrass breeding program at Gainesville, FL which is developing cultivars adapted to the Southeast and Western Oregon and some foreign countries.

## Breeding Methods

Crossing nurseries

Evolutionary recurrent selection (we speed up evolution through our roguing, selection and environment) is practiced on spaced plant nurseries of 6-10,000 plants or larger. Plants for next cycle are selected from units of a grid over nursery. We plant nurseries directly in the field using a Stanhay planter (Stanhay Webb, England) and thin to single plant per hill. We rogue nurseries periodically through the growing season to remove unthrifty and diseased plants, removing 20 to 50% of nursery plants. We plant up to 6 genotypes, each on different rows 2 feet apart in the nursery. One or more genotypes must have demonstrated wide adaptation in the Southeast. We have both diploid and tetraploid nurseries with plant maturities from very early to late. Eight to ten crossing nurseries are planted per season.

We normally have natural epiphytotics of crown rust each season. Rust spreader rows of susceptible perennial ryegrass (L. *perenne*) are planted on outside rows and in rows through the middle of each crossing nursery. The perennial ryegrass does not flower in Florida so it will not cross with the annual ryegrasses. The diseased plants are rogued every 7 to 10, days once a buildup of disease begins. We try to keep inoculum of the disease present in the nursery at all times but rogue the most affected plants present to prevent, disease becoming too severe, thus attacking all plants in the nursery. If this latter event occurs, we select the last plants in each grid unit to get the disease resistant plants to furnish seed for next cycle. In 1998-99 and 1999-00 seasons, we had high incidences of gray leaf spot (GLS) disease in our rust and crossing nurseries. We handled in the same manner as crown rust to try to obtain resistance. Plants in crossing nursery are mown to 4 to 6 inches in height once or twice, as first maturing plants begin to develop seed stalks. This allows plants to reach flowering at the same time and plants of all maturities to intermate. Three to five hundred plants are selected, one or two plants for each area of the grid, over crossing nursery at early flowering by placing a 76 cm tall flag in each selected plant. Selected plants are checked several times to be sure that they continue to be disease free and remain the best plants in a grid unit for both forage and seed production. They are allowed to open pollinate. Equal quantities of seed are harvested from selected plants and composited for next cycle.

It usually takes about four or more cycles of selection in crossing nursery to get adapted and disease resistant plants. Seeds of selected plants from the last Florida nursery are then grown in Oregon. This “prebreeders” field is planted in either a thin-stand or as spaced plants that are rogued for stem rust and other diseases, for unthrifty and poor seed producing plants. Seed from “prebreeder’s” planting are used to plant a “breeder’s” seed field that is rogued similarly to

"prebreeder's" planting. The seed from "breeder's" seed planting is used to plant "foundation" seed fields in Oregon, under their Seed Certification Program. These dual plantings in Florida and Oregon have resulted in plants with good growth in both places.

Contracts are signed with seed companies in Oregon for the growing of "prebreeders" and "breeders" seed, and they are normally given exclusive rights to produce and market seed of the new cultivar. The seed companies are responsible for the testing and evaluation of the new cultivar, using "prebreeders", "breeders" and foundation seed. The State Experimental Stations, in the Southeast including Florida, have ryegrass researchers who evaluate annual ryegrass cultivars. It is this network of testing stations in the Southeast that allows seed companies and ryegrass breeders to properly test and evaluate both new and old ryegrass cultivars.

Rust Nursery

At Gainesville, a crown rust nursery is conducted annually where both old and new ryegrass cultivars are evaluated for resistance to crown rust and other diseases prevalent enough to rate. A crown rust index was developed and is assigned to each genotype after two or more years of testing (Prine, 1995): 0-3 is highly resistant; 3-5 is resistant; 5-7 is susceptible; and 7-10 is highly susceptible to crown rust. Breeders and seed companies can use this rust nursery to evaluate their ryegrass populations for crown rust resistance.

Cold Tolerance

The climate at Gainesville is too warm to make selection progress in cold tolerance. On one occasion a cold resistance North Carolina ecotype, with crown rust susceptibility from North Carolina State University was intercrossed with a Florida experimental population with good crown rust resistance. Crossing nurseries were planted at Gainesville and in North Carolina and seed developed at both locations was used in next selection cycle nurseries. In one season, the

nursery in a North Carolina mountain valley had only 74 plants surviving after a cold period where minimum temperature was -21° C. This cold tolerant material made up 50% of the germplasm in nurseries in the next cycle. Two cycles later the selected plants from Gainesville nursery were released as the cultivar 'Florlina', which has shown good cold tolerance and crown rust resistance. In other cold tolerant trials we have planted nurseries in cooperation with breeders in Oklahoma and Nebraska. This research is underway, but we have not yet gotten the selective cold temperatures that are needed.

Tetraploids

We have planted tetraploids from many sources in our nurseries and developed excellent crown rust resistance. One tetraploid cultivar grown in nurseries at Gainesville and Brownsville, Oregon achieved good forage yields in Southeast and excellent seed production in Oregon. This cultivar 'Big Daddy' is being widely grown in the Southeast. Seed of the sixth cycle of a late-maturing rust-resistant experimental ryegrass population was sent to Deutsche Saatveredung in Germany, where 344 chromosome-doubled seeds were returned to be planted in Florida. After two selection cycles of the composited seed at Gainesville and prebreeder and breeders plantings in Oregon, the doubled population was released as the tetraploid cultivar, 'Jumbo'.

## Cultivars

Named cultivars developed through Florida recurrent selection nurseries are shown in Table 1. Several other possible cultivars are pending and several are still in breeding process. We are carrying all unreleased experimental populations one or two additional cycles in an effort to obtain GLS resistance in these populations.

## References

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**Table 1 -** Currently named annual ryegrass cultivars developed or partially developed though Florida annual ryegrass breeding system.

| Cultivar name (Experimental name) | Seed companies | Seed production started | Cultivar characteristics* |
|---|---|---|---|
| Florida 80 (FL X1984 ER) | CEBECO International Seeds | 1984 | EM, CRR |
| Surrey (FL X1986 LR) | Halsey, OR | 1989 | LM, CRR, SRR, CT |
| Big Daddy (4X) (FL/OR (1994) ARME) | Smith Seed Services Halsey, OR | 1995 | LM, CRR, SRR, GLST |
| Stampede (FL X1995 LR early) | ABT, Olsen Fennel Albany, OR | 1998 | LM, CRR, SRR, CT |
| Natchez (4X) (FL/OR (1994) B-7) | | 1999 | LM, CRR, SRR |
| Fantastic (FL X1995 ER late) | Ampac Seed Company Tangent, OR | 1999 | EM, CRR, SRR |
| Florlina (NC/FL X1997 LR) | Proseeds Marketing Jefferson, OR | 2000 | LM, CRR, SRR, CT |
| Jumbo (4X) (FL X1997 (G) 4X LR) | Smith Seed Services Halsey, OR | 2000 | LM, CRR, SRR, CT, GLST |
| King (FL X1998 (New) MR) | Lewis Seed Company Shedd, OR | 2000 | MM, CRR, SRR |
| Graze-N-Gro (FL X1998 (New) LR) | American Seed Producers Albany, OR | 2000 | LM, CRR, SRR, CT |

*EM, MM and LM = early, mid and late maturity; CRR = crown rust resistance; SRR = stem rust resistance, CT = cold tolerance, and GLST = gray leaf spot tolerance.


**Figure 1 –** Map of USA showing location of annual ryegrass forage production belt in the southeast and seed production of Oregon.