DIRECT SELECTION RESPONSE FOR STEM RUST RESISTANCE IN TALL FESCUE

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ABSTRACT

Resistance to stem rust (caused by *Puccinia graminis* Pers.: Pers. subsp. *graminicola* Z. Urban.) would be beneficial in tall fescue (*Festuca arundinacea* Schreb.). Two cycles of polycross (PX) selection on progenies from thirty-four parent plants (14 forage-types and 20 turf-types) were compared to one cycle of open pollination (OP) followed by one cycle of PX selection using a 2-stage greenhouse screening process. Response from selection was determined from composite half-sib progenies from each cycle. Number of plants with resistant reaction based on pustule type increased from 5 to 54% in the PX forage-type population and from 6 to 50% in the PX turf-types. Overall response from initial OP selection was similar to PX selection, but 78 and 50% of the gain, respectively, occurred in the PX cycle. Results indicated that rapid progress from selection in the greenhouse for stem rust resistance in tall fescue is possible using PX selection.

KEYWORDS

Disease resistance, grass breeding, stem rust, tall fescue.

ACRONYMS

PX, polycross; OP, open pollination; AIT, average infection type.

INTRODUCTION

Tall fescue is an important grass grown for forage and turf in the southeast and midwest regions of the USA and for turf in the mid-Atlantic and west regions of the USA and southern areas of Australia. It ranks third among grasses in number of acres grown for seed in the Willamette Valley of Oregon. Stem rust, first reported on the seed crop in 1987 (Welty and Mellbye, 1989), has increased in economic impact in seed production fields in recent years with fungicides commonly used to control the disease (Pscheidt, 1996). Genetic resistance, however, would provide a more environmentally sound approach to control the disease.

Welty and Barker (1993) surveyed 20 cultivars of tall fescue for resistance to stem rust. None of the cultivars were judged resistant, but there were differences among cultivars for number of plants with a resistant response when inoculated with stem rust. Resistant plants were saved from the survey, and this study reports direct selection response results from two cycles of recurrent selection in controlled environment screening.

MATERIALS AND METHODS

Source plants for this study were selected from among 1,400 plants in a nursery established in 1990 containing 70 plants from each of 20 cultivars (Welty and Barker, 1993). Selection criterion, using procedures described by Welty and Barker (1993), was freedom of any stem rust symptoms during two inoculations on seedlings in a greenhouse and two scoring periods in 1990 after plants were transplanted to the field. Thirty-four plants had resistant reactions in both greenhouse inoculations and in field scoring. Plants with resistant reaction were divided into two populations based on the intended use of the cultivar from which they came. Twenty plants were placed in a turf-type population with plants coming from the cultivars Arid (6 plants), Mesa (6 plants), Thoroughbred (4 plants), Finelawn I (2 plants), Finelawn 5GL (1 plant), and Adventure (1 plant), and fourteen plants in a forage-type population coming from the cultivars Kentucky 31 (10 plants), Forager (3 plants), and Johnstone (1 plant).

Both populations were developed simultaneously through two selection cycles in the same way (Fig. 1). Ten vegetative cuttings (ramets) were collected from each selected plant and established in isolated polycross (PX) blocks. Open pollinated (OP) seed from the resistant plants in the original nursery was also harvested. This seed could have been pollinated with pollen from either resistant or susceptible plants so selection was only on the maternal side. OP selection is often practiced by commercial breeders because onset of stem rust in the field is often delayed until after pollination. Two cycles of PX selection were compared to one cycle of OP selection followed by one cycle of among and within family PX bidirectional selection for susceptibility or resistance.

Following an establishment year, seed was harvested from each plant and composited by maternal line. Sixty seedlings from each maternal line were screened through two inoculations with stem rust spores in the greenhouse (Welty and Barker, 1993). Maternal family lines with the lowest average infection type score were selected and individual plants within families chosen based on freedom of any stem rust symptoms in both inoculations. Three plants were saved from each of seven lines for the turf-type population and from five lines for the forage-type. The second cycle of OP selection included reverse selection for susceptibility to stem rust. Selected plants for all populations were divided into ten ramets each and established in isolated crossing blocks in the field.

Equal quantities of seed from each plant in the isolated crossing block were composited to form the populations used to determine response from selection. Selection progress was measured on ten plants in each of twelve replications and was tested by the two-stage inoculation procedure in the greenhouse. Disease infection type was scored by classes as described by Welty and Barker (1993) with 0 = no macroscopic sign of infection and 4 = large uredinia and abundant sporulation. Average infection type (AIT) was computed for each entry (not all data presented) and the frequency (%) of individual plants with a zero score in both inoculations was determined. Realized gain was calculated as the difference in frequency of plants with resistant reaction between two successive selection cycles, e.g., $\Delta G = C_1 - C_0$.

RESULTS AND DISCUSSION

Number of plants with resistant reaction in both inoculations based on pustule type increased from 5 (AIT = 3.3) to 54% (AIT = 1.1) in the PX forage-type population and from 6 (AIT = 3.1) to 50% (AIT = 1.2) in the PX turf-types (Table 1). The first cycle of PX selection produced 73 and 89% of the realized gain in the two populations, respectively. Overall response from initial OP selection was similar to PX selection, but 78 and 50% of the realized gain, respectively, was made in the PX cycle. Reverse selection for susceptibility caused all resistant plants to be lost in only one cycle of selection. This demonstrates how rapidly realized gains could be lost when utilizing natural field populations of rust for screening in a year with low stem rust pressure.

Results indicated that rapid progress from selection in the greenhouse for stem rust resistance in tall fescue is possible, but most of the additive genetic variance was used after one cycle of PX selection and genetic improvement will be slower in future cycles. Resistance may be easily lost if control of the pollen parent is not restricted to resistant plants. Welty and Barker (1993) demonstrated that resistance detected in the greenhouse is maintained under field conditions. Hence, it is more important to control the pollen parent by selecting at the seedling growth stage under controlled conditions than to select mature plants in the field.

Among check cultivars included, frequency of plants with resistant reaction in both inoculations ranged from 0 to 11% and AIT from 2.9 to 3.7 (Table 1). All cultivars we have tested in this and other studies using this inoculation procedure were classified as susceptible and had less than 11% plants that were judged resistant (data not shown). The PX cycle 2 resistant populations were prepared to provide sources of resistance to stem rust that will be useful in developing improved cultivars. These germplasms were designated ORTFRR-T94 for the turf-type population and ORTFRR-F94 for the forage-type. Seed of ORTFRR-T94 and ORTFRR-F94 will be stored by the USDA-ARS National Forage Seed Production Research Center and limited quantities of each germplasm made available upon written request.

REFERENCES

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Table 1

Frequency (%) of individual tall fescue plants with stem rust resistant reaction for each cycle of selection and for check cultivars in both of two inoculations.

Population/selection method	Selection cycle C_0	C_1	C_2
Forage-types			
Polycross (PX)	5 b[z]	41 d	54 de
Open pollination, “resistant” (OPr)	5 b	18 c	63 e
Open pollination, “susceptible” (OPs)	5 b	18 c	1 a
Turf-types			
Polycross (PX)	6 a	45 c	50 c
Open pollination, “resistant” (OPr)	6 a	25 b	44 c
Open pollination, “susceptible” (OPs)	6 a	25 b	5 a
Check cultivars		AIT	
Kentucky 31	11	2.9	
Arid	8	3.1	
Mesa	5	3.0	
Thoroughbred	4	3.3	
Bonanza	2	3.3	
Forager	2	3.4	
AU Triumph	0	3.7	

[z]Values followed by the same letter have average infection type (AIT) scores (data not presented) that are not significantly different, $LSD_{(0.05)} = 0.3$.

Figure 1

Diagrammatic representation for development of tall fescue populations through two cycles of selection (C_0 to C_2) for stem rust. Each of the turf-type and forage-type populations were developed in the same way in reference to their origin. Open pollinated (OP) and isolated polycross (PX) populations, including bidirectional selection for susceptibility (PXs) and resistance (PXr), are represented.