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Development of Kentucky bluegrass for non-burn seed production

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ABSTRACT

A ban on burning of post-harvest grass seed residue has been implemented in Washington and Idaho and restrictions are in place in Oregon, USA. Without residue burning, Kentucky bluegrass (*Poa pratensis* L.) seed yield decreases over time. Growers have implemented yearly mechanical residue removal (raking and baling) and shorter rotations to maintain adequate seed yield; however, this practice is economically less viable to growers and is potentially harmful to the environment. The goal of this study is to develop turf-type bluegrasses that will maintain seed yield over several years without post-harvest burning. This long-term study began in 1994 at Pullman, WA with the evaluation of 228 Plant Introduction (PI) accessions from the USDA-ARS Kentucky bluegrass germplasm collection and the development of a core collection based on 17 agronomic characteristics using Ward's cluster analysis. In a 3-year residue management and turfgrass quality study of the core, PI accessions that had both high seed yield without burning and good turf quality were identified. This germplasm underwent further selection for two years in a space-plant nursery to identify within accession variation. Seed was obtained from four plants of each accession with the highest seed yield, seed weight, seed per panicle, and panicles per unit area. Seed from the original population (USDA-ARS germplasm collection) were also included. Seed were grown in flats in a greenhouse and plants were transplanted into a seed increase nursery in September 2004, at Central Ferry, WA. This material (eight accessions and two commercial cultivars x five selection parameters x 100 plants per parameter) was harvested June 2006 and is currently being evaluated in on-farm seed production and turfgrass trials at several locations in eastern Washington. Ultimately, turf-type Kentucky bluegrasses that can be grown for several years without burning will be released.

Key words: open-field burning, *Poa pratensis L.*, post-harvest residue removal, turfgrass

INTRODUCTION

A ban on open-field burning of post-harvest residue of grass grown for forage or turfgrass seed has been implemented in Washington State and Idaho and restrictions are in place in Oregon, USA. Previous research has shown that without post-harvest residue burning, Kentucky bluegrass seed yield decreased over time (Johnson et al., 2003). This has forced growers to use mechanical post-harvest residue removal (raking and baling) and shorter rotations to maintain economically viable seed yields. Also, the practice of shorter rotations is environmentally unsound compared to long-term cropping, as it requires increased fertilizer and pesticide inputs and causes soil erosion.

The objectives of this research were to: 1) evaluate the phenotypic diversity in Kentucky bluegrass germplasm with a wide genetic base, 2) determine seed production capacity of diverse germplasm in burn and alternative residue management systems while evaluating for turfgrass potential, 3) assess the within variation in agronomic attributes of selected PI accessions and then select individual plants of each accession for high seed weight, seed per panicle, panicles per unit area, and overall seed yield, and 4) determine the selection response by testing the resulting selections for seed yield and turfgrass quality (current ongoing objective).

MATERIALS AND METHODS

Diversity evaluation of the USDA-ARS Kentucky bluegrass collection.
In 1994, at the Turfgrass Research Area at Pullman, WA, a Kentucky bluegrass nursery was planted using 228 PI accessions from the USDA-ARS Western Regional Plant Introduction Station Kentucky bluegrass collection and 17 commercial cultivar "checks". Bluegrass was planted in 1-m rows in a randomized complete-block (RCB) experimental design with three replications. The accessions were characterized for 17 agronomic parameters during 1994 and 1995 (Nelson, 1996). PI accessions were differentiated using an agronomic core according to Ward's method as executed by PROC CLUSTER, option Ward's (cluster analysis using unweighted pair-group method using arithmetic averages) (SAS Institute, 1985).

Utilization of the agronomic core in residue management and turf trials.
In September 1996, the agronomic core of 20 PI accessions, 16 "free picks" (non-core accessions that had high seed yield and appeared to have turf potential), and nine commercial cultivars were established. The plots were 1.2 m x 6.4 m in a RCB with three replications. Also, in September 1996, separate adjacent turfgrass evaluation plots, 1.2 m x 1.5 m, were established at 25 g plot^{-1} in a RCB with three replications. Turf plots were managed and evaluated according to criteria developed by the National Turfgrass Evaluation Program (NTEP). In fall 1997, seed production plots were subdivided by residue management treatments of open-field burning, raking and baling, and no residue removal. Residue management treatments were again applied fall 1998 and 1999 and seed were harvested in 1998, 1999, and 2000.

Selection within accessions for diversity in seed yield components.
Based on the above research, core accessions having high seed yield without burning (raking

and baling) and good turfgrass quality were selected for further study. A space-plant nursery was planted with a total of 10 entries (eight PI accessions and two commercial cultivars); 28 plants per entry in a RCB with three replications. Individual space plants were harvested in 2002 and 2003. Panicles were counted, threshed, seed was cleaned, counted, and the weight recorded. Based on the data, 100 seed were obtained from four selected plants of each accession. The selection parameters were: 1) plant with highest seed yield, 2) plant with highest seed weight, 3) plant with highest seed per panicle, 4) plant with highest panicles per unit area, and 5) remnant seed from the USDA-ARS Kentucky bluegrass collection.

Seed increase nursery.
One hundred seed of each selected plant and 100 seed from the original USDA-ARS Kentucky bluegrass population for each accession were germinated in vermiculite and individual plants of each accession x selection parameter were established in flats in a greenhouse. In October 2004, the plants were established in a seed increase nursery at Central Ferry, WA. The seed increase nursery consisted of 5000 plants (eight accessions and two commercial cultivars x five selection parameters x 100 plants). The 100 plants of each accession or commercial cultivar x selection parameter were planted in two, 15.2-m rows in a non-replicated block design. In June 2006, plots were swathed, material was placed into cloth bags, air dried, threshed, cleaned with a M2-B seed cleaner, seed was debearded, and weighed.

Seed production and turfgrass trials.
To evaluate turfgrass quality, in August 2006, a NTEP-type trial was established with the 50 entries in a RCB with three replications at the Turfgrass and Agronomy Research Area at Pullman, WA. Individual plot size was 1.5 m x 1.5 m seeded at 11 g m^{-2}. Seed production plots were established in April 2007 at two sites in eastern Washington. Fifty entries were planted in a RCB with three replications. Individual plots consisted of seven, 2-m rows with 35-cm-row spacing. Seeding rate was 5.6 kg ha^{-1}.

RESULTS

Diversity evaluation of the USDA-ARS Kentucky bluegrass collection.
A core collection subset was generated by cluster analysis of the agronomic data from all 245 genotypes (Johnston et al., 1997; Nelson, 1996). Twenty-two clusters were developed (two were later eliminated due to poor seed yield) and one representative accession from each cluster was chosen at random to constitute the core collection. This core represents seven countries and approximately 10% of the 228 accessions studied (Johnston and Johnson, 2000). Core collections of 5 to 10% of the accessions in a collection have been suggested as sufficient to represent the majority of genetic diversity in the entire collection (Casler, 1995; Kouame and Quesenberry, 1993). The core collection, nine commercial cultivars checks from diverse morphological grouping (Murphy, 1990), and 17 non-core selections based on turfgrass potential and seed yield were chosen for further study.

Utilization of the agronomic core in residue management and turf trials.
Compared with burn treatments, yield was reduced 27% when residue was mechanically removed from plots and 63% when residue was retained (Johnson et al., 2003). Higher yield was promoted by a long heading-to-anthesis period, a relatively short anthesis-to-harvest

period, and an early harvest date (maturity). Although both seed per panicle and panicles m^{-2} were positively correlated with yield, lower yield with non-burn residue management was closely associated with panicles m^{-2} (Table 1). Turf quality was negatively correlated with yield. However, panicles m^{-2} were not significantly correlated with turf quality, so indirect selection for yield in genotypes with high panicles m^{-2} should have minimal impact on turf quality.

Table 1. *Correlation between turf quality and seed yield factors at Pullman, WA during 1998 and 1999.*

	Turf quality	Biomass	Yield	Harvest index	Weight $seed^{-1}$	Seed $panicle^{-1}$	Panicles m^{-2}
Texture[1]	-0.33*	0.32*	0.37*	-0.12ns	-0.20ns	0.30ns	0.25ns
Color[2]	0.67**	-0.56**	-0.40*	0.43**	0.23ns	-0.56**	-0.17ns
Quality[3]	-----	-0.53**	-0.48**	0.22ns	0.15ns	-0.55**	-0.26ns
Yield	-0.48**	0.84**	-----	0.12ns	0.05ns	0.76**	0.66**

[1]Leaf texture was rated 1 to 9; 9 = fine.
[2]Genetic color was rated 1 to 9; 9 = dark green.
[3]Turfgrass quality was rated 1 to 9; 9 = excellent.

Selection within accessions for diversity in seed yield components.
To determine the within accession variability, seed yield components and seed yield data were obtained on 840 space plants at Pullman, WA [10 entries (eight PI accessions and two commercial cultivars), 28 plants per entry with three replications] harvested in 2002 and 2003 (Johnston, 2004). The data were analyzed for 1000 seed weight, seed per panicle, panicles m^{-2}, and seed yield (g cm^{-2}). There was considerable variation among and within accessions and we were able to identify the highest contributing single plant within each accession or check for each parameter.

Seed increase nursery.
Seed production at Central Ferry, WA was poor in 2005 due to the late fall planting in 2004. In June 2006, plots were evaluated for seed head height, blade texture, color, uniformity of heads, turf potential, and date of harvest (non-replicated data not presented). Seed was harvested in June 2006 and ample clean seed was obtained for field trials for seed production and turfgrass quality.

Seed production and turfgrass trials.
A turfgrass evaluation trial was established at Pullman, WA in August 2006. Seed production trials were established April 2007 at two on-farm sites in eastern Washington. Currently, limited data is available.

SUMMARY

The goal of this long-term project, begun in 1994, is to develop Kentucky bluegrasses that can produce acceptable seed yield over several harvests without open-field burning of post-harvest residue. To accomplish this goal, the USDA-ARS Kentucky bluegrass collection of 228 PI accessions (along with 17 commercial cultivars) was evaluated for diversity based on 17 agronomic factors and a core collection was developed using Ward's cluster analysis. The core collection, 16 non-core accessions chosen for high seed yield and good turfgrass potential, and nine commercial cultivars were evaluated for several years in residue management and turf trials. Germplasm with high seed yield without burning (residue removed by raking and baling) and good turf quality was identified. This germplasm was evaluated for two years in a space-plant nursery and variation within accessions was identified for seed yield components (seed weight, seed per panicle, panicles m^{-2}, and seed yield). So, the potential exists for plant selection and enhancement in Kentucky bluegrass germplasm. Seed increase was completed on the selected germplasm to obtain sufficient seed for on-farm seed production and turfgrass trials, which were established in April 2007 and August 2006, respectfully. This research is expected to lead to Kentucky bluegrasses cultivars that do not require post-harvest open-field burning to maintain productivity.

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