PROGRESS REPORT #10

November 1993

Improvement of *Poa annua* for Golf Turf

The University of Minnesota

Department of Horticultural Science

Project: Biology and Utilization of Turfgrasses

and

The United States Golf Association

Cooperating

PERSONNEL

Principal Investigator:	Dr. Donald B. White Professor Dept. of Horticultural Science University of Minnesota
Cooperators:	Dr. Peter Ascher Professor Dept. of Horticultural Science University of Minnesota
	Mr. Howard Kaerwer Research Director, Retired Northrup King Co., Inc.
	Mr. Paul Johnson Graduate Assistant Dept. of Horticultural Science University of Minnesota
	Dr. Peter Velguth Dept. of Horticultural Science University of Minnesota
	Mr. Alex Ellram Graduate Assistant Dept. of Horticultural Science University of Minnesota
	Mr. Van Cline Graduate Student Dept. of Horticultural Science University of Minnesota

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II INTRODUCTION

The following is a report of the research conducted under the project: "Improvement of *Poa annua* for Golf Turf" during the 1992 -1993 year. The activities pursued during the year are summarized and offered in outline form. More detail is available upon request.

We continued, in 1993, to shift and increase emphasis toward seed production along with evaluation of the 5 prime selections identified for possible introduction as varieties. Some of these materials have also been selected for use as parents. In addition the crossing program, DNA analysis, and research into the genetic mechanisms associated with flowering were continued.

III EVALUATIONS

A. NEW COLLECTIONS

Approximately 250 new *Poa annua* collections, including at least 18 of which are diploid (2n=14 chromosomes) types which were collected from several golf courses in Minnesota. The 2n=14 plants exhibit wide variation in flowering habit, but all appear to be sterile. Most are characterized by dwarf growth habit, dark green color, and very fine texture while exhibiting variation in vigor. These materials have been propagated by stolons because of sterility and lack of seed production. In addition 10 seeds reported to be *Poa infirma* were received and planted in pots for investigation and to multiply seed numbers.

B. SEEDED GOLF COURSE EVALUATIONS

1. San Diego Country Club, Chula Vista, CA., MR. Gary Dalton, Superintendent

This planting was initiated in 1992 and was evaluated at the end of January 1993. All of the selections performed well in this trial which was maintained at 1/8" height of cut. All exhibited a dark green color, excellent density, texture and general quality. One selection (117) was invaded with a severe algae infestation during establishment but appeared to be recovering well. #42, #184, and # 208 were evaluated slightly above #117 and #234.

2. "The Country Club" Brookline, MA, Mr. Bill Spence, Superintendent

This experimental planting was initiated in June of 1992 and was evaluated on 18 October 1993. Golf course personnel reported that all of the selections overwintered well and that #208, #184, and #42 maintained good color over the winter while #117 and 234 lost some of their green color. All the selections performed well in this trial with #208, # 42 and #184 somewhat superior to #234 and #117 over the season. The observation was that # 208 performed slightly better than the others during mid-summer. #42, #184, and #208 all exhibited well developed root growth throughout the 6" sand profile.

3. Oswego Country Club, Oswego, OR. Mr. Dick Fluter, Superintendent.

This planting was established in the spring of 1993. Observations indicated over the phone correspond to those at other sites with all performing well in general quality. #42, #184, and # 208 were indicated as exhibiting superior ratings when compared to the other selections.

4. University of Minnesota Field Reseach Area

Seasonal observations of the selections in Minnesota, were much the same as the 1992 evaluations. During midsummer, 42, 117, 184, and 208 performed very well, presenting excellent texture, color and general quality characteristics. Color in the fall showed more differences. 184 presented the best color at this time along with fine texture and excellent density. 42, 208, and 234 ranked next and 117 turned off color to light green. This indicates the need for more evaluation of 117. Otherwise, performance, to date, of all of the materials at all sites, indicates work toward introduction should continue as a very high priority.

Seed was also allocated to establish seeded plantings that are to be maintained under golf course conditions. Each of the five *Poa annua* selections was seeded in 6' by 16' foot plots on the University of Minnesota field research area for subsequent stimp meter trials. To minimize the possibility of contamination from background poa, the surface layer of soil was steam-sterilized just prior to seeding. This planting is still in the establishment phase and should be available for use in the Spring of 1994. All selections have performed well during establishment

C. PROGENY TESTING

Initial planting of several new selections from the 1992 space planting were seeded on 9/17/93 at the St. Paul Field research facility. These materials are the result of the planned crossing program. This planting will be evaluated under golf green height and management conditions on native soil. Germination of these materials ranged from 5 to 14 days and materials appear to be well on their way to establishment at the time of this report.

Table 1, Pedigrees of Seeded Materials From Planned Crosses Established in 1993 Experimental Planting - St. Paul*

42 x 117 - F3	117 x 184 - F3
42 x 184 - F3	42 x 661 - F3
42 x 1832 - F4	184 x 117 - F3
208 x 117/117 - F3	184 x 234 - F4
184 S3	117 x 184 - F3

Table 2, Pedigrees of Seeded Materials and Mixtures Established in 1993 Experimental Planting - St. Paul*

208 + 42	42 + 184
208 + 42 + 184	42
42 + 117	184
208 + 184	208

*Seed plantings from crosses and of mixtures were replicated three times in a randomized block design.

There were 2250 accessions established in a space planting at the University of Minnesota for evaluation of individual characteristics, plant type and heritability of selected traits.

D. CONTROLLED CROSSES

Twenty five new, controlled, crosses were executed in 1993 to evaluate the value of the advanced selections as parents and to produce seed for further evaluation in the F2 (segregating) generation.

E. NEW SELECTIONS

Several new materials continue to exhibit characteristics that mark them as candidates for the next cycle of breeding. One is an S3 (third generation self) of one of our *Poa supina*s (PS56-S3) which produced uniform, dark green, fine textured progeny. It is interesting to note here that the first *Poa supina* materials in the project were self incompatible. Another new material is the result of an interspecific cross between *Poa annua* and *Poa supina* , PS79XPA19F. This cross resulted in progeny that segragated for dark green color, vigor and rugged habit of growth which may have fairway applications. Both of these show promise and present interesting opportunities and indicate the potential value of interspecific crosses to the project.

IV SEED AND SEEDLING OBSERVATIONS

A. SEEDLING VIGOR

Observations continue to indicate that plantings of the selections established from seed are more vigorous and productive than plantings established from sod. This seedling vigor may be one of the most important characteristics in the success of *Poa annua* at becoming established . A seeding of approximately 1 pound per 1,000 square feet appears to be adequate for establishment of the materials.

B. SEED DORMANCY AND GERMINATION

Variation continues to be observed in germination of many of the materials in the project. Germination observations indicate that an after ripening treatment is required to overcome seed dormancy in several of the selections. Recent experiments with our selections show benefit from a preplanting vernalization treatment. This was particularly true with #184, and #117. Dormancy was overcome by imbibing the seed for eight hours and subjecting it to 4 degrees C vernalization exposure for about 7 - 10 days. The requirement is exhibited most strongly in #117 and #184. Otherwise, the dormancy or after ripening requirements were fulfilled after 7 months in refrigerated storage. More research into this phenomena is indicated.

V. SEED INCREASE

A. BREEDER'S SEED TRIAL (1992)

1. OREGON

A breeder's seed production trial for increase was planted at Pickseed West in late October and early November of 1992. Because of limitations on the space available, one pound of seed each of numbers 42, 184, 208 and 234 was planted. It was determined that selection # 117 needed further evaluation because of variation in performance and flowering characteristics and was not included for those reasons.

Seed was harvested in July 1993, dried, and processed by Pickseed personnel. Specific data has not as yet been received, however it was indicated informally that about 5 pounds of seed were harvested from each of these selections. This seed harvest did not result in the amount of seed expected. Unfortunately there is no way for us to evaluate the reasons for this first hand because we were unable to be there during harvest time. The seed was harvested in July, apparently after much of the seed had ripened and substantial shattering had taken place. This not only precluded seed production data, but also, as one would expect, resulted in low seed yeilds compared to what we know these materials will produce. Additionally, this is the second year that a mistake has resulted in limited data on #234. This is unfortunate, however under the circumstances, we had no control over the situation. Fortunately a good supply of seed is still available from last years' harvest for a new breeders seed planting.

In addition, the initial (1991) seed increase field trial near Tangent, Oregon, under Pickseed West's supervision was maintained for continued evaluation of the limitations on the length of time a field might be maintained in production . The planting consisted of separate blocks of #42, #117, #184, #208 and #234,

As expected, more than one cycle of seed trials will be needed to produce enough seed for management trials and for completing "Breeder's" seed needs in preparation for production of foundation seed. Plans are for this seeding to be accomplished this fall, however negotiations are continuing at this time for this planting.

2. ST. PAUL

a. In St. Paul, seed was collected from a small planting established 1992 for use in establishing small plantings for early evaluation of these materials. Seed was bulked from F3 and F4 generation families that were phenotypically uniform and sown in the field in 3' x 3' plots to be maintained at greens height.

b. In addition a planting of one of the second cycle selections (1930) which possesses a thick, dark green, curly leaf was established vegetatively. However, #1930 produced no seed in the field. It appears that flowering as well as fertility in this selection are regulated by other mechanisms as well as temperature and photoperiod. Inheritance of the "curly" characteristic is of interest not only because of the habit but also the thickness of leaf structure and predicted wear tolerance. If flowering and fertility can be unravelled, this material could be a productive and interesting parent.

c. Seed harvested from crossing blocks composed of the four genotypes, ie 42, 184, 208, and 234 was used to establish additional small plot for turf evaluations.

d. In addition, seed from varying materials collected in earlier years of the project were combined and sown in a separate planting in the field research area to preserve their germ plasm and maintain the variability represented for continuing use in the breeding and selection program.

VI BREEDING AND GENETICS

A. RECURRENT SELECTION PROGRAM

Propagation of selected plants was recently initiated in an effort to establis a recurrent selection program and to take better advantage of the germ plasm pool that has been built up under this project. A number of superior individual *Poa annua* types have been identified in the breeding - collection - selection program. Currently, project research is focused on utilizing these selections as parents in directed crosses to combine specific characteristics in progeny. Another objective that could be productive would be aimed at improving the population in general by recurrent selection as compared to producing improved individuals. This becomes possible only when a sufficient number of superior types are available for combining.We realize that a program of this nature is employed primarily with cross pollinated crops or in selfed materials where male sterility is found. Although neither of these phenomena are prominent in the poa materials, both do occur to a limited degree. The project reported here is at the point where there is sufficient germ plasm with desireable characteristics that it might be useful to evaluate the potential for such an effort.

In order to be successful, the program is designed to maximize crossing opportunities and generate estimates of crossing or selfing in these populations being researched. This program is also expected to produce some genetic combinations that will be valuable as parent material in future crossing operations as well improving the incidence of desireable characteristics in the population. All of the genotypes included were identified as possessing some superior characteristic(s), including color and flowering habit and were combined in crossing blocks on the University of Minnesota Horticultural field research area.

The proposed procedure assumes establishment of optimal conditions for crossing and includes 1) first generation seed; 2) progeny evaluation (space planting) and identification-selection of materials; 3) second generation seed; 4) progeny evaluation and identification-selection of materials; 5) estimations of cross pollination; and 6) evaluation of ability to compare the new population and calculate gain or progress toward broadening the base of our breeding materials.

B. *POA INFIRMA*

Ten seeds reported to be of *Poa infirma* were obtained with the purpose of incorporating this species into the breeding program. This is on the basis that *Poa infirma* along with *Poa supina* are the evolutionary parents of *Poa annua*. Five of the seeds were planted in individual pots in the greenhouse. The resulting plants resembled most closely the annual type of *Poa annua*, produced a seed crop and died.

However, during the flowering period some of the flowers were allowed to self while others were encouraged to cross with # 184, # 117, and #234. Seed was collected and some was sown to ascertain progeny variation. Several crosses were apparently successful. A small amount of seed, in the range of 100 seeds will be planted along with a few of the original seed for further evaluation.

C. FLOWERING

Research continues to investigate the variation into the inheritance of flowering habit in *Poa annua*. In the wild (on golf courses) and in the literature, it has the reputation for continuous flowering during the growing season and having and of having no photoperiod or cold requirements. However many of the perennial genotypes in our program exhibit definit seasonal flowering characteristics (spring only). Others flower more indescriminately.

The objective of this research is to characterize the inheritance of flowering habit in *Poa annua* in order to develop strategies for breeding for controlled flowering .

The literature reports *Poa annua* as a day-neutral plant and there is no mention of a vernalization requirement for flower induction and development (Hutchinson & Seymour, 1982; and other references). However, it is apparent that, in our perennial selections, flowering habit and requirements differ. As reported in the 1992 annual report, evaluations of parental material, F1, F2, and F3 populations suggest that the inheritance of flowering habit in poa annua fits the genetic model of being controlled by one simply inherited gene. Examination of segregating F2 and F3 progeny reveal a ratio of 3:1, continuous to seasonal flowering habit.

However, recent experiments have revealed that it is, as expected, not so simple and that the photoperiod and cold induction requirements vary substantially between the 5 genotypes under evaluation for introduction .

Initially photoperiod responses were assessed by growing seedlings of the five genotypes under short day (8h) and long days (20h) conditions. Results are indicated below in Table 3. Results from further investigations are indicated in Table 4.

Table 3. Response of 5 Selected *Poa annua* selections to Differing Photoperiod.

Genotype	Response
42	(Seasonal) Unaffected by photoperiod
208	(Seasonal) Unaffected by photoperiod
117	(Seasonal) SD induction indicated, little LD affect
184	(Seasonal) Marginally induced by both LD & SD; SD appeared to have more affect than LD
234	(continuous) induced by LD, marginally induced by SD

Recent research has resulted in our ability to overcome some of the impediments associated with artificial induction which has enabled cold induction under artificial (controlled) conditions. Results indicate that approximately 12 weeks of vernalization are required for flower induction where vernalization is a requirement. No differences were observed between LD and SD treatments during the vernalization treatments.

Table 4. Summary of Photoperiod and Vernalization* Flowering Requirements of Selected Perennial Poa annua Genotypes

Genotype	Requirements
42	Essentially day-nuetral (DN); but vernalization appears to hasten or otherwise enhances floral induction.
117	Short-days (SD) induce flowering; Vernalization enhances induction. Flowering is inhibited by long-days (LD).
184	Vernalization is required for floral induction. Floral development is favored by LD and somewhat inhibited by SD.
234	LD required for induction. There is no response to vernalization either by induction or enhancement of flowering.
2283**	Day-neutral; no vernalization affects

*Vernalization conditions are 3-5C. Short Day = an 8 hour photoperiod.
Long day = 8 hour day + a 2 hour incandescent night light break.
** 2283 is an annual - continuous flowering type

The genetic system and variation described fit well with the high heritability and rapid evolution that has been reported for plant type in *Poa annua*. It also reveals other mechanisms for isolation of genotypes within the species and limitations to cross pollination in nature between the group requiring vernalization and the long day requiring genotypes.

Flowering requirements of *Poa annua* L. Paul G. Johnson and Donald B. White
(A summary from the poster presented at the 1993 American Society of Agronomy annual meetings.)

Significant variation in cold and photoperiod flowering requirements among *Poa annua* genotypes exists. Cold induction requirements in perennial types range from less than eight weeks to approximately 11 weeks. Annual types show little if any cold induction. There is genotypic variation in the cold response therefore more than one gene is likely involved. Photoperiod does not appear critical during the cold induction phase, but does influence floral initiation and/or development. Long days (16 hours) are always favorable for floral development, while in some genotypes, day-neutrality holds. Short days (8 hours) may inhibit floral development in some genotypes. For breeding purposes in our program, selection for cold induction requirement and long day photoperiodicity is preferred.

VII. GIBBERELLIC ACID (GA3) AFFECT ON FLOWERING

Gibberelic acid (GA) has been effective in replacing flower induction requirements in some species. Preliminary experiments were conducted comparing the effects of GA 3 with Ancymidol (a known GA inhibitor). Gibberelic acid increased internode length on all of the genotypes indicating that the chemical was absorbed and active in the plants. Flowering was accellerated by GA treatments. Ancymidol; treatments delayed flowering, as expected.

One of the undesireable characteristics associated with *Poa annua* is a prolific flush of flowering during the spring. It is also well known that removing flowers by mowing is generally not successful because flowers are borne below the normal cutting height and are difficult to cut by greens mowers. On the basis of GA effects on internode elongation, a preliminary experiment was conducted on two genotypes with three concentrations of GA applied on three different dates to ascertain if GA3 might be used to enhance internode elongation when *Poa annua* was flowering. If effective, it could facilitate easy removal of the flower heads by the greens mower.

Results indicate that timely applications of gibberelic acid (GA3) to mowed *Poa annua* turf can effectively enhance elongation of flowering culms to the point that most of the flowers can be removed in one mowing. The most effective timing was associated with peak flower production which resulted in almost complete removal of flowers with little or no new flower formation. Because of some discoloration associated with some treatments, further research is indicated and will be initiated during the spring of 1994.

VIII. CYTOLOGY - DNA ANALYSIS

A. POA INFIRMA

As indicated above plants were grown from seed purported to be *Poa infirma (2n=14)*. Samples were collected for determination of DNA content and comparison with the other plant materials in the project. DNA content for *Poa infirma* has been reported to be greater than that of *Poa supina* (Bennett & Smith, 1976). Although Bennett's estimates were obtained by a different technique the expected relative values for *Poa annua*, *Poa infirma*, and *Poa supina* could be predicted for the techniques employed in our experiment.

Interestingly, all of the accessions that were thought to be *Poa infirma* exhibited a DNA content consistent with *Poa annua.* At this point, it appears that we received a truely annual type of *Poa annua* rather than *Poa infirma.* We plan to continue to evaluate the progeny generated to date and grow plants from the 5 remaining seeds from the original source. In addition we will continue to try to acquire seed of this species from other sources.

B. STOMATAL ACCESSORY CELL LENGTH & PLOIDY

Correlation between stomatal accessory cell length and ploidy level were reported by Tan & Dunn in1973 and Speckman, Post, & Dijkstra in 1965. This could be a rapid technique for evaluating ploidy levels in Poa annua if the correlation existed. On that basis preliminary experiments were conducted with the prime selection in the project. Results of the analysis of variance showed significant differences between ploidy levels. However, the amount of overlap between stomata cell length of individuals in each ploidy level prevented unequivocal attribution of all plants of unknown ploidy level to the correct ploidy class. Only 68% of the variation in stomatal cell length could be accounted for by chromosome number.

C. RELATIVE FREQUENCY OF DIPLOID AND TETRAPLOID *POA ANNUA* PLANTS IN GOLF COURSE POPULATIONS

Earlier studies documented the occurrence of diploid (2n=2x=14) and tetraploid (2n=4x=28) *Poa annua* in breeding populations. The smaller stature of diploid *P. annua* together with different cultural practices (particularly close mowing height) of the greens compared to fairway and rough prompted the hypothesis that management may favor diploids on the green compared to fairway and rough environments. Experiments were conducted to investigate this hypothesis by characterizing ploidy level variation in plants collected directly from the green, fairway and rough. Overall results indicated 24% of the samples collected from the green were diploid, while no diploids occurred in the fairway or rough. These data are consistent with the hypothesis that the cultural conditions of the green allow expression of diploid genotypes. It appears that diploid types are a relatively common occurrence, and prompts questions about the origin and adaptability of diploid types compared to the tetraploid.

The primary objective of this experiment is to characterize the ploidy level variation of *P. annua* in golf turf. This objective is based on the knowledge that there is an association between ploidy level and plant morphological attributes together with the hypothesis that the green environment may select or favor more diminutive diploid plants over larger tetraploid plants due to the short mowing height on greens.

Samples were collected from greens, fairways, and roughs from two golf courses in Minnesota; Interlachen Country Club and Edina Country Club. Plants were selected first by random selection of holes to be sampled. Plant material was prepared for flow cytometric analysis largely according to Keeler et al. (1987).

The DNA content of plants analyzed in the current experiment fell into two distinct distributions. The correlation between chromosome number and DNA content from our earlier analysis, together with the two distinct distributions found in the current experiment allow us to conclude that the low DNA individuals (range 2.03 to 2.28 pg per 2C nucleus) are diploid and the high DNA individuals (range 3.90 to 4.74 pg per 2C nucleus) are tetraploid.

Diploids were found only on greens. Of the ten holes which were sampled, six showed diploids on greens. Of the total of 50 plants sampled from greens, 12, or 24% were diploid. All others were tetraploid. All samples from all holes from fairway and rough environments were tetraploid. A statistical analysis (Table 1) was accomplished after collapsing across fairway and rough environments, since the frequency of diploid and tetraploid plants was equal. Analysis shows that the frequency of each ploidy level are not independent of environment.

Table 1. Frequency of diploid and tetraploid plants for plants from the green versus fairway and rough combined. The null hypothesis of independence of ploidy and environment is rejected (Pearson's Chi square= 26.09; P= 0.0000 or Yates' corrected Chi square= 22.93; P= 0.0000).

	Diploid	Tetraploid	Totals
Green	12	38	50
Fairway + Rough	0	100	100
Total	12	138	150

Our hypothesis that there could be a greater frequency of diploid *P. annua* on greens compared to the other two environments is supported. It remains to be determined whether mowing height or other differences in management of the green compared to the other environments are responsible for the apparent selection for diploid genotypes. The frequency of diploids found on greens and the lack of them in the other environments leads to interesting questions concerning the diploids. What is the origin of the diploids? How well adapted are the diploids compared to the tetraploids? Four diploid plants on hand before this experiment began were identified as perennial and sterile. Future breeding work with the diploids is limited because of this sterility.

Acknowledgements

Thanks are extended to the USGA for funding this research; to superintendent John Ketterheinrich and staff at Interlachen Country Club and Bill Johnson and staff at Edina Country Club for permission in obtaining samples from the golf courses. We also wish to thank Mike Hupke, Immunobiology, University of Minnesota, for running our samples on the flow cytometer.

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X PLANS FOR 1993-94

A. The first priority for the project is to proceed with and complete negotiations for exclusive licensing one or more of the selections for production and sale of seed.

B. Along with A above the highest priority is focused on the increase of Breeder's Seed to be applied to the production of foundation seed for subsequent use in production of certified seed.

C. Imbedded in A nd B above are all of the research, characterization of materials and other operations that accompany naming, registration, trade marking and PVP

D. Initiate reseach to determine optimum seed harvest timing

E. Continue the research into the inheritance of flowering for ultimate application in the breeding program.

F. Expand backcrossing program and including reciprocal backcrossin.

G. Complete flow cytometry research and integrate technique into the program.

H. Follow through on research aimed at the easy removal of *Poa annua* flowers from greens turf in the spring.

I. Expand the field evaluations by installing larger plantings and increasing the number of sites around the country. This might also be the appropriate time to incorporate an overseeding trial in one of the southern states.

J. Maintain all of the program materials and continue progeny evaluation and the crossing program.

K. Increase seed and evaluation of the promising materials in the program

Respectfully Submitted

Donald B. White, Professor
Turfgrass Science

I EXECUTIVE SUMMARY

IMPROVEMENT OF *Poa annua reptans* FOR GOLF TURF #10, 1993
UNIVERSITY OF MINNESOTA

Field evaluations of the five prime selections continued at the San Diego CC, Chula Vista, CA; "The Country Club", Brookline, MA.; Oswego CC, Oswego, OR.; and were expanded at the University of Minnesota. Mowing height varied from 1/8" to 1/2". Evaluations at all locations indicate that all selections contine to produce excellent turf. #42, #184, and #208 received the highest ratings at all locations. All overwintered well at all locations. Approximately 250 new accessions were added to the program. Twenty two (22) of these are diploid (2N=14 chromosomes) while the rest were normal tetraploid (2N=28) types. Some of the diploids produced flowers; all to date are sterile. Purported *Poa infirma* seed were acquired for crossing with *Poa supina* and *P. annua*. Subsequent growth and DNA analysis indicate that the material is probably an annual type of *Poa annua*. Crosses were completed to several selections and selfed seed was also collected for further evaluation. Seeded plots of progeny from crosses: 42x117(F3; 42x184(F30; 42x1832(F4); 208x117/117(F3); 117x184(F3); 42x661(F3); 184x117(F3); & 184x234(F4) were initiated along with mixtures of #208, #42, 184, & 117. 2250 accessions were evaluated in the field space planting. 25 new crosses were executed for combining desireable characteristics. New materials with promise include 1 *Poa supina* (PS56-S3) which produces uniform, fine textured & dark green progeny. Interspecific crosses of *P. supina X P. annua* produced dark green, vigorous, rugged progeny. Flow cytometry has enabled us to conduct the large number of chromosome evaluations and identification of the 14 chromosome types. The 14 chromome *P. annua* plants are all fine textured and dense, with dark green color. Investigations at several golf courses reveal that up to 24% of the of *P. annua* samples collected from greens were 2N=14 chromosome types. No 14 chromosome types were found on either fairways or roughs. Low height of cut and other greens management foster the diploid types. Observations continue to support findings that seeded plantings are superior to sodded plantings. Variation in seed dormancy was observed. Experiments showed that seed of #184, #493, & #117 require a pre-planting, moist, cold treatment of 7 - 14 days to overcome dormancy. Otherwise 7-8 months in seed storage is required. Preliminary research indicated that inheritance of flowering habit acted like a simple, 1 gene inheritance system Recent research indicate a more complicated model. Some *P. annua* types exhibit no flowering requirements, and contrary to the literature, some respond to photoperiod, and some types require cold induction, others respond to both photoperiod and cold. Experiments with gibberelic acid (GA) show that it enhances internode length. Preliminary work revealed that a timely GA treatment can enable removal of all flower heads with one mowing. This could change the way we manage *P. annua* on existing greens. Seed production operations continued at Pick Seed West in Tangent, Oregon. We now have enough seed to expand the field evaluation operations with larger plots and more sites. We have seed ready to plant to produce Breeder's seed that, hopefully, would be sufficient for planting foundation seed next year. Negotiations are still underway to make final arrangements for this planting. Negotiations also continue toward releasing the best materials to a commercial seed company for marketing the first seed by 1996 or 1997.