AN ABSTRACT OF THE THESIS OF

VICTOR ANDREW GIBEAULT for the DOCTOR OF PHILOSOPHY
(Name) (Degree)

in FARM CROPS presented on December 14, 1970
(Major) (Date)

Title: PERENNIALITY IN POA ANNUA L.

Abstract approved: Signature redacted for privacy.
Norman Goetze

Experiments were conducted to determine identification methods that could be used to differentiate annual and perennial plant types within the species *Poa annua* L. Thereafter, *Poa annua* plants were collected from numerous turfed areas in three Northern Pacific Coastal regions and identified as annual or perennial biotypes.

It was found that annual growth forms were characterized by lower leaf and node numbers, lower secondary tiller numbers, and lower adventitious root numbers. The annuals also reached reproductive maturity quicker than the perennials and had a greater percentage of flowering tillers at the completion of the test.

Morphological characteristics that were not useful included blade length and width, ligule length, culm length, inflorescence characteristics, primary tiller number, shoot and root dry weight, and seminal root number.

An examination of seed characteristics showed a post harvest dormancy requirement in annual *Poa annua*. Seed from perennial types

germinated immediately following harvest.

Poa annua plants collected from numerous turfed locations were identified as annual or perennial biotypes based on the above differences. It was found that in excess of 50 percent of the samples exhibited perennial characteristics and that both types were quite evenly distributed throughout Oregon and Western Washington. Results showed that the perennials were most often collected from areas that received moderate or intensive supplemental irrigation. The annuals predominated in non-irrigated golf course roughs.

Descriptive botanical literature on variation in *Poa annua* indicated that the subspecies taxonomic designation would be appropriate to distinguish between the annual and perennial types. It was suggested that all annuals be classified in the subspecies *annua* and the perennials in subspecies *reptans*.

Perenniality in *Poa annua* L.

by

Victor Andrew Gibeault

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Doctor of Philosophy

June 1971

APPROVED:

Signature redacted for privacy.

Professor of Farm Crops
in charge of major

Signature redacted for privacy.

Head of Department of Farm Crops

Signature redacted for privacy.

Dean of Graduate School

Date thesis is presented December 14, 1970

Typed by Donna L. Olson for Victor Andrew Gibeault

Prelude

By observing the seasonal behavior of grass, one touches on the grand rhythm of natural events. With a grassy lawn at our dooryard there is not only respite from the tension and press of the city, but instruction in biological cause and effect. Watching grass respond to soil and season may be, for city people, a last link to the solace and understanding our vanishing wilderness once gave.

(Schery, p. 2)

ACKNOWLEDGEMENTS

To my wife, Katherine, and my parents, Mr. and Mrs. Victor Gibeault, for their continued encouragement;

To Dr. R. C. Wakefield and Dr. C. R. Skogley, Department of Agronomy and Mechanized Agriculture, University of Rhode Island, for their wise counsel through the Bachelor and Master of Science degrees;

To Drs. R. Frakes, T. Jackson, O. Lee and R. Bogart, Oregon State University, for participation on my graduate committee and their suggestions thererelating;

And to Dr. N. Goetze, major professor, constructive critic, and friend;

I wish to extend my most sincere appreciation.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PERENNIALITY IN *POA ANNUA* L.

I. INTRODUCTION

Because of recent technological and economic growth, the American public has been afforded many hours of leisure time to enjoy the "fruits of labor." One of the beneficial results of free time plus affluence has been a tremendous increase in recreation and the supporting facilities as well as an increased awareness of the total environment. Aesthetic and useable turfgrass areas play an important role in both of these leisure-oriented interests. In addition to total turfgrass acreage increase, a new awareness of optimum quality turf has developed, especially on areas such as golf courses, athletic fields, bowling greens, lawn tennis courts, etc.

The quality of a turfgrass stand is based on color, textural uniformity and wearability of the chosen species or mixture of species used as plant cover. Any management practice that detracts from this uniformity is undesirable. Likewise, the activity of any pest, whether it be disease, insect, nematode or weed, that decreases turf quality is also undesirable. Research and subsequent education have helped solve mis-management practices; the introduction of pesticides have solved many of the biological problems.

Annual bluegrass (*Poa annua* L.) is a turfgrass weed that has not been controlled by cultural or chemical methods. Its light green color, constand seedhead production, shallow root system, disease, smog and high temperature susceptibility, supposed annual life cycle, and widespread distribution leave ornamental and functional swards with a spotty or scarred appearance. Because of these characteristics Poa annua is one of the most widespread and troublesome weeds of well maintained turfgrass areas and efforts to effect its control have been numerous.

The most recent and potentially successful control method has been based on the use of preemergent herbicides. Since annual bluegrass is thought to die during summer stress conditions, pass through summer months as seed, and germinate the following autumn, an application of a preemergent herbicide at the proper time should give effective control. Unfortunately, only moderate success has been noted under field conditions. One possible explanation for this negative response could be due to the presence of perennial plant types within the Poa annua species.

The objectives of this study were: first, to determine if perennial growth forms have been described in the world floras; second, to evaluate primarily morphological characteristics that could be used to differentiate the annual and perennial plant types; and third, to determine if perennial plant types are present in turf sward in the Northern Pacific Coastal areas.

II. LITERATURE REVIEW

In an examination of early garden and lawn literature, Rohde (65) related that the first lawns were imitations of natural meadows and were often interspersed with numerous wild flowers. Lawn areas were used for cover on walkways and as a setting for homes. In addition to grass, camomile (Anthemis nobilis L.), a low growing herb, was extensively cultivated. With the introduction of the lawn mower in 1830 by Edwin Budding (20) and subsequent increase in lawn size, grasses assumed dominance because of their fine texture and ability to withstand close cutting.

When the English colonists settled the United States, they brought with them their love of gardens and lawns. Even in the earliest settlements, public squares and plazas were set aside for community use (72). The first city park in a major metropolitan area was established in New York in 1853.

As leisure time increased for many Americans in the twentieth century, sports and the associated playing facilities took on increased importance (8). Also, turf was widely used in airports, cemeteries, campuses, highways, churches and industrial grounds. The management of turfgrass increased from the back lawn and occasional town square to what is now a four billion dollar annual business in this country (61).

The incidence of plant pests in turfed areas has increased markedly because of the evolution of a monoculture system distributed over a wide area and the more intensive use of fertilizer, irrigation and close mowing. Fortunately, new pesticides have kept pace with many potentially widespread problems. Grassy weeds such as tall fescue (*Festuca arundinacea* Schreb.), velvetgrass (*Holcus lanatus* L.) and annual bluegrass (*Poa annua* L.), however, have resisted effective selective control measures. *Poa annua* is now considered to be the most important turfgrass weed.

Poa annua Control

Early control methods for *Poa annua* were based on the concept of competition. Wright (83) suggested that if an *Agrostis* spp. putting green contained less than 40 percent annual bluegrass it should be maintained as a bentgrass green. Ferguson (28) noted that greens should be fertilized when *Poa annua* is weakest in comparison to bentgrass; that greens should be irrigated intensely but infrequently to favor the deeper rooted desired species; that compaction should be alleviated; and that care should be taken to avoid injury from diseases and insects. Successful elimination of *Poa annua* has been obtained (58) with yearly overseeding of Seaside creeping bentgrass (*Agrostis palustris* Huds.). Schery (67) contended that the correct choice of turfgrass varieties was the best competitive control for *Poa annua*.

Unfortunately, with increased play on sports areas and more intense management practices required, control of annual bluegrass through competition has not been totally effective.

Sprague and Burton (70) and Ferguson (30) reported that *Poa annua* is adversely affected when growing in a soil with a low pH whereas bentgrasses grow vigorously under this condition. The Sports Turf Research Institute in England currently suggests that bentgrass turf be maintained at a low pH by using acid forming fertilizer to reduce the incidence of *Poa annua* and other weeds and diseases. Kentucky bluegrass (*Poa pratensis* L.), however, produces poor growth in acid soils. Since it is the major species used for turfed areas in the northern, cool, humid region of the United States, this cultural method cannot be practiced.

Numerous herbicides have been evaluated for the control of annual bluegrass in turfed areas. DeFrance and Kollett (21) examined several copper compounds and noted fair control of the weed. Moderate to objectionable turfgrass discoloration was evident. Over a four year period, Engel (23) obtained a 62 percent reduction of *Poa annua* and a 55 percent increase in colonial bentgrass with endothal[1] with slight injury to colonial bentgrass (*Agrostis tenuis* Sibth).

[1] Chemical names of all herbicides mentioned are listed in Appendix Table 1.

In turf areas where annual bluegrass predominates, efforts have been made to produce an acceptable stand by reducing or eliminating seedhead production. Escritt (25) examined maleic hydrazide, a growth regulator, on mixed turfgrass swards in England and noted a considerable reduction in *Poa annua* seedhead production. The percent *Poa annua* decreased over time in treated plots. Unacceptable discoloration was observed in Chewings red fescue (*Festuca rubra* L.), colonial bentgrass, perennial ryegrass (*Lolium perenne* L.), crested dogstail (*Cynosurus cristatus* L.), Kentucky bluegrass and *Poa trivialis* L. Engel (23) reported similar results on bentgrasses.

Welton and Carroll (82) first used lead arsenate as a herbicide in turfgrass to selectively eliminate crabgrass (*Digitaria* spp.). Daniel (18), Madden (55), and Engel (24) found that various arsenic materials were effective toxicants capable of removing *Poa annua* from Kentucky bluegrass and colonial bentgrass. Daniel suggested that arsenic activity was inversely related to soil phosphorus levels. Moderate to severe injury to colonial bentgrass has been observed with calcium arsenate, lead arsenate and sodium arsenite (18, 23, 24). Difficulty in overseeding following arsenical applications has been recorded (32).

Following the introduction of pre-emergent herbicides for crabgrass control in turf, several investigators examined their effectiveness against annual bluegrass. Schwabauer (68), in a greenhouse study, found that diphenamid, bensulide and trifluralin were effective. Goss (33) reported that good pre-emergent control was obtained under greenhouse conditions with DCPA, DMPA, dipropalin, trifluralin and bensulide. Gibeault (32) observed that, in addition to DCPA, trifluralin and bensulide, the herbicide benefin effectively controlled Poa annua that was artificially introduced into weed free sea-marsh turf (Agrostis palustris and Festuca rubra). Injury to established Poa annua in Seaside creeping bentgrass and Highland colonial bentgrass golf greens was noted by Neidlinger (59) following bensulide application. Juska and Hanson (48) found that Poa annua control was reduced when DCPA, DMPA and bensulide were applied to soils with high phosphorus levels. Although several of the above pre-emergent herbicides are commercially suggested for Poa annua control, inconsistent results have been obtained by professional turfgrass managers.

Thus, numerous cultural and chemical methods for the control of Poa annua have been evaluated. To date, no absolutely effective practices are available.

The Plant

Poa annua is commonly known as annual bluegrass in the United States, annual meadowgrass in England and wintergrass in Australia and New Zealand. Additional common names include Junegrass, Suffolkgrass, speargrass and walkgrass. The accepted botanical name was given by Carl Linnaeus in 1753 (54). Synonyms are listed by Hitchcock (41) as Aira pumila Pursh., Poa infirma H.B.K. (most other references agree this is a separate species), Megastachya infirma Roem. and Schult., Catabrosa pumila Roem. and Schult., Poa aestivalis Presl, and Eragrostis infirma Steud. Hubbard (46, p. 145) describes the plant as follows:

> A loosely to compactly tufted annual or short lived perennial, 3-30 cm. high. Culms erect, spreading, or prostrate, sometimes with a creeping base and rooting at the nodes, smooth. Leaves green, hairless; sheaths compressed, keeled, smooth; ligules thinly membranous, 2-5 mm. long; blades with abruptly pointed or blunt hooded tips, 1-14 cm. long, folded or opening out and 1-5 mm. wide, weak, often crinkled when young, minutely rough only on the margins. Panicles ovate or triangular, open and loose, or somewhat dense, 1-12 cm. long, pale to bright green, reddish or purplish; branches mostly paired or solitary, spreading, smooth, bare and undivided in the lower part; pedicels 0.3-4 mm. long.
>
> Spikelets ovate or oblong, 3-10 mm. long, 3-10-flowered, readily breaking up beneath each lemma at maturity. Glumes persistent, pointed, keeled; lower lanceolate to ovate, 1.5-3 mm. long, 1-nerved; upper elliptic or oblong, 2-4 mm. long, 3-nerved. Lemmas overlapping, semi-elliptic or oblong and rather blunt in side view, 2.5-4 mm. long, keeled, 5-nerved, membranous and with broad delicate tips and margins, sparsely to densely hairy on the nerves below the middle, or hairless. Paleas slightly shorter than the lemmas, with hairy or hairless keels. Anthers 0.7-1.3 mm. long. Grain enclosed by the lemma and palea. Ch. no. 2n=28.

The germination of Poa annua seed was examined under various regimes by several workers. In New Zealand (27) it was shown that alternating temperatures of 30° C day and 20° C night resulted in higher percentage germination than 14.5° C day, 4.5° C night or constant temperatures of 15, 20 or 30° C. Neidlinger (59) in Oregon and Engel (22) in New Jersey found the same regimes gave the highest percentage germination. They both demonstrated that light was essential for optimum germination. Halcrow (37) observed that germination was reduced 50 percent in the absence of light at various temperatures.

Cockerham and Whitworth (14) found that a post harvest dormancy existed in annual bluegrass seed from New Mexico. Maximum germination was recorded two months following harvest. Tutin (78) in England likewise observed a slight delay in the germination of the upright annual. Hovin (42) found that a three month resting period was needed before germination of typical annual bluegrass from the Los Angeles area would occur. A creeping type germinated immediately following seed maturation. The upper threshold temperature at which Poa annua fails to germinate was found to be between 34.5 and 38.5° C (59). The lower limit appears to be between 4.5 and 10° C.

A low pH is also known to inhibit germination of Poa annua. Ferguson (29) noted the absence of the plant on turf plots that had received long term applications of iron and ammonium sulfate that resulted in a pH of 4.2. When annual bluegrass was sown to pots containing peat products adjusted to a pH of 3.6 and 5.2, germination was observed to be zero and 66 percent respectively.

The Association of Official Seed Analysts (2) suggest that Poa annua germination studies be conducted in a lighted chamber at alternating temperatures of 20 and 30° C with the last count being made 21 days following initiation of the trial.

Following germination, Juhren, Noble and West (47) measured the growth rate of annual bluegrass when grown under eight alternating temperature combinations, three photoperiods and two light intensities. They found the optimum condition was 26° C day temperature and 17° C night temperature with a 16 hour photoperiod and high light intensity. Plants in high temperature regimes tended to produce greater growth with high light intensities whereas those under low temperature combinations grew better with lower intensity levels. Greater growth rates were recorded with increased photoperiods.

Sprague and Burton (70) observed the growth of seedlings under four partially controlled light conditions in the summer environment of New Jersey. The regimes included full sunlight, complete shade, and five and ten hour exposures to sunlight. The shaded plants exhibited more rapid growth. The authors concluded the response was due to reduced temperatures and increased relative humidity. Unfortunately, no maximum temperatures were presented.

Sprague and Burton (70) also demonstrated the effect of combinations of pH and fertilizer elements on annual bluegrass growth. The dry matter yield was greatly increased with soluble nitrogen. A positive response was observed from phosphorus. All fertilizers increased dry matter yield on the less acid soil.

It has been observed that annual bluegrass often exhibits symptoms of nutrient and water deficiencies when other turfgrasses do not. Also, the plant grows successfully under compacted conditions (19). These observations indicate that Poa annua is a shallow rooted species. Sprague and Burton (70) examined the rooting capability on the same soil in two locations. One location was compacted by foot traffic while the second was friable, well drained, cultivated cropland where annual bluegrass had invaded. They found that the root system was restricted on the compacted area but relative root weight per depth was comparable to Kentucky bluegrass and colonial bentgrass in the more desirable situation. They concluded that Poa annua did not inherently develop a shallow root system, but instead, restricted rooting was a response to compaction.

Beard (4, 5) has shown that Poa annua in turf conditions characteristically showed severe winter damage in Michigan. When roots were examined, disrupted vascular tissue due to ice formation was noted. A warm spell hastened vegetative growth but the degenerated root system was unable to supply the needed water and nutrients. Plants therefore died from dessication. Since most turfgrass areas are compacted to some extent, the resulting shallow root system evidently accentuates this damage.

Youngner (85) demonstrated that shallow rooting of Poa annua caused water difficiency earlier than bermudagrass (Cynodon dactylon

(L) Pers.). A bermudagrass/annual bluegrass turf sward was irrigated on two schedules: three-quarter inch every ten days and one-half inch every three to four days. Poa annua was completely eliminated from the former whereas it survived under the more frequent watering regime.

When annual bluegrass is placed under either low moisture or high temperature stress, the mature plant will produce seedheads. Stress is not needed, however, to stimulate the normal reproductive cycle. Since annual bluegrass is indeterminent (15, 74), it is capable of producing heads throughout the growing season. Seemingly normal seedhead production occurs even under mowing heights of one-quarter inch. Sprague and Burton (70) observed retarded floral induction following the application of calcium nitrate. Phosphorus and potassium stimulated inflorescence production even with nitrogen present.

It has been reported that the production of secondary tillers in Poa annua varies markedly within the species. Hovin (42) noted that low growing plant types produced numerous secondary tillers on prostrate or semi-prostrate culms whereas plants with an upright growth habit were restricted in this characteristic.

It is interesting to note that tiller production is often associated with plant longevity in grass plants. Langer (52) stated that three types of tillers are present in the grasses. First are those that flower and die in the year of their appearance, second are those that are formed one year and flower and die the following year, and third are those that fail to flower for several years. The relative proportion of the three determines the longevity of the plant. Tillers on annual plants die in the first season of growth and few, if any, new tillers are produced. Perennials constantly have many tillers in the vegetative stage of development.

Upright versus prostrate or semi-prostrate growth has been shown by Evans (26) to be important in successful establishment of secondary tillers on a culm in timothy (*Phleum pratense* L.) and *Agrostis* spp. Tillers that formed at the nodes of typically prostrate species quickly established roots, grew vigorously, and were capable of surviving. Tillers that originated from nodes of upright culms did not produce a root system. Similar observations have been made by Cooper (15) between *Lolium perenne* and *Lolium multiflorum* L.

Origin and Distribution

It is postulated (77) that *Poa annua* arose from a cross between *Poa infirma* H.B.K. (*Poa exilis* (Thomm.) Murb.), an upright annual that now grows throughout much of the Mediterranean region, and *Poa supina* Schrad., a creeping perennial that inhabits Northern and Central Europe and is frequently found in mountainous regions. Both have a chromosome number of 2n=14. According to Tutin (78), *Poa annua* normally a self-pollinating species, was crossed with *Poa supina* by

Nannfeldt. A sterile triploid resulted with seven bivalents and seven univalents. Tutin then crossed Poa annua with Poa infirma and obtained similar results. It was concluded that a close association existed between the chromosomes of Poa infirma and Poa supina and the respective genomes of Poa annua.

Viable seed from a cross by Tutin involving Poa infirma and Poa supina was grown, allowed to produce an inflorescence, and sent to the Royal Botanic Herbarium, Kew, for positive identification. The plant was tetraploid (2n=28). Dr. C. E. Hubbard identified it as Poa annua.

Tutin concluded that Poa annua is an allotetraploid derived from a cross between Poa infirma and Poa supina. He suggested that it is of fairly recent origin, probably being formed on the northern shore of the Mediterranean during the Quaternary glaciation. At that time, Poa supina possibly receded from the mountains to low-lying areas where it came in contact with Poa infirma.

A recent article shed doubt on this theory. Koshy (51) examined chromosome arm ratios of Poa annua, Poa supina and Poa infirma. He repeatedly distinguished three large chromosomes in Poa supina and Poa infirma. If Poa annua arose as Tutin suggested, six large chromosomes would be expected. Koshy found only three. He concluded that either Poa annua arose from a cross between Poa infirma or Poa supina and an unknown species or that it underwent extreme karyotype modification following its origin.

The dissemination of plant species from their origin is dependent mainly on three carriers: wind, water and animals, including man (50). Although dandelion (Taraxacum officinale L.) seed can be easily carried by wind because of a pappus, the bladder-like floats of curly dock (Rumex crispus L.) enhance its movement in water and cocklebur (Xanthium spinosum L.) has spines which cling to animal hair, annual bluegrass has none of these special appendages. Its supposed origin, the northern Mediterranean shores, was an advantage, however, because this area was one of the earlier trades routes of man. King (49) suggested that numerous plants that originated in this area were transported by man's movement.

This reasoning receives support from present day distribution of annual bluegrass: although it is considered a cosmopolitan species it is usually limited to areas of human habitation (78). Poa annua has been observed in Europe, North Africa, North Asia, Australia and surrounding islands, North and South America, and within the Arctic Circle (9, 63). Within these areas, it is more commonly found in intensely managed ornamental locations. In the tropics it is usually confined to mountainous regions. Its absence is obvious in areas of high temperatures with low rainfall, in highly competitive plant communities such as tall grasslands, above the altitude of 4,000 feet in northern parts of the world, and on highly acid soils (32).

Variation Within A Species

Turesson (75, 76) was among the first to observe that species with widespread distribution have quite variable genotypes as measured by morphological characteristics. He examined numerous species from various families commonly found throughout Sweden. Using Hieracium umbellatum L. as a typical example, he found that plants growing under different edaphic and climatic conditions exhibited phenotypic responses that were correlated with a particular habitat. The respective plants maintained the different growth forms, to a large extent, when grown in an environmentally neutral experimental garden. Turesson concluded that within a widespread species there are different biotypes which have been selected by a particular environment within the genetic potential of the species. He defined "the product arising as a result of the genotypical response of an ecospecies or species to a particular habitat" as an ecotype.

Clausen, Keck and Hiesey, working at the Carnegie Institute of Washington in California, together and separately, released a series of publications (12, 13) that examined the concept of species and variation within species. Like Turesson, they also noted distinct morphological variation within species due to environmental difference. It was further observed that plant differences may not be expressed in the external appearance (40), but as physiological variation. Clausen, Keck and Hiesey therefore coined the term ecological races to encompass both types of variation.

Nelson (60), studying the variation of Prunella vulgaris L. due to differences in longitude and latitude in California, was able to correlate morphological characteristics to various locales. He also observed differences in life-length between the ecological races. Plants from coastal and interior low-land areas were annual whereas montane races were biennial or perennial.

Tutin (78) examined several ecological races of Poa annua in England and observed annual and perennial growth forms within the species. The majority of the plants studied were collected from the same garden but the growth habit varied from upright growing types with light green leaves to low growing darker green leaved plants that rooted at the nodes. The former were annual as indicated by the production of seedheads 50 days following germination whereas the latter were found to be biennial or perennial.

Hovin (42) examined variation in Poa annua in southern California and from seed collected from numerous countries. He also noted annual and perennial biotypes within the species. The perennial biotypes formed secondary tillers on the upper nodes of the culm and produced more tillers per plant than did the annual. Hovin concluded that the most common plant type in the United States was the upright annual but noted the presence of the creeping perennial.

A recent survey of Poa annua in Europe by Timm (73) revealed that 99 percent of samples collected from Finland to Portugal were biennial or perennial whereas only one percent were found to be the upright annual. He distinguished a procumbent, vigorous perennial race, mainly from Germany, that comprised 62 percent of the samples; a procumbent, less vigorous perennial race from Northern Europe and the mountains of Southern Europe that accounted for 37 percent of the samples; and an erect annual race from the Mediterranean region. The biennials and perennials had a strongly fibrous root system whereas the annuals characteristically exhibited a less extensive rooting habit.

As would be expected with a widespread species, numerous "botanical varieties" of annual bluegrass have been described in the various world floras. Dr. C. E. Hubbard, formerly of Kew Botanic Gardens, Richmond, Surrey, England, has listed 48 recorded varieties (45). The original description of 32 of these has been translated and arranged below according to annual and perennial types.

Annual Varieties

The most common annual variety of Poa annua mentioned in the European floras[2] is var. typica Beck. Recently, Tutin (78) indicated

---

[2] The floras used as source reference are given in Appendix Table 3.

var. annua would be the correct designation. This variety would be similar to the upright annual type described by Hitchcock (41) in the United States. Variety annua (typica Beck) is found at low elevations; leaves are pale green; the plant is erect, often up to 35 cm tall; the spikelets are 2-5 flowered.

Differences in seedhead color of the typical upright annual type have resulted in the following varietal designations:

var. viridis Lej. and Court. Spikelets are green with white margins on the glumes and lemma.

var. picta Beck. The 1-5 flowered spikelets are violet. The inflorescence branches are more diffuse than var. annua.

var. variegata G. Meyer. The florets are variegated with purple to violet coloration. Spikelets are 5-7 flowered.

var. silvatica Jansen and Wachter. The seedhead exhibits a silvery appearance because of wide transparent margines on the on the lemmas. The plants are slender, small leaved, and have a small inflorescence.

var. flavescens Hausm. The spikelets are gold colored.

Because of variation in the gross morphology of the inflorescence or in certain parts of the inflorescence, the following varieties have been described:

var. pumila Anders. Spikelets are 1-4 flowered and the paleae have very prominent keels. The 2-4 noded culms are non-branched and have short leaves.

var. pauciflora Fiek. The rachis has 1-4 thin branches with one spikelet per branch. Spikelets are 1-3 flowered. The culms are erect and have small leaves. Found in dry areas.

var. racemosa Aschers. The rachis has very short branches. Spikelets are 5-7 flowered.

var. or forma longiglumis Lindm. Glumes I and II (upper and lower) are 4-5 mm. long.

var. or forma latisquama Lindm. Similar to longiglumis but the glumes are ovate to semi-circular. Very rare plant.

var. or forma pseudopratensis Jansen and Wachter. The lower branches of the inflorescence are grouped in clusters of 4-6. Normally the branches on annual bluegrass are paired or solitary. The branches point in all directions.

vars. or formae bracteata (?) and ramifera (?). The lower branches of the inflorescence are surrounded by a sheath.

var. vivipara S.F. Gray. The inflorescence is viviparous. Found in Amsterdam.

Two annual types were characterized by the presence of pubescence on the florets:

var. villosa Bluff. and Nies. The keels of the paleae have small hairs. Only a few plants were found in any one area. The flowers are small.

var. pubescens Peterm. The lemmas and paleae have small hairs on the keels. It is a short plant. The panicles are usually green but violet variegations are noted.

One variety was classified on its different leaf morphology:

var. rigidula Aschers. The leaves are stiff and blue-green. The rachis is elongated. Spikelets are small and 3 flowered.

One variety was named because of its size:

var. macerrima Nakai ex Jansen and Wachter. A small plant only a few cm tall. The leaves are small, and poor flowering is obvious on a contracted inflorescence. This European variety is found on lanes and between bricks in walkways.

The following varieties were classified because of their adaptation to a particular edaphic or climatic condition:

var. umbrosa (?) Found in shaded locations. The spikelets are 3-7 flowered.

var. remotiflora (?) Found mainly in white sand in exposed areas. Culms are slender and the plants are tufted. The leaves are linear, keeled and the spikelets are small. Observed only infrequently in Southern Europe.

var. caespitosa Terracc. Found in sunny areas with calcareous soils. The leaves are deep green and the plant is tufted but small (5-10 cm). The culms are slightly compressed; the panicles are dense. Described in Southern Europe.

var. Santiago Gay. From Chile. Similar to the common European type but the lemmas have only 3 pubescent nerves.

Perennial Varieties

The most commonly cited perennial type of Poa annua is var. reptans Hausskn. The plant is characterized by long, strongly branching, creeping stolons that root at the nodes. It was described from plant material found in damp sandy soils in the high wooded hills of Germany. This variety has occasionally been mentioned in popular English turfgrass articles where it occurs in tufted areas.

Other perennial varieties of Poa annua include:

var. sericea Parnell. The stem is somewhat creeping, with roots formed at the lower nodes. Leaves are short and the ligule is prominent, thin, obtuse. Frequently found on wet, marshy areas in Scotland, from sea level to 1,200 m.

var. triflora Schur. The loosely tufted plant has decumbent stems that extend 60 cm and root at the nodes. The soft, linear, elongated leaves have an erect and rounded ligule. Spikelets have 3 or 4 florets. Found in Europe.

var. alpigena Schur. The 15-22 cm culm is prostrate at the base, erect thereafter. Leaves on the culm are oblong to linear, succulent and blunt. The small ligule is blunt. The dense panicle has lanceolate spikelets that are 7-11 flowered. The florets are small, vilose and variegated. This variety was found in mountainous areas (2800 m) of Central Europe. It flowers in August.

var. minima Schur. The presence of fibrous rhizomes results in a tufted plant. The 5-10 cm culms have pointed, linear to oblong leaves. The ligule is short and truncate. A 1-2 cm long panicle has 1-2 spikelets per branch. The spikelets are 2-3 flowered. Lemmas are green with violet variegations. Found at 1800 m in Central Europe where it flowers in July.

var. or forma decumbens Nolte ex Junge. A prostrate plant with long "offshoots" (branches); nodal rooting is common.

var. nepalensis Griseb. Stem 50 cm tall with leaves 30-50 cm long. The ligule is shorter than the common type found in India. Panicles up to 15 cm long; spikelets are distant, green. The keel and outer nerves of the lemma are pubescent to the middle.

var. sikkimensis Stapf. The rootstock is slender giving off stems and stolons at the nodes; leaves are up to 5 mm wide; ligule .3 to .6 mm long, denticulate. The panicle is 7.5 to 15 cm long with slender branches; lemmas are nearly glabrous. Found in India.

var. rigidiuscula L. H. Dewey (Hitchcock (41) considers this a synonym of Poa annua whereas Hubbard (46) recognizes it as a variety). Culms 15-20 cm high, rather robust, striate, glabrous, tufted from running rootstocks, leaves flat, mostly erect, 2-4 mm wide, 2-5 cm long; ligule obtuse, about 2 mm long. The panicle is pyramidal, 3-4 cm long and spreading to nearly that width at the base; axis rigidly erect with 5 or 6 nodes; spikelets 3-5 (usually 4) flowered, about 5 mm long. The lower glume is ovate, acute; the upper lanceolate, obtuse. The lemmas are 3 mm long, lanceolate to oblong, obtuse, membranous above, prominently ciliate on the 5 nerves below the upper third. The paleae are shorter than the paired lemma and are prominently ciliate on the keels. Described in Eastern Oregon.

var. aquatica Aschers. Found at waters edge and on ditch banks; usually in shaded areas in Central Europe. The slender culms are to 50 cm tall. The inflorescence is large with overhanging branches that have distant spikelets.

It should be noted that the term "variety" was often used to distinguish plant types that differed in growth habit, size of parts, types of leaves, color, life length, etc., by earlier amateur and professional botanists, hence the numerous "varieties" described. More recently, the taxonomic category of "variety" has been disfavored because of the different ways systematists, horticulturalists and others have used the term (71). Many, or all, of the varieties listed could probably be attributed to ecotypic adaptations as described by Turesson, physiological races as described by Clausen, Keck and Hiesey, or genetic mutations. Nevertheless, the varietal descriptions do indicate the variability within the species, especially with reference to life length and general growth habit.

Subspecies Concept

From the above, it is obvious that numerous annual and perennial biotypes of *Poa annua* have been described in the world floras. In general, the annuals are erect plants and are normally found at low elevations. Most seedhead production occurs during May and June (32); plants die thereafter. The perennials are prostrate or semiprostrate in growth habit. They root and produce tillers at the nodes of stolons or rhizomes. Many of the perennial plants are found in mountainous areas and/or continually moist locations. They generally flower later than the annuals.

Unfortunately, the present system of varietal nomenclature appears inadequate within this complex species since no distinction is made between the two growth habits. Tutin (78) suggested the possible use of subspecies but felt further consideration was needed. Following a survey of *Poa annua* plant types throughout Europe, Timm (73) concluded that three subspecies designations would be appropriate. These were subspecies *annua* (*typica* Beck.), subspecies *reptans* (var.

reptans Hausskn.) and subspecies aquatica (var. aquatica Aschers.).

To clarify the concept of subspecies, the following quotation from Stebbins (71, p. 33) may be taken as an acceptable definition:

> The subspecies or geographical variety is a series of populations having certain morphological and physiological characteristics in common, inhabiting a geographic subdivision of the range of the species or a series of similar ecological habitats, and differing in several characteristics from typical members of other subspecies, although connected with one or more of them by a series of intergrading forms.

First, it has been shown that significant morphological variation exists between the annual and perennial forms. The most obvious common physiological characteristic would be length of life.

Second, the plant types do not inhabit "geographic subdivisions" since both are reported throughout Europe. They do, however, appear consistently to inhabit different ecological niches in nature, however close these niches are to one another. As an example, the author observed the typical annual type growing on a gravelled area, the very tall var. aquatica at the edge of a small lake, and the creeping perennial in a wooded area, near Fussen, Germany. They were within several meters of each other. Since Poa annua is mainly a self-pollinating species (44), the plant types would be stable within their respective areas. Both Hovin (43) and Tutin (78) have shown however, that successful crossing between the upright annual and the creeping perennial is possible. It can be assumed that such crosses occur in nature and result in "intergrading forms".

In conclusion, the author would agree with the suggestion of Tutin and the report of Timm that the category of subspecies be used within the species *Poa annua*. Following Timm's (73) formal proposal, three subspecies of *Poa annua* should be recognized, namely, subspecies *annua* (L.) Timm, subspecies *reptans* (Hausskn.) Timm, and subspecies *aquatica* (Aschers.) Timm.

Identification Within a Species

The classification of plants into well defined groups has been the main goal of taxonomists. External morphology has been, and according to Gould (34) will continue to be, the basis for species recognition in the Gramineae family. Most taxonomic categories have been based on leaf length and width, ligule length, tiller number and type, length of culm, root and shoot dry weight, and inflorescence characteristics (6).

The recognition of crop varieties has long been a problem in agriculture, especially in the certification of species where numerous cultivars exist. Considerable emphasis has therefore been placed on methods to differentiate these cultivars by seed characteristics. The length, width, thickness, shape, color, presence of pubescence, and rachilla length are some common parameters examined (35). Also, the fluorescence and phenol tests are employed. Although these techniques are used to distinguish cultivated plants within a species, their application for differentiating natural variation within Poa annua will be examined.

The importance of the fluorescence analysis in seed testing was reported by Gentner (from Grabe (36)) when he demonstrated that the roots of annual ryegrass fluoresced when placed under ultraviolet light. Roots of perennial ryegrass did not. Rampton (64) found the fluorescence test to be an aid, although not an infallible guide, to identify annual and perennial ryegrass in western Oregon. The fluorescence reaction is thought to be caused by the exudation of a substance that partially hydrolyzes cellulose of the paper media. The root does not fluoresce (56).

The phenol test is based on differential coloration of the seed pericarp following a phenol treatment over a certain time period. Milner and Gould (57) suggested that the reaction was due to the oxidation of phenol by enzymes in the pericarp. The phenol test was used with success to distinguish between certain wheat varieties (56). A modification of this method has been useful in identifying several varieties of Kentucky bluegrass (31).

Summary

To summarize the literature review, three concepts should be stressed. First, annual bluegrass is considered the most troublesome pest in well maintained turfed areas and efforts to effect its control have not been successful. Second, *Poa annua* is a variable species. Although it is considered an annual in the United States, repeated references to perennial growth forms have been recorded in the European literature. And third, the possible presence of perennial plant types in the Pacific Northwest could partially explain the lack of a complete success with pre-emergent herbicides, the most recent and potentially successful control method.

III. THE INVESTIGATION

Methods and Materials

Plant Material

Numerous *Poa annua* plants were collected from various turfed areas in Oregon, California and Arizona by Dr. N. Goetze, Professor of Farm Crops, Oregon State University and the author. One plant type was sent from England by Mr. T. G. Tutin, Professor of Botany, University of Leicester, Leicester, England.

In the autumn of 1967, the samples were planted in 10 cm diameter tin cans that contained the greenhouse potting soil commonly used at the Oregon State University Agricultural Greenhouses. This soil is described in detail in Appendix Table 2; it was the medium used for all subsequent trials. The plants were randomly arranged on a greenhouse bench and watered as needed. The daily greenhouse temperature most frequently ranged from 13 to 18^{o} C from September to June. Summer daytime temperatures in excess of 30^{o} C were occasionally observed.

Mature seed was harvested as produced and stored in paper envelopes at room temperature.

Throughout the summer of 1968 the plant collections were examined for morphological variation. Particular emphasis was placed on upright versus prostrate or semi-prostrate growth habit and the capacity to produce secondary tillers on mature culms. In August 1968, five interesting samples were selected for further study.

The selections were transplanted to wooden flats that measured 30 x 54 cm and contained the greenhouse soil. The flats were relocated in a greenhouse maintained at 15.5^{o} C by artificial heating and cooling. A 21-4-4 granular fertilizer was applied to the selections at the rate of 5 gms per flat or approximately equal to 680 kg/ha. Thereafter, they were purposefully kept at a low fertility level. In September 1968, the plants were dusted with DDT (10% Dichloro diphenyl trichloro-ethane) to control aphids.

The five Poa annua selections are described below: all measurements smaller than 2 cm were made with a measuring magnifier calibrated to 0.1 mm.

Selection 1

This plant type was collected by Dr. N. Goetze at Golden Gate Park, San Francisco, California. It is upright, loosely tufted, 9-15 cm high, branched and tillering only at the base. The smooth, slender culms have four to six nodes.

The light green glabrous leaves have slightly compressed, keeled sheaths; hooded tips terminate the 2.7-3.5 cm long, 2.0-2.7 mm wide blades. The ligules are acute and 1.1-1.6 mm long.

The oblong spikelets, 3.8-5.0 mm long, have two to four florets;

upper glumes are 2.1-2.8 mm long, three-nerved; lower glumes are 1.9 to 2.1 mm long, one-nerved; both are lanceolate to oblong and have prominent margins that are pale purple when immature, later white to hyaline, the lemmas are 2.6-3.2 mm long, oblong, keeled, hyaline, with five nerves the entire length that are pubescent half the distance from the base. The nearly rectangular paleas are 2.4-3.0 mm long, two-keeled, pubescent near the base. Anthers are 0.5-0.6 mm long.

This plant form was considered typical of subspecies annua.

Figure 1. Selection 1. Collected from Golden Gate Park, San Francisco, California.

Selection 2

Plant type 2 was collected by Professor T. G. Tutin on Home Farm, Knighton, Leicester, England. It was selected by Tutin because of its obvious perennial life length.

The plants are prostrate at the base, ascending thereafter. The culms are loosely tufted, 11-15 cm high, smooth, with four to seven nodes.

The leaves vary from light to dark green; sheaths are slightly compressed, keeled, glabrous, with obvious purple coloration at the base; blades are from 4.0-5.0 cm long, 2.1-2.5 mm wide, somewhat glossy underside, with hooded tips; ligules are 1.4-1.5 mm long, acute to blunt apex.

The panicles are triangular, light green, 2.7-2.9 cm long; the one-nerved lower glumes are lanceolate, sharply pointed, 1.6 mm long; both glumes have hyaline margins. Lemmas are 2.3-2.4 mm long, keeled, oblong, with five prominent nerves that are pubescent near the base. Paleas are 2.0-2.1 mm long, lanceolate, two-keeled, with pubescence near the base. The anthers are 0.6 mm long.

Tutin (79) suggested that this plant is perennial and therefore belongs to subspecies <u>reptans</u>.

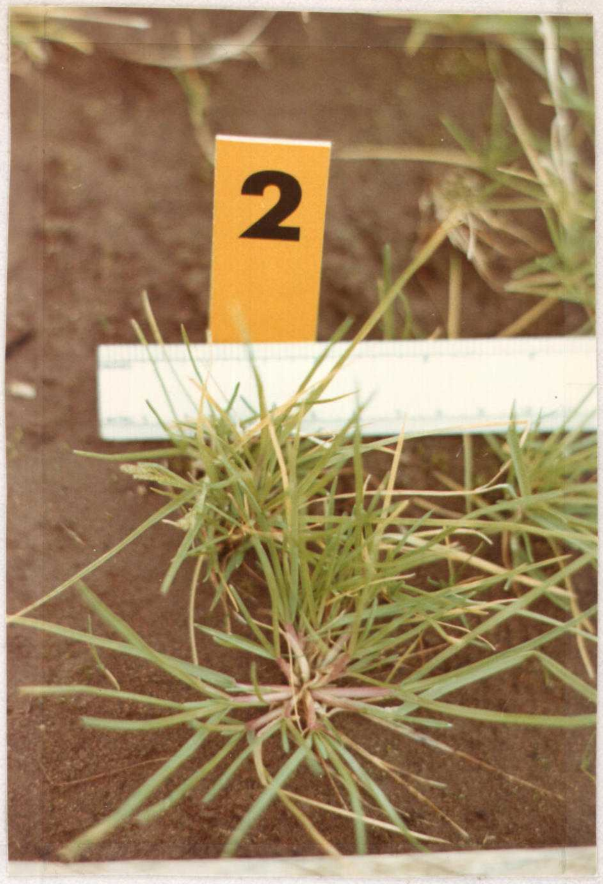

Figure 2. Selection 2. Collected from Home Farm, Knighton, Leicester, England.

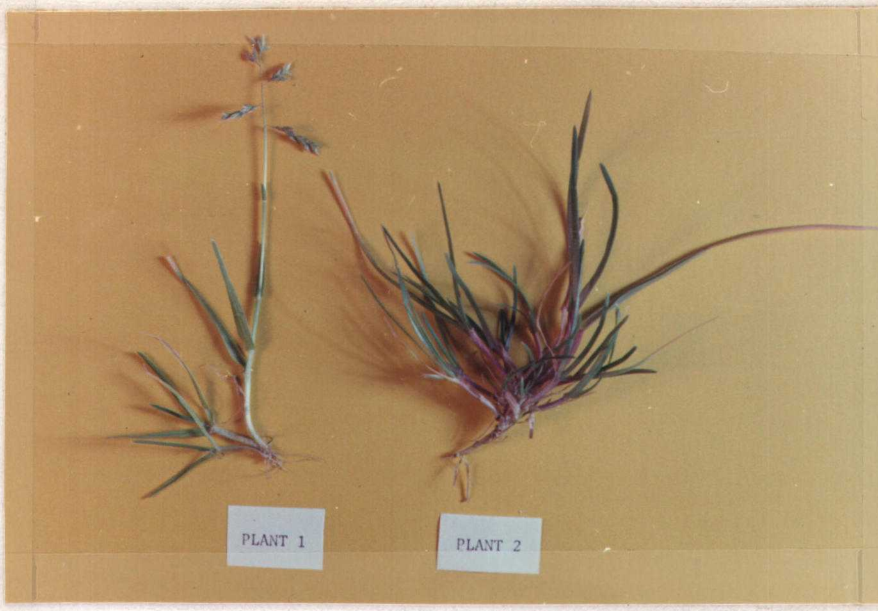

Figure 3. A comparison of growth habit of Selections 1 and 2.

Selection 3

This plant type was collected from the third green at Shadow Hills Golf Club, Junction City, Oregon by the author. It is commonly referred to as "black Poa" because of dark coloration throughout the winter.

The plants are stoloniferous, tillering at the base and on the 8-10 cm long, smooth, slender culms that have eight or nine nodes; they are densely tufted. The seedheads are purple when newly formed, white thereafter, and those at the outer edge frequently nod toward the soil surface.

The dark green leaves have glabrous, slightly compressed, keeled sheaths; blades are hooded, 1.6-3.0 cm long and 2.5-3.5 mm

Figure 4. Selection 3. Collected from the third green, Shadow Hills Golf Course, Junction City, Oregon.

wide; ligule lengths range from 1.1-2.0 mm.

The triangular panicles are 1.4-2.4 cm long and have solitary rays.

Spikelets are two or three-flowered with lengths ranging from 3.0-4.4 mm; upper glumes are oblong, pointed, three-nerved, 1.5-2.1 mm long; lower glumes are more lanceolate, pointed, one-nerved, 1.2-1.8 mm long; both have prominent hyaline margins at maturity. Lemmas are oblong, 1.7-2.4 mm long, five-nerved, with sparse to prominent pubescence near the base. Paleas are 1.5-2.2 mm long, two-keeled with very prominent pubescence near the base. Anthers are 0.6 mm long.

The length of life of this plant is uncertain, but it is probably _Poa_ _annua_ subspecies _reptans_ as described in the earlier proposed classification system.

Selection 4

Plant type 4 was collected by the author from the eleventh green at Shadow Hills Golf Club, Junction City, Oregon.

The plants are prostrate with only newly formed tillers being somewhat erect. Tiller formation occurs both at the base and on rooting nodes of the culm. Culms are from 9-13 cm long with 7 to 13 nodes.

The leaves are an intemrediate green; sheaths are slightly compressed, keeled, glabrous; hooded blades are from 2.0-3.2 cm

Figure 5. Selection 4. Collected from the eleventh green, Shadow Hills Golf Course, Junction City, Oregon.

Figure 6. Typical culm formation of Selections 1 and 4.

cm long, 2.5-3.4 mm wide; blunt to acute ligules are 0.8-1.3 mm long.

Triangular panicles 1.7-2.5 mm long have solitary rays at the base and paired or solitary rays toward the tip.

The two-flowered spikelets are ovate, 2.5-4.3 mm long; upper glumes are oblong, three-nerved, 1.9-2.2 mm long with hyaline margins; one-nerved lower lanceolate glumes are 1.4-2.0 mm long. Lemmas are 2.2-2.5 mm long, oblong to ovate, pointed, five-nerved with pubescence only on the keel very close to the base. Narrow paleas, 1.6-2.3 mm long, are two-keeled with pubescence except on the outer end.

The life length of this plant is uncertain, but its prostrate growth would indicate its being within the sub-species reptans.

Selection 5

Plant type 5 was collected from the lawn of Mr. J. C. Johnson, Astoria by Mr. J. Wood, Clatsop County Extension Agent, Astoria, Oregon.

Partially erect to prostrate growth and extensive tiller formation on the rooting nodes results in a densely tufted plant. The panicles are pale purple when newly formed. Seedheads nod toward the soil surface at the uppermost node, especially at the outer edge of the plant. Culms are 5.7-8.5 cm long, branched, with 8 to 13 nodes.

The leaves are dark green; slightly compressed sheaths are

Figure 7. Selection 5. Collected from a home lawn in Astoria, Oregon.

Figure 8. A comparison of growth habit of Selections 1 and 5.

keeled and glabrous; blades are hooded, 1.7-3.0 mm long, 2.9-3.3 mm wide; the ligule ranges from 0.8-1.5 mm in length.

The purplish, triangular panicles, 1.0-1.7 cm long have paired and solitary rays.

The two to three-flowered ovate spikelets are 3.0-3.5 mm long; the upper glumes are purple tipped, oblong, 1.4-2.0 mm long, three-nerved, with pale to deep purple margins when young, hyaline when mature; lower glumes are lanceolate, one-nerved, 1.2-1.8 mm in length and also purple, later hyaline. The lemmas are 2.2-2.4 mm long, purple tipped, with pale purple margins, turning hyaline, five-nerved with pubescence near the base. Paleas 1.8-2.2 mm long are two-keeled, with pubescence near the base. Anthers range from 0.4-0.6 mm long.

The life length of this plant is uncertain. It is most probably in the subspecies reptans.

Selection 6

This selection was used in one germination test so it is briefly described below:

Selection 6 was collected from a non-cultivated area near the Agricultural Greenhouses on the Oregon State University campus. The author had observed plants in this area for a two year period. They appeared typical of the annual subspecies. They produced upright vigorous growth during the winter and spring months, exhibited most abundant seedhead formation in April, May and June, and died during the dry period.

Figure 9. A comparison of growth habit of Selections 1, 2, 3, 4 and 5.

Chromosome Counts

It was the objective of this trial to determine the chromosome numbers of the five plant types to insure their proper classification within the species *Poa annua*.

Newly initiated adventitious root tips, approximately 5 mm long, were harvested from young plants grown from seed. The seed was collected from the five selections and grown as described in detail in a later section. The tips were placed in vials that contained a dilute monobromonaphthalene solution and stored at 5° C for five hours. This procedure resulted in contraction of the chromosomes for easier counting. The monobromonaphthalene was removed with a pipette and replaced with a 6:3:1 fixative (6 parts 95% alcohol, 3 parts chloroform and 1 part glacial acetic acid). The root tips were stored at 5^{o} C for one month before counts were made.

A squash technique as described by Haunold (38) was used. The root tips were hydrolyzed in 4 mls of 1 N HCl at 60^{o} C for ten minutes. A thermoblock maintained the desired temperature. The tips were removed from the acid solution, rinsed in tapwater, and stained for one hour in Feulgen's reagent.

Following the transfer to a microscope slide, excess water was removed with a filter paper and one drop of propionic-carmine was added. The deeply stained portion of the tip was separated, by cutting, from the nonmeristematic part and the latter was removed. Two dissecting needles were used to mascerate the root tips under a 30 X microscope. One drop of Venetian turpentine was added prior to the placement of a cover slip. A very acceptable squash was obtained by placing limited pressure with a needle to the cover slip in the area of the root tip. Three chromosome counts per selection were made using a magnification 1000 X microscope. All counts were made at the metaphase stage of division.

Seed Characteristics

It was the objective of the following trials to obtain characteristics that would aid in the identification of annual and perennial subspecies of *Poa annua*. Experiments included fluorescence, phenol and germination tests, and an examination of seed physical characteristics. All tests were conducted at the Oregon State University Seed Testing Laboratory.

Fluorescence Test

Ten seeds of each selection were placed linearly in a 12 x 12 x 3 cm plastic box that contained two filter papers saturated with distilled water. There were three observations per selection. By arranging the containers at approximately a 60^{o} angle against the wall of a continually lighted germination chamber with an alternating temperature regime of $15\text{-}25^{o}$ C, a geotropic growth response was obtained which facilitated the evaluations. One, two and three weeks following germination the seedling roots were examined for the fluorescence reaction under a blacklight tube located in a darkroom.

Phenol Test

Two phenol tests were conducted on seed that was harvested from the five selections at different times. In the first trial, seed was harvested over several months, stored in envelopes, and randomly chosen for testing. The second test examined newly produced seed, immediately after harvest.

The procedure described below is used by the Oregon State University Seed Testing Laboratory to differentiate cultivars of Kentucky bluegrass (31) and was followed in the experiment.

In the first trial, ten seeds of each selection were placed in 10 cm diameter petri dishes that contained two filter papers saturated with distilled water. There were three observations per selection. Following a 24 hour imbibition period, the filter paper and seeds were removed from the dishes and placed on a blotter to absorb excess water. The paper and seeds were replaced, saturated with one percent phenol solution (5 grams carbolic acid crystals in 500 mls distilled water), and stored at room temperature. A preliminary test indicated that the optimum time to evaluate a phenol reaction on *Poa annua* was 24 hours following treatment. Both trials were therefore recorded at that time.

The procedure of the second trial was identical to the first except that 50 seeds were included per observation and the seeds were at a similar stage of maturity. Seed of Selection 2 was not examined because of insufficient seed production.

Germination Test

Two trials were conducted to examine the germination characteristics of Selections 1, 3, 4 and 5. Selection 2 was not included since it failed to produce seedheads during the period of the tests.

Harvest Maturity. Seed was collected from panicles in three stages of maturity as indicated by senescence of the culm and panicle. In stage A, the culm and florets on the lower part of the panicle were still green. Obvious senescence to the second culm leaf characterized stage B; the panicle was tan in appearance and some seeds had already dehisced. Stage C was characterized by a nearly complete senescence of the culm. A large percentage of seeds had dehisced.

The seeds from the three stages were placed in 10 cm diameter petri dishes that contained two filter papers. They were germinated in a continuously lighted chamber with alternating temperatures of 20-30^{o} C. The medium was kept moist with distilled water and counts were made 21 days following initiation of the trial. Because of a limited seed source per selection per stage of development (between 50 and 100 seeds), the trial was not replicated. Results are presented in Table 3 as germination percentage the seeds tested.

Post Harvest Dormancy. One hundred seeds harvested from Selections 1, 3, 4, 5 and 6 from culms in Stage C as described above were divided into lots of 50 seeds each. A germination test was conducted on one lot at time of harvest; the remaining lot was tested seven weeks following harvest. Both lots contained two observations of 25 seeds.

The seeds were germinated as described above. Data were subjected to an analysis of variance and significance was determined at the five percent level by the Duncan's Multiple Range Test (53). A summation of the analysis is presented in Appendix Table 5.

Physical Characteristics

Ten seeds of Selections 1, 2, 3, 4 and 5 were examined for five characteristics: seed[3] length and width, caryopsis length and width, and rachilla length. A 30 X microscope equipped with an eyepiece micrometer was used for all measurements. The data were taken from the same ten seeds of each selection.

Data for each characteristic were treated as a completely randomized design with ten observations. An analysis of variance was performed and significance determined at the five percent level by the Duncan's Multiple Range Test. A summation of the five analyses is presented in Appendix Table 5.

---

[3] Seed is here defined as the caryopsis and its enclosing lemma and palea.

Plant Characteristics

The objective of the following trial was to examine the morphological characteristics of the five plants in question to determine markers that could be used for identification of the annual and perennail subspecies.

Seed that had been harvested from the parent plants over a several month period and stored at room temperature were planted individually in 5.5 x 5.5 x 6.0 cm pressed peat pots that contained 72 gms of air-dried greenhouse soil, and the pots were watered daily thereafter. The 540 pots were randomly arranged on a bench in the Oregon State University Agricultural Greenhouses. A border of two rows of pots was cultured to eliminate microclimatic border effects. The greenhouse temperature was maintained at 21.5^{o} C by artificial heating and cooling although infrequently temperatures rose above that level on very warm days. A photoperiod of 12 hours was controlled from time of planting until early April with Sylvania Gro-Lux Lamps (F40-GRO). Light intensities at plant level, as measured with a Weston Illuminometer model 756, ranged from 350 to 1100 ft. c. when overcast and 1100 to 2000 ft. c. on partly cloudy to clear days; at darkness, the lampss supplied 200 ft. c. The relative humidity in the experimental area ranged from 39 to 66 percent.

Four weeks following germination and every two to three weeks thereafter the plants were rearranged in a randomized design to eliminate microclimate variation.

Six plants of each selection were randomly chosen for examination on the 13, 26, 49, 64, 88 and 100 days following germination. All size measurements larger than 2 cm were made with a ruler with an accuracy of 1 mm while measurements smaller than 2 cm were recorded with a magnifier calibrated to 0.1 mm. Appropriate physical measurements were taken only on those above dates when the characteristics were adequately developed.

Data were subjected to an analysis of variance and significance was determined at the five percent level by the Duncan's Multiple Range Test. Summation of all analyses is presented in Appendix Table 5.

Leaf

The length and width of the longest leaf blade per plant were measured on 13, 26, 49, 64 and 88 days following germination. Normally, several blades were examined to determine the longest before the finite measurement was made. The leaves were separated from the culm to obtain an accurate measurement.

The ligule length was measured on the 88th day from the third leaf of a flowering, nearly mature culm. Preliminary observations indicated the most typical ligule was located at that position.

Culm

The four culm measurements taken 88 days following germination were length, leaf number, node number and inflorescence characteristics. Mature and fully elongated culms were chosen for the above measurements. The average of five individual measurements for culm length, leaf number and node number were analyzed whereas inflorescence characteristics were collected only from the longest culm.

The procedure included clipping the culms at the base and recording its length and the number of leaves. Following the removal of all leaves and secondary tillers, node numbers were easily obtained.

The panicle length was measured along the rachis from the lowest branch to the top spikelet. A spikelet was removed from a similar position on the second branch of each inflorescence. The upper and lower glumes were separated from the florets prior to measurement. The lemma and palea length were recorded from the lowest floret of the respective spikelet.

Tiller

The total primary tiller number per plant was recorded on all observation dates. Tillers located at the crown at time of counting were considered primary in origin. On the final date, the total number of secondary tillers per plant was also obtained.

Flowering

Two observations were made on the flowering capacity of the five selections. First, on 44, 55, 68 and 93 days following germination the number of plants flowering in the greenhouse was recorded as a percentage of the plant number present per selection at each date. A plant was considered flowering irrespective of the number of seedheads present. Second, 100 days following germination the number of flowering primary tillers per plant was counted as were the secondary vegetative tillers. The percentage of flowering tillers per total number on each plant was then calculated.

Shoot Dry Weight

On the six harvest dates, following the above recordings, the vegetative plant material was clipped at soil level, placed in open ended envelopes and dried at 100° C for at least 14 hours. The air dry weights were determined to the nearest 0.1 mgm.

Root Dry Weight, Seminal Root Number

Root weights were obtained on 13, 26, 49 and 64 days following germination. Thereafter, the roots had penetrated the peat pots in such quantity that an accurate measurement was impossible.

Plants removed from the greenhouse were placed in a water bath for approximately 15 minutes to thoroughly saturate the peat pots. The pots were then carefully teased free from the enclosed soil and roots. On the last two dates, some roots had penetrated the pot walls; their tensil strength, however, was sufficient to allow the removal of the soft peat containers. The roots and soil were placed on a fine mesh screen and washed under a small stream of tap water. This process was continued until the roots were nearly free of soil and organic matter. They were then placed in a petri dish that contained water approximately 1 cm deep. The remaining soil and organic matter was removed with a needle and fine brush. Dry root weights were then determined as described for shoot weights. Seminal root numbers were recorded the first two observation dates.

Adventitious Rooting

Preliminary observations indicated a differential ability of the five selections to produce adventitious roots at the culm nodes, especially under humid conditions. To test the total rooting capacity, five plants of each selection were encircled with paper toweling and placed directly above a water bath. The towels were arranged so the lower portion was constantly in water. Acting as a sponge, they remained saturated throughout the trial period and thus created a humid environment for the vegetative plant material within.

The number of nodes producing adventitious roots on the longest culm was recorded one week later. Also, the number of secondary tillers on the same culm was counted.

Survey of *Poa annua* Subspecies in Oregon and Western Washington

From February through April, 1969, established *Poa annua* plants were collected from 32 locations in Oregon and Western Washington. Pertinent information for each location is listed in Appendix Table 4. Care was taken to select sites that had been in turf for many years thereby insuring the natural selection of *Poa annua* subspecies within the particular environment. All lawn sites chosen were considered well managed and, generally, were irrigated at least at the level of a golf course fairway during the dry summer months. If possible, three areas were sampled on each golf course:

1. A green, surrounding apron, or tee that was intensely irrigated (approximately 7.5 cm water per week).
2. A fairway that was moderately irrigated (approximately 4 cm water per week).
3. A rough that was not irrigated.

From one to three samples, each containing several plants, were collected from all locations or areas within a location. The number was dependent on the amount of annual bluegrass present, the variability observed, and the cooperation of the superintendent or groundsman. A total of 64 samples were collected and evaluated from the 32 locations.

Plants were harvested with a 10.5 cm diameter cup cutter. Approximately 5 cm of the local soil was removed with each sample. The plants and soil were stored in plastic bags until transplant was achieved.

The plant material was established in 10.5 x 10.5 x 10.0 cm plastic pots that contained greenhouse soil. They were arranged on a bench in the greenhouse as previously described. The plants were watered approximately every two days.

On May 20, 1969, seed was harvested from nearly mature culms. Two observations of 25 seeds were germinated in a $30/20^{\circ}$ C continuously lighted chambers for 21 days. Results are presented as percent germination per sample.

The average node, secondary tiller, and adventitious root number from five flowering culms were recorded on June 9, 1969 for each sample. Also a distinction was made between upright, semi-prostrate or prostrate growth habit at that time.

The locations sampled were grouped into three regions based on similar climatic conditions. The three regions were:

1. Oregon Coast - Characterized by cool to moderate

temperatures throughout the year. Precipitation follows a Mediterranean pattern - moderate to limited during autumn, winter and spring. Precipitation occurs as rainfall.

2. Willamette Valley and Western Washington - Characterized by cool to moderate winter and moderate to warm summer temperatures. The precipitation pattern is similar to the Oregon Coast with the exception of dryer summer months.

3. Southwestern, North Central, South Central and Northeatern Oregon - Characterized by cool to cold winter and warm to very warm summer temperatures. The comparatively low precipitation occurs in autumn, winter, and spring as snowfall and scattered showers. Summer precipitation is limited.

Results and Discussion

Chromosome Counts

It was found that the five selections had a somatic chromosome number of 28. This agrees with the Index of Plant Chromosome Numbers (10). Bowden (7) reported that *Poa annua* from several areas in Canada was characterized by the somatic number of 28. He mentioned that all European sources likewise found the species to be uniform in this respect. The only differing report was presented by Hovin (43) who collected plants in the Los Angeles area that resembled Poa annua but had reduced morphological characteristics in comparison to the normal species type. These dwarfs had a chromosome number of 2n=14. Hovin concluded that they were amphihaploid forms of the species Poa annua.

Because the morphological characteristics of the five selections are within the Poa annua range mentioned in the United States (41) and Europe (46) and the chromosome number is identical to the majority of references, it was concluded that the selections are members of the taxonomic species Poa annua.

Seed Characteristics

Fluorescence Test

In excess of 80 percent germination was obtained in all containers and the seedlings grew uniformly over the trial period. At one, two and three weeks following germination, root lengths averaged 2, 3 and 5 cm long, respectively.

At no time throughout this test did any selection show the fluorescence reaction as is commonly observed in annual ryegrass. It was therefore concluded that the fluorescence test is not useful to distinguish between the Poa annua selections in this study. In an extensive review of the literature, Grabe (36) noted that although numerous crops have been examined, very few species did show the fluorescence root reaction.

Phenol Test

Three obviously different reactions were noted in the first trial. One type exhibited no stain. In another, the embryo was stained black but the endosperm remained unstained or only slightly stained; and in the third, the embryo and endosperm were both stained dark brown to black. Unfortunately, this variation occurred within observations as well as among selections. The data are therefore presented in Table 1 as percentages of seed within selections exhibiting one of the above color reactions.

Table 1. Seed reaction of five Poa annua selections to phenol.

Selection	Percent seeds per selection exhibiting color reaction		
	A*	B**	C***
1	63	37	0
2	80	20	0
3	0	0	100
4	0	100	0
5	0	33	67

*A - no stain
**B - Endosperm non-stained or only slightly stained; black embryo.
***C - Dark brown endosperm; black embryo

Selections 1 and 2 had a high percentage of seed that was not stained whereas selections 3, 4 and 5 exhibited either a completely stained seed or seed that had a stained embryo. The variation within observations could be due to differing seed age since the samples used for testing were harvested over an extended period. This concept is based on a report (84) that showed the response of rye (Secale cereale L.) and wheat (Triticum aestivum L.) was affected by the age of seed subjected to the phenol treatment.

The phenol reaction results of seeds harvested at a similar stage of maturity are presented in Table 2.

Table 2. Seed reaction of four Poa annua selections to phenol.

Selection	Percent seeds exhibiting color reaction		
	A*	B**	C***
1	43	54	3
2	------No seed available------		
3	9	73	18
4	21	77	2
5	7	76	17

*No stain
**Endosperm non-stained or only slightly stained; black embryo
***Dark brown endosperm; black embryo

Again, there was obvious variation within selections which negated the "age concept". The variation was similar, although not identical, to that observed in the initial trial. It is interesting to note that Poa annua seed examined at the Oregon State University Seed

Testing Laboratory usually exhibited variable color reactions within lots as was reported here (31).

Because of an inconsistent reaction within the Poa annua selections tested, it was concluded that the phenol treatment, as performed by the method outlined, is not adequate as an aid to distinguish between plant types of this species. The reason for variation within selections to the phenol treatment was not pursued but future work should examine this response.

Germination Test

Harvest Maturity. Results of the trial designed to determine the optimum seed maturity to examine differences in germination characteristics are presented in Table 3.

Table 3. Germination of seed harvested at three stages of maturity.

	Percent Germination Stage		
Selection	A*	B**	C***
1	0	6	2
2	------No seed available------		
3	72	20	41
4	0	0	22
5	46	36	96

*Limited senescence of panicle.
**Senescence obvious to second culm leaf.
***Culm senescent nearly to the base.

Selection 1 was characterized by low germination when harvested at the three maturity stages in question. This agrees with Hovin's (42) report that annual types of Poa annua are normally dormant immediately following harvest. The germination of Selections 3 and 5 was not influenced by harvest maturity although differences can be observed between stages. The reason for the relatively high germination of Selection 3, Stage A, in comparison to the lower results obtained in Stages B and C can easily be attributed to the limited number of seeds examined. Germination of Selection 4 was noted at Stage C.

Assuming that Selection 1 is morphologically similar to the annual subspecies and Selections 3, 4 and 5 exhibit perennial characteristics, it can be concluded that germination of the three perennial forms was observed at maturity Stage C. Therefore, to accurately determine differences in germination response of annual versus perennial plant types, seed from Poa annua should be collected from culms that are nearly mature to the base.

Post Harvest Dormancy. Results of the trial designed to examine the germination of seed harvested from mature panicles are presented in Table 4.

Selections 3, 4 and 5 recorded significantly higher germination percentages than did Selections 1 and 6 when tested immediately following harvest. It was concluded that the latter produce seeds that are primarily dormant when harvested from culms that were senescent nearly to the base whereas the former selections do not. It should be recalled that Selection 6 was considered morphologically similar to the annual subspecies and its growth habit closely resembled Selection 1.

Table 4. Seed germination of five Poa annua selections at harvest and following harvest.

Selection	Percent Germination	
	At harvest	Seven weeks following harvest
1	6 a*	92 b
2	--------No seed available------	
3	96 b	94 b
4	98 b	98 b
5	86 b	92 b
6	4 a	4 a

*Values followed by common letters are not significantly different at the five percent level of proability.

Germination results of seed that had been stored for seven weeks at room temperature are also presented. Selections 3, 4 and 5 exhibited similar germination characteristics in comparison to the earlier testing date. However, Selection 1 had broken dormancy during storage and a high percent germination was noted. Selection 6 remained dormant throughout the seven week period indicating that the length of the resting period following harvest for upright growth forms differs among genotypes.

As mentioned in the Literature Review, several authors (14, 42) noted post harvest dormancy in the upright annual subspecies whereas the perennial plant type normally germinated immediately following harvest (42). Therefore, Selections 1 and 6 exhibited an "annual" germination response while Selections 3, 4 and 5 are more typical of the perennial growth form in this characteristic. It was concluded that the germination characteristic is a useful tool to distinguish between the upright subspecies annua and the low growing perennial subspecies reptans.

It is interesting to note here that Cooper (17) examined various species within the genus Lolium that ranged in distribution from Northern Europe to the Mediterranean region. He found that species from Northern and Central Europe were normally perennial and exhibited no seed dormancy, i.e., Lolium perenne L. The environment in the general area was characterized by cold winter and moderate summer temperatures, with a uniform distribution of rainfall throughout the year.

Conversely, the Mediterranean area had cool winter and warm to hot summer temperatures. Rainfall occurred mostly in the autumn, winter and spring with infrequent precipitation during the summer months, as it does in much of the Northern Pacific Coastal areas. Mediterranean plants survived the summer stress period either as seeds, such as the annual growth habit of Lolium rigidum L., or through summer dormancy, as did an ecotype of Lolium perenne.

Seeds produced from Mediterranean originated plants were dormant throughout the dry summer thus insuring their survival irrespective of infrequent summer precipitation.

Since the supposed origin and initial distribution of Poa annua occurred in this region, it can be suggested that the germination characteristics observed between the annual and perennial subspecies could be due to environmental selection as Cooper indicated from his Lolium spp. studies.

Physical Characteristics

Measurements of seed length and width, caryopsis length and width, and rachilla length are presented in Table 5.

Table 5. Average seed length and width, caryopsis length and width, and rachilla length for five Poa annua selections.

	Seed (mm)		Caryopsis (mm)		Rachilla (mm)
Selection	Length	Width	Length	Width	Length
1	2.28*	.72 c**	1.31 b	.56 b	.60 ab
2	2.41	.56 a	1.29 b	.46 a	.62 ab
3	2.23	.70 c	1.37 b	.64 c	.62 ab
4	2.45	.70 c	1.38 b	.57 b	.54 a
5	2.24	.64 b	1.18 a	.53 b	.70 b

*No significance

**Values followed by common letters are not significantly different at the five percent level.

Although significant differences were recorded, it was concluded that the size relationships were not sufficiently consistent to be helpful in distinguishing between annual and perennial growth types. The differences appeared more related to the individual genotype rather than a basic division between subspecies.

Plant Characteristics

Little difference was noted among the five selections in germination time or amount. On January 25, Selections 1, 2, 3, 4 and 5 recorded 88, 93, 96, 88 and 86 percent germination respectively. Since the seed had been stored for several months prior to establishment, difference in germination time was neither expected nor noted. Lack of uniform germination was observed in the border area; this response was random among selections and was attributed to rapid drying of the edge pots.

Leaf

The results of leaf blade length and width and ligule length are presented in Tables 6, 7 and 8. Although significant differences were recorded with blade lengths at most observation dates, the only consistent trend was that Selection 3 generally exhibited a shorter blade. The observed decrease in blade length of Selections 1, 2 and 4, 64 and 88 days following germination was due to the maturation and subsequent senescence of the longer, young leaves, whereas leaf length of Selections 3 and 5 remained fairly constant at these dates. The overall longer lengths recorded in comparison to the parent plants could have been due to the warmer environment in the test area. Possibly the low light intensity that resulted from supplemental lighting during early morning and evening hours also influenced this characteristic.

Selection 5 recorded the narrowest leaf blade during the early growth stages but at the final observation time was significantly wider in this respect. There was no consistent trend among the selections that could be associated with distinctive growth forms. The measurements indicated that blade widths were a response of individual plants to a particular environment.

The relatively low coefficient of variation[4] at each testing date with both characters suggested a strong confidence in the method of measurement and the results obtained.

Although leaf lengths and widths are commonly used in most studies to describe genus, species, and lower taxonomic units, it has been consistently found that these characters are extremely variable (39), especially below the species level. Generally, this variability can be attributed to the local habitat from which the samples were collected and the environmental conditions under which they were tested (12). Leaf length and width, it appears, would be more

[4]The coefficient of variation for all analyses are presented with the respective ANOVA summation in Appendix Table 5.

Table 6. Average leaf blade lengths of five Poa annua selections at five dates following germination.

	Blade length, in cm				
	Days following germination				
Selection	13	26	49	64	88
1	4.5 bc*	8.4 b	14.0 c	11.9 b	10.2 NS**
2	3.5 ab	6.6 a	14.5 c	12.1 b	10.5
3	4.6 c	5.8 a	8.3 a	8.6 a	8.8
4	4.9 c	6.0 a	13.6 c	12.2 b	11.6
5	3.0 a	5.4 a	10.8 b	10.8 b	9.1

*Values followed by common letters are not significantly different at the five percent level of probability.
**No significance.

Table 7. Average leaf blade widths of five Poa annua selections at five dates following germination.

	Blade width, in mm				
	Days following germination				
Selection	13	26	49	64	88
1	1.1 b*	2.2 b	4.2 c	3.9 c	3.3 a
2	1.0 b	1.9 ab	3.8 bc	3.6 abc	3.4 a
3	1.0 b	2.1 b	3.3 ab	3.7 bc	3.3 a
4	1.0 b	1.9 ab	2.9 a	3.3 ab	2.9 a
5	0.8 a	1.7 a	3.1 a	3.2 b	3.9 b

*Values followed by common letters are not significantly different at the five percent level of probability.

meaningful in an examination of ecological races of Poa annua rather than a study of subspecies, as was the objective of this trial.

Concerning ligule lengths of the five selections in question, it was found that ligules of Selection 4 was significantly shorter than that of Selection 3. Ligule length measurements at previous dates, while not presented, indicated little or no difference among selections.

Table 8. Average ligule length of five Poa annua selections 88 days following germination.

Selection	Ligule length in mm
1	1.4 ab*
2	1.7 ab
3	1.9 b
4	1.3 a
5	1.6 ab

*Values followed by common letters are not significantly different at the five percent level of probability.

Carrier (11) and Pechanec (62) reported that ligule morphology was extremely important to identify grass species by vegetative characteristics. Such confidence is based on ligule stability within species over wide environmental conditions. In addition to being useful in classification between species, Artschwager (1) has demonstrated that agricultural cultivars and botanical varieties of sugar cane (Saccharum officinarum L.) can be accurately distinguished by the ligule length, midrib, flange and pubescence characteristics.

Although previous works indicate the value of ligule morphology to classify grasses both within and among species, it was concluded that ligule length was not a useful measurement to differentiate among the selections in this study.

Culm

The results of culm length, leaf and node number measurements are presented in Table 9. Inflorescence characteristics are given in Table 10.

Selection 3 exhibited a significantly shorter culm length than the remaining selections. However, the difference was not great. The culms of all selections were approximately 10 cm longer than those of the respective parent plants which far outweighed any variation among selections. This response was attributed to higher greenhouse temperatures and different light conditions, as previously described. Booth (6) pointed out that although there is a wide variation in culm length in the grass family - from two inches for *Festuca ovina* var. *brachyphylla* L. to 120 feet in certain *Bambusa* Schreb. species - the height characteristic within a species is greatly influenced by the environment, as these results confirm. It therefore was concluded that culm height is not a useful character to distinguish between subspecies of *Poa annua*.

The node number and leaf number per culm revealed differences

Table 9. Culm length, leaf and node number of five Poa annua selections 88 days after germination.

Selection	Culm length in cm	Leaf number	Node number
1	24.9 b*	5.1 a	6.1 a
2	27.0 b	8.5 c	11.1 bc
3	22.5 a	6.5 b	9.0 b
4	25.2 b	8.0 c	10.5 b
5	24.7 b	12.8 d	13.2 c

*Values followed by common letters are not significantly different at the five percent level of probability.

Table 10. The length of panicle, upper and lower glumes, lemma and palea of five Poa annua selections.

Selection	Panicle (cm)	Glumes (mm)		Lemma (mm)	Palea (mm)
		upper	lower		
1	6.5 NS*	2.1 ab**	1.6 a	2.4 NS	2.1 NS
2	8.2	2.9 c	2.4 c	2.8	2.5
3	6.7	1.8 a	1.6 a	2.5	2.3
4	6.7	2.2 ab	1.9 a	2.8	2.6
5	7.2	2.5 bc	2.2 bc	2.6	2.4

*No significance.

**Values followed by common letters are not significantly different at the five percent level of probability.

between Selection 1 and the remaining plant types. With both characteristics, Selection 1 recorded significantly lower numbers; obviously, the lower leaf number was due to the reduced node number per culm. The node numbers are consistent with those observed on the parent plants.

Selection 5 had a significantly greater leaf number than did Selections 1, 2, 3 and 4 whereas the node number was greater than Selections 1, 3 and 4.

An accurate measure of significance was indicated by a coefficient of variation of 6.9 percent for leaf number and 13.4 percent for node number.

Three considerations indicated that leaf number and, more importantly, node number are meaningful characteristics to distinguish between the annual and perennial subspecies of *Poa annua*. First, the test was statistically accurate as indicated by the coefficient of variation; the methods of testing and measurement therefore appeared reliable. Second, obvious differences were noted between Selection 1, which was morphologically typical of the annual subspecies, and the remaining selections which either exhibited perennial plant type characteristics or were questionable in this regard. And third, progeny node numbers were similar to those recorded on the respective parent plants.

No measurable differences were observed in panicle length, lemma length and palea length. The upper and lower glumes of Selection 2 were significantly longer than those of Selections 1, 3 and 4. Measurements were within the range listed for Poa annua (46) with the exception of the upper glume of Selection 3. It recorded an average length of 1.8 mm in comparison to the accepted range of 2.0-4.0 mm. This difference was not considered important.

Because of these results, it appears doubtful that inflorescence characteristics would be useful to distinguish between subspecies within the species Poa annua.

Tiller

The average number of primary tillers recorded on six observation dates following germination are presented in Table 11. Secondary tiller numbers are given in Table 12.

At the first two measurement dates no differences in primary tiller number were observed between the five selections thus indicating a similar capacity to produce tillers at the early growth stages. Tiller numbers rapidly increased from 26 to 49 days following germination, and at the latter date Selections 1, 3 and 4 had a greater number of primary tillers than did Selection 2. At 49 and 64 days after germination Selection 3 was characterized by a greater tiller number than the remaining selections. The decrease in basal tiller number of Selections 3 and 5, 110 days following germination was due to a

Table 11. Primary tiller numbers of five Poa annua selections at six dates following germination.

	Primary tiller numbers					
	Days following germination					
Selection	13	26	49	64	88	100
1	1 NS*	2 NS	11.8 c**	13.3 a	14.3 a	15.8 c
2	1	2	5.7 a	12.3 a	10.8 a	9.7 ab
3	1	2	12.2 c	20.0 b	22.7 b	14.0 c
4	1	2	10.0 bc	16.2 ab	13.7 a	10.3 b
5	1	2	7.5 ab	12.8 a	15.2 a	6.7 a

*No significance

**Values followed by common letters are not significantly different at the five percent level of probability.

Table 12. Secondary tiller number of five Poa annua selections 88 days following germination.

Selection	Secondary tiller number
1	2.7 a*
2	7.3 b
3	10.8 b
4	10.8 b
5	18.3 c

*Values followed by common letters are not significantly different at the five percent level of probability.

slight culm elongation in the basal portion which resulted in a branched appearance as described with the parent plants.

Selections 2, 3, 4 and 5 produced significantly greater secondary tiller numbers in comparison to Selection 1. Also, Selection 5 recorded more secondary tillers than did Selections 2, 3 and 4.

Whereas the production of primary tillers appeared more related to the respective selections at the different measurement dates, secondary tiller numbers showed an obvious difference between Selection 1 and the remaining plant types. Hovin (42) indicated that perennial forms of _Poa annua_ exhibited a higher secondary tiller number. The perennial varieties previously discussed also showed this difference.

It is therefore concluded that Selections 2, 3, 4, and 5 produced greater secondary tiller numbers than did Selection 1 and this response appears to be related to perennial plant types within the species _Poa annua_.

Flowering

Table 13 presents the percentage of plants of each selection that were producing seedheads at four dates following germination. The percentages of primary and total tiller number exhibiting seedhead formation 100 days following germination are listed in Table 14.

Table 13. Percentages of plants producing seedheads at four dates following germination.

	Percent flowering			
	Days following germination			
Selection	44	55	68	93
1	8	50	74	93
2	-	10	16	93
3	-	-	40	91
4	-	-	22	86
5	-	-	-	26

Table 14. The percentage of primary and total tillers flowering 100 days following germination.

	Percent tillers flowering	
Selection	Primary	Total
1	73 bc*	71 c
2	61 b	45 b
3	90 c	51 b
4	75 bc	40 b
5	13 a	5 a

*Values followed by common letters are not significantly different at the five percent level of probability.

Selection 1 was the first to produce seedheads and at 44 days following germination, eight percent of the plants were flowering. The order of seedhead production for the remaining selections was: Selection 2, 55 days; Selections 3 and 4, 68 days; and Selection 5, 93 days. With the exception of Selection 5, little difference was observed in the percentages of plants flowering at the final date among Selections 1, 2, 3 and 4.

Tutin (78) has noted a correlation between the speed of reproductive maturity and the life length of Poa annua plants. In his trial, the annual types produced seedheads 50 days following germination whereas seedhead formation was obvious 81 days following germination with a perennial "race". The results presented here tend to confirm these findings. It is expected that the time to achieve reproductive maturity will vary depending on plant types examined, light and temperature regimes, and moisture levels. However, the trends between annual and perennial subspecies should be similar to those observed.

An examination of primary tillers that were flowering 100 days following germination revealed little difference among Selection 1, 2, 3 and 4 although Selection 3 was significantly different from Selection 2. The most obvious variation was noted with Selection 5. It had fewer basal tillers in the flowering stage than did the remaining sections.

When considering total tillers per plant, Selection 1 had a significantly greater tiller number that had reached reproductive maturity. Again, Selection 5 had significantly fewer flowering tillers per plant. The decrease in the percent flowering tillers of Selections 2, 3, 4 and 5 was due to the larger number of secondary vegetative tillers as presented in Table 12. Although the primary tillers of Selections 2, 3 and 4 flowered as much as Selection 1, the former selections continually had secondary vegetative tillers present.

Langer (52) has suggested that annual versus perennial growth in grasses is often determined by the plant's capacity to maintain an adequate percentage of vegetative tillers. It has been demonstrated that Selections 2, 3, 4 and 5 have larger numbers of vegetative tillers present, and, because of more numerous nodes per culm, have a greater potential for continued tiller production.

Shoot Dry Weight

There was no difference in shoot weights when harvested 26, 64, 88 and 100 days following germination as results in Table 15 indicate. The only meaningful data were obtained 49 days after emergence. At that time, Selection 1 yielded a significantly greater dry weight than did the other selections. The more rapid growth during this development stage could possibly account for the earlier seedhead production that was observed.

A high coefficient of variation at all dates indicated a large

Table 15. Shoot dry weights of five Poa annua selections at six dates following germination.

	Dry weights in mgm.					
	Days following germination					
Selection	13	26	49	64	88	100
1	1.2 c*	7.7 NS**	257.0 b	407.1 NS	840.7 NS	924.6 NS
2	0.7 ab	4.8	149.0 a	363.9	860.8	787.8
3	1.1 bc	10.2	151.2 a	429.6	1010.9	963.0
4	1.1 bc	7.6	154.1 a	327.0	766.0	908.4
5	0.6 a	4.3	91.0 a	272.8	916.6	1035.0

*Values followed by common letters are not significantly different at the five percent level of probability.
**No significance

experimental error.

Root Dry Weight, Seminal Root Number

As shown in Table 16, no significant root weight difference was noted among selections when harvested 26, 49 and 64 days following germination. The coefficient of variation calculated from these results indicated a large experimental error.

Table 16. Root dry weights of five Poa annua selections at four dates following germination.

	Weight in mgm			
	Days following germination			
Selection	13	26	49	64
1	0.4 b*	3.1 NS**	63.0 NS	129.3 NS
2	0.1 a	2.3	47.1	104.6
3	0.4 b	4.1	54.3	108.4
4	0.5 b	3.8	55.8	117.6
5	0.3 b	2.4	32.4	93.0

*Values followed by common letters are not significantly different at the five percent level of probability.
**No significance.

At 13 and 26 days after emergence, all selections had one seminal root per plant. It was easily distinguished from the secondary roots by its slender, white, poorly-branched appearance. Although Booth (6) indicated that seminal root numbers frequently differ among plant types within a species, this characteristic was not observed among the selections examined.

Adventitious Rooting

The number of adventitious roots on the longest culm of each selection is presented in Table 17. Also, the number of secondary tillers on the same culm is shown.

Table 17. The number of adventitious roots and secondary tillers per culm 93 days following germination.

Selection	Adventitious roots	Secondary tillers
1	1.6 a*	1.2 a
2	4.4 b	3.4 bc
3	4.4 b	3.8 bc
4	4.8 b	2.4 ab
5	6.0 b	4.6 c

*Values followed by common letters are not significantly different at the five percent level of probability.

Selection 1 produced fewer adventitious roots per culm than did Selections 2, 3, 4 and 5. There was a high correlation (r = .86) between the adventitious root number and secondary tiller number which indicated those nodes that produced tillers likewise produced the supporting root system. Generally, both roots and secondary tillers were located on the lower nodes of the culms examined.

Repeated reference has been made to adventitious root production at the nodes of perennial varieties or subspecies in *Poa annua*. It has been shown here that significant differences do exist in this respect between Selections 2, 3, 4 and 5, which appear typical of the perennial subspecies, and Selection 1 which is morphologically similar to subspecies annua.

Survey of Poa annua Subspecies in Oregon and Western Washington

As described in Methods and Materials, the 32 sample locations were grouped into three climatically similar regions, namely Oregon coast; Willamette Valley and Western Washington; and Southwestern, North Central, South Central and Northeastern Oregon, hereafter referred to as Region 1, 2 and 3, respectively. This grouping is the result of an examination of temperature and rainfall characteristics of Oregon and Western Washington (80, 81) as is presented in Tables 18 and 19. Also given are the same climatic data for two locations in Germany and one in Southern France for future discussion.

The plant samples were classified as exhibiting an annual or perennial subspecies growth form by directly relating the results obtained in the previous sections to the sample characteristics. Therefore, samples were considered annual if the culms had a low node number (six or less), a low secondary tiller number (one or less), a low adventitious root number (one or less), and the seed was characterized by post-harvest dormancy (ten percent germination or less). Perennial characteristics included a greater number of nodes, secondary tillers, and adventitious roots per culm in addition to a high percentage seed germination. This method of evaluation was felt to be

Table 18. Average monthly rainfall for three regions of Oregon and Western Washington and three locations in Europe.

Location	Monthly rainfall in mm.											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Region 1												
North Coast	312.4	264.2	274.3	154.9	91.4	78.7	30.5	38.1	76.2	198.1	284.5	353.1
South Coast	317.5	231.1	221.0	152.4	81.3	43.2	10.2	10.2	45.7	147.3	208.3	264.2
Region 2												
Willamette Valley	195.6	157.5	150.0	83.8	71.1	55.9	12.7	17.5	58.4	124.5	185.4	221.0
West. Washington	172.0	138.0	116.0	68.0	48.0	43.0	20.0	24.0	53.0	107.0	166.0	195.0
Region 3												
South West	124.5	94.0	83.8	48.3	50.8	35.6	7.6	7.6	22.9	71.1	50.8	129.5
North Central	63.5	48.3	45.7	43.2	30.5	27.9	7.6	7.6	17.8	38.1	58.4	66.0
South Central	53.3	30.5	27.9	22.9	33.0	30.5	10.2	7.6	15.2	25.4	33.0	40.6
North East	48.3	43.2	43.2	38.1	45.7	45.7	15.2	12.7	22.9	38.1	45.7	50.8
Germany												
Stuttgart	49.3	47.4	26.4	44.6	69.4	89.1	86.5	94.5	61.9	54.3	38.3	47.7
Hamburg	59.9	36.5	38.2	33.3	51.8	72.8	77.5	107.4	60.3	57.4	51.1	67.6
France												
Nice	58.8	69.3	79.6	78.8	48.7	37.2	28.5	32.3	96.5	137.1	151.7	126.3

Table 19. Average monthly temperatures for three regions of Oregon and Western Washington and three locations in Europe.

Location	Monthly temperatures in °C											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Region 1												
North Coast	6.2	6.7	7.1	8.2	11.6	14.3	15.4	16.1	15.5	12.2	8.8	5.7
South Coast	8.3	8.8	8.1	8.6	11.7	14.6	15.7	16.0	13.3	13.3	11.5	7.4
Region 2												
Willamette Valley	3.5	5.3	7.3	10.4	13.4	15.8	18.8	18.5	18.4	12.0	7.1	5.0
West. Washington	3.4	5.0	6.8	9.8	13.0	15.8	18.4	17.6	15.1	11.1	6.6	4.8
Region 3												
South West	4.0	4.8	7.0	10.2	13.6	16.6	20.5	19.9	17.1	11.9	6.4	3.9
North Central	-0.2	2.5	6.3	10.3	14.3	17.5	21.5	20.6	17.0	11.2	4.7	1.4
South Central	-1.8	0.6	3.5	7.5	11.2	14.6	19.0	17.9	14.2	9.1	3.1	.6
Germany												
Stuttgart	-0.5	0.0	5.0	8.2	12.9	15.9	17.5	16.6	13.8	9.0	3.8	1.8
Hamburg	0.6	-0.4	3.2	7.2	11.8	15.2	16.8	16.2	13.4	9.3	5.0	2.9
France												
Nice	7.6	8.3	10.6	13.1	16.6	20.0	22.6	22.2	20.0	15.7	11.5	9.1

accurate, and useful in field observations, since only four of the 64 samples resulted in a questionable designation.

The results obtained at each location within the three regions are presented in Table 20. Table 21 summarizes the number of annual and perennial subspecies found under the three management regimes within the respective regions.

It was found that in excess of 50 percent of the samples collected in Oregon and Western Washington exhibited perennial characteristics. In addition to a relatively high node number, secondary tiller number, adventitious root number and germination percentage, all samples considered perennial had a prostrate or semi-prostrate growth habit. The annual plant types, with the exception of one sample, were characterized by an upright growth form. The response observed supports the earlier descriptive literature that reported perennial varieties in the *Poa annua* species were generally prostrate or semi-prostrate whereas the annual forms were erect.

Poa annua subspecies *annua* and *Poa annua* subspecies *reptans* were found to be fairly equally distributed within the three regions as is shown in Table 21. Evidently the environmental conditions in the three areas, as modified by management practices, were conducive to the growth and development of both the annual and perennial subspecies.

When the percentage of annual and perennial subspecies was

Table 20. The percent germination, growth habit, node, tiller and adventitious root numbers per culm of Poa annua collected from Oregon and Western Washington.

Location	Growth Habit*	Percent Germination	Number Nodes	Number Tillers	Number Roots	Life Length
Region 1						
Astoria Agr. Expt. Sta.	U	0	4.6	0.0	0.0	Annual
Astoria Column	U	6	3.8	0.0	0.0	Annual
Astoria Country Club						
Green	P	98	8.4	3.0	2.4	Perennial
Fairway	P	48	9.2	1.4	2.6	Perennial
Rough	SP	72	7.6	1.6	2.2	Perennial
Astoria Post Office	SP	84	9.2	1.8	3.0	Perennial
Alderbrook Golf Club						
Green	SP	66	6.0	1.2	2.0	Perennial
Fairway	SP	98	7.0	1.2	2.2	Perennial
Rough	U	2	5.2	0.4	0.6	Annual
Agate Beach Country Club						
Tee	SP	78	7.0	1.6	2.0	Perennial
Fairway	U	4	3.8	0.0	0.0	Annual
Rough	U	10	3.6	0.4	0.2	Annual
Rhod-O-Dunes Golf Club						
Apron	SP	36	8.6	2.4	2.2	Perennial
Fairway	U	2	5.4	0.4	0.4	Annual
Coos Country Club						
Green	SP	70	7.0	0.8	2.8	Perennial
Fairway	U	10	5.8	0.0	0.2	Annual
Rough	U	0	5.2	0.0	0.4	Annual

Table 20 continued.

Location	Growth Habit*	Percent Germination	Number			Life Length
			Nodes	Tillers	Roots	
The Elks Golf Club						
Apron	SP	76	7.6	1.6	2.2	Perennial
Fairway	U	0	5.2	0.4	0.4	Annual
Rough	U	0	3.6	0.0	0.0	Annual
Coquille Courthouse	U	10	4.0	0.2	0.0	Annual
Region 2						
O.M.S.I. Turf Plots	SP	88	9.0	2.8	3.0	Perennial
Illahe Country Club						
Apron	SP	92	9.0	2.2	2.6	Perennial
Fairway	SP	94	8.0	1.2	2.2	Perennial
Rough	U	0	5.6	0.0	0.2	Annual
Salem Courthouse	U	0	5.2	0.4	0.0	Annual
Albany Golf Club						
Apron	SP	72	8.8	2.0	2.2	Perennial
Fairway	SP	70	10.0	1.8	2.8	Perennial
Rough	U	8	4.8	0.2	0.6	Annual
Corvallis Country Club						
Green	SP	92	8.6	2.2	2.8	Perennial
Fairway	SP	88	8.4	1.8	2.4	Perennial
Rough	SP	2	3.6	0.0	0.0	Annual
Eugene Country Club						
Green	SP	58	8.0	2.0	2.4	Perennial
Fairway	SP	70	9.2	1.0	1.6	Perennial
Rough	U	2	4.0	0.0	0.0	Annual

Table 20 continued.

Location	Growth Habit*	Percent Germination	Numbers			Life Length
			Nodes	Tillers	Roots	
Seattle Golf Club						
Tee	SP	86	9.2	2.4	2.4	Perennial
Jefferson Park Golf Club						
Fairway	SP	44	6.2	1.4	1.0	Perennial
Carnation Golf Club						
Green	SP	86	8.0	1.8	3.0	Perennial
Region 3						
Rogue Valley Country Club						
Green	SP	56	8.8	2.4	1.2	Perennial
Fairway	SP	42	9.6	2.2	3.8	Perennial
Rough	U	0	5.0	0.2	0.2	Annual
Roseburg Courthouse	SP	82	9.6	2.4	3.6	Perennial
Roseburg Country Club						
Apron	U	8	5.4	0.0	0.2	Annual
Fairway	U	50	6.0	0.0	0.2	Questionable
Rough	SP	90	7.2	1.0	1.8	Perennial
Grants Pass Golf Club						
Green	SP	66	7.2	1.2	2.0	Perennial
Fairway	SP	50	9.0	3.6	2.2	Perennial
Rough	U	0	3.4	0.0	0.0	Annual
Hood River Golf Club						
Apron	SP	36	6.8	0.4	1.0	Questionable
Tee	U	0	5.2	0.4	0.2	Annual

Table 20 continued.

Location	Growth Habit*	Percent Germination	Numbers			Life Length
			Nodes	Tillers	Roots	
The Dalles Country Club						
Apron	P	74	9.0	1.4	2.2	Perennial
Fairway	SP	76	7.0	1.2	2.0	Perennial
Rough	U	6	4.6	0.0	0.0	Annual
The Dalles High School	SP	86	8.2	1.8	2.4	Perennial
South Sorosis Park	SP	50	9.2	1.4	1.6	Perennial
9 Peaks Golf Club						
Green	SP	80	7.4	1.6	1.6	Perennial
Juniper Golf Club						
Green	U	22	4.4	0.0	0.2	Questionable
Fairway	U	0	5.2	0.2	0.2	Annual
Bend Golf Club						
Green	U	8	3.0	0.0	0.0	Annual
Tee	U	4	3.4	0.0	0.0	Annual
Reames Country Club						
Green	U	16	4.0	0.4	0.2	Questionable
Tee	U	6	3.8	0.6	0.0	Annual
Fairway	U	0	2.8	0.0	0.0	Annual
Pendleton Agr. Expt. Sta.	U	0	5.2	0.2	0.2	Annual

*U = Upright growth habit, SP = Semiprostrate growth habit, P = Prostrate growth habit.

Table 21. The number of annual and perennial subspecies found under three management regimes within three climatically similar regions.

Region	Green		Fairway		Rough		Total	
	A*	P**	A	P	A	P	A	P
1	0	6	7	3	4	1	11	10
Percent	0	100	70	30	80	20	52	48
2	0	6	1	6	4	0	5	12
Percent	0	100	14	86	100	0	29	71
3	5	4	3	6	3	1	11	11
Percent	56	44	33	67	75	25	50	50
Total	5	16	11	15	11	2	27	33
Percent	31	69	42	58	85	15	45	55

*Annual - *Poa annua* subspecies *annua*
**Perennial - *Poa annua* subspecies *reptans*

observed within and among the management regimes, obvious differences were noted. Annual bluegrass collected from golf course greens had a higher percentage of perennial plant types than did those samples from the non-irrigated rough areas. Only the perennial subspecies was found in greens located in Regions 1 and 2 whereas both subspecies were noted in greens from Region 3. Samples from golf course roughs were predominately the annual plant type in all regions. The annual and perennial subspecies were represented in collections from golf course fairways, or lawn areas managed similar to fairways.

The large number of _Poa annua_ samples that would be classified in the taxonomic subspecies _reptans_ was surprising since reports of perennial plant types in the United States are limited. Whereas European literature is consistent in acknowledging the presence of annual and perennial growth forms, reference to the latter in this country is as follows: Hovin (42) reported finding perennial _Poa annua_ in Southern California; Beard (4) has recently collected samples of annual bluegrass from various areas in Michigan and observed perennial plant types; and Skogley (69) has sampled at least one location in Rhode Island where the perennial subspecies was found. In contrast, the findings of this survey show that _Poa annua_ subspecies _reptans_ is present to a significant extent in turfed areas where annual bluegrass is a problem in Oregon and Western Washington.

To further consider these results, it should be recalled that

Timm (73) sampled Poa annua under natural conditions from Finland to Portugal and noted a high percentage of perennial types from Northern and Central Europe whereas the annual subspecies was found mainly in Southern Europe. Also, most perennial varieties mentioned in the Literature Review were collected and described in Central Europe. If the rainfall and temperature data of Central Europe are compared to that from the Mediterranean area, as presented in Tables 18 and 19, it can be seen that the former are characterized by moderate summer temperatures and an even distribution of moisture throughout the year. In this climate Poa annua seldom would be exposed to moisture or temperature stress so perennial growth forms of the species would survive easily. The Mediterranean region, however, has warm summer temperatures and infrequent precipitation. "Annual" Poa annua would evidently survive the stress environment as dormant seed.

This interpretation is similar to Cooper's (15, 17) conclusions following a study of Lolium spp. as previously discussed. It also gives insight to a probable explanation of the results obtained.

Throughout Oregon and Western Washington, which is climatically similar to the Mediterranean climate, it would appear likely that the high percentage of Poa annua subspecies annua in golf course rough areas can be attributed to the lack of summer precipitation, either natural or as supplied by irrigation. The annual subspecies would die, "oversummer" as dormant seed, and germinate the following autumn with the advent of seasonal rainfall. Likewise, the perennial subspecies in a non-irrigated golf course rough would be unable to survive the dry summer months. The seed from the perennial parent, however, would germinate following the slightest summer precipitation, only to die thereafter from moisture stress. This would result in an environmental selection against the perennial but a condition under which the annual could exist.

Conversely, golf course greens are irrigated at times of moisture stress and are often syringed during periods of high evapotranspiration. Moisture is seldom a limiting factor under this intensely managed situation. Continued germination, growth, and development of the perennial subspecies is therefore possible. The annual subspecies also would be able to complete its natural life cycle in golf course greens. Competition from the summer growing perennial would theoretically result in a dominance of *Poa annua* subspecies *reptans* over time, as the data suggest.

From the above discussion, it would follow that the presence of the annual or perennial subspecies in fairways, or lawns managed on a similar intensity level, could be correlated to the method of water supply. Fairway type turf that was watered infrequently but thoroughly, with the surface four to six inches reaching or approaching the wilting point prior to irrigation, would have mainly annual types present. The perennial subspecies could be anticipated in swards that are more frequently irrigated. The apparent randomness of annual and perennial subspecies found under fairway turf would tend to support this contention.

IV. SUMMARY AND CONCLUSIONS

A weed is defined as a plant growing where it is not desired by man, or more concisely, a plant that is out of place. Annual bluegrass (Poa annua) is "out of place" when present in a turfgrass sward because of several undesirable characteristics.

Until recently, methods to effect the control of Poa annua have been based on competition, seedhead inhibition, and postemergent herbicide treatment. Unfortunately, none have been absolutely effective. The newest method of control involves the use of preemergent herbicides. Their success is dependent on the death of established annual bluegrass plants during the warm, dry summer months and subsequent chemical toxicity to the germinating seed. Acceptable Poa annua control has been obtained with various preemergent herbicides in ideal test conditions. However, practical field usage has resulted in only moderate control of the weed. The reason for this failure could be due to the presence of perennial plant types within the Poa annua species which would negate the preemergent concept.

The following were the objectives of this study:

1) To determine if perennial plant types have been described.

2) If so, to determine an identification method based primarily on morphological characteristics to differentiate the annual

and perennial plant types.

3) To determine if perennial plant types are present in turfed areas in the Northern Pacific Coastal region.

Descriptive botanical literature of annual bluegrass varieties was collected from numerous world floras. The results of the literature search indicated that the subspecies taxonomic designation would be appropriate to distinguish between described annual and perennial plant types. It was suggested that all annual varieties of _Poa annua_ be classified in subspecies _annua_ and the perennial varieties in subspecies _reptans_.

Seeds from five morphologically different _Poa annua_ selections were planted in a soil medium and the progeny were grown in an environmentally controlled greenhouse. Plants were harvested at several times following germination and numerous characteristic measurements were obtained. Also, the seed from the parent selections was subjected to various analyses.

The results showed that the following morphological characteristics were not sufficiently reliable to be useful in distinguishing the annual or perennial subspecies: blade length and width; ligule length; culm length and inflorescence characteristics; primary tiller number; shoot and root dry weight; and seminal root number. Generally, the response of these characters could be attributed to the individual selection rather than to a morphological difference between subspecies.

The following characteristics could be associated with annual versus perennial growth forms: leaf and node number; secondary tiller number; adventitious root number; the speed of reproductive maturity; and the percentage of tillers that were flowering at the completion of the test. Annual plant types were characterized by lower leaf and node numbers, lower secondary tiller numbers, and lower adventitious root numbers. They also reached reproductive maturity quicker than the perennial plant types. At the completion of the test, the annuals had a greater percentage of flowering tillers.

It was concluded from these results that perennial life length within Poa annua can be attributed to the continued presence of secondary vegetative tillers. Since the perennial plant types have prostrate or semi-prostrate culms that root at the nodes, these non-flowering tillers evidently root and continue growth and development.

An examination of seed from the five selections showed that the fluorescence and phenol tests and physical characteristic measurements were not useful to distinguish between the subspecies in question. A fluorescent reaction was not observed from any selection. A different phenol response was observed among seed samples, but a variable reaction was noted within selections. The test was thus deemed useless for the objectives of this study. Seed length and width, caryopsis length and width, and rachilla length were related to the individual selections and not to subspecies.

Results of a test designed to evaluate seed dormancy revealed differences between annual and perennial plant types. Seed from annual plants exhibited a definite post harvest dormancy whereas the seed from perennial plants germinated immediately following harvest. To observe this response most clearly, it was found that seed should be collected from culms that are senescent nearly to the base.

Using some of the positive identification characteristics to differentiate annual and perennial plant types, 65 representative samples of Poa annua were collected from 32 turfgrass locations in Oregon and Western Washington. The samples were harvested from three management regimes: golf course greens that received frequent irrigation during the dry summer months; golf course fairways, or lawn areas managed similar to fairways, that received moderate summer irrigation; and golf course roughs that received no supplemental moisture.

It was found that in excess of 50 percent of the samples exhibited perennial characteristics and that both subspecies were quite evenly distributed throughout Oregon and Western Washington. Results showed the greatest percentage of the perennial subspecies were collected from turfed areas that had received moderate or intensive supplemental irrigation. The annual predominated in non-irrigated golf course roughs.

Four conclusions can be drawn from this study:

First, perennial plant types in the species Poa annua have been described in various world floras. There appears to be sufficient reasons to identify the annual and perennial growth forms as taxonomic subspecies.

Second, several plant characteristics were found useful to distinguish accurately between the annual and perennial subspecies.

Third, the perennial subspecies was found to a significant extent in golf course greens and fairways, or swards managed similar to fairways, throughout Oregon and Western Washington.

And fourth, the presence of perennial plants within the Poa annua species could account for the variable control results that have been obtained with preemergent herbicides.

BIBLIOGRAPHY

1. Artschwager, E. The role of the ligule in sugarcane taxonomy. American Journal of Botany 38(2): 144-146. 1951.

2. Association of Official Seed Analysts. Rules for testing seed. Proceedings, Association of Official Seed Analysts 54(2): 44. 1965.

3. Beard, J. B. Effects of ice, snow and water covers on Kentucky bluegrass, annual bluegrass and creeping bentgrass. Crop Science 4(6): 638-640. 1964.

4. ______________ An ecological study of annual bluegrass. United States Golf Association Green Section Record 8(2): 13-18. 1970

5. Beard, J. B. and C. R. Olien. Low temperature injury in the lower portion of _Poa annua_ L. crowns. Crop Science 3(4): 362-363. 1963.

6. Booth, W. E. Agrostology. Bozeman, Montana, The Endowment and Research Foundation, 1964. 222p.

7. Bowden, W. Chromosome numbers and taxonomic notes on northern grasses. IV. Tribe _Festucaeae_: _Poa_ and _Pucinella_. Canadian Journal of Botany 39(1): 123-138. 1961.

8. Brightbill, C. K. The challenge of leisure. Englewood Cliffs, N. J., Prentice-Hall, 1960. 118p.

9. Butcher, R. W. A new illustrated British flora, Vol. 2, London, Leonard Hill, 1961. 941p.

10. California Botanical Society. Index to plant chromosome numbers, ed. by M. S. Cove, Chapel Hill, The University of North Carolina Press, Vol. 2(6). 84p.

11. Carrier, L. The identification of grasses by their vegetative characters. United States Department of Agriculture Bulletin 461, January 19, 1917. 30p.

12. Clausen, J. Stages in the evolution of plant species. 2d rep. New York, Hafner, 1967. 206p.

13. Clausen, J., D. D. Keck and W. M. Hiesey. Experimental studies on the nature of species. Washington, Carnegie Institute of Washington Publication 520, 1940. 449p.

14. Cockerham, S. T. and J. W. Whitworth. Germination and control of annual bluegrass. The Golf Superintendent 35(5): 10-17, 45-46. 1967.

15. Cooper, J. P. Studies on growth and development of Lolium. I. Relation of the annual habit to head production under various systems of cutting. Journal of Ecology 37(2):233-259. 1949.

16. ______________ The use of controlled life cycles in the forage grasses and legumes. Herbage Abstracts 30(2): 71-79. 1960.

17. ______________ Species and population differences in climatic response. In: Environmental control of plant growth ed. by L. T. Evans. New York, Academic Press, 1963. p. 381-403.

18. Daniel, W. H. Poa annua control with arsenic materials. Golf Course Reporter 23(1): 5-9. 1955.

19. Davies, W. Vegetation of grass verges and other excessively trodden habitats. Journal of Ecology 26(1): 38-49. 1938.

20. Dawson, R. B. Practical lawn craft. 6th ed. London, Crosby Lockwood, 1968. 320p.

21. De France, J. A. and J. R. Kollett. Annual bluegrass (Poa annua L.) control with chemicals. Golf Course Reporter 27(1): 14-18. 1959.

22. Engel, R. E. Temperatures required for germination of annual bluegrass and colonial bentgrass. The Golf Superintendent 35 (9): 20-23. 1967.

23. Engel, R. E. and R. J. Aldrich. Reduction of annual bluegrass, Poa annua, in bentgrass turf by the use of chemicals. Weeds 8(1): 26-28. 1960.

24. Engel, R. E., A. Morrison and R. D. Illnicki. Preemergence chemical effects on annual bluegrass. The Golf Superintendent 3(2): 20-21, 39. 1968.

25. Escritt, J. R. Maleic hydrazide as a grass growth regulator. Journal of the Sports Turf Research Institute 31: 76-84. 1955.

26. Evans, M. W. The life history of timothy. United States Department Bulletin No. 1450. 1927. 56p.

27. Experiments on the control of wintergrass. Grass Research 7: 10-12. June, 1962.

28. Ferguson, M. H. Poa annua control. United States Golf Association Journal 12(5): 25-28. 1959.

29. Ferguson, N. L. A greenskeppers guide to the grasses - 7. the meadowgrasses. Journal of the Board of Greenskeeping Research no. 15, 274-279. 1936.

30. ______________ Annual meadowgrass (Poa annua L.) New Zealand Golf Illustrated Feb. 1, 1938. p. 9-12.

31. Ford, B. Laboratory Assistant, Oregon State University Seed Testing Laboratory, Department of Farm Crops. Personal communication. Corvallis, Oregon. February, 1969.

32. Gibeault, V. A. Investigations on the control of annual meadowgrasses. Journal of the Sports Turf Research Institute 42: 17-40. 1967.

33. Goss, R. L. Preemergence control of annual bluegrass (Poa annua L.) Agronomy Journal 56(5): 479-481. 1964.

34. Gould, F. W. Grass systematics. New York, McGraw-Hill, 1968. 382p.

35. Grabe, D. F. Professor, Oregon State University, Department of Farm Crops. Personal communication. Corvallis, Oregon. January, 1969.

36. ______________ Laboratory methods for identification of varieties of soybeans and oats. Ph.D. thesis. Ames, Iowa State College. 1957. 169 numb. leaves.

37. Halcrow, J. G. Unpublished research on Poa annua germination. Bingley, Yorkshire, England. The Sports Turf Research Institute. 1966.

38. Haunold, A. Venetian turpentine as an aid in squashing and concomitant production of desirable chromosome mounts. Stain Technology 43(3): 153-156. 1968.

39. Hiesey, W. M. Growth and development of species and hybrids of Poa under controlled temperatures. American Journal of Botany 40(4): 205-221. 1953.

40. Hiesey, W. M. and H. W. Milner. Physiology of ecological races and species. Annual Review of Plant Physiology 16: 209-216. 1965.

41. Hitchcock, A. S. Manual of the grasses of the United States. Washington, United States Government Printing Office, 1935. 1040p.

42. Hovin, A. W. Variation in annual bluegrass. The Golf Course Reporter 25(7): 18-19. 1957.

43. ________________ Meriotic chromosome pairing in amphihaploid Poa annua L. American Journal of Botany 45(2): 131-138. 1958.

44. ________________ Reduction of self-pollination by high night temperature in naturally self-fertilized Poa annua. Agronomy Journal 50(7): 369-371. 1958.

45. Hubbard, C. E. Personal correspondence titled: Variation in Poa annua L. Kew Botanic Gardens, Richmond, Surrey, England. January 26, 1966.

46. ________________ Grasses. Baltimore, Md., Penguin, 1954. 428p.

47. Juhren, M, W. Noble and F. W. Went. The standardization of Poa annua as an indicator of smog concentrations. Plant Physiology 32(6): 576-586. 1957.

48. Juska, F. V. and A. A. Hanson. Factors affecting Poa annua control. Weeds 15(2): 98-101. 1967.

49. King, L. J. Weeds of the world, biology and control. New York, Interscience, 1966. 526p.

50. Klingman, G. C. Weed control as a science. New York, John Wiley, 1963. 421p.

51. Koshy, T. K. Evolutionary origin of Poa annua L. in the light of karyotypic studies. Canadian Journal of Genetics and Cytology 10(1): 112-118. 1968

52. Langer, R. H. M. Tillering in herbage grasses. Herbage Abstracts 33(3): 141-148. 1963.

53. LeClerg, E. L., W. H. Leonard and A. G. Clark. Field plot technique. 2d ed. Minneapolis, Burgess, 1962. 373p.

54. Linnaeus, C. V. Species plantarum. Vol. 1. Facs. ed. Berlin, W. Junk. (1908). 1753. 560p.

55. Madden, E. A. Poa annua - a problem in sports greens. The Golf Superintendent 35(1): 13-14. 1967.

56. Mercer, S. P., and P. A. Linehan. Experiments in the diagnosis of species and varieties of Lolium by the Gentner screening ultra-violet light method. Proceedings of the International Seed Testing Association 3: 180-191. 1931.

57. Milner, M. and M. R. Gould. The quantitative determination of phenol oxidase activity in wheat varieties. Cereal Chemistry 28(6): 473-478. 1951.

58. Morgan, W. C. New methods of renovating turfgrass. The British Golf Greenkeeper, no. 250, 1966. p. 7-8.

59. Neidlinger, T. J. Poa annua L.: Susceptibility to several herbicides and temperature requirements for germination. Master's thesis. Corvallis, Oregon State University. 1965. 97 numb. leaves.

60. Nelson, A. P. Racial diversity in Californian Prunella vulgaris. New Phytologist 66: 707-746. 1967.

61. Nutter, G. C. Turfgrass is a $4 billion dollar industry. Turfgrass Times 1(1): 1-24. 1965.

62. Pechanec, J. F. The identification of grasses on the upper Snake River Plains by their vegetative characters. Ecology 17 (3): 479-490. 1936.

63. Peck, M. E. A manual of the higher plants of Oregon. 2d ed. Portland, Oregon, Binsford & Mort, 1961. 936p.

64. Rampton, H. H. The use of morphological characters as compared with fluorescence tests with ultra-violet light in classifying the ryegrasses (Lolium spp.) of western Oregon. Agronomy

Journal 30(11):915-922. 1938.

65. Rohde, E. C. The story of the garden. Boston, Hale, Cushman and Flint, 1936. 325p.

66. Schery, R. W. The lawn book. New York, Macmillan, 1961. 207p.

67. ______________ Bluegrass/bentgrass checks Poa annua. The Golf Superintendent 36(10):32-34. 1968.

68. Schwabauer, R. A. The effect of soil mixture and soil cover on residual activity of herbicides measured by seedling emergence of Poa annua L. Master's thesis. Corvallis, Oregon State University. 1964. 76 numb. leaves.

69. Skogley, C. R. Associate Professor, University of Rhode Island, Department of Agronomy and Mechanized Agriculture. Personal communication. Kingston, Rhode Island. July, 1969.

70. Sprague, N. B. and G. W. Burton. Annual bluegrass (Poa annua L.) and its requirements for growth. New Jersey Agricultural Experiment Station Bulletin 630. 1937. 24p.

71. Stebbins, G. L. Variation and evolution in plants. New York, Columbia University Press, 1950. 643p.

72. Sutherland, W. C. History of recreation. In: Recreation: pertinent readings, ed. by Jay B. Nash, Dubuque, Iowa, Wm. C. Brown, 1965. p. 13-14.

73. Timm, G. Biology and systematics of Poa annua. Feitschrift für Acker-und Pflanzenbau 122(3):267-294. 1965.

74. Tincker, M. A. H. The effect of length of day upon the growth and reproduction of some economic plants. Annals of Botany 39 (CLVI):721-754. 1925.

75. Turesson, G. The species and the variety as ecological units. Hereditas 3:100-113. 1922.

76. ______________ The genotypical response of the plant species to the habitat. Hereditas 3:211-350. 1922.

77. Tutin, T. G. Origin of Poa annua L. Nature, 169 (pt. 1):160. January 26, 1952.

78. Tutin, T. G. A contribution to the experimental taxonomy of Poa annua L. Watsonia 4:1-10. 1957.

79. ________________ Professor, The University of Leicester, Department of Botany. Personal communication. Leicester, England. September 12, 1967.

80. United States Department of Commerce. World Weather Records - Europe (1951-1960). Vol. 2 Washington, United States Printing Office, 1966. 547p.

81. United States Department of Commerce. Climatological Data, Annual summary, Vol. 73(1). Washington, United States Printing Office, 1967. 251p.

82. Welton, F. A. and J. C. Carroll. Control of lawn weeds and the renovation of lawns. Ohio Agricultural Experiment Station Bulletin no. 619, 1941. 85p.

83. Wright, G. The botanical composition of golf greens with special reference to Poa annua (annual meadowgrass). Golf Illustrated, April 20, 1934, p. 38-41.

84. Young, M. Graduate Assistant, Oregon State University, Department of Farm Crops. Personal communication. Corvallis, Oregon. June, 1968.

85. Youngner, V. B. Ecological studies on Poa annua in turfgrasses. Journal of the British Grassland Society 14(4):233-247. 1959.

APPENDIX

Appendix Table 1. The trade name, W. S. A. accepted name, and chemical name of herbicides mentioned in the test.

WSA accepted name	Trade name	Chemical name
Endothall	Endothal	7-oxabicyclo[2, 2, 1]heptane-2, 3 dicarboxylic acid
MH	MH-30	1, 2-dihydro-3, 6-pyridazinedione
DCPA	Dacthal	dimethyl tetrachloroterephthalate
Diphenamid	Dymid Enide	N, N-dimethyl-2, 2-diphenylacetamide
Bensulide	Betasan Presan	0, 0-diisopropyl phosphorodithioate S-ester with N-(2-mercaptoethyl) benzenesulfonamide
Trifluralin	Treflan	a, a, a-trifluo-2, 6-N, N-dipropyl-p-toluidine
DMPA	Zytron	disodium 3, 6-endohexahydrophthalate
Benefin	Balan	N-butyl-N-ethyl-a, a, a-trifluro-2, 6-dinitro-p-toluidine
Paraquat	Paraquat	1-1'-dimethyl-4, 4'-bipyridinium ion chlorinated benzoic acid
	X-77	alkylarylpoloxyethelene, flycols, Free Fatty acids, isopropanol

Appendix Table 2. Characteristics of greenhouse soil. Analyses performed by the Oregon State University Soil Testing Laboratory.

Physical Characteristics					Chemical Characteristics			
Particle Size Distribution (%)								
Total Sand	Total Silt	Total Clay	Organic Matter (%)	Textured Class	Reaction	Phosphorus (P) lbs/A	Potassium (K) lbs/A	Potassium (K) me/100 g
57.10	30.91	11.99	2.35	Sandy loam	5.6	29	164	0.21

Appendix Table 3. Varieties of Poa annua and sources of descriptions in order as presented in text.

Variety	Source
Annual Varieties	
typica Beck.	Flora von Neider-Osterreich. 1890. 1:84.
viridis Lef. and Court.	Compendium Florae Belgicae. 1828. 1:80.
picta Beck.	Flora von Nieder-Osterreich. 1890. 1:84
variegata G. Meyer	Chloria Hanoverana. 1836. p. 635.
silvatica Jansen and Wachter.	Nederlandsch Kruidkundig Archief. 1951. p. 78.
flavescens Hausm.	Flora von Tirol. 1852. 2:994.
pumila Anders.	Plantae Scandinaviae. Fasc. II. Gramineae. 1852. p. 48.
pauciflora Frik.	Synopsis der Mitteleuropaischen Flora. 1900. 2:389.
racemosa Aschers.	Synopsis der Mitteleuropaischen Flora. 1900. 2:389.
longiglumis Lindm.	Botaniska Notiser. 1926. p. 275.
latisquama Lindm.	Botaniska Notiser. 1926. p. 275.
pseudopratensis Jansen and Wachter	Nederlandsch Kruidkundig Archief. 1933. 43:162.
braeteata ?	Nederlandsch Kruidkundig Archief. 1932. p. 433.
ramitera ?	Nederlandsch Kruidkundig Archief. 1932. p. 433.
vivipara S.F. Gray	A Natural Arrangement of British Plants. 1821. 2:106.
villosa Bluff and Nies.	Compendium Florae Germanicae. ed. 2. 1836. 1:158.
pubescens Peterm.	Flora Lipsiensis. 1938. p. 91.

Appendix Table 3 continued.

Variety	Source
rigidula Aschers.	Synopsis der Mitteleuropaischen Flora. 1900. 2:389.
macerrima Nakai ex Jansen and Wachter.	Nederlancsch Kruidkundig Archief. 1933. 43:162.
umbrosa ?	Mitteilunger aus den Botanischen Staatsinstituten. 1901-1912.
remotiflora ?	Flora Nierlandica. 1951. p. 78.
caespitosa Terracc.	Nuovo Giornale Botanico. 1907. 14:212.
santiago Gay.	Flora de Chile. 1853. 6:406.
Perennial Varieties	
reptans Hausskn.	Mitteilungen der Geographischer Gesellschaft (fur Thuringen) zu Jena. Zugleich Organ des Botanischen Vereins fur Gesamtthuringen. 1890. p. 7.
sericea Parnell	Grasses of Scotland. 1842. p. 91.
triflora Schur.	Enumeratio Plantarum Transsilvaniae. 1866. p. 767.
alpigena Schur.	Enumeratio Plantarum Transsilvaniae. 1866. p. 767.
minima Schur.	Enumeratio Plantarum Transsilvaniae. 1866. p. 767.
decumbens Nolte ex Junge.	Jahrbuch der Hamburgischien Wissenschaftlichen Austalten. 1913. 30:229.
nepalensis Griseb.	Nachrichten von der Gesellschaft de Wissenschatten zu Gottingen. 1868. p. 73.
sikkimensis Stapf.	Flora of British India. 1896. 7:346.

Appendix Table 3 continued.

Variety	Source
rigidiuscula L. H. Dewey	Contributions of the U.S. Natural Herbarium. 1895. 3:262.
aquatica Aschers.	Flora des Provinz Brandenburg. 1864. L:844.

Appendix Table 4. Pertinent information relative to locations sampled for *Poa annua* survey.

Location	Address	Turf type/sample site
Region 1		
Astoria Agr. Expt. Sta.	Astoria, Oregon	Lawn near weather station
Astoria Column	Astoria, Oregon	Lawn in front of column
Astoria Country Club	Warrenton, Oregon	
Green		Green #9
Fairway		Fairway #9
Rough		Next to #9 fairway
Astoria Post Office	Astoria, Oregon	Front lawn
Alderbrook Golf Club	Tillamook, Oregon	
Green		Green #9
Fairway		Fairway #1
Rough		Next to #1 fairway
Agate Beach Country Club	Newport, Oregon	
Tee		Tee #9
Fairway		Fairway #6
Rough		Next to #6 fairway
Rhod-O-Dunes Golf Club	Florence, Oregon	
Apron		Practice green
Fairway		Fairway #9
Coos Country Club	Coos Bay, Oregon	
Green		Green #7
Fairway		Fairway #6
Rough		Next to #6 fairway
The Elks Golf Club	Coquille, Oregon	
Apron		Green #9
Fairway		Fairway #1
Rough		Next to clubhouse
Coquille Courthouse	Coquille, Oregon	Front lawn
Region 2		
O. M.S. I. Turf Plots	Portland, Oregon	Bluegrass plots
Illahe Country Club	Salem, Oregon	
Apron		Green #14
Fairway		Fairway #18
Rough		Next to #18 fairway
Salem Court House	Salem, Oregon	West lawn
Albany Golf Club	Albany, Oregon	
Apron		Green #18
Fairway		Fairway #18
Rough		Near clubhouse

Appendix Table 4 continued.

Location	Address	Turf type/sample site
Corvallis Country Club	Corvallis, Oregon	
Green		Practice green
Fairway		Fairway #1
Rough		Next to #1 fairway
Eugene Country Club	Eugene, Oregon	
Green		Green #15
Fairway		Fairway #16
Rough		Next to #16 fairway
Seattle Golf Club	Seattle, Washington	
Tee		Tee #15
Jefferson Park Golf Club	Seattle, Washington	
Fairway		Fairway #?
Carnation Golf Club	Fall City, Washington	
Green		Green #?
Region 3		
Rogue Valley Country Club	Central Point, Oregon	
Green		Green #1
Fairway		Fairway #9
Rough		Next to #9 fairway
Roseburg Courthouse	Roseburg, Oregon	Front lawn
Roseburg Country Club	Roseburg, Oregon	
Apron		Green #9
Fairway		Fairway #9
Rough		Next to #9 fairway
Grants Pass Golf Club	Grants Pass, Oregon	
Green		Green #7
Fairway		Fairway #1
Rough		Near clubhouse
Hood River Golf Club	Hood River, Oregon	
Apron		Green #9
Tee		Tee #1
The Dalles Country Club	The Dalles, Oregon	
Apron		Practice green
Fairway		Fairway #3
Rough		Next to #3 fairway
The Dalles High School	The Dalles, Oregon	Football field
South Sorosis Park	The Dalles, Oregon	Lawn
9 Peaks Golf Club	Madras, Oregon	
Green		Green #2

Appendix Table 4 continued.

Location	Address	Turf type/sample site
Juniper Golf Club	Redmond, Oregon	
Green		Green #1
Fairway		Fairway #1
Bend Golf Club	Bend, Oregon	
Green		Green #8
Tee		Tee #8
Reames Country Club	Klamath Falls, Oregon	
Green		Green #1
Tee		Tee #2
Fairway		Fairway #11
Pendleton Agr. Expt. Sta.	Pendleton, Oregon	Greenhouse lawn

Appendix Table 5. Summary of statistical analyses presented in the text.

Date from Table 4. Seed germination of five *Poa annua* selections at harvest and following harvest.

Source of variation	d.f.	M.S.	F.	.05	.01
At Harvest					
Selections	4	6126	165.5**	5.19	11.39
Error	5	37			
Total	9				
Coefficient of variation = 12.6%					
Seven weeks following harvest					
Selections	4	5252	203.0**	5.19	11.39
Error	5	16			
Total	9				
Coefficient of variation = 5.3%					

Data from Table 5. Average seed length and width, caryopsis length and width, and rachilla length for five *Poa annua* selections.

Source of variation	d.f.	M.S.	F.	.05	.01
Seed Length					
Selections	4	.10	1.59	2.58	3.77
Error	45	.063			
Total	49				
Coefficient of variation = 10.8%					
Seed Width					
Selections	4	.04	14.8**	2.58	3.77
Error	45	.0027			
Total	49				
Coefficient of variation = 7.9%					
Caryopsis Length					
Selections	4	.0625	6.7**	2.58	3.77
Error	45	.0093			
Total	49				
Coefficient of variation = 7.3%					
Caryopsis Width					
Selections	4	.045	20.4*	2.58	3.77
Error	45	.0022			
Total	49				
Coefficient of variation = 7.4%					
Rachilla Length					
Selections	4	.0375	2.91*	2.58	3.77
Error	45	.0129			
Total	49				
Coefficient of variation = 18.4%					

Date from Table 6. Average leaf blade lengths of five Poa annua selections at five dates following germination.

Source of variation	d.f.	M.S.	F.	.05	.01
13 Days					
Selections	4	3.69	5.60**	2.76	4.18
Error	25	.66			
Total	29				
Coefficient of variation = 19.7%					
26 Days					
Selections	4	8.43	73.3**	2.76	4.18
Error	25	1.15			
Total	29				
Coefficient of variation = 16.6%					
49 Days					
Selections	4	41.25	17.63**	2.76	4.18
Error	25	2.34			
Total	29				
Coefficient of variation = 12.5%					
64 Days					
Selections	4	13.5	5.13**	2.76	4.18
Error	25	2.63			
Total	29				
Coefficient of variation = 14.6%					
88 Days					
Selections	4	7.72	1.42	2.76	4.18
Error	25	5.42			
Total	29				
Coefficient of variation = 23.3%					

Data from Table 7. Average leaf blade widths of five *Poa annua* selections at five dates following germination.

Source of variation	d. f.	M. S.	F.	. 05	. 01
13 Days					
Selections	4	. 0525	10. 94**	2. 76	4. 18
Error	25	. 0048			
Total	29				
Coefficient of variation = 7. 3%					
26 Days					
Selections	4	. 2375	4. 68**	2. 76	4. 18
Error	25	. 0508			
Total	29				
Coefficient of variation = 11. 2%					
49 Days					
Selections	4	1. 750	8. 18**	2. 76	4. 18
Error	25	. 214			
Total	29				
Coefficient of variation = 13. 4%					
64 Days					
Selections	4	. 5275	3. 70*	2. 76	4. 18
Error	25	. 1424			
Total	29				
Coefficient of variation = 10. 7%					
88 Days					
Selections	4	. 785	5. 69**	2. 76	4. 18
Error	25	. 138			
Total	29				
Coefficient of variation = 11. 1%					

Data from Table 8. Average ligule length of five *Poa annua* selections 88 days following germination.

Source of variation	d.f.	M.S.	F.	.05	.01
Ligule Length					
Selections	4	.405	3.2*	2.76	4.18
Error	25	.126			
Total	29				
Coefficient of variation = 22.5%					

Data from Table 9. Culm length, leaf and node number of five *Poa annua* selections 88 days after germination.

Source of variation	d.f.	M.S.	F.	.05	.01
Culm Length					
Selections	4	15.25	5.1**	2.76	4.18
Error	25	2.99			
Total	29				
Coefficient of variation = 6.9%					
Leaf Number					
Selections	4	50.5	40.7**	2.76	4.18
Error	25	1.24			
Total	29				
Coefficient of variation = 13.4%					
Node Number					
Selections	4	54.2	15.06**	2.76	4.18
Error	25	3.60			
Total	29				
Coefficient of variation = 6.1%					

Date from Table 10. The length of panicle, upper and lower glumes, lemma and palea of five *Poa annua* selections.

Source of variation	d.f.	M.S.	F.	.05	.01
Panicle Length					
Selections	4	2.92	2.37	2.76	4.18
Error	25	1.23			
Total	29				
Coefficient of variation = 15.6%					
Upper Glume Length					
Selections	4	.95	6.63**	2.76	4.18
Error	25	.144			
Total	29				
Coefficient of variation = 16.4%					
Lower Glume Length					
Selections	4	4.175	28.99**	2.76	4.18
Error	25	.144			
Total	29				
Coefficient of variation = 20.5%					
Lemma Length					
Selections	4	.20	1.18	2.76	4.18
Error	25	.17			
Total	29				
Coefficient of variation = 16.2%					
Palea Length					
Selections	4	.20	1.25	2.76	4.18
Error	25	.16			
Total	29				
Coefficient of variation = 16.7%					

Date from Table 11. Primary tiller numbers of five *Poa annua* selections at six dates following germination.

Source of variation	d.f.	M.S.	F.	.05	.01
13 Days		No analysis			
26 Days		No analysis			
49 Days					
Selections	4	47.0	7.01**	2.76	4.18
Error	25	6.7			
Total	29				
Coefficient of variation = 27.6%					
64 Days					
Selections	4	61.5	3.09*	2.76	4.18
Error	25	19.9			
Total	29				
Coefficient of variation = 30.0%					
88 Days					
Selections	4	116.75	9.7**	2.76	4.18
Error	25	12.08			
Total	29				
Coefficient of variation = 22.8%					
100 Days					
Selections	4	79.0	10.8**	2.76	4.18
Error	25	7.3			
Total	29				
Coefficient of variation = 23.9%					

Data from Table 12. Secondary tiller number of five <u>Poa annua</u> selections 88 days following germination.

Source of variation	d.f.	M.S.	F.	.05	.01
<u>Secondary vegetative numbers</u>					
Selections	4	197.0	10.3*	2.76	4.18
Error	25	19.1			
Total	29				
Coefficient of variation = 43.9%					

Data from Table 14. The percentage of primary and total tillers flowering 100 days following germination.

Source of variation	d.f.	M.S.	F.	.05	.01
<u>Primary</u>					
Selections	4	5197.0	14.4**	2.76	4.18
Error	25	360.6			
Total	29				
Coefficient of variation = 30.3%					
<u>Total</u>					
Selections	4	3441	12.2**	2.76	4.18
Error	25	282.0			
Total	29				
Coefficient of variation = 40%					

Data from Table 15. Shoot dry weights of five Poa annua selections at six dates following germination.

Source of variation	d.f.	M.S.	F.	.05	.01
13 Days					
Selections	4	.495	4.03*	2.76	4.18
Error	25	.123			
Total	29				
Coefficient of variation = 37.6%					
26 Days					
Selections	4	3.49	2.20	2.76	4.18
Error	25	1.59			
Total	29				
Coefficient of variation = 57.4%					
49 Days					
Selections	4	2160.90	6.54**	2.76	4.18
Error	25	330.25			
Total	29				
Coefficient of variation = 36.1%					
64 Days					
Selections	4	23645.34	1.77	2.76	4.18
Error	25	133046.4			
Total	29				
Coefficient of variation = 32.0%					
88 Days					
Selections	4	500498.5	0.85	2.76	4.18
Error	25	590110.9			
Total	29				
Coefficient of variation = 27.6%					
100 Days					
Selections	4	489764.0	0.85	2.76	4.18
Error	25	578888.1			
Total	29				
Coefficient of variation = 26.0%					

Data from Table 16. Root dry weights of five *Poa annua* selections at four dates following germination.

Source of variation	d.f.	M.S.	F.	.05	.01
13 Days					
Selections	4	1001.30	5.51**	2.76	4.18
Error	25	182.5			
Total	29				
Coefficient of variation = 43.2%					
26 Days					
Selections	4	3.88	2.11	2.76	4.18
Error	25	1.84			
Total	29				
Coefficient of variation = 43.0%					
49 Days					
Selections	4	806.83	2.43	2.76	4.18
Error	25	332.01			
Total	29				
Coefficient of variation = 36.4%					
64 Days					
Selections	4	1121.88	0.82	2.76	4.18
Error	25	1370.34			
Total	29				
Coefficient of variation = 33.4%					

Data from Table 17. The number of adventitious roots and secondary tillers per culm 93 days following germination.

Source of variation	d.f.	M.S.	F.	.05	.01
Adventitious Roots					
Selections	4	125.4	31.04**	2.76	4.18
Error	25	4.04			
Total	29				
Coefficient of variation = 47.0					
Secondary Tillers					
Selections	4	8.65	4.20**	2.76	4.18
Error	25	2.06			
Total	29				
Coefficient of variation = 47.0%					