Progress Report: The Effect of Seven Management Factors and their Interaction on the Competitive Ability of Annual Bluegrass and Creeping Bentgrass.

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INTRODUCTION

The intent of this report is to inform the USGA of the research progress that has been made in the past year concerning the project intitled 'The Effect of Seven Management Factors and their Interactions on the Competitive Ability of Annual Bluegrass and Creeping Bentgrass'. Our key study in this project, a five level factorial competition study, has been in progress for three years and will be terminated after collecting all the data this fall. Two other studies will be terminated this fall that will have two years of data. Several other studies have been initiated this year and will be carried through the fall of 1987.

Roch Gaussoin, a PhD student who has done the bulk of the research on this project, should be completing his degree in the summer of 1987. His thesis will deal entirely with annual bluegrass creeping bentgrass competition and will be forwarded to the USGA upon its completion. Another graduate student, Michael Hendricks, began working on his MS degree in the winter of 1986 and will pickup the project. He has initiated several field trials and our plan is to begin another large factorial competition study in 1987, building on what we have learned in the past three years.

Experiments Completed

Three field studies were completed with data collection taking place in the fall of 1986.

The first study was initiated on May 15, 1984 at the Hancock Turfgrass Research Center. The experimental design is a five factor factorial arranged as a split-split plot with 72 treatment combinations. The five factors are irrigation (daily at 75% of open pan evaporation (OPE), 3x per week at 110% of OPE, and irrigation at wilt); clipping removal or return; nitrogen fertility (2 lbs N/M/YR or 6 lbs N/M/YR); plant growth regulator treatment (mefluidide at 1/8 lb/AI/A, flurprimidol at 1.0 lb/AI/A, or a control); and overseeding with bentgrass or no overseeding.

A second study was initiated in July of 1984 to study the effects of compaction and coring on the competition between annual bluegrass and creeping bentgrass. A four factor factorial consisting of irrigation (same treatments as above), clippings removed or returned, compaction (compaction or no compaction), and coring (1x/yr,3x/yr, or control) treatments. Compaction was applied 3 times per week with a vibrating, water-filled roller.

For both of the studies described above, data was taken as species counts. The relative percentage of annual bluegrass in a mixed stand of predominantly annual bluegrass and creeping bentgrass was determined using a grid consisting of 112 individual points. A plot was evaluated by determining the number of points on the grid which overlay annual bluegrass. The result is an estimate of the percentage annual bluegrass in the plot.

A third field study was designed to measure the effect of flurprimidol on the competitive balance between annual bluegrass and creeping bentgrass. Flurprimidol has been observed to yield a more phytotoxic effect on annual bluegrass than creeping bentgrass. The hypothesis is that creeping bentgrass can take advantage of the weakened condition of the annual bluegrass and become

the primary species. To test this hypothesis, ten treatments of differing rates and timing of flurprimidol were applied to an essentially pure stand of annual bluegrass into which three 4" diameter plugs of 'Penncross' creeping bentgrass had been transplanted. The area of each bentgrass plug is determined periodically by tracing the diameter of the plug and measuring the area of trace with a planimeter.

EXPERIMENTS IN PROGRESS

A field study initiated in the spring of 1986 examines the effects and interactions of clipping removal, nitrogen fertility level (0,1,2 and 6 lbs N/M/YR) and potassium fertility (0, soil test recommendations, and 3 times soil test recommendations) on the competition between annual bluegrass and creeping bentgrass. Competition is measured by placing 3-4" diameter plugs of 'Penncross' creeping bentgrass in each plot and measuring their spread over time.

Another field study was designed to examine fairway management practices used with annual bluegrass and creeping bentgrass. Fertility rates (2,4, and 6 lbs N/M/YR) and cultivation practices (no cultivation, coring spring, coring fall, coring spring and fall, and vertical mowing spring and fall) were applied across three different fairway grasses, annual bluegrass and Penncross and Penneagle creeping bentgrasses. Data being collected includes thatch accumulation, poa invasion, and overall visual quality. This study was initiated in the fall of 1985.

A field study was initiated this fall to examine techniques for converting fairways to creeping bentgrass. The treatments consisted of either Roundup or Embark application to aid the overseeding process, bentgrass seeding rate (1,2,3 lbs seed/M), and cultivation practice (core cultivation, vertical mowing, or no cultivation). The Embark and Roundup applications were followed five weeks later by 1.0 lb/A applications of ethofumesate (Prograss) to further reduce annual bluegrass competition and prevent reestablishment of annual bluegrass from seed.

In our progress report of May 1, 1986 I stated that we would have minirhizotrons installed in annual bluegrass and creeping bentgrass plots to monitor root growth in the field by July 20, 1986. Unfortunately, Mike Hendricks, the graduate student working on this project, had a severe allergic response to a mold present on some annual bluegrass seed he was cleaning. He was hospitalized for a week and had to stay away from the Hancock Center until the nature of the allergic material was determined. This delayed our installation of the tubes until October, 1986. Treatments will be initiated in the spring of 1987. Two fertility levels of 4 lbs N/M/YR will be applied, one as a foliar feeding treatment and one as a granular (root feeding) treatment. This will permit us to characterize seasonal rooting patterns of annual bluegrass and creeping bentgrass as well as determine the effects of foliar feeding on root growth.

A final area we are actively researching is the use of ethofumesate (Prograss) as a selective herbicide for annual bluegrass eradication. Field studies in progress include three studies examining different rate combinations on annual bluegrass and 'Penncross' creeping bentgrass maintained as fairways

and on 'Emerald' creeping bentgrass maintained at greens height. A fourth study looks at different timings and rates on annual bluegrass.

Laboratory and Greenhouse Studies

We are in the process of characterizing the photosynthetic response of annual bluegrass and creeping bentgrass to light levels, CO_2 levels, temperatures, and vapor pressure deficit. This will permit us to determine the photosynthetic effects, if any, of various turf growth regulators. Much has been made of the effects of flurprimidol (Cutless) and paclobutrazol (Scotts TGR poa annua control); these studies are aimed at examining some of the plant physiological responses to PGR application. In addition, we have examined the effect of flurprimidol on annual bluegrass and creeping bentgrass germination in the greenhouse.

Results and Discussion

Table 1 contains the analysis of variance summarizing the results of the five factor competition study over the past three years. When examining the data several points need to be considered. First, there is some variability from year to year. Some factors are significant one year and not the next. Clearly, environment plays a large role in this study and we are in the process of attempting to correlate environmental data with the observed results. Also, when examining the data remember that unless numbers are significantly different they are considered equal regardless of what kinds of trends you may see.

We are in the process of reanalyzing the data using covariate analysis. The covariable will be the initial percentage of annual bluegrass in the plot as of May 1984. If the change in plot composition is dependent upon the initial annual bluegrass percentage, which would be the case of annual bluegrass was allelopathic, covariate analysis will improve the analysis and may show some other factors to be significant.

Table 2 shows the significant factors and their interactions for 1986 and combined over all three years. The most striking aspect of this analysis is the effect of clipping removal. The other dramatic result from the combined data is the effect of bentgrass overseeding. Bentgrass overseeding was done around September 1 of each year with data counts taken October 15-30. Thus while three years of data exist, the effects of overseeding are probably only seen for the last two years because the time needed for seedling development would imply that seed planted in the same year the data was taken would not be a significant component of the stand. While overseeding was not significant in any one year, over the three years of the study overseeding with bentgrass caused a highly significant increase in the bentgrass population.

The results of this study show that overseeding is the predominate factor in this study. Clipping removal can be considered not overseeding with annual bluegrass while clippings returned could be considered as overseeding with

annual bluegrass. This is corroborated by the article of Koshy[1] who showed that annual bluegrass panicles clipped on the day of anthesis still were capable of producing viable seed.

Over the three year period two interactions were significant. A significant PGR x fertility interaction and PGR x clipping removal x overseeding interaction were observed. The significant numbers in the PGR x fertility interactions occur at the 6 lb N/M/YR level. Here the control PGR treatment decreased by -19.3% which was significantly lower than mefluidide (-9.8) and flurprimidol (-0.7) treated plots. At higher fertility rates it would appear that PGR's enhance annual bluegrass survival. We realize the this is in direct conflict to what has been observed by most superintendents and some other researchers in the industry. We have examined the effects of flurprimidol from many angles and can't see any reason to use it for annual bluegrass removal. We are the only researchers, to our knowledge, who have quantified annual bluegrass populations with other than visual means. The only time I have observed reductions in annual bluegrass populations occurred when using visual evaluations. Every quantitative measurement we have made, three years data on one study and two years data on another, has shown no benefit to the use of flurprimidol. We have also examined paclobutrazol (the active ingredient in Scott's TGR) this past year and observed more activity than from flurprimidol however species counts again showed no measurable species shift.

This is not the first instance of companies introducing a product which does not work in the manner in which it is claimed. Gaul and Christians[2] will report their research findings on fenarimol at the ASA meetings in early December of this year showing no Poa annua reduction by fenarimol.

One other point in the analysis is the lack of a consistent nitrogen effect. It has often been stated that lower N fertility will reduce annual bluegrass populations. This was only true in one of three years and did not show up in the combined years data either. This may appear somewhat contradictory, however, this may also serve to illustrate the extent of environmental interaction. The current year (1986) was extremely wet with over nine inches of rain in both June and September. In contrast, 1985 was a year characterized by a very dry spring and early summer periods. It is conceivable that the high rainfall of 1986 washed out any effects due to nitrogen; that leaching, NH_4^+ volatility, and denitrification losses may have removed a significant portion of the N applied during 1986. Thus N may affect species composition but will depend strongly on the environment.

The study designed to measure compaction and core cultivation effects is shown in table 3. The effects of compaction are not as dramatic as anticipated, however, compaction frequency was cut in half this year because we

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[1]Koshy, T.K. 1969. Breeding systems in annual bluegrass, Poa annua L. Crop Sci. 9:40-43.

[2]Gaul, M.C. and N.E. Christians. 1986. The response of Annual Bluegrass to Fenarimol and Cholorsulfuron in field and Greenhouse trials. Agronomy Abstracts. 1986 Annual meetings. p. 134.

felt the plots were very compacted and the frequent compaction was causing too much wear damage on the plots. The results for 1986 show a larger decrease in annual bluegrass in the compacted plots than in the uncompacted plots. This is difficult to explain. Because of the intense compaction of 1985, many of the compacted plots were between 90-95% annual bluegrass. When the compaction frequency was decreased it is conceivable that these plots dropped more rapidly in annual bluegrass because of their high initial counts.

Data for the 2nd year of the flurprimidol rate and timing study is unavailable at this time. The record wet weather in Michigan during September and October (25 straight days with rain in Michigan) prevented us from collecting our data early enough to get it included in this report. It will be forwarded to you when the analysis is completed.

Data from 1985-1986 trial with ethofumesate is shown in Table 4. The data reported showed a shift in species composition of nearly 45% from September 15, 1985 through May 15, 1986. The 1.5 lbs/A and 0.75 lb/A treatments applied sequentially thirty days apart showed very large shifts from annual bluegrass to Kentucky bluegrass. However, the 1.5 lb/A rate was high enough to give outright kill of the annual bluegrass. Because of its preemergence activity, germinating annual bluegrass plants were also killed so that the dead areas remained bare until Kentucky bluegrass filled in those spots. Interestly, the 0.75 lb/A rate of Prograss functions much as some of the PGR's are supposed to work. The annual bluegrass was discolored for a one-to-five month period and during this period of herbicide injury the Kentucky bluegrass present was able to expand and become a sizable portion of the stand. Based on these results we have initiated five field trials this fall to better evaluate ethofumesate's potential for selective removal of annual bluegrass. The key here is not try to make a transition in one year but to gradually increase the stand of desirable species by using low ethofumesate rates.

Laboratory and Greenhouse Results

Table 5 shows the effects of various rates of flurprimidol on annual bluegrass and creeping bentgrass germination. This study was conducted in the greenhouse. Our hypothesis was that if flurprimidol was more active on annual bluegrass than creeping bentgrass than this same phenomenona may apply to seedling plants, conferring a competitive advantage to creeping bentgrass. As the data indicates, no differences in seed germination response where observed between the two species, however germination percentage did decrease with increasing flurprimidol rate. Thus flurprimidol is a weak preemergence herbicide and the stunting of those seedlings which did develop would imply that they may not survive in a competitive turfgrass canopy. Flurprimidol and paclobutrazol could conceivably be very effective preemergence herbicides.

Also shown are two figures displaying the photosynthetic response of annual bluegrass, creeping bentgrass and kentucky bluegrass to various concentrations of CO_2 and light intensity. When this study is complete, we will have characterized the above mentioned species for their response to CO_2 levels, light intensity, temperature, and time of day. This will be an important resource for other turfgrass investigators studying the physiological properties of these turfgrasses.

TABLE 1. Analysis of Variance of Five Factor Field Study

	df	SP84-FA84	FA84-FA85	FA85-FA86	SP84-FA86
Blocks (B)	2	NS	NS	NS	NS
Irrigation (I)	2	NS	NS	NS	NS
Error	4	-	-	-	-
Clipping Removal (CR)	1	**	NS	*	**
IxCR	2	NS	NS	NS	NS
Error	6	-	-	-	NS
Fertilizer (F)	1	NS	**	NS	NS
FxI	2	NS	NS	NS	NS
FxCR	1	NS	NS	NS	NS
IxCRxF	2	*	NS	NS	NS
Growth Regulators (G)	2	NS	NS	NS	NS
GxI	4	NS	NS	NS	NS
GxCR	2	NS	NS	NS	NS
GxIxCR	4	NS	NS	NS	NS
GxF	2	NS	NS	NS	*
GxFxI	4	NS	NS	NS	NS
GxFxCR	2	NS	NS	*	NS
GxIxCRxF	4	NS	NS	NS	NS
Overseeding (O)	1	NS	NS	NS	*
OxI	2	NS	NS	NS	NS
OxCR	1	NS	NS	NS	NS
OxIxCR	2	NS	NS	NS	NS
OxF	1	NS	NS	NS	NS
OxFxI	2	NS	NS	NS	NS
OxFxCR	1	NS	NS	NS	NS
OxIxCRxF	2	NS	*	NS	NS
OxG	2	NS	NS	NS	NS
OxGxI	4	NS	NS	NS	NS
OxGxCR	2	NS	NS	*	**
OxGxIxCR	4	NS	NS	NS	NS
OxGxF	2	NS	NS	NS	NS
OxGxFxI	4	NS	NS	NS	NS
OxGxFxCR	2	NS	NS	NS	NS
OxGxIxCRxF	4	NS	NS	NS	NS
Error	132	-			

*,** Significant at the 5 and 1 percent levels, respectively.

TABLE 2. Summary of Significant Effects from Five Factor Field Study

Values shown represent change in annual bluegrass populations.

	1984	1985	1986	1984-1986
Clippings removed	-5.7*	NS	- 8.8**	-22.6**
Clippings returned	+1.0		- 3.4	- 9.5
2 lbs N/M/YR	NS	-10.1*	NS	NS
6 lbs N/M/YR		- 5.8		
OVERSEEDED	NS	NS	NS	-18.1**
NOT OVERSEEDED				-14.1

1984-1986 PGRxFERT

	2#N	6#N
Mefluidide	-17.5	- 9.8
Flurprimidol	-14.6	- 0.7
Control	-18.2	-19.3

LSD (0.05) = 8.3

PGRxCRxOS	C+		C-	
	OS	NOS	OS	NOS
Mefluidide	-11.3	-8.2	021.8	-13.3
Flurprimidol	-14.7	-2.6	-20.9	-25.7
Control	- 9.7	-11.7	-31.4	-22.8

LSD (0.05)

Within clipping treatments = 8.3
Across clipping treatments and within PGR or OS treatments = 13.2

1986 only

PGRxCRxN	C+		C-	
	2#N	6#N	2#N	6#N
Mefluidide	-1.3	-8.5	- 9.8	- 3.5
Flurprimidol	-1.3	-0.7	- 3.7	-13.9
Control	-2.3	-6.5	-10.1	-11.7

PGRxCRxOS	C+		C-	
	OS	NOS	OS	NOS
Mefluidide	-3.6	-6.2	- 8.7	- 4.5
Flurprimidol	-3.4	1.4	- 6.0	-11.6
Control	-2.8	-6.0	-15.0	-6.8

Within clipping treatments = 7.9
Across clipping treatments and within PGR, FERT, or OS treatments = 10.6

TABLE 3. SUMMARY OF SIGNIFICANT EFFECTS FROM THE COMPACTION AND CORING TREATMENTS.

	1985	1986	1985-1986
Compacted	+9.6**	-15.6**	- 6.1**
Non-Compacted	-5.4	-10.8	-16.3

1985 - 1986

Compaction x clipping treatments (P=0.056)

	C+	C-
Compacted	-5.3	-6.9
Non-Compacted	-11.1	-21.4

TABLE 4.

The percent Kentucky Bluegrass cover in plots treated with Ethofumesate.

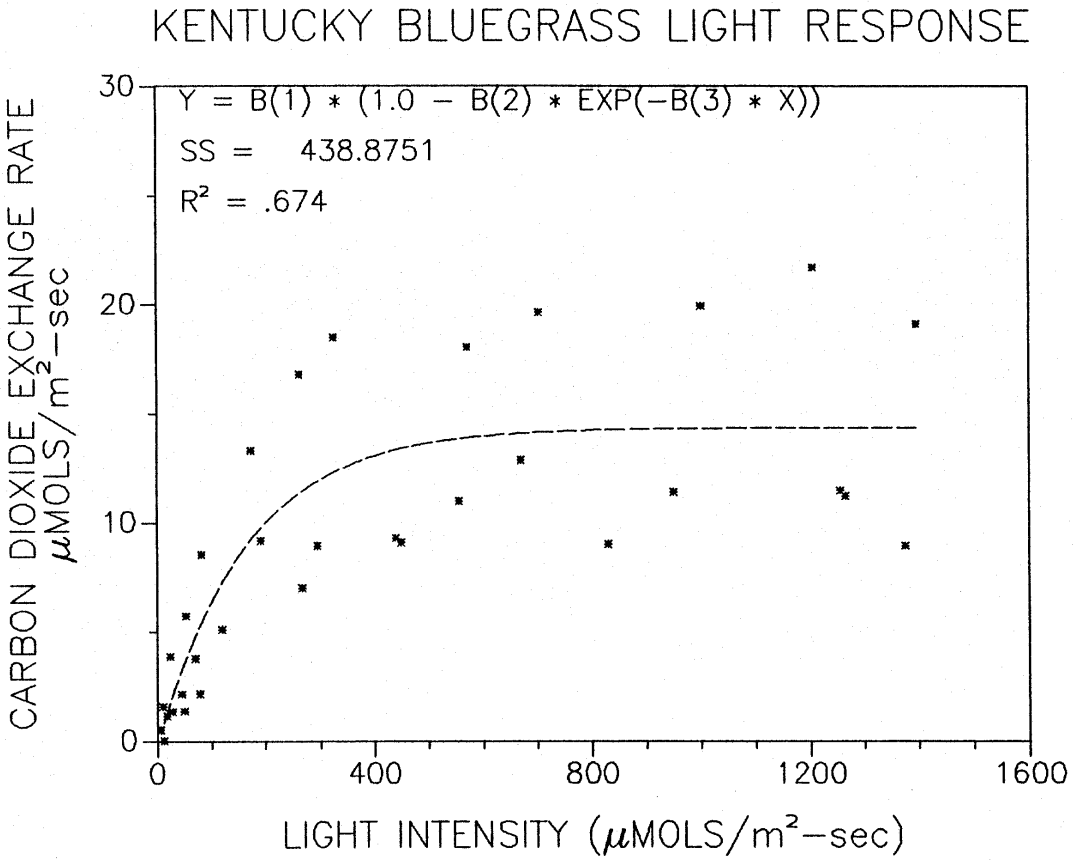
Treatment Dates	% Kentucky Bluegrass
1.5 lbs/A: 9/15, 10/16	50.3
0.75 lbs/A: 9/15, 10/16	46.7
1.0 lbs/A: 9/15, 10/16	43.8
0.75 lbs/A: 9/6, 10/2, 11/1	30.4
0.75 lbs/A: 10/2, 11/1	13.4
0.75 lbs/A: 9/6, 10/2	10.7
Control	5.4

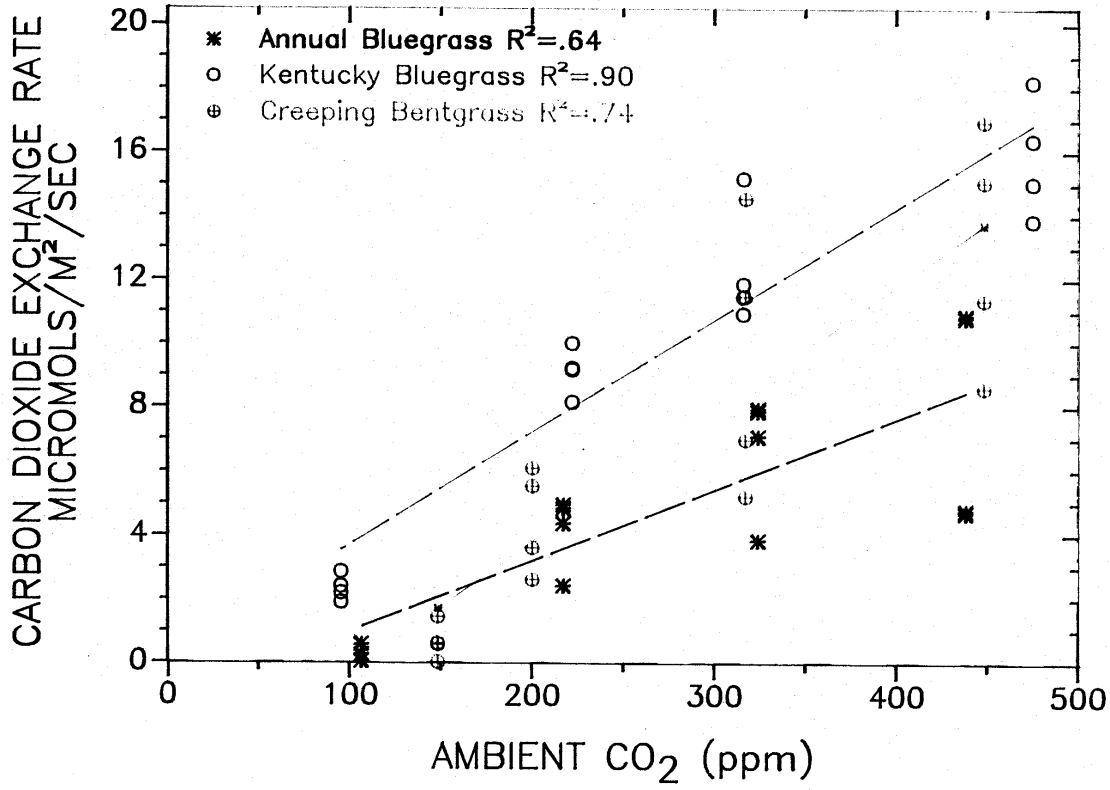
$LSD_{5\%} = 14.0$

TABLE 5. Flurprimidol effects on annual bluegrass and creeping bentgrass germination. Value presented represents mean of both species.

RATE kg ha^{-1}	PERCENT GERMINATION
0.00	100
0.28	94.8
0.56	90.3
0.84	87.3
1.12	82.3
1.68	67.4
2.24	68.8

lsd ($P_{.05}$ = 6.5% $P_{.01}$ = 7.7%)


KENTUCKY BLUEGRASS LIGHT RESPONSE
Y = B(1) * (1.0 − B(2) * EXP(−B(3) * X))
SS = 438.8751
R² = .674
CARBON DIOXIDE EXCHANGE RATE
μMOLS/m²−sec
30
20
10
0
0
400
800
1200
1600
LIGHT INTENSITY (μMOLS/m²−sec)


CARBON DIOXIDE EXCHANGE RATE
MICROMOLS/M²/SEC
Annual Bluegrass R²=.64
Kentucky Bluegrass R²=.90
Creeping Bentgrass R²=.74
0
4
8
12
16
20
0
100
200
300
400
500
AMBIENT CO2 (ppm)

Executive Summary: The Effect of Seven Management Factors and their Interaction on the Competitive Ability of Annual Bluegrass and Creeping Bentgrass.

A three year study was completed in the fall of 1986 measuring the effects of five cultural practices on the competition between annual bluegrass and creeping bentgrass maintained under fairway conditions. The five cultural practices were irrigation (daily at 75% replacement of open pan evaporation (OPE), 3x/week at 110% OPE, and irrigatin at wilt), clippings removed or returned, nitrogen fertility level (2 lb N/M/YR or 6 lb N/M/YR), plant growth regulator treatment (mefluidide 1/8 lb/A, fluriprimidol 1.0 lb/A and a control) and overseeding with 'Penncross' creeping bentgrass or no overseeding. The results show that clipping removal is the single most important factor, in terms of increasing creeping bentgrass populations, of the variables studied. Over a three year period removing clippings resulted in a 22.6% decrease in annual bluegrass where as returning clippings resulted in a 9.5% decrease. The other significant main effect was bentgrass overseeding. While not significant over any single year, when averaged over three years overseeding resulted in a highly significant 18.1% decrease compared to a 14.1% decrease without overseeding. Lowered nitrogen fertility resulted in a significant annual bluegrass decline in one of the three years however when averaged over all three years no effect was seen due to lowered N fertility. This points to a significant effect due to environmental interactions. Neither plant growth regulator treatment nor irrigation treatment played a significant role in annual bluegrass reduction. Another study was concerned with the effects of compaction (compaction and no compaction) and coring (no coring, coring 1x/YR, and coring 3x/YR) on annual bluegrass and creeping bentgrass competition. Over a two year period compaction resulted in significantly more annual bluegrass in the compacted plots than in plots receiving no compaction. Compacted plots saw a 6.1% decrease in annual bluegrass compared to a 16.3% decrease for non-compacted plots.

A separate two year study comparing flurprimidol rates and timings has shown no signigicant effects on the competition between annual bluegrass and creeping bentgrass. All of these studies confirm a previously held principle that creeping bentgrass is a more agressive species than annual bleugrass. This is seen in our studies where we quantitatively measure the distribution of these species and in each year the overall species composition increases by several percentage points in favor of creeping bentgrass. However, because of annual bluegrass's unique ability to reseed itself, it can rapidly fill in any void left from disease, insect or other damages. Clipping removal is the best method for reducing annual bluegrass from fairway turf.