Impact of Overseeded Grass Species, Seeding Rate and Seeding Time on Establishment and Persistence in Bermudagrass[1]

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Abstract

Cool-season grass species are often overseeded into bermudagrass turf for both aesthetics and functionality during the winter months. When the overseeded grass persists beyond the spring, however, it becomes a weed. Experiments were conducted to evaluate overseeded grass species and seeding rate on turf cover during the fall, spring, and summer. The ability of perennial ryegrass, Italian ryegrass, and hybrid bluegrass to then persist in bermudagrass one year after seeding was determined. Both perennial ryegrass and Italian ryegrass produced acceptable ground cover in the spring after fall seeding. Hybrid bluegrass did not establish well, resulting in unacceptable cover. Perennial ryegrass generally had the most persistence one year after seeding, either because of the survival of plants through the summer or because of new germination the following fall. The highest cover seen one year after seeding was 24% with perennial ryegrass in the 2005 trial. Maximum cover seen with Italian ryegrass and hybrid bluegrass 12 months after seeding was 19 and 8%, respectively. Seeding perennial or Italian ryegrass in February achieved acceptable cover in spring in the first trial but not the second. Persistence the following fall, however, was greater in the second trial, suggesting new germination. Percent cover 12 months after seeding tended to increase as the seeding rate increased, also suggesting new germination the following fall. Although quality is lower with Italian ryegrass compared to perennial ryegrass, it transitions out easier than perennial ryegrass, resulting in fewer surviving plants one year after fall seeding.

Index words: turfgrass, winter color, cool-season grasses, turfgrass persistence, winter cover.

Species used in this study: Bermudagrass, *Cynodon* spp.; perennial ryegrass, *Lolium perenne* L.; Italian ryegrass, *Lolium multiflorum* Lam.; hybrid bluegrass, *Poa pratensis* L. × *P. arachnifera* Torr.

Significance to the Nursery Industry

Landscape maintenance firms, golf course superintendents, sports turf managers, and homeowners sometimes overseed bermudagrass turf to maintain green color through the winter months. If the overseeded grass persists after bermudagrass resumes growth in spring, then the overseeded grass becomes a weed. Perennial ryegrass is more likely to persist one year after seeding than Italian ryegrass or hybrid bluegrass. Persistence tended to increase as seeding rate increased, suggesting either that new germination was occurring or that plants had survived the summer. Management of the overseeded grass species would thus have to focus on both controlling ryegrass plants during the transition phase back to bermudagrass in the spring, as well as stopping new germination the following fall. Hybrid bluegrass is not an acceptable species for overseeding since acceptable cover was not achieved in bermudagrass. Italian ryegrass transitions better than perennial ryegrass but has lower quality. Delayed overseeding until winter allows the use of nonselective herbicides in dormant bermudagrass but may not result in acceptable cover of the overseeded grass species in spring.

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Introduction

Bermudagrass is the primary turfgrass grown on athletic fields and golf courses in regions ranging from the transition zone of the United States to the tropics of the world (12). The density, color, texture and summertime vigor of bermudagrass have lead to the adaptation of many cultivars for use on athletic fields, leisure areas, and home lawns (16). While bermudagrass typically provides an ideal turf during the summer, an underlining negative trait of bermudagrass is its winter dormancy period, especially in the transition zone where cold temperatures persist for several months. Overseeding with cool-season grasses is a cultural management technique commonly utilized to maintain both aesthetic and playability features in dormant bermudagrass during the winter (3, 14).

Overseeding was first practiced on golf courses in the 1930s after initially being used in pasture grasses (5). While the overseeding process has evolved since it was first adopted, the goals remain the same: to provide green turf during bermudagrass dormancy and then transition to bermudagrass in the late spring. If the overseeded grass persists into the summer, it may reduce bermudagrass density and overall turf quality. The cool-season grass selected for overseeding largely determines the success or failure of the overseeding process. There are two transitional phases to consider when selecting a cool-season grass for overseeding: ease of fall establishment of the overseeded grass and ease of spring transition back to bermudagrass (6). Each species of cool season grass has both positive and negative attributes

that affect its overseeding performance. In the past, Italian ryegrass, commonly referred to as annual ryegrass, was the overseeding species of choice because of its rapid germination and establishment. However, Italian ryegrass is coarse-textured, requires frequent mowing and has inadequate cold and heat tolerance (12). Italian ryegrass also tends to have a less desirable, lighter green color than other overseeding species, resulting in overall lower quality (18). Improved Italian ryegrass cultivars, such as 'Panterra' (10), were bred for increased quality as well as improved spring transition. Compared to Italian ryegrass, perennial ryegrass has a finer leaf texture, darker green color, and generally produces a higher quality turf. Consequently, it is often used as both an overseeding species in warm climates and as a year-round turf in cooler climates. The popularity of perennial ryegrass has lead to the breeding of heat tolerant, drought tolerant, and disease resistant cultivars. While these are generally desirable attributes, perennial ryegrass will often survive the summer and persist as a perennial weed in overseeded bermudagrass (4). Italian ryegrass is listed as either a winter annual, biennial, or occasionally a perennial while perennial ryegrass is described as a short-lived perennial (2).

Hybrid bluegrass (*Poa pratensis* L. × *Poa arachnifera* Torr.) was created by crossing Kentucky bluegrass (*Poa pratensis* L.) and Texas bluegrass (*Poa arachnifera* Torr.) (11). Hybrid bluegrass has many of the desirable qualities of Kentucky bluegrass such as dark green color, brown patch (*Rhizoctonia solani*) resistance, and utility, but was bred to have increased heat and drought tolerance. Its ability to survive heat and drought may be problematic when used as an overseeded grass when transitioning back to bermudagrass in late spring. However, if the hybrid bluegrass transitions into dormancy during the heat of the summer and then returns to normal growth in the fall, it may be able to coexist with bermudagrass, providing a two grass system that does not require overseeding each year. However, overseeded cool-season grasses persisting through the summer may become a weed problem the following fall and winter. The overseeded grass would be clumpy and sporadically distributed throughout the bermudagrass stand. Currently, little information is available on the long-term persistence of overseeded grasses in bermudagrass.

Environmental conditions and cultural practices greatly affect the spring-time transition to bermudagrass regardless of which overseeded species is used. Elevated temperatures and low rainfall in fall may adversely affect overseeded grass establishment. Conversely, low temperatures and high rainfall in late spring and early summer of the following year may allow the overseeded grass to persist well past bermudagrass green-up. Cultural practices such as seeding rate, fertility, thatch removal, aeration, irrigation, mowing frequency, and application of herbicides each affect the rate of transition (8, 9). Current recommended ryegrass overseeding rates in the coastal mid-Atlantic region are approximately 480 to 730 kg·ha^{-1} (430 to 650 lbs·A^{-1}) (13). Overseeding in the mid-Atlantic with ryegrass is typically done in October. Most overseeding is performed in the fall before bermudagrass goes dormant; however, if green color is desired only in the spring, it might be possible to overseed bermudagrass in late winter. By delaying overseeding, nonselective weed control products such as glyphosate can be used for winter weed control in dormant bermudagrass (7). This overseeding option would thus allow turf managers to control both annual and perennial weeds without injuring desirable turf. However, establishment from winter overseeding in the transition zone has not been adequately studied. Information is also needed on the impact of winter overseeding on long-term survival of the overseeded grass species.

Objectives of these trials were to determine the impact of overseeding grass species, seeding rate, and seeding timing on overseeding success in bermudagrass, and to evaluate the long-term persistence of overseeded cool-season grasses in bermudagrass turf. This research compared perennial ryegrass, an improved Italian ryegrass, and hybrid bluegrass.

Materials and Methods

General conditions. The experiments were conducted in Virginia Beach, VA, from 2004 to 2006. Experiments were established in the fall of 2004 and monitored through the end of 2005 and were repeated in an adjacent area in the fall of 2005 and evaluated through the end of 2006. Soil type was a Tetotum loam (fine-loamy, mixed, thermic Hapludults) and averaged 3.2% organic matter and pH 5.6. Three cool-season grass species were evaluated for overseeding performance. The species included an overseeding blend of three perennial ryegrass cultivars ('Charger II', 'Manhattan 4', 'Citation Fore'), 'Panterra' Italian ryegrass, and 'Thermal Blue' hybrid bluegrass. The ryegrasses were seeded at 224, 448, and 673 kg·ha^{-1} (200, 400, and 600 lbs·A^{-1}), consistent with currently recommended overseeding rates (13), while the hybrid bluegrass was seeded at 67, 101, and 135 kg·ha^{-1} (60, 90, and 120 lb·A^{-1}) without any soil disturbance. In a trial with 'Thermal Blue' hybrid bluegrass, the optimum seeding rate ranged from 50 to 150 kg·ha^{-1} (45 to 134 lb·A^{-1}) (15), comparable to the seeding rates used in this research. Plots, each measuring 1.8 × 3.0 m (6 × 10 ft), were mowed weekly at 3.2 cm (1.25 in) in the fall and 2.2 cm (0.9 in) in the spring with clippings returned. All studies were fertilized with a slow-release 24-6-12 N-P-K fertilizer at the rate of 49 kg N per ha (43 lb·A^{-1}) at the time of seeding. Percent ground cover for each overseeded grass species was visually evaluated in November, December, April, and the following November, which relates to 1, 2, 4, and 12 months after ryegrass seeding. Overseeded grass color was evaluated in April and overseeded grass quality was determined in May using a 0 to 100 scale, with 0 equal to completely brown turf and 100 equal to a very dark green color and highest quality. Stands of each overseeded grass species were counted 12 months after the fall seeding.

In all trials, the experimental design was a factorial arrangement of treatments in a randomized complete block with four replications. Data were subjected to analysis of variance ($\alpha = 0.05$) (Statistical Analysis Software v. 9.1, SAS Institute Inc., 100 SAS Campus Drive, Cary, NC 27513-2414). Main effects of overseeding species, seeding rate and seeding timing and interactions were tested. Where interactions were not significant results were averaged across main effects. Mean separation was determined using the Fisher's protected least significant difference test (LSD) at the 0.05 level.

Comparison of seeding species and seeding rate. The three cool-season grasses were overseeded into established 'Riviera' (*C. dactylon* var. *dactylon* L.) bermudagrass. Perennial ryegrass and Italian ryegrass were seeded in mid-October and hybrid bluegrass was seeded in mid-September. Hybrid

bluegrass was seeded one month earlier than the ryegrasses because of its slower germination and establishment rate.

Fall versus winter over-seeding. A separate trial comparing fall versus winter overseeding was conducted in 'Tifsport' (*Cynodon dactylon* × *C. transvaalensis*) bermudagrass. The overseeded grasses and seeding rates were the same as the seeding rate and species comparison described above. An additional treatment variable in this experiment was seeding time. Fall-seeded plots were seeded in September (hybrid bluegrass) or October (Italian and perennial ryegrasses); winter seeded plots were seeded during the first week of January (hybrid bluegrass) and mid-February (Italian and perennial ryegrasses). As with the previous trials, the experimental design was a factorial arrangement of treatments in a randomized complete block with four replications.

Results and Discussion

Impact of seeding species and seeding rate. Establishment of overseeded species differed between years; therefore data for each year are presented separately (Table 1). Italian and perennial ryegrass and hybrid bluegrass cover was higher in the 2004 trial compared to the 2005 trial in winter and spring. This was most likely because of rainfall differences during the germination period between the two years. In 2004, 5.1 cm (2 in) of rain was recorded from October 14 through November 14. In 2005, only 0.7 cm (0.3 in) of rain was recorded from October 14 through November 14. Interestingly, though, there was higher cover one year after seeding in the 2005 study compared to the 2004 study. It is possible that some of the seed applied in the fall of 2005 did not germinate until the fall of 2006. Alternatively, the overseeded species may have been able to tolerate summer conditions better in 2006 compared to 2005. In the summer of 2005, only 4.6 cm (1.8 in) of rain fell between June 11 and July 12, while in 2006, 23.9 cm (9.4 in) of rain fell during this period. Italian ryegrass appears to behave as a true winter annual, thus being less persistent compared to perennial ryegrass, for which a proportion of the population appeared to survive the summer in southeastern Virginia.

In 2004, Italian ryegrass cover was 37% on the fall rating date and 1% one year after seeding while perennial ryegrass covered 27% of the plots on the fall rating date and 5% one year after seeding (Table 1). In 2005, plots seeded with Italian ryegrass had 21% percent ground cover on the fall rating date and 7% ground cover one year after seeding. Perennial ryegrass seeded in 2005 covered 24% of the ground in the fall and 15% one year after seeding. Perennial ryegrass establishes slightly slower than Italian ryegrass but is more likely to persist. Italian ryegrass provided 90% or greater cover in spring of both trials, while seeding of perennial ryegrass resulted in 75 to 96% cover. Hybrid bluegrass did not provide acceptable cover during the fall and spring rating dates, especially in the second trial when cover was only 26% in spring. We therefore would not recommend this species for bermudagrass overseeding in this region.

The percent cover of perennial ryegrass present one year after seeding is lower than that reported by Van Dam (17), who observed greater than 40% cover for 'Manhattan' and 'Manhattan II' perennial ryegrass one year after overseeding. That trial was conducted in California, where environmental conditions would differ from that in Virginia. In the Virginia trials, the majority of plants for each species exhibited a winter annual life cycle. Perennial and Italian ryegrass present at a low density one year after seeding would grow without competition in dormant bermudagrass, leading to unsightly clumps in the dormant turf. Italian ryegrass had the lowest color and quality (data not shown) of the three grass species because of its light green color as well as the development of seedheads and seed stalks (data not shown), similar to that reported by Zhang et al. (18).

Table 1. Percent cover of the overseeded grass as affected by species and year averaged over seeding rate in 'Riviera' bermudagrass.

	Percent cover[z]			
Species	Fall	Winter	Spring	Fall 12 MAS[y]
2004 trial				
Italian ryegrass	37a	90a	95a	1b
Perennial ryegrass	27b	88a	96a	4a
Hybrid bluegrass	15c	42b	73b	1b
2005 trial				
Italian ryegrass	21a	75a	90a	7b
Perennial ryegrass	24a	67a	75b	15a
Hybrid bluegrass	0b	10b	26c	3c
ANOVA[x]				
Overseeded grass	*	*	*	*
Year	*	*	*	*
Overseeded grass × Year	*	NS	*	*

[z]Means within a column and year with the same letter are not significantly different according to the Fisher's protected least significant difference test at the 0.05 level.

[y]MAS = months after seeding. Plots were evaluated 1, 2, 4, and 12 months after ryegrass seeding.

[x]* Indicates significance at 0.05 using ANOVA. NS indicates no significant effect at $\alpha = 0.05$.

The effect of seeding rate differed between the two years; therefore data for each year are presented separately (Table 2). While statistically significant differences existed among seeding rates at several rating dates, the majority of differences observed were small and of little practical significance. Percent cover in the highest seeding rate was double that of the low rate in the fall of 2004. However, percent cover in the winter and spring was similar across seeding rates in 2004, and no differences were observed among seeding rates in the 2005 trial. These results are in contrast to those of Bornino (1) who observed greater cover when the perennial ryegrass seeding rate was increased. Almost all of their seeding rates, however, were much higher, ranging from 610 to 4,880 $kg \cdot ha^{-1}$.

A significant difference (p value < 0.05) between study years was detected in plant persistence one year after seeding. Averaged across species, plots from study year two had 120.6 plants per m^2 while plots from study year one had 72.3 plants per m^2 (data not shown). When overseeding species was averaged across years, plots seeded with perennial ryegrass had higher turfgrass density than plots overseeded with Italian ryegrass or hybrid bluegrass (Table 3). Plant stand counts (Table 3) followed the same pattern as percent cover (Table 1), indicating that size per plant was similar across the three overseeding species. One year after seeding, percent cover for perennial ryegrass was approximately two to five times that seen for Italian ryegrass or hybrid bluegrass

Table 2. Percent cover of the overseeded grass as affected by year and seeding rate averaged over species in 'Riviera' bermudagrass.

Seeding rate[y]	Percent cover[z]			
	Fall	Winter	Spring	Fall 12 MAS[x]
2004 trial				
Low	15c	69b	87a	1a
Med	27b	76a	88a	3a
High	31a	77a	91a	2a
2005 trial				
Low	12a	47a	59a	7a
Med	16a	52a	64a	9a
High	17a	53a	68a	9a
ANOVA[w]				
Rate	*	*	NS	NS
Year	*	*	*	*
Rate × Year	*	*	NS	NS

[z]Means within a column and year with the same letter are not significantly different according to the Fisher's protected least significant difference test at the 0.05 level.

[y]The ryegrasses were seeded at 224, 448, and 673 kg·ha^{-1} and the hybrid bluegrass was seeded at 67, 101, and 135 kg·ha^{-1}.

[x]MAS = months after seeding. Plots were evaluated 1, 2, 4, and 12 months after ryegrass seeding.

[w]* Indicates significance at 0.05 using ANOVA. NS indicates no significant effect at $\alpha = 0.05$.

(Table 1) and the stand counts for perennial ryegrass were approximately 3 to 4 times higher than that seen in Italian ryegrass or hybrid bluegrass.

Impact of seeding timing and rate. General trends among overseeded grass species (Table 4) were similar to those observed in the previously described experiment (Tables 1 through 3). Fall overseeding resulted in greater percent cover in spring compared to winter overseeding, regardless of species (Table 4). Percent cover of the overseeded species in the spring was generally greater in the 2004 experiment compared to 2005. In 2004, percent cover from fall overseeding was similar among the three species. However, in 2005 percent cover in spring for Italian ryegrass was greater than perennial ryegrass, which was greater than hybrid bluegrass, 94, 80 and 42% cover, respectively (Table 4). Plots overseeded with Italian ryegrass had a lighter green color than the other turfgrasses in winter and spring (data not shown).

Table 3. Effect of overseeded grass species on plants per square meter in 'Riviera' bermudagrass one year after seeding, averaged over study year and seeding rate.

Overseeded species	Plants per m^{2}[z]
	Riviera
Italian ryegrass	58.2b
Perennial ryegrass	163.5a
Hybrid bluegrass	36.7b

[z]Means within a column with the same letter are not significantly different according to the Fisher's protected least significant difference test at the 0.05 level.

Averaged over species, overseeding in the fall resulted in 71% percent cover in the spring, which was significantly greater than the winter overseeding percent cover rating of 57% (Table 4). It appears that a January or February seeding could provide acceptable cover in April depending on aesthetic thresholds and environmental conditions since acceptable cover was achieved in the 2004 trial. Winter seeding did not result in acceptable cover in the 2005 trial. The difference between trials was probably due to rainfall amounts since a total of 11.6 cm (4.6 in) accumulated in February through March in 2005 while only 3.0 cm (1.2 in) fell during this period in 2006.

Percent cover one year after seeding was very similar between trials for each overseeded species/timing combination (Table 4). Highest cover was seen in fall-seeded perennial ryegrass, with the lowest following winter seeding of hybrid bluegrass. Higher cover was noted for perennial ryegrass seeded in fall compared to winter, suggesting that fall-seeded plants were better able to survive the summer. Greater cover was seen for winter seeding of Italian ryegrass compared to fall seeding, suggesting that some of the applied seed did not germinate until the following fall.

Overseeded grass cover tended to increase slightly as seeding rate increased when evaluated in winter and spring (Table 5). Overseeded grass cover the following fall also increased slightly with increasing seeding rate. Seeding with perennial ryegrass in the fall resulted in greater plant stand one year later compared to Italian ryegrass or hybrid bluegrass (Table 6), similar to that seen with percent cover (Table 4). In the 2005 trial, winter seeding resulted in greater Italian ryegrass plants per square meter one year after seeding compared to the fall seeding. In contrast, the number of perennial ryegrass and hybrid bluegrass plants was slightly less when seeded in the winter than in the fall. Perhaps fall-seeded plants are better able to withstand summer heat and drought compared to seed applied in winter for these two species. Greater stand of Italian ryegrass and hybrid bluegrass was noted in the fall

Table 4. Percent cover of overseeded turfgrasses in the spring and following fall as affected by species and seeding timing in 'Tifsport' bermudagrass.

Species	Seeding time	Percent cover[z]			
		2004 trial		2005 trial	
		Spring	Fall	Spring	Fall
Italian ryegrass	Fall	97a	6c	94a	8c
Perennial ryegrass	Fall	98a	26a	80b	28a
Hybrid bluegrass	Fall	88a	6c	42c	8c
Italian ryegrass	Winter	77c	18b	21d	19b
Perennial ryegrass	Winter	75cd	13b	18d	15b
Hybrid bluegrass	Winter	69d	0d	8e	1d
ANOVA[y]					
Overseed species		*	*	*	*
Timing		*	NS	*	*
Overseed species × Timing		NS	*	NS	*

[z]Means within a column with the same letter are not significantly different according to the Fisher's protected least significant difference test at the 0.05 level.

[y]* Indicates significance at 0.05 using ANOVA. NS indicates no significant effect at $\alpha = 0.05$.

Table 5. Percent cover of the overseeded grass as affected by seeding rate, averaged over species, study year, and seeding timing in 'Tifsport' bermudagrass.

	Percent cover[z]		
Seeding rate[y]	Winter	Spring	Fall 12 MAS[x]
Low	34b	61b	7b
Med	38a	65a	8ab
High	39a	67a	10a

[z]Means within a column with the same letter are not significantly different according to the Fisher's protected least significant difference test at the 0.05 level.

[y]The ryegrasses were seeded at 224, 448, and 673 kg·ha^{-1} and the hybrid bluegrass was seeded at 67, 101, and 135 kg·ha^{-1}.

[x]MAS = months after seeding.

after winter seeding in the 2005 compared to the 2004 trial. This is surprising since plant stand in the spring was much higher in the 2004 compared to the 2005 trial for the winter seedings. Again, this suggests that some of the seed applied in winter may not have germinated until the following fall, especially for the 2005 trial.

Increasing seeding rate resulted in increased plant counts taken one year after seeding (Table 7). A higher seeding rate resulted in more plants per square meter, which suggests that either some of the seed may not have germinated until the following year or that a higher number of plants survived due to a higher initial plant stand the previous spring. If due to new germination, then a preemergence herbicide may need to be applied in late summer to prevent emergence of the overseeded grass species if no overseeding was to be done.

Annual bluegrass (*Poa annua L.*) plants were counted in April for the 2004 trial. Seeding timing as well as overseeded grass species had a significant effect on the number of annual bluegrass plants. Overseeding with hybrid bluegrass in the winter resulted in 26.3 annual bluegrass plants per m^2, which was more than any other overseeded species/seeding timing treatment combination when averaged over seeding rate. Conversely, plots seeded with perennial ryegrass, Italian ryegrass, and hybrid bluegrass in the fall had 2.8, 0.6, and 7.0 annual bluegrass plants per m, respectively, when averaged over seeding rate. Unseeded plots had 45.0 annual bluegrass plants per m^2, while plots overseeded in February with perennial ryegrass and Italian ryegrass contained 18.8 and 22.6 annual bluegrass plants per m^2, respectively. Overseeding rate did not have an impact on annual bluegrass plant density.

In all trials, study year affected percent cover and plants per square foot, underscoring the importance of environmental factors on establishment of overseeded grasses. Rainfall and temperature readings recorded in late spring to early summer revealed that 2005 was hotter and drier than 2006. Therefore, the hot weather may have killed the cool-season grasses more effectively from study one while providing unfavorable conditions for the germination of fall-seeded overseeded grasses in 2005. The higher percent cover one year after seeding for study two may be attributed to new germination one year after seeding.

Perennial and Italian ryegrass each provided acceptable coverage when overseeded into bermudagrass. Although Italian ryegrass provided an acceptable level of coverage, it produced a lighter green color than perennial ryegrass. Based on the results of these trials, hybrid bluegrass does not appear to be a viable species for successfully overseeding bermudagrass. Overall, seeding rate did not have a large effect on percent ground cover for the overseeded grasses. A disadvantage to the high seeding rate was a tendency towards increased ryegrass plants present in the fall one year after seeding. This would be considered a weed problem if no overseeding was done that fall. Overseeding in the winter produced less coverage than overseeding in fall; however, winter overseeding appears to be an option to provide some green color in the spring. Therefore, if an athletic field is only used in the spring and not the fall, a turf manager would have the option of winter overseeding, which would allow for more effective weed control options. Winter overseeding allows for nonselective weed control in dormant bermudagrass prior to overseeding.

Italian and perennial ryegrasses are behaving primarily as winter annuals when overseeded into bermudagrass (4). However, a low density of perennial and Italian ryegrass was present one year after seeding, necessitating changes in management practices to remove these species if over-

Table 6. Plants per square meter as affected by species and timing in 'Tifsport' bermudagrass taken one year after overseeding.

	Plants per m[z]	
	Seeding time	
Species	Fall	Winter
2004 trial		
Italian ryegrass	75.2b	54.6a
Perennial ryegrass	108.4a	86.2a
Hybrid bluegrass	11.2c	0.0b
2005 trial		
Italian ryegrass	97.1b	161.7a
Perennial ryegrass	226.5a	161.4a
Hybrid bluegrass	97.4b	43.0b
ANOVA[y]		
Overseeded grass	*	*
Year	*	*
Overseeded grass × Year	*	NS

[z]Means with the same letter are not significantly different according to the Fisher's protected least significant difference test at the 0.05 level.

[y]* Indicates significance at 0.05 using ANOVA. NS indicates no significant effect at $\alpha = 0.05$.

Table 7. Effect of seeding rate on overseeded grass plants per square meter one year after seeding in 'Tifsport' bermudagrass, averaged over study year, species, and seeding timing.

Seeding rate[z]	Plants per m[y]
Low	75b
Med	97ab
High	108a

[z]The ryegrasses were seeded at 224, 448, and 673 kg·ha^{-1} and the hybrid bluegrass was seeded at 67, 101, and 135 kg·ha^{-1}.

[y]Means within a column with the same letter are not significantly different according to the Fisher's protected least significant difference test at the 0.05 level.

seeding is not done annually. As observed in these trials, environmental factors play a critical role in the overseeding process. Although the same protocols were duplicated in both years of the trials, significant differences between the years were observed. These differences were most likely because of variations in rainfall and temperatures during the germination and transition periods. Monitoring rainfall and irrigation should be practiced in order to ensure successful establishment and ease transition of overseeded turfgrass.

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