Morphology, Turf Quality, and Heat Tolerance of Intermediate Ryegrass

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Abstract. Bermudagrass (*Cynodon* spp.) turf is often overseeded with a cool-season species such as perennial ryegrass (*Lolium perenne* L.) to provide an improved winter surface for activities such as golf or athletic events. Perennial ryegrass can become a persistent weed in overseeded turf due to the heat and disease tolerance of improved cultivars. Intermediate ryegrass is a relatively new turfgrass that is a hybrid between perennial and annual ryegrass (*L. multiflorum* Lam.). Very little information is available on intermediate ryegrass as an overseeding turf. Greenhouse, field, and growth chamber studies were designed to compare two cultivars of intermediate ryegrass ('Transist' and 'Froghair') with three cultivars of perennial ryegrass ('Jiffie', 'Racer', and 'Calypso II') and two cultivars of annual ryegrass ('Gulf' and 'TAM-90'). In a greenhouse study, the perennial ryegrass cultivars had finer leaf texture (2.9–3.2 mm), shorter collar height (24.7–57.0 mm), and lower weight/tiller (29–39 mg) than the intermediate and annual cultivars. In the field studies, the intermediate cultivar Transist exhibited improved turfgrass quality (6.1–7.1) over the annual cultivars (4.5–5.8) and the other intermediate cultivar Froghair (5.4–5.7). However, neither of the intermediate cultivars had quality equal to the perennial ryegrass cultivars (7.0–7.9). The perennial ryegrass cultivars exhibited slow transition back to the bermudagrass compared to the annual and intermediate ryegrass cultivars. In the growth chamber study, the annual and intermediate cultivars all showed increased high-temperature stress under increasing temperatures compared to the perennial cultivars, which did not show stress until air temperature exceeded 40 °C. Collectively, these studies indicate that the intermediate ryegrass cultivar Transist may have promise as an overseeding turfgrass due to its improved quality compared to annual types and a lack of heat tolerance relative to perennial cultivars, but with transition qualities similar to perennial ryegrass.

Bermudagrass (*Cynodon* spp.) continues as the predominate turfgrass species used for golf courses and sports fields in tropical and transition zone areas of the world. This widespread use reflects an ability of this species to resist wear, pests, and environmental stresses, while producing a high-quality surface for many types of sporting activities. Although bermudagrass has many positive attributes, a negative aspect of the species is the long winter dormancy period that is experienced in many areas of bermudagrass use. In the northern limits of adaptation, bermudagrass may be dormant for as long as 7 months per year. Because of the long dormancy period, bermudagrass is commonly overseeded with a cool-season grass to provide a year-long green surface to enhance sporting activities (Dudeck and Peacock, 1980; Schmidt and Shoulders, 1977). Overseeding dormant bermudagrass turf has been an integral component of the continued growth in the golf industry in sunbelt states such as Florida, Texas, Arizona, and California.

The practice of overseeding dates back to the 1930s and was first adapted to golf courses and sports fields from pasture management, where cool-season annual grasses and legumes

are often used for winter livestock grazing (Hoveland et al., 1978). Success in overseeding is affected by a number of management decisions and practices, such as the turfgrass species to be used, propagation techniques, fertilizer and water management, mowing practices, and pest management (Horgan and Yelverton, 2001; Johnson, 1976; Kneebone and Major, 1969; Mazur and Rice, 1999; Mazur and Wagner, 1987). A wide range of grasses has been successfully used for overseeding, including annual (Italian) ryegrass (*Lolium multiflorum* Lam.), perennial ryegrass (*L. perenne* L.), creeping bentgrass (*Agrostis stolonifera* L.), rough bluegrass (*Poa trivialis* L.) and fine fescues (*Festuca* spp.) (Kneebone and Major, 1969; Schmidt and Shoulders, 1977; Ward et al., 1974). Annual ryegrass was initially the primary grass used in overseeding due to its rapid germination, establishment and availability. However, the species had poor cold and heat tolerance, poor density and texture, and required frequent mowing due to its rapid growth rate. Creeping bentgrass and rough bluegrass have been used for overseeding in niche areas such as closely mowed putting greens, but have not been well-accepted for overseeding use on golf course fairways and tees and sports fields.

Of the many grasses used for overseeding dormant turf, perennial ryegrass is the most widely used. Breeding efforts with this species have led to significant improvements in turf quality, leaf texture, mowing quality, wear

tolerance, growth habit, disease resistance, establishment vigor, and dark green color (Meyer and Funk, 1989). Perennial ryegrass is a dual-purpose species which is used both as an annual grass in the semi-tropical and tropical regions and as a perennial in temperate climates of the world. Because of its dual purpose, breeding efforts have often focused on plant types that are more persistent under environmental stresses and better adapted to the perennial environment. Increases in heat tolerance, drought tolerance, and disease resistance of improved cultivars have served to make perennial ryegrass a problematic weed following overseeding because the grass is too persistent and does not behave as an annual in southern climates (Horgan and Yelverton, 2001).

In the past decade, intermediate ryegrass cultivars have been developed by plant breeders as an alternative species for overseeding golf and sports turf (Schmitz, 1999). Intermediate ryegrass is a species hybrid between annual and perennial ryegrass (*L. multiflorum* × *L. perenne*) and has been extensively used as a forage grass. Although several cultivars of turf-type intermediate ryegrass are in various stages of development and production, there is very little available information on the characteristics of this hybrid species relative to the parents, annual and perennial ryegrass. This report summarizes a series of field, greenhouse and growth chamber studies that compare two intermediate ryegrass cultivars with annual and perennial cultivars. The objectives of the studies were to: 1) determine the rate of tiller development and leaf characteristics of intermediate ryegrass compared to annual ryegrass or perennial ryegrass, 2) evaluate turf characteristics of intermediate ryegrass in comparison with perennial and annual ryegrass in both a prepared seed-bed situation and an overseeded test, and 3) compare heat tolerance of intermediate ryegrass to annual and perennial ryegrass.

Materials and Methods

Seven cultivars of intermediate, annual, and perennial ryegrass were compared in all studies (Table 1). The annual (A) cultivars represent an industry standard, 'Gulf', and a new cultivar, TAM-90, while the perennial (P) cultivars ('Racer', 'Jiffie', and 'Calypso II') were chosen based on their performance in other tests and their genetic similarity to the intermediate (I) cultivar, 'Transist' (D. Floyd, personal communication). The intermediate cultivars Transist and Froghair were the only cultivars available at the time of these studies.

Greenhouse study. A greenhouse study was conducted in which individual seedlings of each cultivar were established in a 10-cm pot (vol. = 1178 cm³) containing a commercial potting mix (Strong-Lite High Porosity Mix; Strong, Pine Bluff, Ark.). Three seeds were placed near the center of each pot and covered lightly with additional potting mix. After germination, each pot was thinned to one seedling for the remainder of the test. Pots were fertilized weekly with 100 mL of a commercial nutri-

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ent solution (Peters 20N–4.4P–16.6K General Purpose Special) containing N at 50 mg·kg⁻¹. At 4 and 6 weeks after planting, six replicate pots of each cultivar were harvested at the soil surface and separated into leaf sheath and blade components. Data collected at each harvest included total number of tillers per pot, width of fully expanded leaf blades (average of four sub-samples per rep), dry weight of leaves, dry weight of sheath, and average height of leaf collar (average of four sub-samples per rep). From the data collected, calculations were used to determine total shoot weight (leaf dry weight + sheath dry weight), leaf blade weight/tiller (leaf dry weight per no. of tillers), and sheath weight per tiller (sheath dry weight per no. of tillers). The experimental design was a randomized complete block.

Field studies. Two field studies were conducted to determine turf characteristics of annual, perennial, and intermediate ryegrass. Plots were established at Pinnacle Country Club in Rogers, Ark., and at the Univ. of Arkansas Research and Extension Center, Fayetteville. The field studies included a planting into a prepared seed bed area (Rogers) and an overseeded planting (Fayetteville) on 'Tifway' bermudagrass. Soil type at the Fayetteville location was a Captina silt loam soil (typic Hapludult) with a pH of 6.2, while the soil at the Rogers site was a Nixa Cherty silt loam (typic Hapludult) with a pH of 5.9. Plot size at each location was 2 × 2 m and each cultivar was replicated four times at each site. Seeding rates were 20 g·m⁻² for the prepared seed-bed test and 50 g·m⁻² for the overseeded test. Prior to seeding, the overseeded test area was vertically mowed in two directions prior to seeding and the debris removed from the site. Beginning one month after establishment and continuing throughout the test, plots were fertilized monthly with a N rate of 2.5 g·m⁻² as 13N–5.7P–10.8K. Mowing height was 2.54 cm throughout both tests. Plots were rated every 2 weeks for establishment rate, color, and turf quality. Clipping weights for

each plot were determined during early spring by taking a representative swath (55.8 cm × 144.1 cm) through each plot. Clippings were dried in a forced-air oven at 60 °C, weighed, and reported on a g·m⁻² basis. Turf quality and transition characteristics of each ryegrass cultivar were monitored through June.

Growth chamber study. A growth chamber study was conducted to assess the overall heat tolerance of the ryegrass cultivars. Eight replicate 10-cm pots (vol. = 1178 cm³) of each experimental cultivar was established in a standard potting mix (Strong-Lite High Porosity Mix). Seeding rates were 20 g·m⁻² and pots were fertilized weekly with 100 mL of a complete nutrient solution containing N at 100 mg·kg⁻¹. Pots were established in the greenhouse for 6 weeks and mowed weekly at 5.0 cm using an electric hand clipper. After the 8-week establishment period in the greenhouse, pots were moved into a growth chamber (model

PGW36; Conviron, Pembina, N.D.) set at 25 °C with a 14-h light/10-h dark photoperiod and acclimated for 1 week. The photosynthetically active radiation in the growth chamber was maintained at 600 μmol·m⁻²·s⁻¹. Beginning in week two, the temperature of the growth chamber was raised 1 °C every 2 d for 40 d. Canopy temperature of each pot was measured every 4 d using a hand-held infrared thermometer held ≈30 cm above the canopy. Canopy temperature was monitored to assess changes in transpiration rates under increasing temperature (Kluitenberg and Biggar, 1992). Heat stress was indicated when leaf temperature exceeded air temperature.

Data analysis. Data for all studies were analyzed by analysis of variance (SAS Inst., Cary, N.C.) procedures and means were separated by Fisher's protected least significant difference (LSD) (*P* = 0.05).

Table 1. Morphological characteristics, at 4 weeks and 6 weeks after planting, of ryegrass cultivars grown as a single plant in a greenhouse.

Cultivars	Species	No. of tillers/plant	Leaf texture	Collar height	Sheath wt	Leaf wt	Shoot wt	Total wt/tiller	Leaf wt/tiller	Sheath wt/tiller
<i>Four weeks after planting</i>										
Gulf	Annual	10.0	6.4	54.7	226	661	887	89	67	23
TAM-90	Annual	11.3	7.0	50.3	324	923	1246	112	84	29
Froghair	Intermediate	9.7	6.4	61.0	234	688	922	102	75	27
Transist	Intermediate	11.3	3.8	43.3	174	478	652	39	29	11
Racer	Perennial	15.7	3.0	24.7	151	322	483	30	21	9
Jiffie	Perennial	10.3	2.9	26.7	116	265	381	39	27	12
Calypso	Perennial	10.7	3.2	27.0	69	238	307	30	24	7
LSD _{0.05}		NS	1.3	12.1	132	328	442	38	29	10
<i>Six weeks after planting</i>										
Gulf	Annual	19.7	7.58	86.0	731	1602	2333	121	83	38
TAM-90	Annual	18.0	7.58	79.0	710	1594	2304	155	106	49
Froghair	Intermediate	23.3	5.92	73.3	666	1631	2297	99	70	29
Transist	Intermediate	18.7	4.08	58.0	541	1098	1639	100	67	20
Racer	Perennial	21.0	3.08	57.0	277	625	902	52	35	17
Jiffie	Perennial	13.0	3.08	42.3	126	288	415	43	29	14
Calypso	Perennial	16.7	3.67	38.7	275	623	897	56	39	17
LSD _{0.05}		NS	1.42	17.3	154	394	509	55	38	18

^{NS}Nonsignificant.

Table 2. Turf characteristics of ryegrass cultivars grown in a prepared seed-bed in Rogers, Ark. and overseeded into 'Tifton 419' bermudagrass in Fayetteville, Ark.

Cultivar	Species	Establishment rate		Turf color ^c		Turf Quality		Clipping wt (g·m ⁻²)	
		10 DAP ^y	20 DAP	Dec. 1998	Mar. 1999	Dec. 1998	Mar. 1999	Mar. 1999	Apr. 1999
<i>Prepared seedbed</i>									
Gulf	Annual	4.0	8.2	4.2	4.5	5.3	5.5	ND ^x	14.2
TAM-90	Annual	4.5	8.8	4.4	4.6	5.0	5.7	ND	12.0
Froghair	Intermediate	4.0	7.8	4.8	4.8	5.7	5.4	ND	14.5
Transist	Intermediate	3.0	6.5	6.1	6.3	7.1	6.8	ND	11.8
Racer	Perennial	1.3	4.5	7.5	7.9	7.7	7.7	ND	8.1
Jiffie	Perennial	1.0	4.2	7.4	7.6	7.6	7.9	ND	8.4
Calypso II	Perennial	2.5	5.5	7.9	8.0	7.9	8.2	ND	7.1
LSD _{0.05}		0.8	1.1	1.3	0.9	1.2	1.0		2.6
<i>Overseeding trail</i>									
Gulf	Annual	4.8	8.6	3.2	4.7	4.5	5.8	11.1	12.1
TAM-90	Annual	4.9	8.4	4.0	4.9	4.5	5.3	14.5	13.8
Froghair	Intermediate	4.5	7.9	3.8	4.8	5.2	5.2	13.9	12.5
Transist	Intermediate	3.1	7.5	4.9	6.5	6.1	6.6	11.9	11.8
Racer	Perennial	2.3	5.5	6.8	7.4	7.0	7.2	8.5	9.9
Jiffie	Perennial	2.0	6.6	7.3	7.4	7.1	7.4	9.1	9.8
Calypso II	Perennial	3.0	6.0	7.4	7.7	7.4	7.8	8.7	8.0
LSD _{0.05}		1.4	1.5	1.3	0.9	1.1	0.7	2.3	2.7

²Ratings from 1 to 9, with 1 = poor and 9 = excellent.

³DAP = days after planting.

⁴ND = not determined at that date.

Table 3. transition of perennial ryegrass back to 'Tifton 419' bermudagrass in an overseeding trial planted on 22 Oct. 1998 in Fayetteville, Ark.

Cultivar	Species	14 May	28 May	8 June	15 June
		% ryegrass ^a			
Gulf	Annual	73	46	15	1
TAM-90	Annual	81	55	21	1
Froghair	Intermediate	93	52	19	5
Transist	Intermediate	93	77	49	28
Racer	Perennial	99	95	81	58
Jiffie	Perennial	100	97	68	49
Calypso II	Perennial	100	100	82	60
LSD _{0.05}		9	13	17	11

^aTransition was estimated visually as the percent ryegrass remaining in the plots at each evaluation time.

Results and Discussion

Cultivar differences were observed for all morphological parameters measured in the greenhouse, with the exception of tiller number per plant (Table 1). As expected, leaf texture was significantly coarser for the annual cultivars (6.4–7.0 mm) compared to the perennial cultivars (2.9–3.2 mm). However, leaf texture of the two intermediate cultivars was not truly intermediate between the other species. 'Froghair' (I) had a leaf texture (6.4 mm) that was similar to the annual cultivars, while leaf texture of 'Transist' (I) was 3.8 mm and was not significantly different from the perennial cultivars. Other parameters, including total weight per tiller, leaf weight per tiller, and sheath weight per tiller exhibited similar results. There was not a significant difference in the tillering capacity between the cultivars, which suggests that they would be equally competitive in a mixed-species stand.

Collar height was significantly different between the two intermediate cultivars (Table 1), as 'Froghair' (I) had an average collar height of 61.0 mm, while 'Transist' (I) had a collar height of 43.3 mm. The perennial ryegrass cultivars all had significantly lower collar heights than the annual and intermediate ryegrasses (Table 1), evidence of advances made in breeding toward dwarf or semi-dwarf growth habits (Meyer and Funk, 1989). This parameter is significant for overall turf performance, in that an elevated collar height would reduce the amount of leaf production that would occur below the mowing height and subsequently affect turf density and turf quality. Therefore, 'Transist' (I) may be more adapted to lower mowing heights than 'Froghair' (I), although this has not been investigated.

A complete turfgrass stand was established for all cultivars in both field trials. The annual ryegrass cultivars germinated within 4–5 d and quickly established a dense turf, as reported previously (Schmidt and Shoulders, 1977). The intermediate ryegrass cultivars also established quickly and 'Froghair' (I) was not significantly different from the annual ryegrass cultivars in relation to establishment rates (Table 2). 'Transist' (I) also established quickly, but the establishment rate was slightly less than either 'Froghair' (I) or the annual cultivars. The perennial ryegrass cultivars were marginally slower to establish than the annual cultivars, similar to observations by Dudeck and Peacock (1980). However, all cultivars and species had

formed an acceptable turfgrass stand by 20 d after planting (DAP) (Table 2).

The effect of cultivar and species on turfgrass color and quality was very similar across rating dates, so the data were summarized for two evaluation dates. The perennial ryegrass cultivars exhibited better overall turf quality than either of the annual cultivars or the intermediate cultivar Froghair (I) and there were no significant differences between the perennial cultivars (Table 2). Within the intermediate cultivars, 'Transist' (I) had better color and quality than 'Froghair' (I). The annual ryegrass cultivars produced an inferior turf relative to the perennial cultivars or Transist (I). However, the annual cultivars performed similar to 'Froghair' (I).

Growth rates in the field tests were assessed by harvesting and weighing clipping samples on two dates in the spring. The annual and intermediate cultivars had significantly

higher clipping yields than the perennial cultivars on all dates (Table 2) except Apr. 1999, where 'Transist' (I) had similar clipping yields to the perennial cultivars, Racer (P) and Jiffie (P). These results from the annual ryegrass cultivars were similar to earlier findings (Schmidt and Shoulders, 1977). The excessive growth observed during the spring indicates that mowing requirements of annual or intermediate ryegrasses would be substantially higher than perennial ryegrass. This is an important observation, as many turfgrass managers consider annual or intermediate ryegrass as a low-cost alternative to perennial ryegrass, based primarily on the cost of the seed. However, based on this trial, mowing costs, as a result of increased equipment maintenance, fuel, and labor will be considerably higher for either the annual or intermediate cultivars compared to any of the perennial cultivars.

The transition from the overseeded, perennial ryegrass back to the base bermudagrass turf was a problem in the overseeding trial, as the perennial ryegrass cultivars had only reached ~50% to 60% transition on 15 June, even though active bermudagrass growth had initiated in the surrounding, non-overseeded plots (Table 3). Both of the intermediate ryegrass cultivars had significantly improved transition over the perennial cultivars, but 'Transist' (I) still had ~28% ryegrass remaining in the plot on 15 June, while 'Froghair' (I) was almost completely transitioned on that date. The annual ryegrass cultivars also transitioned very easily back to bermudagrass.

Fig. 1. Differential temperature between leaf and air, as measured by an infrared thermometer, for seven ryegrass cultivars grown in a growth chamber under increasing air temperatures. The temperature of the growth chamber was increased by 1 °C every 2 d. Vertical bars represent a significant difference between cultivars at each temperature, as determined by least significant difference ($P = 0.05$).

In the growth chamber study (Fig. 1), the perennial grasses had a slightly higher canopy temperature under low or moderate air temperatures, presumably due to the darker overall genetic color of the perennial ryegrasses (Table 2). However, as the temperature of the growth chamber was raised to about 38 °C, the annual ryegrass cultivars started to show severe signs of physiological heat stress. Relative to the perennial ryegrasses, canopy temperatures of the annual cultivars increased significantly as temperatures exceeded 40 °C, while the perennial cultivars were able to maintain transpiration and moderate canopy temperature. The intermediate cultivar Transist (I) had intermediate heat tolerance between the annual and perennial, while 'Froghair' (I) responded to the increased air temperature similar to the annual cultivars.

The differential morphological and physiological characteristics between 'Froghair' (I) and 'Transist' (I) would suggest that, while both cultivars are intermediate species, 'Froghair' (I) performs more like the annual parent, while 'Transist' (I) behaves much more like a true intermediate. Results from the field trials also suggest that 'Transist' (I) had much better overall turf quality than 'Froghair' (I). Although

these initial observations suggest that certain intermediate ryegrass cultivars have desirable turf characteristics, long-term evaluations of these species under various field conditions are needed to fully assess the value of intermediate ryegrass to southern turf managers.

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