Rhizomatous tall fescue and regenerative perennial ryegrass performance in Ontario (2011-2014)

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Background

With the passing of the Cosmetic Pesticides Ban, management of turf pests and weeds has been challenging. Many of the pests that either attack or infest turf are more difficult to control using a one product – one pest approach. We must really integrate all of our tools, including cultural practices, turf species selection and bio-pesticides for success. In addition, there has been increasing pressure on water supplies, necessitating watering restrictions or bans in many municipalities. Pest tolerant grass species that are also drought tolerant would be a valuable tool for turf managers in Ontario.

With that in mind, a trial was established to investigate the potential use of novel grass species that may be drought tolerant, but may also be able to resist weed invasion and be less susceptible to insect feeding. Rhizomatous tall fescue (RTF) and regenerative perennial ryegrass (RPR) have recently been introduced into the market place in Ontario. Rhizomatous tall fescue is purported to grow better in summer and late fall than tall fescues that are currently on the market. RTF has endophytes that are different from other tall fescues currently on the market. They require less water because of their deep roots and have rhizomes which should give them the ability to fill in on their own if the turf stand thins due to wear, pest damage or other stress (Wipff, J.K, 2012).

RPR is a subspecies of perennial ryegrass that produces stolons. It is also referred to as stoloniferous perennial ryegrass. Until now, the cultivars of perennial ryegrass that have been marketed in Ontario have been bunch types. In addition to having stolons, RPR was selected under intense traffic stress for its ability to survive traffic and recover. RPR also contains endophytes.

A trial was established in fall 2011 at the Guelph Turfgrass Institute (GTI) to evaluate drought tolerance and weed invasion of RTF, RPR compared to a standard home lawn mix (HLM) (50% Kentucky bluegrass, 20% perennial ryegrass and 30% fine fescue) under two irrigation regimes (irrigated vs. non-irrigated).

The summer of 2012 was very dry, which provided ideal conditions for an experiment to evaluate the drought tolerance and recovery of these new turfgrasses in irrigated vs. non-irrigated plots. Although the drought stress was imposed on immature stands of the turfgrass species and may not reflect the performance of mature stands, it did allow us to provide a first evaluation of these characteristics in what may be a common scenario in areas undergoing renovation. During the 2013/2014 winter, all the plots at the GTI were covered with a thick layer of ice (>5 cm) for more than 100 days with colder than average temperatures. This provided the opportunity to further evaluate RTF and RPR for winter-hardiness and to assess their ability to recover from winter injury.

Materials and Methods

Establishment, treatments and maintenance

A plot area was worked and prepared for seeding at the GTI. The experimental plots were arranged in a two by three factorial design (two irrigation regimes and three species/mixtures) with 4 replications of each treatment. Plots measured 2 m x 2 m (4 m^2) and were seeded on Sept. 21, 2011 using a hand held shaker. Treatments and seeding rates are as indicated in Table 1.

Table 1. Treatments and seeding rates

Treatment Number	Turf species/mixture	Irrigation regime	Seeding rate
1	Rhizomatous tall fescue (RTF)	Irrigated	2.5 kg/100 m^2
2	Rhizomatous tall fescue (RTF)	Non-irrigated	2.5 kg/100 m^2
3	Regenerative perennial ryegrass (RPR)	Irrigated	3.0 kg/100m
4	Regenerative perennial ryegrass (RPR)	Non-irrigated	3.0 kg/100m^2
5	Home lawn mix[1] (HLM)	Irrigated	2.0 kg/100m^2
6	Home lawn mix (HLM)	Non-irrigated	2.0 kg/100m^2

[1] HLM = 50% Kentucky bluegrass, 20% perennial ryegrass and 30% fine fescue

All plots were mowed on a weekly basis (beginning in May 2012) at a height of 5 cm and were fertilized three times a season in 2012, 2013 and 2014: on May 25, Aug. 10 and Sept. 14, 2012; June 7, Aug. 15 and Sept. 15th, 2013; and June 9, Aug. 7, Sept. 16, 2014, with a 25-5-10 fertilizer applied at a rate of 0.5kg of N/100m^2. No other cultural practices were performed.

Irrigation

Irrigated plots were individually watered to supply 25mm of water once in a one week period during June, July and the first two weeks of August using a hose-end sprinkler. A flow meter was used to ensure that a precise volume of water was delivered to each plot (Figure 1). If rainfall was equal to 25mm of water, no irrigation was applied. If rainfall was between 0 and 25mm of water, irrigation was applied to bring the total water applied up to 25mm for the one week period. Non-irrigated plots received rainfall only.

Figures 2, 3 and 4 show the amount of rainfall and irrigation applied per week to the irrigated plots in 2012, 2013 and 2014. The blue bars represent the amount of rainfall that the non-irrigated plots received per month. On July 18th 2012, all irrigated and non-irrigated plots received 25mm of irrigation. This was done because there was a fear that all of the non-irrigated plots would die due to lack of water.

In 2013 there was one irrigation event and in 2014 there was sufficient rainfall that none of the plots received supplemental irrigation.

Figure 1. Application method for irrigating individual plots with a flow meter and hose end sprinkler

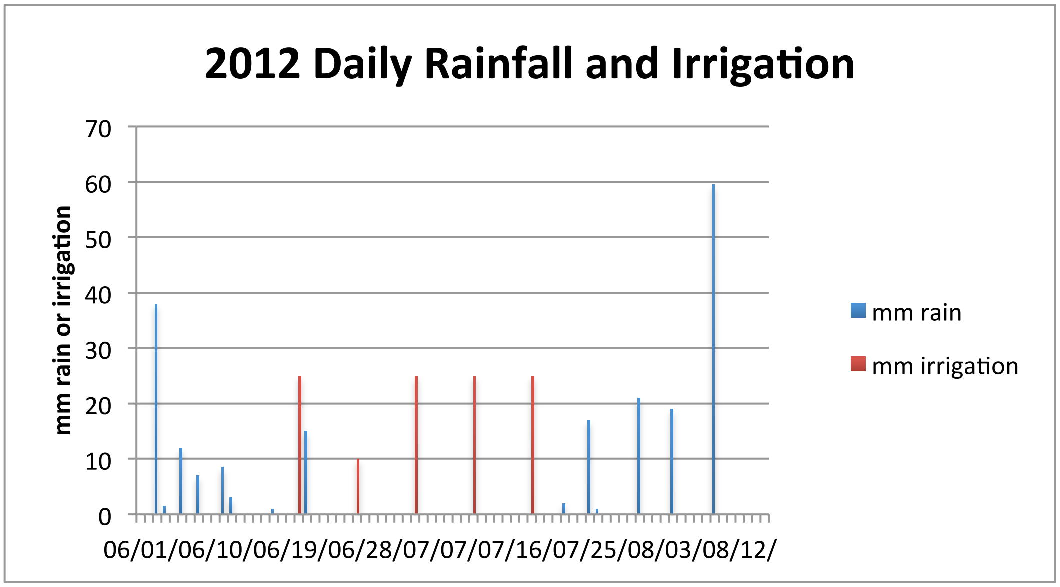


Figure 2. Millimetres of rain and irrigation for June to mid-Aug. 2012

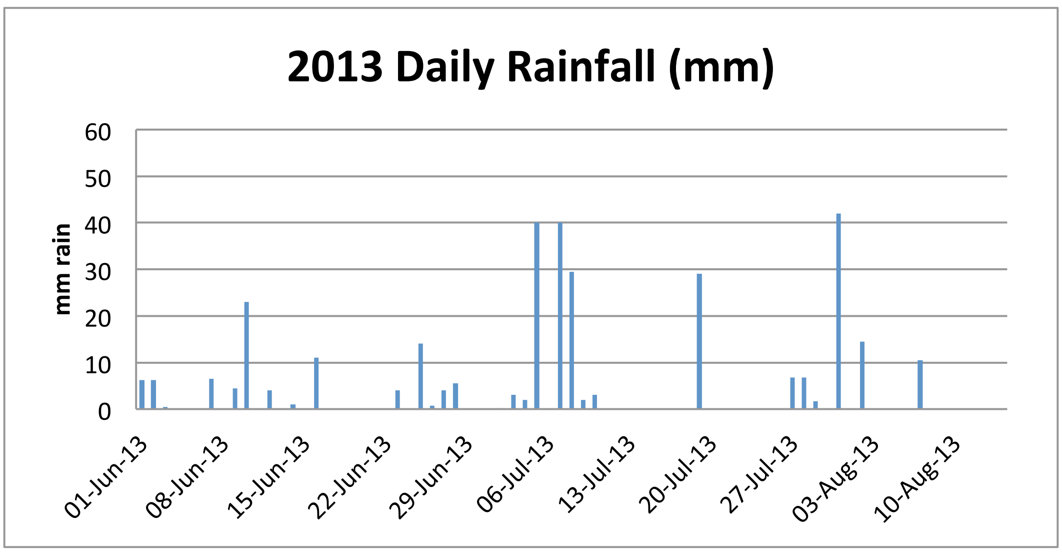


Figure 3. Millimetres of rainfall June to mid-Aug. 2013

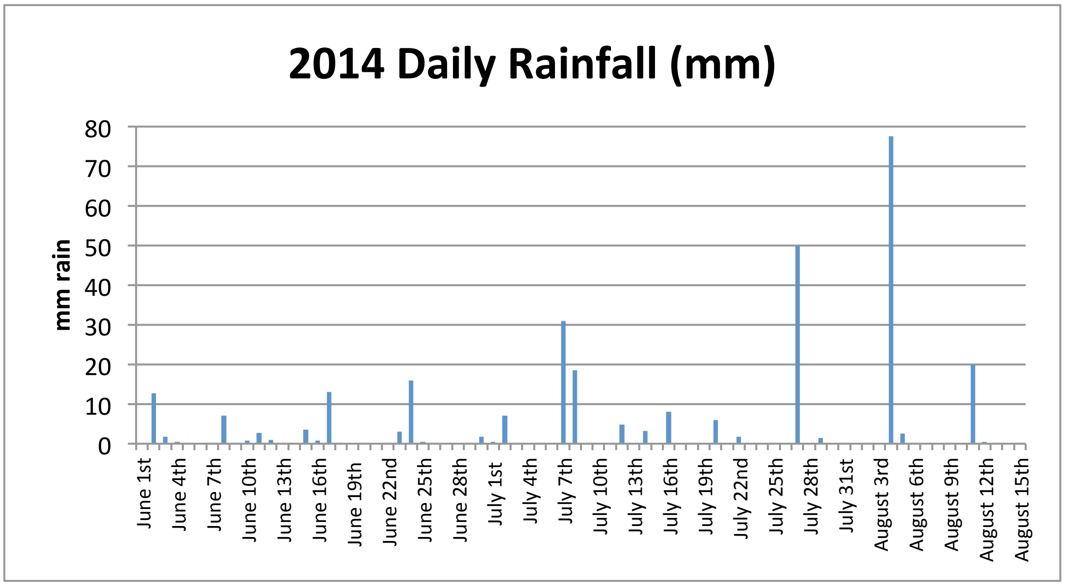


Figure 4. Millimetres of rain and irrigation for June to mid-Aug. 2014

Species composition and weed invasion

Percent cover of each grass species [tall fescue (TF), perennial ryegrass (PR), Kentucky bluegrass (KB) and fine fescue (FF)], broadleaf weeds (BLW), annual bluegrass (AB) and bare areas (bare) was recorded on five dates in 2013 (June 8, Aug. 4, Aug. 23 and Oct. 18), four dates in 2013 (May 31, June 26, Aug. 8 and Oct. 11) and three dates in 2014 (May 22, July 3 and Oct. 16). Four randomized point quadrats measuring 60 cm x 60 cm with 25 points in each quadrat (points 10 cm apart) (Figure 5) for a total of 100 points in each plot were used to determine percent species cover of each of the turfgrass species, broadleaf weeds and bare at each assessment date. A new category (dead/brown) was added on Aug. 4 and 23rd, 2012 assessment dates. The broadleaf weeds found in the plots during the 2012 season were mainly annuals (i.e. black medick, whitlow grass, thyme-leaved sandwort, speedwell, purslane, chickweed, shepherd's purse, henbit, goldenrod and pineapple weed). Dandelions were also found in the plots but were one of the few perennial broadleaf weeds. The following years (2013 and 2014) the main species of broadleaf weeds was dandelion. All data were analysed using appropriate statistical methods.

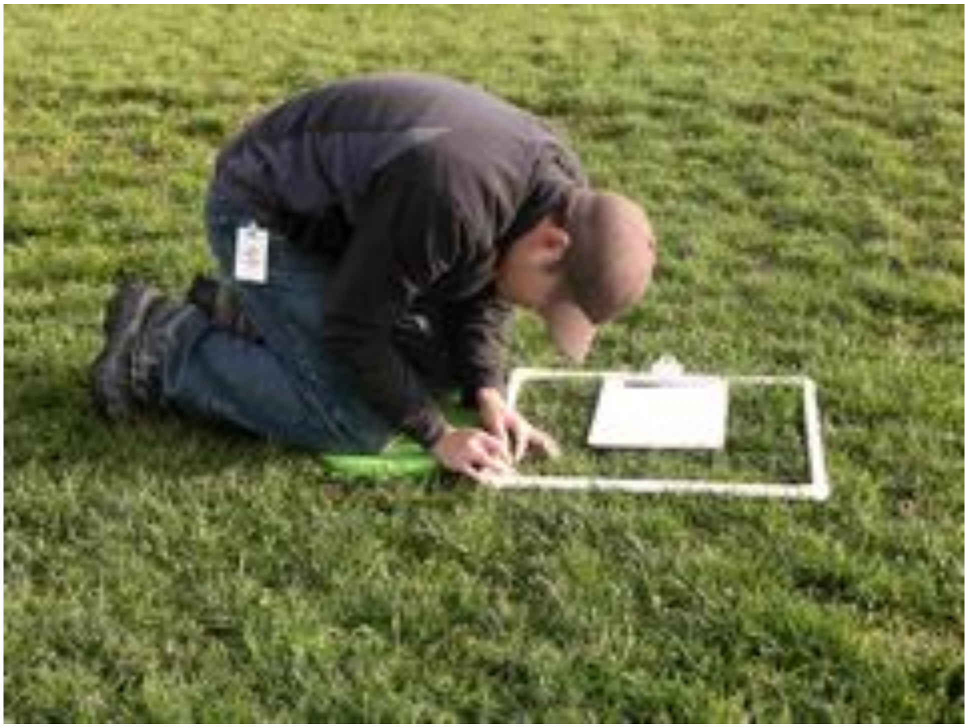


Figure 5. Point quadrat used to estimate percent species cover in plots.

Results

Percent cover of weeds, grass species and bare and dead/brown is presented in Table 2. Only data collected after the irrigation treatments began is presented in Table 2 for 2012. For 2013 and 2014 the initial spring data and the final fall data are presented.

Table 2. Percent cover of weeds, grass species and bare and dead/brown for 2012, 2013 and 2014

Treatment	Broadleaf weeds (BLW)						
	08/04/12	08/23/12	10/18/12	06/21/13	10/11/13	05/22/14	10/16/14
Non-irrigated RTF	30.25 b[1]	74.25 a	46.25 a	34.25 a	NS	4.75 a	7.25 b
Irrigated RTF	64.25 a	41.00 b	27.00 b	13.75 b	NS	2.25 ab	14.50 b
Non-irrigated HLM	7.75 c	69.50 a	16.50 bc	12.25 bc	NS	3.50 ab	0.75 b
Irrigated HLM	31.25 b	26.00 c	15.75 bc	4.50 bc	NS	0.00 b	1.25 b
Non-irrigated RPR	4.75 c	49.75 b	11.75 c	4.25 c	NS	3.75 ab	17.75 b
Irrigated RPR	31.00 b	24.25 c	9.25 c	8.00 bc	NS	3.25 ab	35.50 a

Treatment	Perennial ryegrass (PR)						
	08/04/12	08/23/12	10/18/12	06/21/13	10/11/13	05/22/14	10/16/14
Non-irrigated RTF	3.25 c	4.25 c	3.50 d	0.75 d	9.00 e	7.50 b	2.50 b
Irrigated RTF	12.00 bc	5.00 c	2.50 d	2.50 d	2.25 e	2.50 b	0.75 b
Non-irrigated HLM	2.75 c	7.50 c	20.50 c	23.75 c	24.25 d	3.00 b	0.50 b

Irrigated HLM	26.25 ab	26.50 b	32.75 c	31.50 c	37.25 c	5.00 b	2.00 b
Non-irrigated RPR	1 5.00 bc	27.50 b	52.00 b	68.25 b	82.50 b	47.25 a	46.25 a
Irrigated RPR	32.00 a	68.00 a	88.75 a	88.25 a	95.50 a	16.00 b	31.50 a

Treatment	**Tall fescue (TF)**						
	08/04/12	08/23/12	10/18/12	06/21/13	10/11/13	05/22/14	10/16/14
Non-irrigated RTF	2.75 b	8.50 b	19.00 b	29.25 b	51.25 b	26.00 b	30.50 b
Irrigated RTF	15.75 a	36.75 a	68.25 a	73.25 a	90.75 a	52.25 a	65.25 a
Non-irrigated HLM	0.00 b	3.75 b	0.25 c	0.00 c	0.00 c	0.25 c	0.00 c
Irrigated HLM	0.25 b	5.00 b	0.25 c	0.00 c	0.00 c	0.25 c	0.00 c
Non-irrigated RPR	0.00 b	4.25 b	0.00 c	0.00 c	0.00 c	1.25 c	0.25 c
Irrigated RPR	0.50 b	1.25 b	0.00 c	1.00 c	0.00 c	0.75 c	1.50 c

Treatment	**Fine fescue (FF)**						
	08/04/12	08/23/12	10/18/12	06/21/13	10/11/13	05/22/14	10/16/14
Non-irrigated RTF	0.00 b	7.50 ab	0.50 c	1.00 c	3.75 c	7.75 b	9.50 b
Irrigated RTF	0.00 b	5.00 ab	0.25 c	1.00 c	0.50 c	3.50 b	3.25 b
Non-irrigated HLM	6.50 b	0.50 b	20.50 b	24.00 b	50.50 a	73.75 a	80.00 a
Irrigated HLM	13.75 a	11.25 a	39.75 a	48.75 a	30.00 b	68.00 a	78.00 a
Non-irrigated RPR	0.00 b	0.25 b	0.50 c	0.75 c	0.00 c	0.75 b	0.75 b
Irrigated RPR	0.75 b	0.75 b	0.00 c	0.00 c	0.00 c	0.75 b	2.00 b

Treatment	**Kentucky bluegrass (KB)**						
	08/04/12	08/23/12	10/18/12	06/21/13	10/11/13	05/22/14	10/16/14
Non-irrigated RTF	1.25 b	1.50 b	3.00 b	3.50 ab	4.75 c	20.50 a	41.25 a
Irrigated RTF	0.75 b	5.75 b	0.00 b	2.75 ab	0.75 c	3.75 b	10.75 b
Non-irrigated HLM	3.25 b	7.25 b	0.50 b	3.25 ab	12. 50 b	7.25 b	16.50 b
Irrigated HLM	20.25 a	28.50 a	11.50 a	8.75 a	28.25 a	23.25 a	19.25 b
Non-irrigated RPR	2.50 b	1.50 b	4.50 ab	0.00 b	1.25 c	1.25 b	16.00 b
Irrigated RPR	23.00 a	2.75 b	0.00 b	0.00 b	0.00 c	1.75 b	15.50 b

Treatment	**Annual bluegrass (AB)**						
	08/04/12	08/23/12	10/18/12	06/21/13	10/11/13	05/22/14	10/1614
Non-irrigated RTF	NS	NS	NS	20.25 a	20.75 a	19.75 a	7.75 ab
Irrigated RTF	NS	NS	NS	0.50 b	2.75 b	9.00 bc	5.50 ab
Non-irrigated HLM	NS	NS	NS	16.25 a	6.75 b	9.00 bc	1.75 b
Irrigated HLM	NS	NS	NS	0.50 b	0.25 b	3.25 c	0.00 b
Non-irrigated RPR	NS	NS	NS	3.75 b	3.75 b	18.25 ab	12.25 a
Irrigated RPR	NS	NS	NS	0.00 b	0.00 b	5.50 c	10.75 a

Treatment	Dead/Brown						
	08/04/12	08/23/12	10/18/12	06/21/13	10/11/13	05/22/14	10/16/14
Non-irrigated RTF	44.00 b	4.25 bc	NS	NS	NS	10.75 bc	NS
Irrigated RTF	4.50 c	4.50 bc	NS	NS	NS	26.25 b	NS
Non-irrigated HLM	69.50 a	8.75 ab	NS	NS	NS	1.75 c	NS
Irrigated HLM	1.75 c	0.75 c	NS	NS	NS	0.25 c	NS
Non-irrigated RPR	69.00 a	14.75 a	NS	NS	NS	20.75 b	NS
Irrigated RPR	4.00 c	2.75 bc	NS	NS	NS	70.25 a	NS

Treatment	Bare						
	08/04/12	08/23/12	10/18/12	06/21/13	10/11/13	05/22/14	10/16/14
Non-irrigated RTF	18.50 a	4.25 a	22.00 b	10.50 b	3.00 b	3.00 ab	0.25 b
Irrigated RTF	2.75 c	4.50 a	2.00 c	6.25 bc	0.50 b	0.50 b	0.00 b
Non-irrigated HLM	10.25 b	8.75 a	37.50 a	17.25 a	2.50 b	1.50 b	0.00 b
Irrigated HLM	5.50 bc	0.75 a	0.00 c	5.75 bc	0.00 b	0.00 b	0.00 b
Non-irrigated RPR	8.75 bc	4.50 a	29.25 ab	21.25 a	10.50 a	6.75 a	5.50 a
Irrigated RPR	8.75 bc	2.75 a	2.00 c	2.75 c	0.25 b	1.75 b	3.00 a

[1] Percent cover area estimated by point quadrat counts. 100 points per plot x 4 replicates. Means within columns followed by the same letter are not significantly different (Tukey's HSD, p=0.05).

Establishment and weed invasion 2012

The species composition in the plots prior to the irrigation treatments is shown in Figure 6 and reflects how quickly each of the species established and how well they crowded out broadleaf weeds. The main interest was the percent BLW cover and the percent bare. At this stage of the experiment, RPR and HLM provided good cover with very little bare area and were not significantly different from each other (11.75 and 13.625 % bare respectively), while RTF had significantly more bare area (18.5%). Also, the three species/mixture treatments differed significantly from each other for BLW invasion with RTF having the most BLW (47.75%), HLM having moderate weed invasion (31.25%) and the RPR having the least (23%).

These results show that RTF is slower to emerge and fill in than the RPR and HLM and that resulted in more BLW and more bare area with this slow to establish species. The RPR is very rapid to emerge and fill in and the perennial ryegrass in the HLM acted as a nurse grass and provided quick establishment that helped to out-compete weeds and fill in the bare areas.

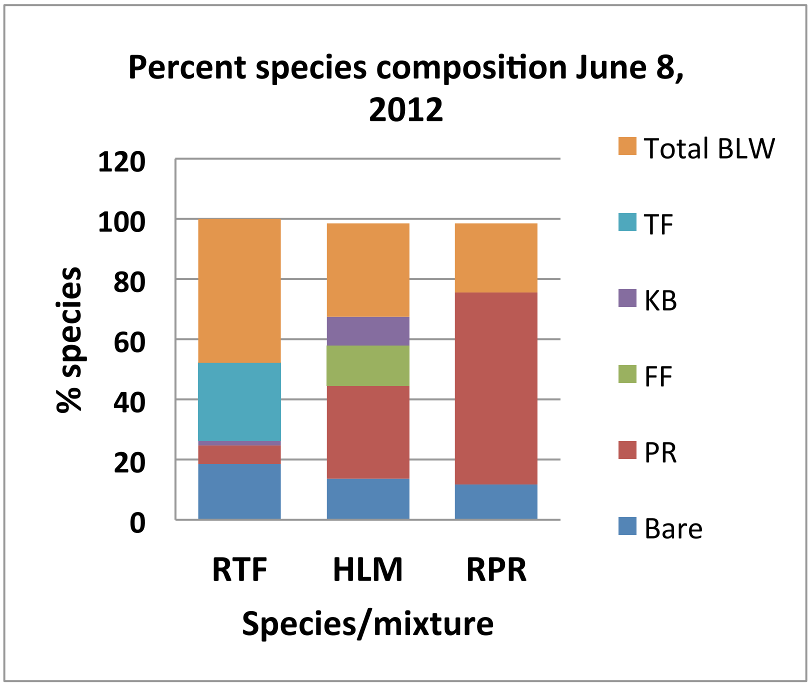


Figure 6. Percent species composition on June 8, 2012

Irrigation effect on species composition 2012

The species composition after six weeks of irrigation vs. non-irrigation treatment on the two turfgrass species and one mixture is shown in Figure 7. The main differences were in the percent bare, dead/brown and total BLW. At this point in the season only the non-irrigated RTF had significantly greater percent bare area than all of the other treatments (18.5%). The non-irrigated HLM and RPR had the highest percentage of dead/brown (69.5 and 69% respectively) which was significantly higher than the non-irrigated RTF (44%). The non-irrigated RTF had significantly less dead/brown than all of the other non-irrigated species/mixture treatments. Surprisingly, the irrigated RTF had significantly more BLW (64.25%) than any of the other treatments. The incidence of BLW in the irrigated HLM, irrigated RPR and non-irrigated RTF plots did not differ significantly from each other (31.25, 31 and 30.25% respectively). The non-irrigated HLM and RPR had very few BLW.

When plots that contained a high percent of bare ground were irrigated, they were invaded by annual broadleaf weeds. Fewer annual weeds were recorded in the non-irrigated plots because there was insufficient soil moisture during the drought for weed seed germination. In addition, the non-irrigated RTF had fewer dead/brown plants showing that it is superior at maintaining live non-dormant plants during prolonged periods without water.

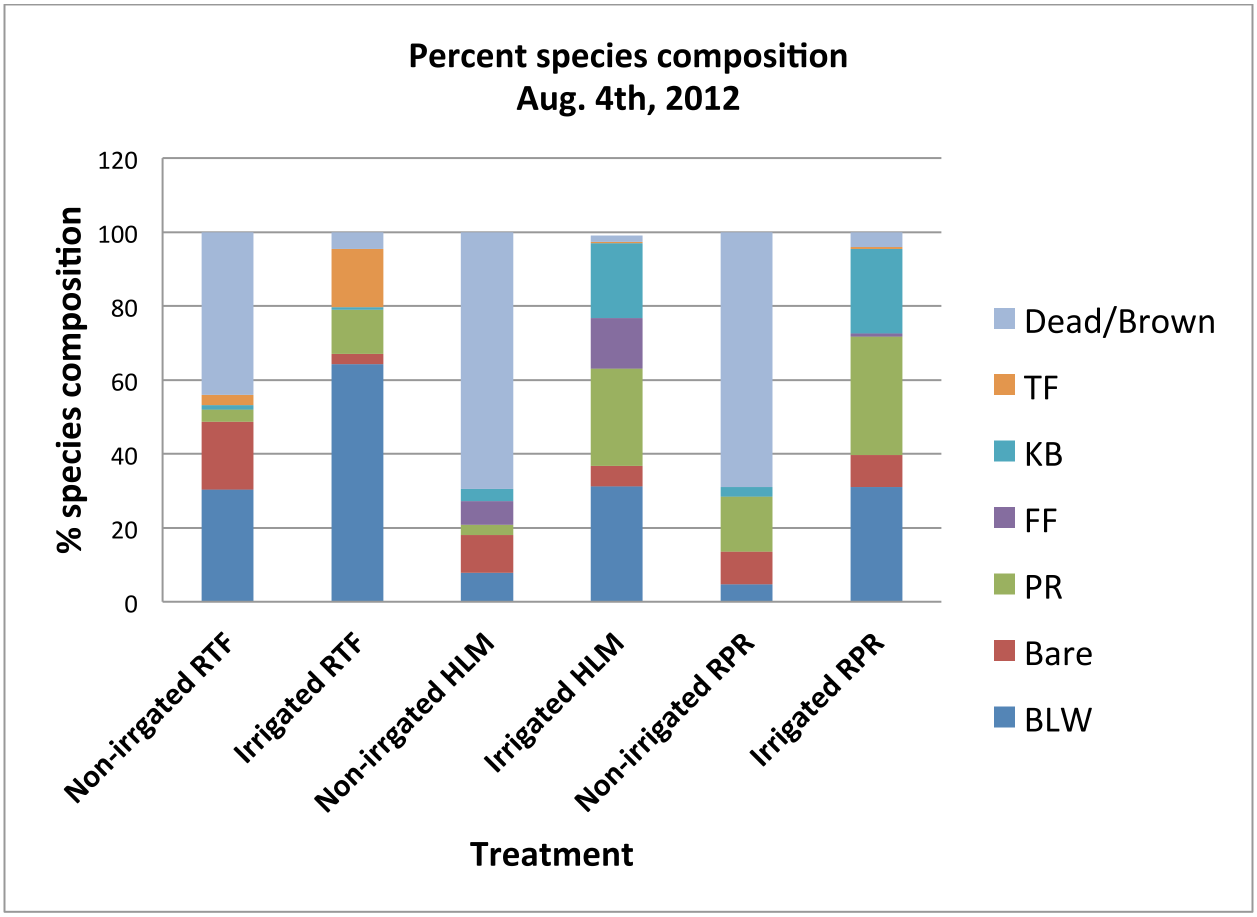


Figure 7. Percent species composition Aug. 4, 2012

Figure 8 provides an indication of the ability of the non-irrigated turf species/mixture treatments to recover from drought and for the irrigated turf species/mixture treatments to recover from broadleaf weed invasion. The percent dead/brown decreased from Aug. 4 to Aug. 23, 2012 in all of the non-irrigated plots. The non-irrigated RPR had significantly more dead/brown plants (14.75%) than the irrigated RTF, non-irrigated RTF and the irrigated RPR (4.5, 4.25 and 2.75% respectively) on Aug 23. Overall there was very good recovery of the dead/brown turf in most of the non-irrigated treatments, with the non-irrigated RPR taking slightly longer to recover.

Regarding the total BLW cover, the non-irrigated RTF and HLM had significantly more broadleaf weeds than any of the other treatments (74.25 and 69.5% respectively). The non-irrigated RPR and the irrigated RTF had the same amount of broadleaf weed cover (49.75 and 41% respectively) and the treatments with the fewest broadleaf weeds were the irrigated HLM and RPR (26 and 24.25% respectively).

With the onset of timely rains during August 2012, the bare areas in the non-irrigated plots were quickly populated by weeds as indicated by the total BLW cover in the non-irrigated RTR, HLM and RPR. Because the irrigated RTF also had a high percentage of bare areas, it also was invaded by broadleaf weeds at this time.

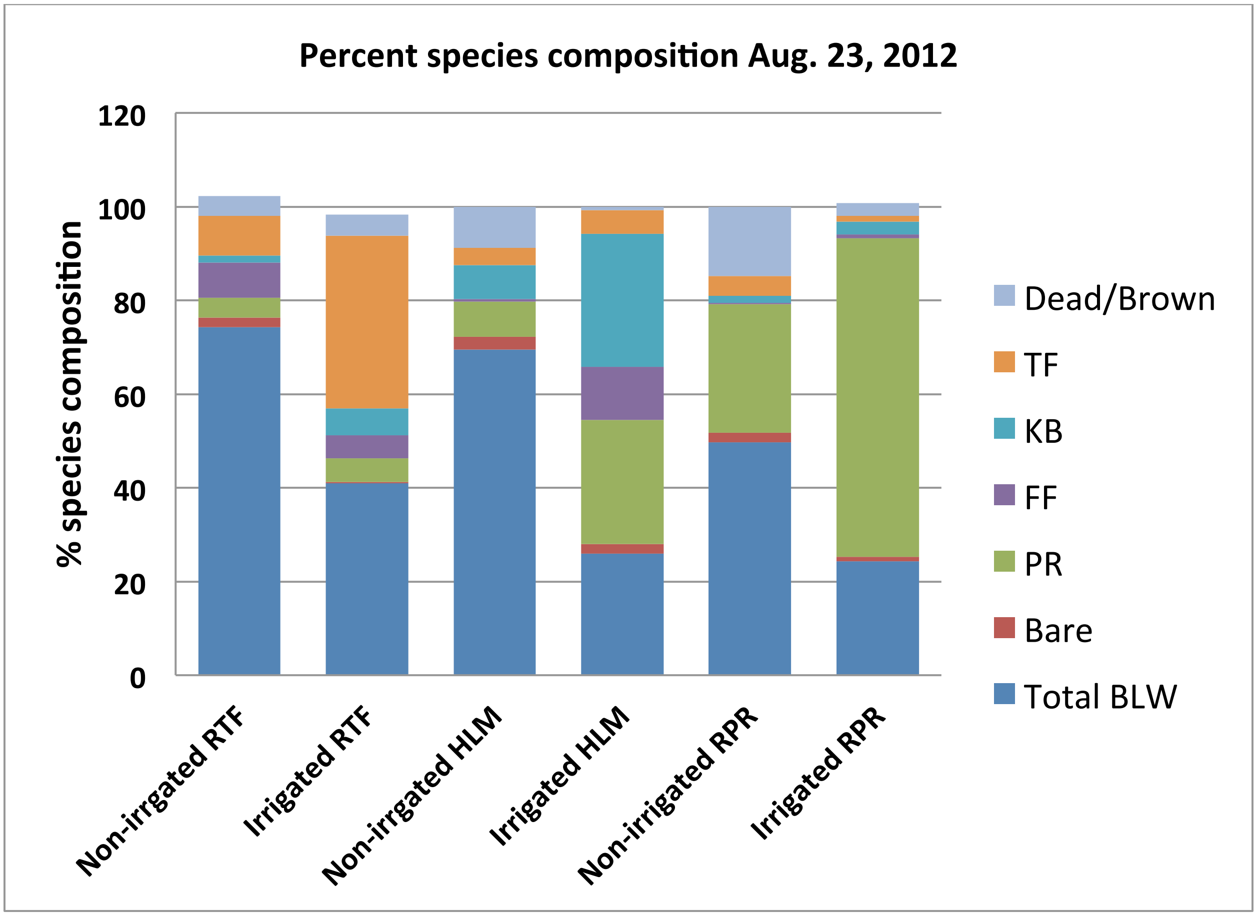


Figure 8. Percent species composition Aug. 23, 2012.

Figure 9 shows the percent species composition of the treated plots at the end of the first treatment year (Oct. 18, 2012). Non-irrigated RTF had the most BLW of all of the treatments (46.25%). The percent bare areas in the non-irrigated treatments increased from the Aug. 23rd, 2012 to Oct. 18th, 2012 because many of the broadleaf weeds were annual weeds that died off after the first frost leaving bare areas. These bare areas could also be a result of some of the plants categorized as dead/brown actually being dead.

Another observation at the end of the season was the species composition of the irrigated and non-irrigated HLM. The non-irrigated HLM had almost no Kentucky bluegrass plants in it (<1%) whereas the irrigated HLM had 11.5%, in spite of it comprising 50% of the seed mixture at seeding. There was significantly more FF in the irrigated HLM, so even though it is supposed to be more drought tolerant than KB or PR it might take at least one full growing season for it to establish deep roots to exhibit superior drought tolerance.

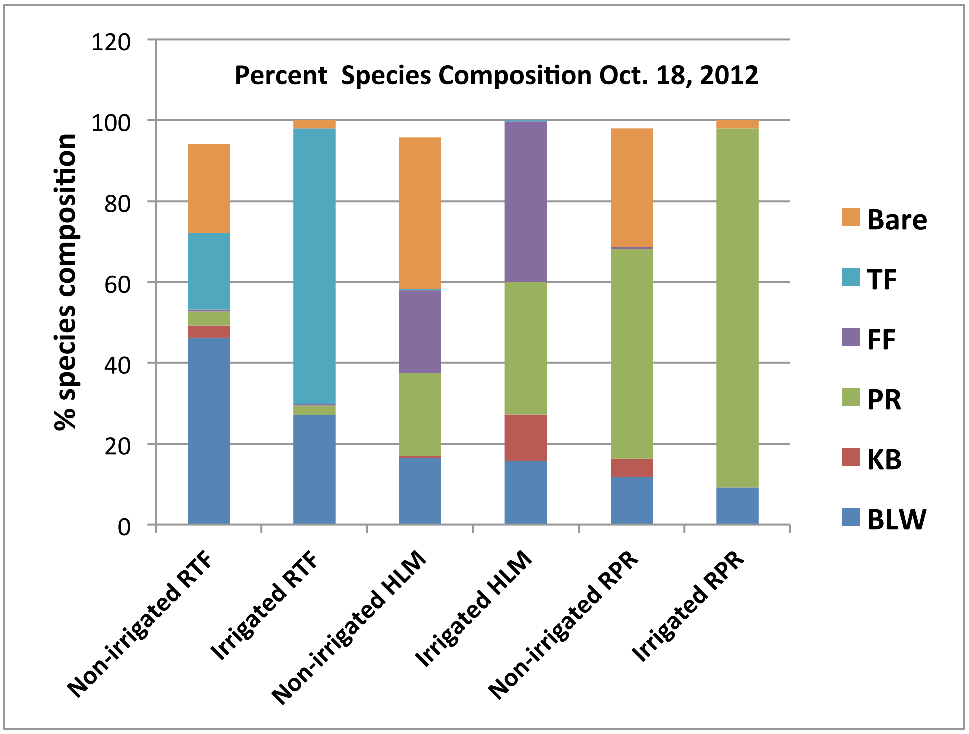


Figure 9. Percent species composition Oct. 18, 2012.

Species composition 2013

It should be noted that during the 2013 growing season there was only one irrigation treatment because there was at least 2.5 mm of rain during most weeks (Figure 3). The data presented below (Figure 10 and 11) reflects the residual effects of the 2012 irrigation treatments and the ability of the different turfgrass species/mixture to recuperate after the drought and their ability to out-compete broadleaf weeds during a growing season with adequate rainfall.

By the spring, the non-irrigated RTF had 29.25% TF, 34.25% BLW and 20.25% AB in the plots (Figure 10). By the end of the season (Figure 11), this had increased to 51.25% TF and there was no difference in BLW incidence among all of the treatments. The non-irrigated RTF was invaded by annual bluegrass (20.75%) to a level that was significantly higher than the other treatments.

The incidence of PR in the non-irrigated RPR plots went from 68.25% (Figure 10) in the spring to 82.50% (Figure 11) in the fall, and in the irrigated RPR plots, PR rose from 88.25 to 95.50%.

There were no differences in the incidence of BLW in non-irrigated and irrigated HLM by the spring of 2013. Similarly, differences in the PR component of the non-irrigated and irrigated HLM plots were not significant by the spring of 2013 (23.75 and 31.50%, respectively) or in the fall of 2013 (24.25 and 37.25%, respectively). The FF cover in the non-irrigated and irrigated HLM differed significantly in the spring 2013 (24.00 and 48.75%, respectively) and in the fall 2013 (50.50 and 30.00%). The FF cover of the non-irrigated HLM increased from spring to fall 2013 (24.00 to 50.50%) and the FF cover of the irrigated HLM decreased from spring to fall 2013 (48.75 to 30.00%). KB comprised a very small percent of the cover in the non-irrigated and irrigated HLM in the spring species counts (3.25 and 8.75%, respectively); this increased to 12.50 and 28.25%, respectively, by the end of the growing season in 2013.

By spring 2013 the non-irrigated RTF and HLM has a significant invasion of annual bluegrass which persisted in the RTF but not in the HLM for the fall 2013 species counts. By fall, only the non-irrigated RTF plots contained a significant amount of annual bluegrass. The non-irrigated HLM and RPR had significantly more bare areas in the spring of 2013 than the other species/mixture treatments.

By the end of the 2013 growing season, the TF content of the non-irrigated RTF plots was still significantly lower than in the irrigated RTF plots. The PR content of the non-irrigated RPR plots was significantly lower than in the irrigated RPR, and KB was significantly higher in the irrigated HLM plots.

The TF content in the non-irrigated RTF plots increased during the 2013 growing season (from 29.25 to 51.25%). The PR in the non-irrigated RPR plots increased from 68.25 to 82.50%, demonstrating the capacity that both species have to spread.

As would be expected, the KB content in the non-irrigated and irrigated HLM plots increased through 2013, when growing conditions were ideal for this turf grass.

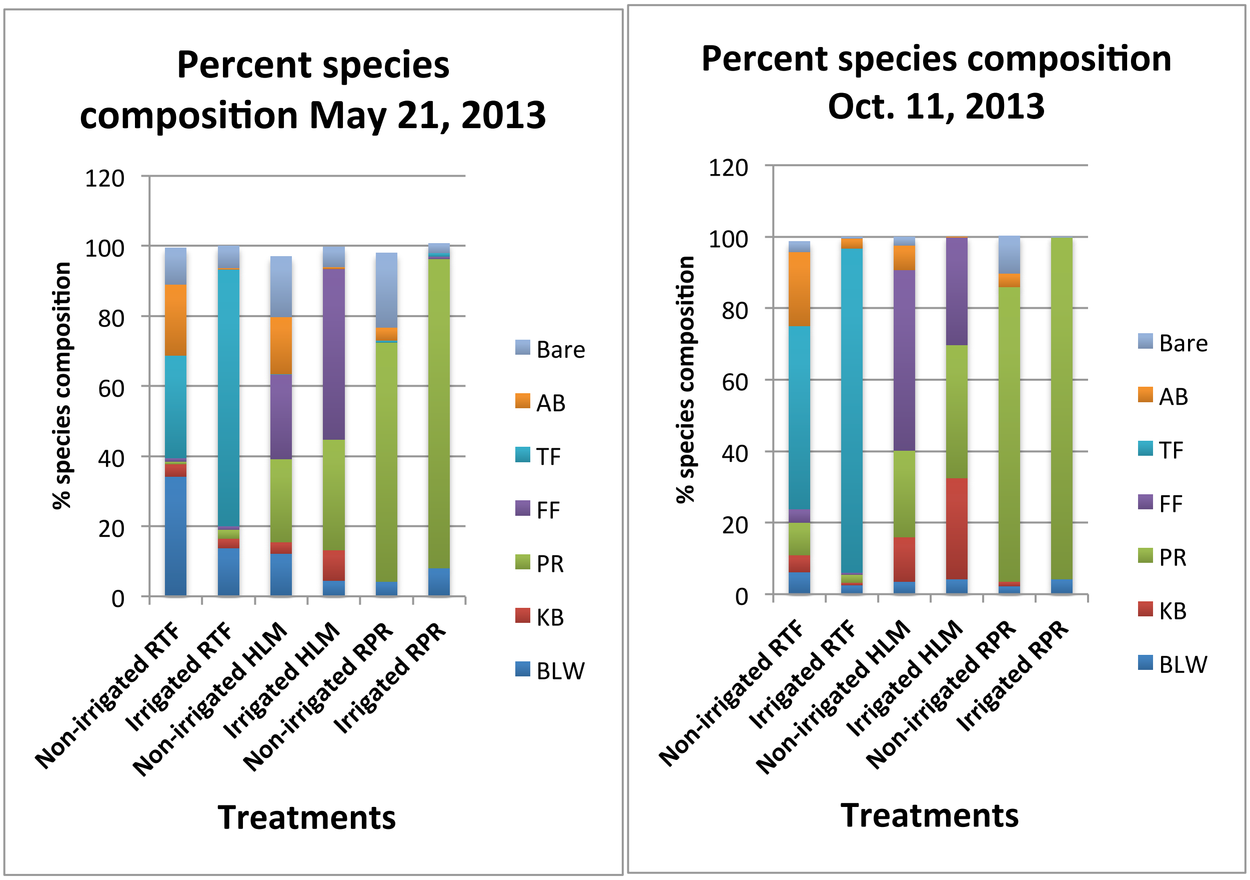


Figure 10. Percent species composition May 21 and Oct. 11, 2013

Species composition 2014

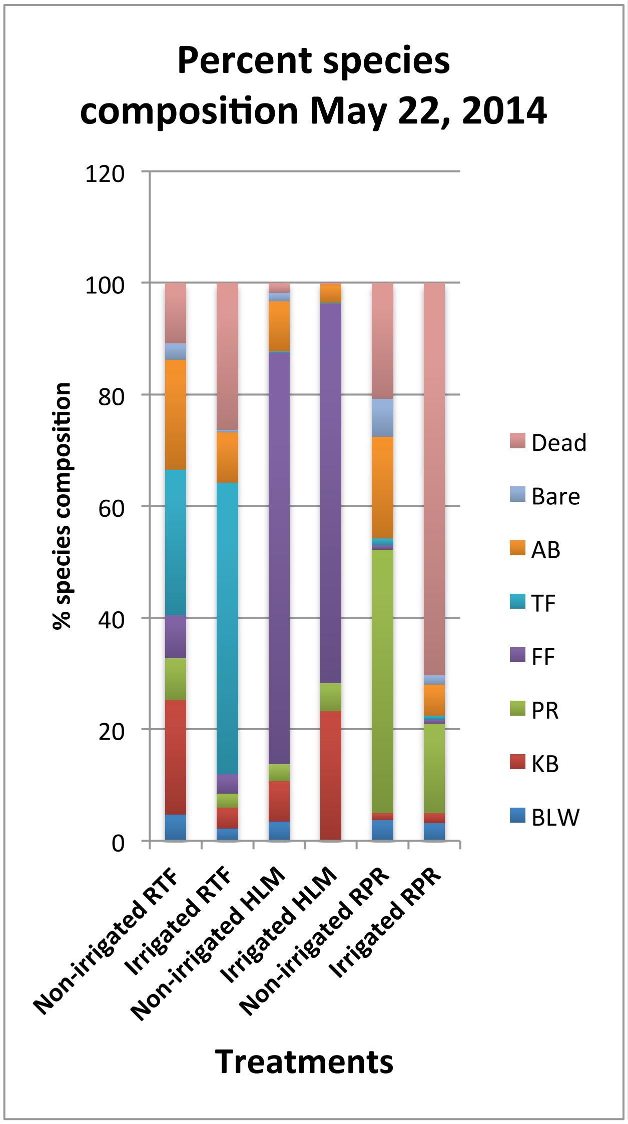
During the winter of 2013/2014, the plots in this trial were covered in a thick layer of ice and were exposed to very low temperatures. Once the turf greened up in the spring 2014, it was obvious that there was turf loss due to winter injury. As expected the species that suffered the most winter injury was RPR followed by RTF. There was a significant difference in the winter damage observed in the non-irrigated and irrigated RPR plots in the spring of 2014. There was only 20.75% dead turf in the non-irrigated RPR plots, whereas the irrigated RPR plots showed significantly higher levels of dead turf than all of the other species/mixtures (70.35%). The non-irrigated RTF and irrigated RTF did not differ significantly for winter die-back in spring 2014 (10.75 and 26.25%, respectively).

Other signs of winter injury were shown by the decline in TF and PR in the RTF, RPR and HLM plots from the fall of 2013 to the spring of 2014. The percent TF in the non-irrigated RTF decreased from 51.25 to 26.00%, and from 90.75% to 52.25% in the irrigated RTF plots. The percent PR in the non-irrigated RPR plots fell from 82.50 to 47.25%, and from 95.50 to 16% in the irrigated RPR plots.

A similar trend was observed in the HLM plots. The percent PR in the non-irrigated HLM plots fell from 24.25 to 3.00 %, and from 37.25 to 5.00% PR in the irrigated HLM plots. As with the RPR plots, the greatest loss of PR due to winter injury was in the HLM and RPR plots that were irrigated in 2012.

From spring to fall 2014, the percent TF in the non-irrigated RTF plots increased slightly (25% to 30.50%) and the same was true for the irrigated RTF plots (52.25% to 65.25%). The PR cover in the non-irrigated RPR plots decreased from spring to fall 2014, though, while the levels increased from 16.00 to 31.50% in the irrigated RPR plots.

By the end of the trial in fall 2014, the irrigated RPR plots contained significantly more BLW than all of the other species/mixture treatments (35.50%). Very little PR remained in both the non-irrigated and irrigated HLM plots. The FF component was effectively the same in both the non-irrigated and irrigated HLM plots (80.00 and 78.00%). The percent KB cover did not differ significantly between the non-irrigated and irrigated HLM plots (16.50 and 19.25%, respectively).



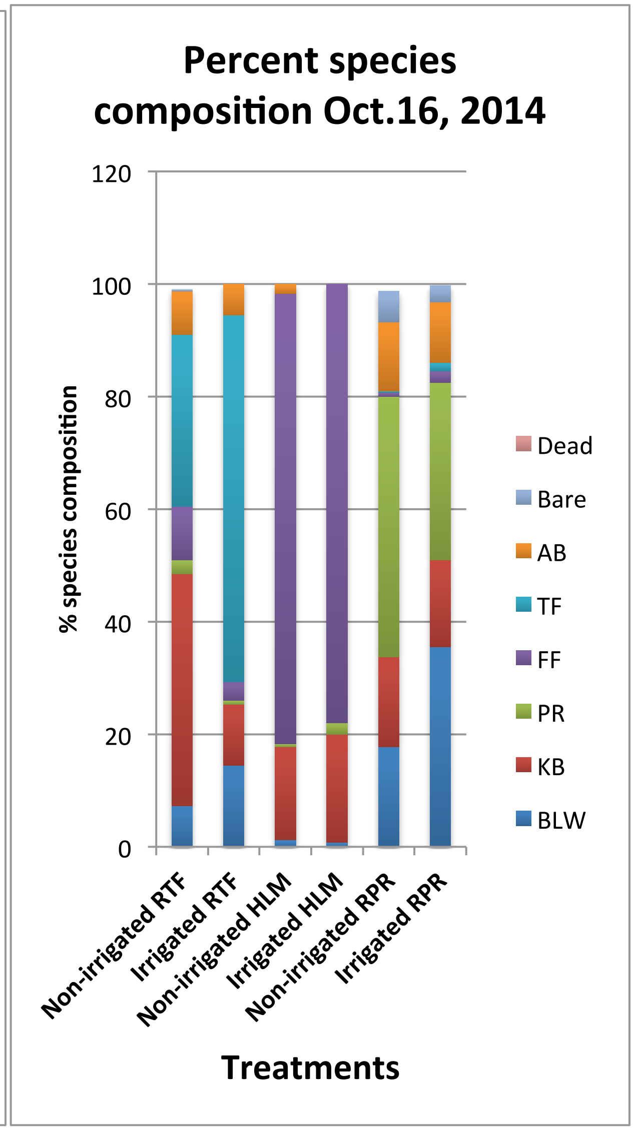


Figure 12. Percent species composition May 22 and Oct. 14, 2014.

Conclusions

The climatic conditions during this study allowed the drought tolerance and recovery of two novel grass species (RTF and RPR) to be compared to a standard HLM under a non-irrigated and irrigated regime during the summer of 2012. Although this was imposed on non-mature turf plots that had been seeded in the fall 2011, this is not atypical of current seeding practices and the weather conditions that newly seeded areas would (potentially) experience in any given year after sowing. The turf loss in the non-irrigated plots provided the opportunity to evaluate the capacity for different species to recover from drought. In addition, the harsh winter of 2013/2014 and resulting injury to the RTF and RPR grasses also provided an opportunity to evaluate the potential for species to recover from winter injury. This trial also provided information on the ability of these species to out-compete weeds compared to the standard HLM.

Rhizomatous tall fescue

The seeding date for the RTF on Sept. 21, 2011 was later than optimal for tall fescue species in general and the RTF did not establish well during the fall of 2011. By June 8, 2012 there was 18% of the RTF plot area was bare, while there was 26% TF content and 47.50% BLW. After 4 weeks without rainfall, the TF content in non-irrigated RTF plots was reduced to 2.75%, recovering to 19.00% by the fall of 2012. In that same time frame the TF content in irrigated RTF plots rose from 15.75% to 68.25%. During the 2013 growing season the TF content in the non-irrigated RTF increased to 51.25 % and in the irrigated plots increased to 90.75%, demonstrating the need for sufficient irrigation or rain during the first year of establishment for RTF. In the year following the winter injury (2014) the TF content in the RTF plots only increased from 26.00 to 30.50% in the non-irrigated plots, and from 52.25 to 65.25% in the irrigated plots, showing only slight spreading. There was significant invasion of KB into the non-irrigated RTF plots (41.25%). It could not be confirmed in this study if the spreading of the RTF was due to tillering or due to the rhizomes but it did demonstrate a slight ability to spread.

Following the irrigation treatments applied on Aug. 4, 2012 there was significantly less dead/bare ground in the non-irrigated RTF plots than in the non-irrigated RPR or HLM plots, demonstrating the superior ability of RTF to maintain its green colour through periods of drought. In 2013, though, the non-irrigated RTF plots were invaded by annual bluegrass (20.75%), levels that were significantly higher than in all other plots, probably due to the high percent of bare ground in non-irrigated RTF plots in the fall of 2012.

RPR

RPR was very quick to establish and plots contained 63.75% PR by June 8, 2012. After the 2012 irrigation treatments, the non-irrigated RPR had significantly fewer BLW than the both the non-irrigated RTF and HLM treatments, perhaps because of this high PR content prior to irrigation. The non-irrigated RPR and HLM plots showed similar levels of performance through the same period, and did not hold their colour through the 4 week dry period.

The PR content in the non-irrigated RPR plots rose from 52.00 to 82.5% from the fall of 2012 to the fall of 2013, and the PR cover in the irrigated RPR plots rose from 88.75 to 95.5% over the same period, demonstrating the grass' ability to spread, especially in a thinned stand of turf (as seen in the non-irrigated RPR plots). After the damage caused by the winter conditions of 2013/2014 RPR appeared to be the least winter-hardy. The PR content decreased in the irrigated RPR plots from 95.5 to 16.00%, and from 82.5 to 47.25% in the non-irrigated RPR plots. It is not clear why the irrigation treatment from the previous season seemed to have an adverse effect on winter survival of the PR. The PR cover in the irrigated RPR plots increased from 16.00 to 31.5% during the 2014 growing season, again demonstrating the ability of the grass to spread. However, the same trend was not demonstrated in the non-irrigated RPR plots and the same PR cover was maintained from the spring to the fall of 2014 (47.25 and 46.25%, respectively). As the non-irrigated RPR plots contained the highest dead/brown content in the spring of 2014 it follows that these dead plants were replaced by BLW (33.5%) by the fall of 2014.

HLM

Prior to the irrigation treatments in 2012 the HLM plots were comprised of 30% PR, 13.37% FF, 9.5% KB, 31.25 BLW and 13% bare. After the 2012 irrigation treatments, the non-irrigated HLM plots contained the same percent dead/brown area as the non-irrigated RPR plots (69.5%). After the fall rains, the PR and FF content increased, but the KB content decreased; 37.5% of the plot area was bare by the fall rating date. The non-irrigated HLM was better at out-competing BLW than the non-irrigated RTF, but was similar to the non-irrigated RPR. In spite of these differences, after the 2013 growing season, mowing and fertilization, none of the treatments differed significantly from each other for BLW.

The composition of PR, FF and KB in the non-irrigated HLM and the irrigated HLM plots were significantly different at the end of fall 2013; FF dominated the non-irrigated HLM plots while the irrigated HLM plots contained approximately 30% of PR, KB and FF. These levels were anticipated based on the original HLM seed content which was comprised of 50% KB, 20% PR and 30% FF.

After the winter of 2013/2014, both the non-irrigated and irrigated HLM plots lost most of their PR content (3 and 5% remaining, respectively). The species composition at the end of the 2014 growing season was similar, though, with FF dominating (80 and 78%, respectively) and KB cover at 16.5 and 18.25% of the total area.

At the end of the trial, all of the treatments, with the exception of the irrigated RPR were able to out-compete BLW but there were no significant differences in BLW incidence between non-irrigated RTF, irrigated RTF, non-irrigated HLM, irrigated HLM and non-irrigated RPR.

Grub invasion

In late October 2012 there was evidence of animal and bird digging which appeared to be restricted to certain plots (Figure 13). In fall 2012, spring 2013 and spring 2014 six cup changer plugs of turf per plot were examined for the presence of grubs. The results are shown in Table 3. Although the grub species was not confirmed, it is likely that they were European chafer grubs. In fall 2012 (after the drought) there were significantly more grubs in the irrigated RTF and HLM plots. This could be because the female European chafers preferred to lay eggs in the irrigated plots or because there was better egg survival and larval development in the irrigated RTF and HLM plots following the dry summer conditions. In spring 2013 all of the irrigated plots had significantly fewer grubs than the non-irrigated plots. It could be speculated that there may have been some natural infections as a result of the wet soils in the grub populations in the irrigated plots that resulted in a higher grub mortality. By spring 2014 there were no significant differences amongst any of the treatments.

Table 3. Number of grubs per plot for 2012, 2013 and 2014

Treatment	Number of grubs/0.1m^2		
	11/15/12	05/21/13	05/22/14

Non-irrigated RTF	5.00 b[1]	6.25 a	NS
Irrigated RTF	12.92 a	0.00 b	NS
Non-irrigated HLM	2.10 b	5.62 a	NS
Irrigated HLM	13.33 a	0.62 b	NS
Non-irrigated RPR	3.33 b	7.50 a	NS
Irrigated RPR	7.50 ab	1.87 b	NS

[1] Means within columns followed by the same letter are not significantly different (Tukey's HSD, p=0.05).

Figure 12. Plot on the left shows the non-irrigated HLM and the plot on the right shows the irrigated HLM; animal feeding damage clearly evident in the irrigated plot.

References

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