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Comparative Shade and Drought Resistance Among Various Warm-Season Turfgrass Types in Riyadh Area

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Abstract. This experiment was conducted to study the effect of shade and drought on ten selected warm-season turfgrass types. Three types of *Cynodon dactylon*: Local bermudagrass, common bermudagrass, Tifgreen bermudagrass; Tifway bermudagrass, *Paspalum vaginatum:* Adalyd paspalum; three types of *Stenotaphrum seaundatum:* Variegata St. Augustinegrass, Floratine St. Augustinegrass, Floratam St. Augustine, *Zoyzia tenuifolia* ; Korean velvetgrass, and *Dactyloctenium aegyptium*, Egyptian crabgrass were used in this study.

Most of turfgrass types gave slow growth rate and low quality under the shade treatment (70-80% shading). The Egyptian crabgrass gave the highest fresh yield weight while the Tifway gave the lowest yield. Tifgreen bermudagrass produced the best quality rating, while the Korean velvetgrass gave the lowest quality. The quality of most turfgrasses was much better under field condition than under shade. However, Variegata St. Augustinegrass showed better quality in the shade than in the open field.

The ten turfgrasses were also exposed to a complete drought (no irrigation water) for six weeks, until most of the turfgrasses showed 80-90% leaf firing. The leaf firing and shoot recovery were visually assessed. Adalyd seashore paspalum was the most affected turfgrass showing the highest leaf firing (80%) and the lowest shoot recovery (28%). On the other hand, Tifgreen bermudagrass showed the highest shoot recovery. The Korean velvetgrass gave the lowest leaf firing, but with slow shoot recovery.

Introduction

Light quality, duration and intensity are responsible for the turfgrass growth and development [1]. Shade was reported as the most common reason for the deterioration of turf [2]. The net result might be a complete loss of turfgrass if the light reduction is severe enough [3]. The establishment rate under shaded conditions was seriously inhibited due to the reduced rhizome number, more upright growth habit, decreased tillering, and limited carbohydrate reserves [1 and 3]. Moreover, the turf under these conditions is well tolerant to stresses such as cold, heat and drought.

The drought resistance is a term for the ability of a plant to survive in unfavorable external moisture stress [1]. Turfgrass can tolerate the drought by different means; escape, resistance, avoidance and endurance [4]. Emmons [2] and Beard [1] explained that turfgrass can tolerate drought by escaping soil drought by means of short life cycle.

The turfgrass performance under reduced irrigation was studied by Kim *et al.* [5] who reported that drought stress decreases turf quality which was an important factor in growing functional turfs. Leaf firing and loss of color during moderate to severe drought conditions should be taken into consideration in selecting turfgrass species and cultivars.

The tolerance performance of ten selected turfgrass types to drought or reduced light intensity was studied under the semiarid conditions of Riyadh, Saudi Arabia.

Materials and Methods

Two experiments were conducted at the Agricultural Research and Experimental Station of Derab, College of Agriculture, King Saud University, Riyadh, Saudi Arabia, for shade and drought studies. Ten different species and cultivars of warm-season turfgrasses were selected and obtained from various sources for the use in these studies (Table 1). Each of these turfgrasses was vegetatively propagated by springs and planted in an open field. The planting media consisted of 3 sandy loam

Tabel 1. Turfgrass types selected for the study

Common name	Scientific name	Source
Bermudagrass	*Cynodon dactylon* "Local"	Derab Station, Riyadh
Bermudagrass	*Cynodon dactylon* "Common"	Derab Station, Riyadh
Bermudagrass	*Cynodon dactylon* "Tifgreen"	Southern Turf Nurseries
Bermudagrass	*Cynodon dactylon* "Tifway"	Georgia, USA (imported)
Paspalum grass	*Paspalum vaginatum* "Adalyd"	Local Nurseries, Riyadh
St. Augustinegrass	*Stenotaphrum secundatum* "Variegata"	
St. Augustinegrass	*Stenotaphrum secundatum* "Floratine"	Nursery Department International Airports Projects – Jeddah
St. Augustinegrass	*Stenotaphrum secundatum* "Floratam"	
Zoysia grass	*Zoysia tenuifolia* Willd "Korean velvet"	
Dactyloctenium	*Dactyloctenium aegyptium* "Egyptian crab"	

soil: peatmoss (by volume). The initial soil pH was 7.9 and the EC was 0.24 dsm^{-1}. These grasses were treated with pesticides and NPK fertilizers whenever it was needed, and each study was treated differently in this regard. A secondary treated municipal sewage water with an EC of 1.6 dsm^{-1} was used to irrigate the grasses throughout these studies.

First experiment: Shade study

This study was initiated in March 1990, to evaluate the growth rate of the ten selected turfgrass types under the shade condition. These types were sprigged in 1 × 2 m plots size, and arranged in a randomized complete block design. The grasses were irrigated daily by sewage water until new root system was developed, thereafter they were watered every other day by flooding system. Simulated shade treatments were started after a full establishment of the turfgrasses. The shade environment was obtained by covering the whole experimental area (6 × 15 m) enclosure with a green shade screen to eliminate 70-80 of the incident sunlight. The shade screen was raised two meters high from the ground to allow follow up and data recording. The light intensity under the shade condition was measured through the experiment. The average light intensity was about 8.5 klux in the summer, 8.2 klux in the fall and 6.3 klux in the winter months.

Tissue content of total chlorophyll was determined by sampling the third leaf from the tip of an individual shoot to obtain leaves of approximately the same physiological age. These samples were taken at the three different seasons. One gram sample of each turfgrass type was used. These samples were prepared for analysis by extracting the leaf tissue contents by using 80% acetone and pure white sand [6]. Photometric determination was made by measuring the absorbency at 652 mm with a spectrophotometer and reported as milligram total chlorophyll per gram of fresh weight, as suggested by Wilkinson and Beard [1]. The turfgrass type in each plot was harvested every 4-6 weeks and the fresh clippings were weighed to determine the growth rate during the study period. Turfgrass quality was determined visually on monthly basis based upon uniformity, density and color. Scores ranging from (1) for the poor quality to (9) for the excellent turfgrass quality were used.

Second experiment: Drought study

During the fall of 1990, the same ten turfgrasses were evaluated for their survival then exposed to a severe progressive drought stress under Derab environment. The grasses were first established in February 1990 by springing in 1 × 2 m plots, arranged in a randomized complete block design containing three replicates for each turf type. Each plot was 50 cm apart from the nearby block. The turfgrasses were allowed to grow from February to September 1990 before they were exposed to drought stress. N.P.K. (18.18.5) fertilizer was added in an amount of 44 gm/plot before irrigation was stopped. Irrigation (flooding system) was applied using a secondary treated sewage water whenever it was needed to prevent visual wilt. This study was done in the fall to minimize the effect of environmental factors such as heat stress which may cause leaf firing or low temperature which may cause leaf killing.

At the beginning of this study, the irrigation frequency was at a rate of once a week for a period of one month. Then the interperiod was increased to 10 days, followed by a period up to two weeks until the middle of November, the time by which the irrigation was completely stopped and the turfs were exposed to progressive drought condition. Whenever there was possibility of rain, a plastic cover was installed above the experimental area to avoid possible water input. The percentage of leaf firing caused by drought stress was assessed weekly until the end of the stress period which was 42 days, started when the water supply was totally stopped. After this period, the turfs were re-watered. A weekly assessment of data of the shoot recovery as a percentage of plot size was visually estimated after 42 days from resuming normal irrigation for turfgrasses. This assessment continued for 6 weeks until most of the turfgrasses were re-established. This method was suggested by Kim *et al.* [5].

Results

Shade study

There were significant differences in the overall mean of clipping fresh weight among the turfgrass types under shade (Table 2). Egyptian crabgrass gave the greatest overall mean of clipping weight (316 gm). It was significantly different from the Floratam St. Augustinegrass which was not significantly different from Floratine St. Augustinegrass and Tifgreen bermudagrass. On the otherhand, Tifway bermudagrass showed a very little growth rate by having the lowest clipping weight of 90.0 gm. It was also significantly different from the Local bermudagrass which ranked before Tifway. Generally, the growth rate under shade was very slow and decreased for most of the turfgrass types.

Turfgrass quality under shade condition was generally greater in spring and summer than in fall and winter (Table 3). Some grasses showed acceptable quality even after 6 months of shading. Tifgreen bermudagrass gave the best quality among the studied turfgrass types. Egyptian crabgrass gave similar yield to Floratam St. Augustinegrass under the shade showed better quality compared to the other grasses. Korean velvetgrass showed the lowest quality under the shade, although, both Tifway and common bermudagrass had lower quality. A comparison between shade and field condition for the overall mean quality was shown in Fig. 1 for the selected turfgrasses. The quality of most turfgrass types was better under field condition than under the shade. However, Variegata St. Augustinegrass showed better quality under the shade than in the field.

Tabel 2. Clipping fresh weight (gm/0.25 m^2) of the selected turfgrass types at different cutting months under shade condition

Turfgrass types	1st cut MAY	2nd cut JUNE	3rd cut JULY	4th cut SEPT	5th cut NOV	6th cut JAN	Overall mean
Local bermuda	165.8	143.8	137.8	162.8	123.8	136.0	145 d Y
Common bermuda	223.8	160.8	162.0	159.5	336.0	106.3	191 c
Tifgreen bermuda	388.5	247.0	215.0	189.8	174.5	150.0	228 bc
Tifway bermuda	70.0	142.5	117.0	73.8	74.5	60.5	90 e
Adalyd paspalum	286.8	254.0	180.3	185.0	187.8	138.8	205 c
Variegata St. Aug	232.5	219.0	242.3	222.3	152.5	115.0	197 c
Floratam St. Aug	344.5	292.0	338.3	248.0	169.8	162.0	259 b
Floratine St. Aug	218.5	306.3	241.8	238.0	178.3	206.5	232 bc
Korean velvet Z	–	–	–	–	–	–	–
Egyptian crab	489.0	272.5	262.3	333.0	278.3	262.5	316 a
Overall mean	268.8 a	226.4 b	210.8 bc	201.3 bc	186.1 c	148.6 d	

L.S.D. AT(0.05) For turf types = 40.7

L.S.D. AT(0.05) For cutting time = 33.3

L.S.D. AT(0.05) For interaction = 102.1

Y All means followed by the same letter(s) are not significantly different at the 0.05 level.

Z Korean velvetgrass was not clipped because of its slow growth rate.

Tabel 3. Seasonal Turfgrass quality for the selected turfgrass types at different months under shade condition

Turfgrass types	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	Overall mean
Local Bermuda	5.9 X	6.4	7.0	7.7	7.4	6.4	5.8	5.8	6.44 d Y
Common Bermuda	6.6	6.5	7.3	7.7	7.90	7.4	4.9	4.2	6.54 d
Tifgreen Bermuda	5.5	7.6	5.6	7.8	8.3	7.7	7.5	7.3	7.39 b
Tifway Bermuda	5.4	7.4	4.6	6.6	4.6	3.6	2.4	3.5	4.90 f
Adalyd paspalum	7.2	7.5	7.4	7.3	7.6	8.4	7.9	8.4	7.70 a
Variegata St. Aug	3.3	3.8	4.2	3.5	4.1	4.6	4.4	4.7	4.09 g
Floratine St. Aug	5.4	5.9	7.2	7.5	7.6	7.4	6.9	6.9	6.85 c
Floratam St. Aug	5.4	5.9	6.7	7.2	7.4	7.8	7.2	6.9	6.83 c
Korean velvet	2.7	2.8	5.1	5.4	5.9	6.8	7.1	6.9	5.34 e
Egyptian crab	6.7	7.1	7.3	7.5	7.5	6.5	7.3	7.3	7.16 b
Overall mean	5.57 c	6.11 b	6.25 b	6.83 a	6.84 a	6.67 a	6.15 b	6.17 b	

L.S.D. AT(0.05) For turf types = 0.24
L.S.D. AT(0.05) For months = 0.21
L.S.D. AT(0.05) For interaction = 0.68

X Rating scale based on 9=best and 1=poorest; 5 represents the minimal acceptable turfgrass quality
Y Means followed by the same letter(s) are not significantly different at the 0.05 level.

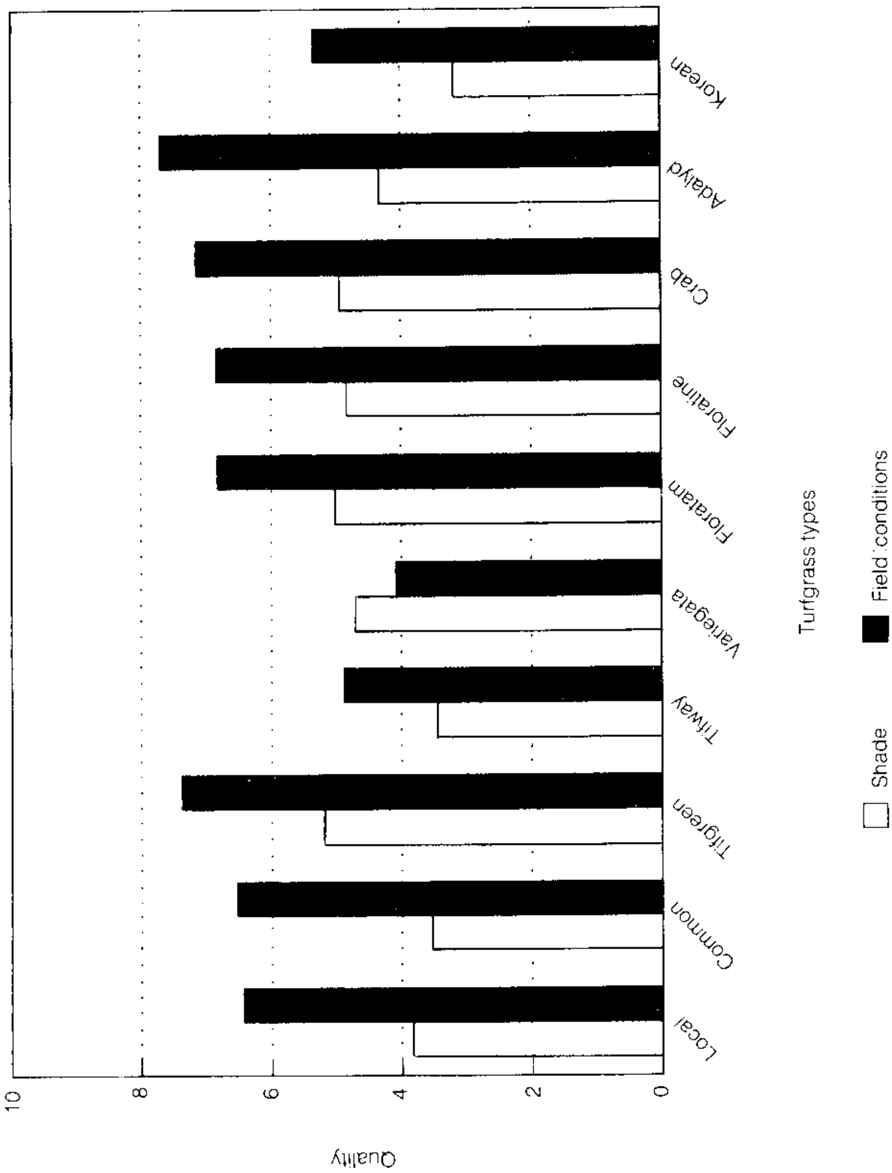

Fig. 1. Overall mean of quality comparison under shade and field conditions for the selected turfgrasses.

Chlorophyll content (mg/gm fresh weight) decreased as the light intensity increased, however the leaves were lighter green at the lower light intensity (Table 4). Floratine and Variegata St. Augustinegrasses had the lowest chlorophyll content while Egyptian crabgrass had the greatest content. However, the turfgrasses with fine leaves tend to be soft with an upright growth and with a grayish green color.

Tabel 4. Assessment of the chlorophyll content (mg/gm fresh weight) for the selected Turfgrass types at different seasons under shade condition

Turfgrass types	Summer*	Fall	Winter	Overall
	chlorophyll content (mg/gm)			MEAN
Local Bermuda	1.00	1.07	1.13	1.07
Common Bermuda	1.10	1.15	1.23	1.16
Tifgreen Bermuda	0.83	0.92	1.03	0.93
Tifway Bermuda	1.17	1.25	1.33	1.25
Adalyd paspalum	0.79	0.85	0.89	0.84
Variegata St. Aug	0.51	0.56	0.63	0.52
Floratine St. Aug	0.49	0.56	0.62	0.56
Floratam St. Aug	1.00	1.03	1.07	1.03
Korean velvet	0.98	1.05	1.11	1.05
Egyptian crab	1.37	1.42	1.45	1.41

*The average light intensity was about 8.5 klux in summer (Aug.), 8.2 klux in fall (Oct.), and 6.3 klux in winter (Dec.).

Drought study

The leaf firing and shoot recovery of various turfgrass species and cultivars exposed to drought stress during 6 weeks were shown in Figs. 2-4. Shoot recovery represents the drought resistance of each grass. Both local and common bermudagrasses had the lowest leaf firing percentage, however, their shoot recovery percentage was the lowest within 6 weeks (Fig. 2). On the other hand, Tifway and Tifgreen had the highest leaf firing percentage, although their shoot recovery percentage was the greatest within 6 weeks.

Variegata and Floratam St. Augustinegrasses had greater leaf firing percentage than Floratine. However the shoot recovery percentage of both Floratine and Floratam was greater than Variegata within 6 weeks (Fig. 3). Korean velvetgrass had lower leaf firing percentage than Adalyd paspalum and Egyptian crabgrass, although, the shoot recovery percentage of Adalyd was lower than the other cultivars within 6 weeks (Fig. 4).

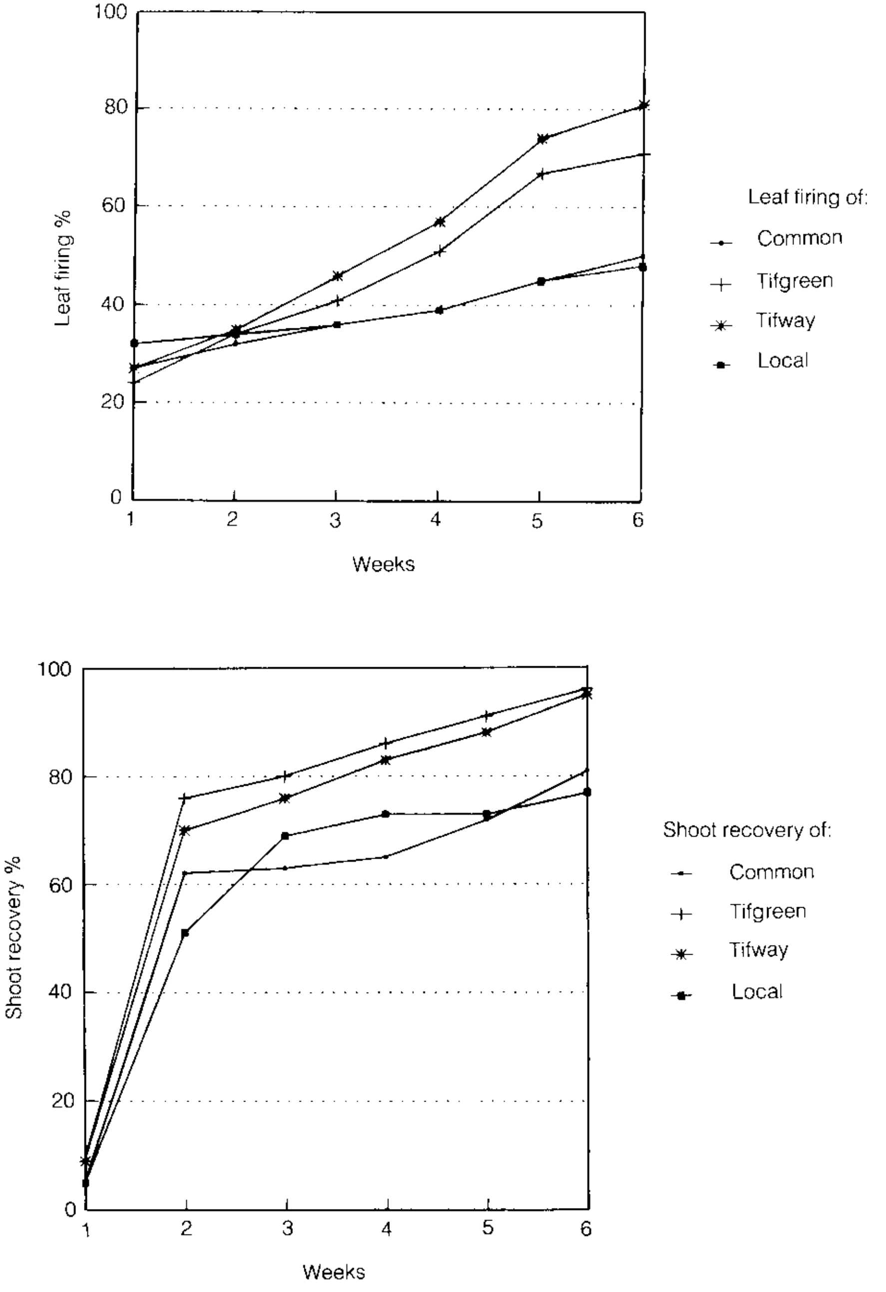

Fig. 2. Drought effect as leaf firing and shoot recovery on Bermudagrass cultivars.

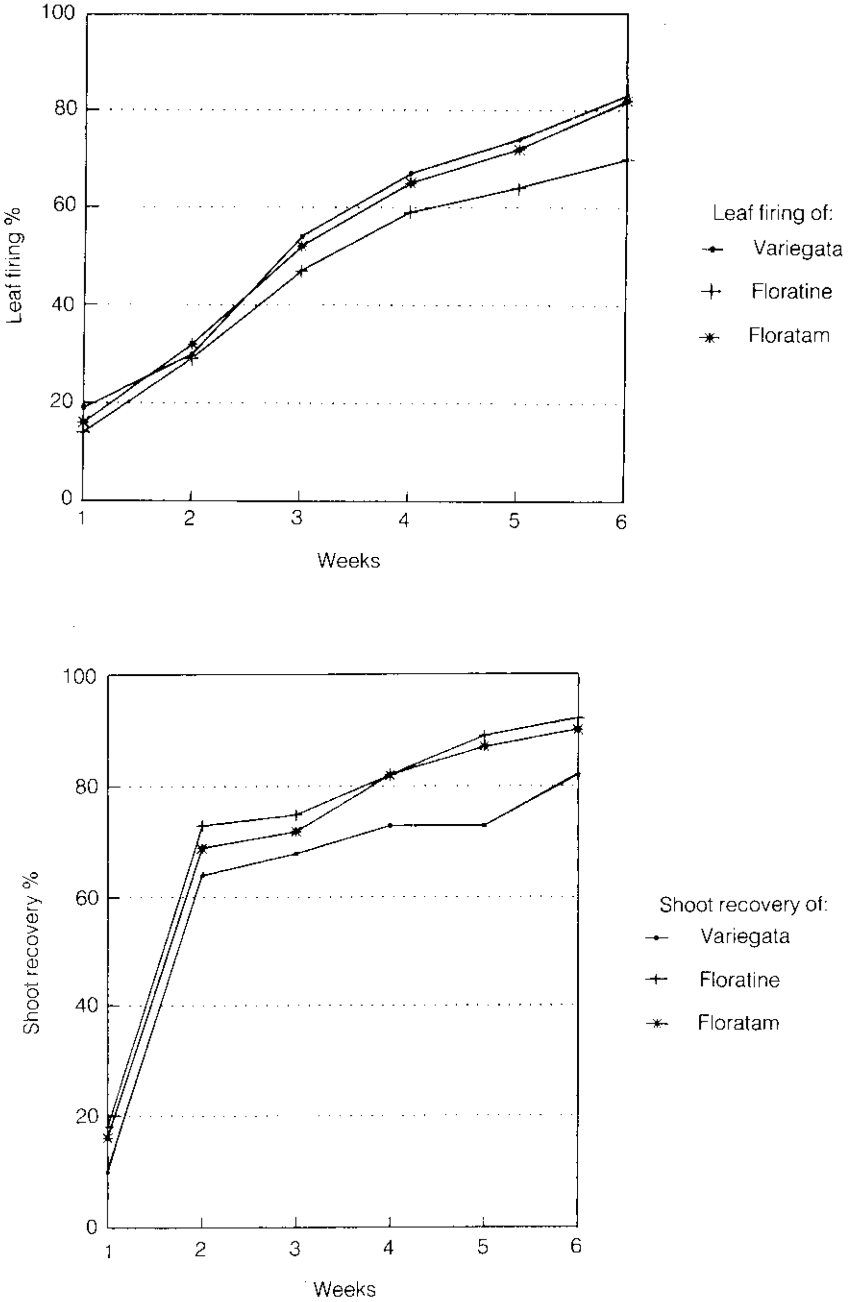

Fig. 3. Drought effect as leaf firing and shoot recovery on St. Augustinegrass cultivars.

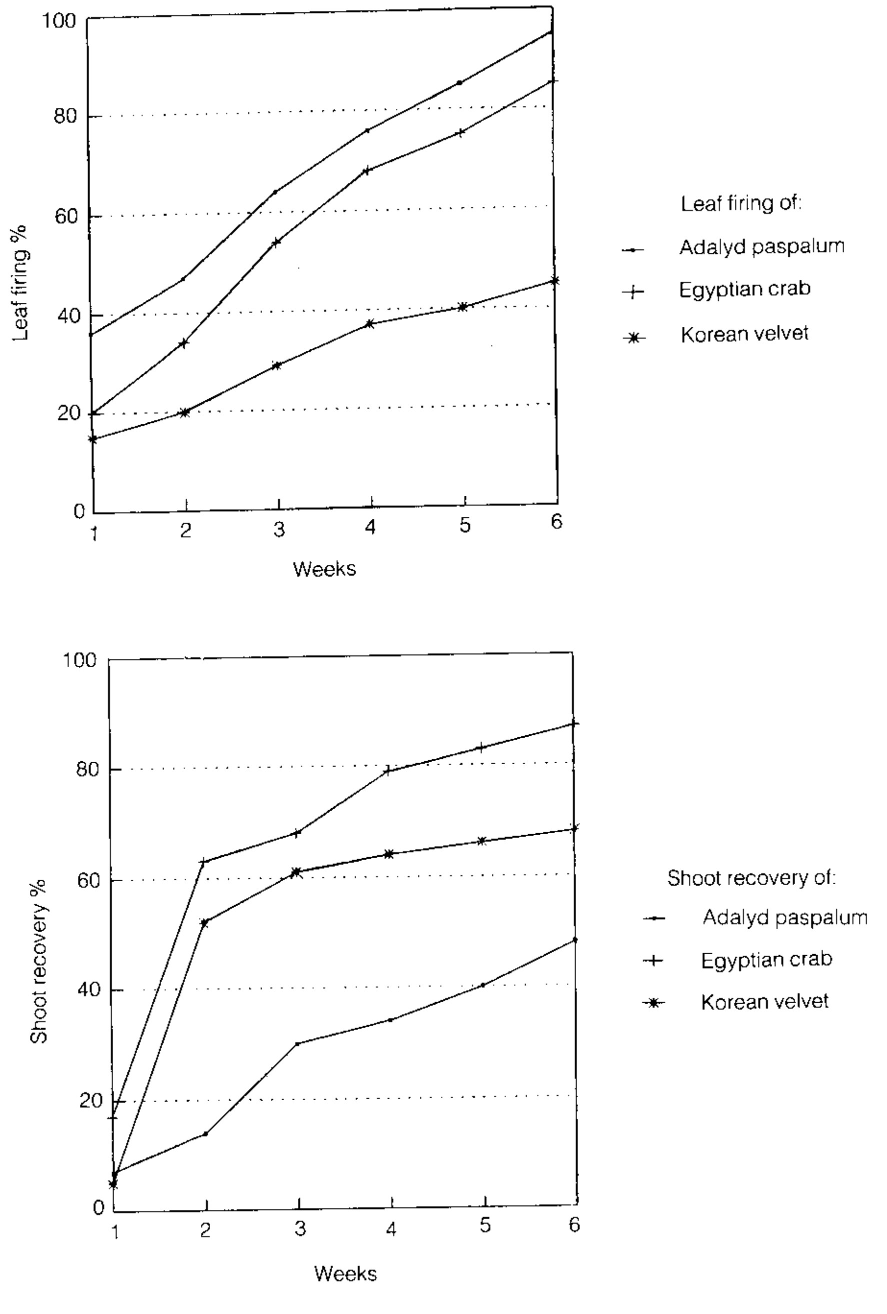

Fig. 4. Drought effect as leaf firing and shoot recovery of other turfgrass species.

Tabel 5. Assessment of the chlorophyll content (mg/gm fresh weight) for the selected turfgrass types at different seasons

Turfgrass types	Summer*	Fall	Winter	Overall MEAN
	chlorophyll content (mg/gm)			
Local Bermuda	0.76	0.80	0.85	0.80
Common Bermuda	0.63	0.67	0.81	0.70
Tifgreen Bermuda	0.75	0.79	0.84	0.79
Tifway Bermuda	0.72	0.76	0.83	0.77
Adalyd paspalum	0.88	0.96	0.99	0.94
Variegata St. Aug	0.40	0.45	0.51	0.45
Floratine St. Aug	1.03	1.10	1.25	1.13
Floratam St. Aug	0.72	0.76	0.81	0.76
Korean velvet	0.42	0.47	0.53	0.47
Egyptian crab	0.87	0.95	0.99	0.94

*The average light intensity was about 91 klux in summer (Aug.), 80 klux in fall (Oct.), and 64 klux in winter (Dec.).

A comparison between the selected turfgrasses for both leaf firing and shoot recovery was shown in Fig. 5. Adalyd seashore paspalum showed the greatest overall mean of leaf firing which was significantly different from the other turfs. It was followed by Egyptian crabgrass, Variegata St. Augustinegrass, common bermudagrass, and Floratam St. Augustinegrass, in decreasing order. However, the differences in leaf firing percentages were not statistically significant. The Korean velvetgrass was the best, giving the lowest mean of leaf firing percentage, which was significantly lower than Tifway bermuda, Local bermuda, Floratine St. Augustine and Tifgreen bermuda turfgrasses (Fig. 5). Visual estimation for the shoot recovery of Tifgreen bermudagrass gave the greatest mean. It was not significantly different from Floratine St. Augustinegrass and common bermudagrass respectively, followed by Floratam St. Augustinegrass (Fig. 5). Egyptian crab, Variegata St. Augustine, Tifway bermuda, and local bermuda were ranked in the same order after Floratam, for the shoot recovery which was significantly different. The Adalyd seashore paspalum was the least recovering grass which ranked after the Korean velvetgrass.

Discussion

Turfgrass quality and clipping yield of the various turfgrasses were significantly decreased by the shade condition during the duration of this study. Barrious *et al.* [3] indicated that clipping yield of Floratam St. Augustinegrass was higher than those of Floratine. The results obtained from this study disagreed with those of Barrious *et al.*

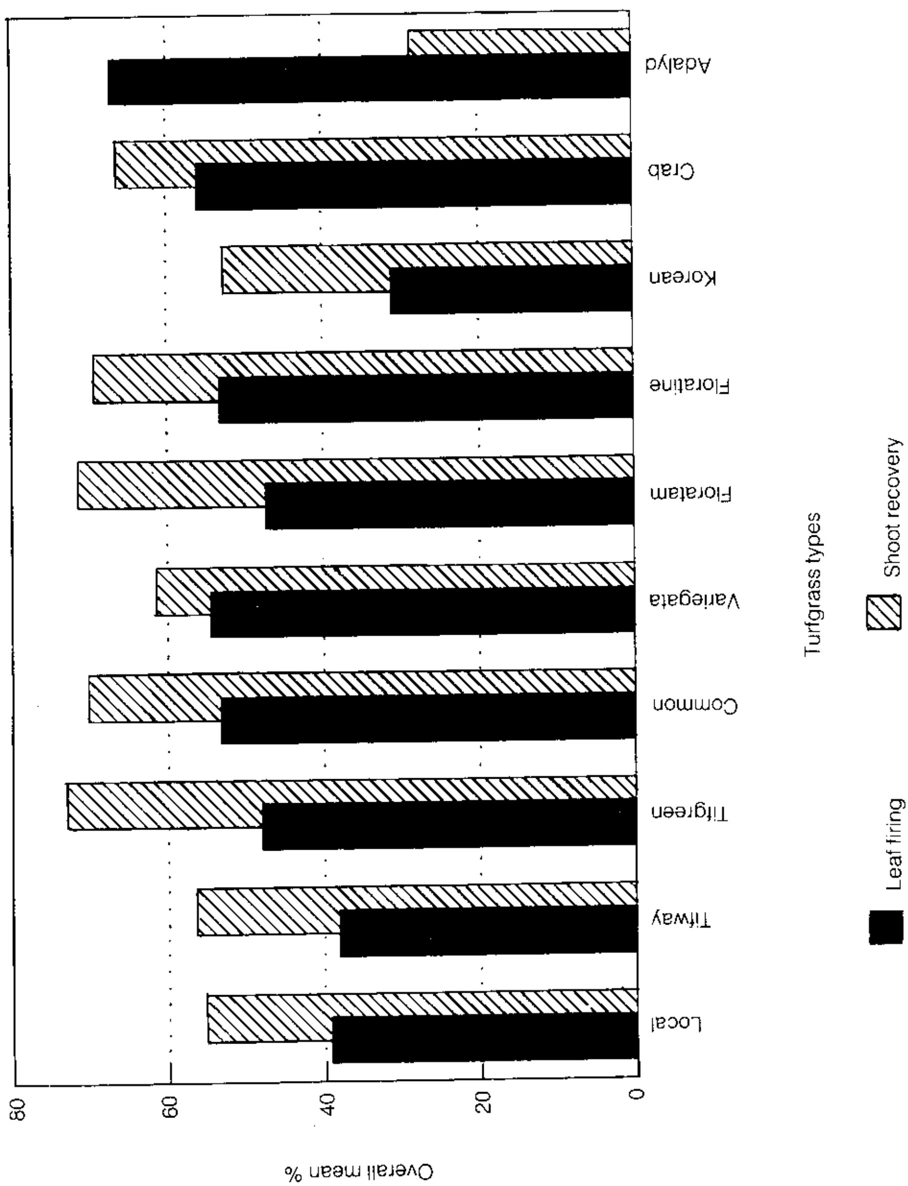

Fig. 5. Overall mean (6 weeks) of visual estimation of leaf firing and shoot recovery (% of plot size).

[3] regarding the ranking of Floratine before Floratam. These discripancies between the two studies could be attributed to the different experimental conditions. Our results also disagreed with those of Menn *et al.* [7] who reported complete failure of Floratam under shade. Bermudagrass compared to St. Augustinegrasses produced less dense turf under shade. This was similar to the findings of Winstead and Ward [8] who reported that St. Augustinegrass could possibly increase the photon-absorbing surface enabling this grass to become more adaptive to shade than bermudagrass. Bermudagrass cultivars had more total chlorophyll content than St. Augustinegrass cultivars. Similar results were reported by Winstead and Ward [8] who suggested that total cholorphyll content of grasses grown in shade environments had little, if any, effect on their adaptability to shade.

The 48 days of water stoppage have a good indication of the comparative drought resistance among the selected turfgrasses. Our results are partly in agreement with those of Kim *et al.* [5] in regard to bermudagrass cultivars, showing that Tifgreen and common bermudagrasses are the most drought tolerant types while Tifway on the contrary is not tolerant to drought. The results of this study unlike those of Kim *et al.* [5] who classified seashore Paspalum as a moderate drought resistant type, indicated that this turfgrass is the least drought resistant type. This could be due to the very low humidity prevailing at Derab where the present study was conducted, besides this cultivar is a seashore turfgrass.

There was no significant difference between Floratine (the best of St. Augustinegrasses) and Floratam in regard to shoot recovery and they both had high green shoot recovery, as reported by Kim *et al.* [5]. However, the shoot recovery of Variegata was much less than that of Floratine and Floratam. Korean velvetgrass showed a different behavior as it gave the lowest shoot recovery, which was different from those suggested by Kim *et al.* [5]. However, it is partly in agreement with the result found by Meyer and Gibeault [9] who indicated that under drought conditions, Zoysiograss appearance declined and it could be due to nematode activity.

Conclusion

The data from shade study indicated that turfgrasses responded differently to reduced light. The turfgrasses were lacking the correlation between quality and yield under shading environment. The quality and clipping yield of some turfgrasses (i.e bermudagrasses) significantly reduced as the light was decreased. The quality of other turfgrasses such as Tifgreen bermudagrass, Variegata St. Augustinegrass and Egyptian crabgrass was less affected, although their clipping yields were decreased. The data suggested also that among the tested ten turfgrasses, Korean velvetgrass was the most shade intolerant while Tifgreen bermudagrass was the most tolerant to reduced light conditions. The turfgrass chlorophyll content (mg/gm fresh weight) increased under shade compared to the open field, and it was also greater in winter than in summer. However, the turfgrass color was lighter green under shade condition.

The data of turfgrass drought resistance is very important because there is a potential need for water saving. It is suggested that some turfgrasses have a low leaf firing during the drought period and a fast shoot recovery after resuming irrigation. Tifgreen, Common bermuda, Floratine and Floratam St. Augustinegrasses are suggested to have good drought resistance. However, Adalyd seashore paspalum and Korean velvet were not drought resistant, under these study conditions.

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استجابة بعض أنواع مسطحات الموسم الدافىء للظل والجفاف تحت ظروف منطقة الرياض

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ملخص البحث. تم إجراء هذه التجربة على أنواع وأصناف مختارة من المسطحات الخضراء، منها أربعة أصناف من عشب البرمودا Bermudagrass هي البرمودا البلدي "Local" ، والبرمودا المحلي "Common" ونوعان من البرمودا الهجين "Tifgreen" "Tifway" وكذلك ثلاثة أصناف من النجيل الفرنسي St. Augustinegrass هي المبرقش "Variegata", "Floratine", "Floratam" بالإضافة إلى نوع الباسبالم "*Adalyd Seashore paspalum*" ونوع *Zoysiagrass* (صنف النجيل الكوري Korean velvet) ونوع *Dactyloctenium* (صنف رجل الغراب *Egyptian crabgrass*) .

أجريت تجربة لدراسة تأثير ٧٠ـ٨٠٪ من الظل على نمو المسطحات الخضراء وتحديد تحملها، وقد تم قياس الوزن الرطب، وذلك لتقدير معدل النمو والذي أظهرت فيه جميع الأنواع إستجابة معنوية حيث كان الوزن يتناقص كثيرًا تحت ظروف الظل، كما تم تقدير درجة النوعية للمسطحات المختلفة تحت الظل حيث انخفضت إنخفاظًا ملحوظًا مقارنة بالظروف العادية، وذلك في جميع الأنواع ما عدا النجيل الفرنسي المبرقش، وقد كان نجيل البرمودا الهجين صنف «Tifgreen» أفضل الأنواع من حيث درجة النوعية إلا أن معدل نموه كان قليلاً مقارنًا بنجيل رجل الغراب Egyptian crab والذي أعطى أفضل نمو إلا أن نوعيته كانت أقل من Tifgreen . وأعطت معظم أنواع النجيل الفرنسي نموًا متوسطًا إلا أن نوعيتها كانت منخفضة مقارنة بالأنواع الأخرى، وكذلك أظهر كل من Tifway والنجيل الكوري درجة نوعية منخفضة مقارنة بالأنواع الأخرى.

وقد تم إجراء تجربة أخرى بغرض مقارنة تحمل أنواع المسطحات المختارة لفترات من الإجهاد الجفافي عن طريق قطع الماء عنها لفترة زمنية تصل إلى ٦ أسابيع، ومن ثم متابعة تأثر هذه الأنواع والذي

يظهر من خلال إحتراق الأوراق Leaf firing والذي تم تقديره كنسبة مئوية من مساحة القطع التجريبية. وبعد هذه الفترة تم إعادة الري كالمعتاد ومتابعة سرعة أو معدل النمو الخضري لهذه الأنواع، وقد دلت النتائج على أن أفضل الأنواع تحملاً للجفاف هو صنف البرمودا الهجين "Tifgreen" يليه صنف النجيل الفرنسي "Floratam" . ومن الجانب الآخر فإن نجيل الباسبالم "Adalyd" كان من أقل الأنواع تحملاً حيث وصلت نسبة الجفاف فيه إلى ٨٠٪، ولم يمكنه إستعاضة نمواته لأكثر من ٢٨٪ وبالرغم من ظهور نسبة بسيطة من احتراق الأوراق على النجيل الكوري إلا أن مقدرته على استعاضة النمو لا تزال بطيئة.