Influence of Shading and Paclobutrazol Concentrations on Growth and Quality Characters of Three Different Turf Grasses Genera

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DOI: https://doi.org/10.36077/kjas/2023/v15i1.10277

Received date: 8/9/2022

Accepted date: 10/10/2022

Abstract

This study was carried out in Pirmam,, Erbil Governorate - Iraq for two years, from 15 March 2020 to 15 March 2021 in the spring season and from 15 September2020 to 15 September 2021 in the autumn season, to study the responses of three turf grass genera, including Bermuda grass (*Cynodon dactylon* L. var. cd4), Tall fescue grass (*Festuca arrundaceae* L. var. Barleroy) and Creeping bent grass (*Agrostis palustris*) cultivated by seeds to two shading levels of 0 and 75% and sprayed with three paclobutrazol concentrations at 0, 750 and 1500 mg. l^{-1}. The experiment was performed by using Randomized Complete Block Design (RCBD) in a split-plot design with three factors and three replications. The results showed that the shading level (0%) led to a significant increase in most studied characters like mowing number, cumulative dry weight of turf grass clipping yield, dry root weight, total chlorophyll and carbohydrate percentage and was superior to those grown under 75% shading. Both levels of shading had no significant effects on color degree and coverage percentage of the used turf grasses. It also showed that foliar spray of paclobutrazol had a significant impact on those traits. The highest values of plant density, mowing number, and cumulative dry weight of clipping yield were recorded when turf grasses were unsprayed with paclobutrazol, while the highest values of color degree, coverage percentage, total chlorophyll content, and carbohydrate percent were obtained when turf grasses were sprayed with 1500 and 750 mg.l^{-1} of paclobutrazol, respectively. Significant differences were shown among turf grass genera that were grown from seeds in those traits. Agrostise genus was significantly superior to other genera only in plant density, while Festuca genus was significantly superior to other genera in the rest of the other characteristics. As for triple interactions, the highest significant values for most characteristics were found in Festuca genera that were sprayed with 750 and 1500 mg.l^{-1} concentrations of paclobutrazol and grown in open fields.

Keywords: Shading levels, Paclobutrazol concentrations, Turf grasses genera.

Introduction

Turf grasses are the most important components of landscape art. They are defined as any grass that can be cut and is made up of thick vegetation that covers the soil surface, or places where a collection of adjacent and convergent herbal plants are planted. When its creeping branches are clipped, they sprout profusely to span the distance between planted plants, and their growth, when integrated, produces a lovely green carpet (2 and 11). The lawn grasses follow Gramineae (Poaceae) family. It has distinguishing features such as low growth habit, prostrate creeping propensity, high shoot density, and coarse-to-fine leaf texture, and it occupies about 70-80% of the area of our land in gardens (5, 16 and 11). Turf grass plants contain Meristematic zones at the soil surface create rhizomes and stolons, which help grass grow and endure agricultural services like mowing, fertilizing, and irrigation (28). Turf grass product is a major economic industry in several countries, including the United States, United Kingdom, and Netherlands (10 and 28).

Generally, Bermuda grasses (*Cynodon dactylon* L.) have poor shade tolerance; they perform best when grown in full sunlight conditions, needing a suitable for almost all turf in large parts of Europe, minimum of 8 to 10 hours of full sunlight per day (18). Bermuda grass is Asia, and North Africa. Golf courses, athletic fields, household lawns, industrial parks, and soil stabilization are just some of the places where it's used. Bermuda grass is popular in hot, humid tropical and subtropical areas because it thrives in dry, saline soil and is resistant to most diseases and insect pests (12). One of the most significant species of fescue, tall fescue (*Festuca arundinacea* Schreb.), has a bright future in our environment and is noted for its resistance to wear, heat, and drought. It's also rather well adapted to being in the shade. It’s native to (34) and has been widely planted in other temperate regions as well (19). Creeping Bent grass (*Agrostis palustris*) is a cool-season perennial grass that is often used for golf course greens, tees, and fairways. Because bent grass spreads by stolons, it is feasible for it to invade neighboring turf areas. The Agrostis genus contains a number of species that are ideal for a variety of turfs, particularly in temperate climates with cold, damp summers. With the exception of redtop, all turf grass species in the genus Agrostis are referred to as bent grass (9).

Plants require light to survive, the amount of solar energy turned into chemical energy by photoautotrophic plants via photosynthesis determines plant growth and development (32). The majorities of turf grass species are acclimated to and thrive in full sun, turf grass plant undergoes several morphological and physiological changes as a result of being in the shade, Plant shadow adaptation occurs at the expense of practically all other plant processes. Shade tolerance varies across turf grass species, in sunny conditions, most turf grasses grow well and produce nice turf, but in low light conditions, the opposite occurs, resulting in poor turf quality, shades restrict sun radiation, which has an impact on the microclimate in turf-growing areas (8). The root dry weight of plants grown in full light is higher than those grown in partial shade (3).

Paclobutrazol interacts with phase 2 of the gibberellin production pathway. It inhibits the action of the enzyme Kaurene Oxidase,

which inhibits the conversion of kurene to kaurenol and, as a result, any type of gibberellin generation as well as cellular elongation, resulting in compact leaves. (15, 22 and 24). Brend and John (7) noted the effectiveness of turf grass seed planting in the Mexican state of the United States depends on the appropriate time for planting. They also indicated that the best date for planting seeds of cold-season grass is in late summer, and seeds of hot-season grass are in late spring when the critical soil temperature is 18.33 °C, because cultivation in cooler soils usually produces weak lawns.

The purpose of this research is to look into the responses of several turf grass genera to two shading levels and different concentrations of paclobutrazol in Erbil governorate conditions throughout the year and to select the best turf grass genus that can be grown commercially through warm and cold seasons.

Materials and Methods

This research was conducted for two years from 15 March 2020 to 15 March 2021 in the spring season and from 15 September 2020 to 15 September 2021 in the fall season in the Pirmam district of Erbil Governorate, Iraq. The goal of the experiment was to see how three variety of turf grass seed genera, such as Bermuda grass (Cynodon dactylon L. var. cd4) (C), Tall fescue grass (Festuca arrundaceae L. var. Barleroy) (F), and Creeping Bent grass (Agrostis palustris) (A), responded to two different shading levels, 0 and 75 percent, and three different Paclobutrazol concentrations (0, 750, and 1500 mg. l-1). The seeds are planted in 1 m x 1 m wooden boxes (built from strong wooden plates) with a depth of 40 cm as an experimental unit,. The boxes were filled with a mixed loam medium with the addition of 1 liter of peat moss and 1 liter of perlite.m^{-2} as an experimental unit the physical and chemical characteristics of the agriculture medium before planting were evaluated as shown in Table (2). The media were sterilized by Beltanol fungicide with a concentration of 50% at a rate of 10 ml per 10 L of water before sowing the seeds, they were sterilized and mixed thoroughly to avoid fungal disease attachment (19), and then the seeds were sown by hand in the boxes at seeding rates of 15 g of seeds/m2 for a total of 15 g of seeds.m^{-2} for a total of 15 g of seeds.m^{-2} for a total of 15 g of seeds.m^{-2} for a total of 15 g of seeds.m^{-2} for Bermuda, 40 g of seeds.m^{-2} for Fescue, and 10 g of seeds.m^{-2} of Bent grass (30), and had practical coverage with a thin layer of soil by using a small wooden roller. The boxes were fertilized and irrigated as needed for each treatment.

The experiment was carried out in a split-plot with a Randomized Complete Block Design with three replications. Each treatment was replicated three times. The data was analyzed on a computer using the SAS program, and the mean comparison was done using Duncan's Multiple Ranges Test, which was stated to be under 5% (SAS, 2001).

The studied characteristics included plant density (plants per m^2), mowing numbers within the experimental period, starting with the first mowing and ending with the last mowing, and the cumulative dry weight of vegetative growth (g) according to the equation: cumulative dry weight = dry weight of first mowing product (1) + dry weight of second mowing product (2) +... x of dry weight of mowing clipping, cumulative dry weight of roots (g). Color

degree, which is measured monthly using card colors (18) and gives a measure of degrees of color from 1 to 9: Cumulative dry weight = first mowed dry weight (1) + second mowed dry weight (2) Al-Manna(1). coverage percentage (percent), which is calculated monthly by comparing the covered area to the total area, total chlorophyll content in leaves (mg. gm^{-1}), percentage of total carbohydrates (20), and by using a spectrophotometer (Shimadzu Recording UV-160).

Table (1): Some of the physical and chemical characteristics of the used medium.

Soil texture USDA					
Sand %	**Silt %**	**Clay %**	**Soil texture**		
55.8	23.4	20.8	Sandy clay L		
PH	**EC Ds/m**	**N %**	**P ppm**	**K ppm**	**O.M %**

Results

Influence of shadow, paclobutrazol and turf grass genera on some growth characteristics

Table (2) indicated that shading levels had a significant impact on the characteristics of plant density, number of mowing, cumulative dry weight of clipping yield, and root dry weight. The highest significant values of plant number 45.46/100 cm^2, mowing number 7.44, cumulative dry weight 564.98 g, and root dry weight 19.06 g, were recorded for turf grasses grown in the open field and were superior to those grown under 75% shading, It also showed that foliar spray of turf grasses with varied paclobutrazol concentrations had a substantial impact on those characteristics. The most significant values of plant number 37.44/100 cm^2 and root dry weight of 14.92 g were recorded for turf grasses treated with paclobutrazol at 1500 $mg.l^{-1}$, while the highest values of mowing number at 8.28 when turf grass is unsprayed with paclobutrazol and the highest weight of cumulative dry of clipping yield of 445.31 g when turf grasses treated with 750 $mg.l^{-1}$ paclobutrazol, There were significant variances among turf grass genera that were used on those characteristics. Agrostise genus was significantly superior to other genera in plant density at 46.33 plants/100 cm^2, while Festuca genus was significantly superior to other genera in mowing numbers, cumulative dry weight of clipping yield, and root dry weight were 7.97, 516.53 g, and 16.28 g respectively.

Table (2). Effect of shading levels and paclobutrazol concentrations on some growth characteristics of different turf grass genera

Characteristics	Shading levels %		Paclobutrazol concentrations $mg.L^{-1}$			Turf grass genera		
	0	**75**	**0**	**750**	**1500**	**C**	**F**	**A**
Plant density (plant numbers/100 cm^2)	45.46 A	25.67 b	32.75 B	36.50 a	37.44 a	29.44 c	30.92 b	46.33 a

Mowing numbers	7.44 A	6.78 b	8.28 A	6.64 B	6.42 C	7.11 b	7.97 a	6.25 c
Dry weight cumulative (g) of clipping yield	564.98 A	214.87 b	445.31 A	358.25 B	366.22 C	301.25 c	516.53 a	352.00 b
Root dry weight (g)	19.06 A	9.39 b	13.25 B	14.50 A	14.92 A	12.28 c	16.28 a	14.11 b

Means with same letter for each factor are not significantly different at 5% level based on Duncan's Multiple Range test.

Influence of shadow, paclobutrazol and turf grass genera on some growth quality characteristics

The data in Table (3) showed that there was no significant difference in color degree and coverage percentage according to the different percentages used of shading, while total chlorophyll content and carbohydrate percent were significantly affected, with the highest value 3.34 $mg.gm^{-1}$ recorded for total chlorophyll and 0.58% for carbohydrate when turf grasses were grown in open field. The foliar spray of different concentrations of paclobutrazol had significant effects on those traits, with the highest values of color degree being 5.81 and 5.64, coverage percentage being 77.72 and 78.12%, total chlorophyll content being 3.38 and 3.24 $mg.gm^{-1}$, and total carbohydrate percent being 0.59 and 0.60%, respectively, when turf grasses were sprayed with 1500 and 750 $mg.l^{-1}$ concentrations of paclobutrazol. Significant differences were also shown among turf grass genera in those traits, where Festuca grass genus was significantly superior in color degree, coverage percentage, total chlorophyll content, and carbohydrate percent to all other genera, reaching 6.97, 80.05%, 3.66 $mg.gm^{-1}$, and 0.61% respectively.

Table (3). Effect of shading levels and paclobutrazol concentration on some growth characteristics of different turf grass genera

Characteristics	**Shading levels %**		**Paclobutrazol concentration $mg.L^{-1}$**			**Turf grass genera**		
	0	**75**	**0**	**750**	**1500**	**C**	**F**	**A**
Color degree	5.39 A	5.60 a	5.04 B	5.64 A	5.81 A	4.09 c	6.97 a	5.42 b
Coverage percentage %	75.87 A	76.65 a	72.94 b	78.12 A	77.72 A	71.86 c	80.05 a	76.88 b
Total chlorophyll ($mg.gm^{-1}$)	3.34 A	2.86 b	2.97 b	3.24 A	3.38 A	3.05 b	3.66 a	2.77 c
Carbohydrates %	0.58 A	0.57 b	0.55 b	0.59 A	0.60 A	0.56 b	0.61 a	0.57 b

Means with same letter for each factor are not significantly different at 5% level based on Duncan's Multiple Range test.

Influence of triple interaction among shadow, paclobutrazol and turf grass genera on some growth characteristics

Table (4) shows that the triple interaction among levels of the studied factors had a clear significant difference in the averages of those traits. The growth of Agrostis genus grass in an open field and sprayed by paclobutrazol at 750 and 1500 mg.l^{-1} gave the significant high values for plant density, 63.00 and 64.83/100 cm^2, respectively, while The lowest value was 19.83 plants/100 cm2 for the Cynodon genus grown under 75% shading and untreated with paclobutrazol, the mowing number results indicated significant differences, and Festuca genus grass grown in the open field and unsprayed with paclobutrazol gave the significant highest mowing number of 9.50, while it decreased to 5.33 in Agrostis grass sprayed with 1500 mg.l^{-1} of paclobutrazol under 75% shading. Ccumulative dry weight of clipping yield for unsprayed Festuca genus grass with paclobutrazol grown in an open field was 834.67 g, significantly higher than other interactions, while it decreased to 151.33 g in Agrostis grass treated with 750 mg.l^{-1} of paclobutrazol under 75% shading. The root dry weight data indicated the superiority of Festuca grass sprayed with 1500 mg.l^{-1} of paclobutrazol and grown in an open field on other interactions, as it reached 22.67 and 23.33 g, respectively, while it decreased to the lowest 8.33 g in Agrostis grass unsprayed with paclobutrazol under 75% shading.

Table (4). Effect of triple interactions among shading levels, paclobutrazol concentrations and turf grass genera on different characteristics of turf grass genera.

Shading levels %	Paclobutrazol concentration (mg.L^{-1})	Turf grass genera	Characteristics			
			Plant density (plant number /100 cm^2)	Mowing numbers	Cumulative dry weight (g) of clipping yield	Roots dry weight (g)
0	0	C	34.67 de	9.00 a	494.67 e	15.67 d
		F	34.83 de	9.50 a	834.67 a	20.50 b
		A	57.83 b	7.50 bc	608.83 c	17.50 c
	750	C	37.50 cd	7.17 cd	388.33 f	15.67 d
		F	40.50 c	7.83 b	685.50 b	22.67 a
		A	63.00 a	5.83 ef	479.33 e	19.83 b
	1500	C	36.17 de	7.00 cd	390.00 f	15.83 d
		F	39.83 c	7.00 cd	688.50 b	23.33 a
		A	64.83 a	6.17 e	515.00 d	20.50 b
75	0	C	19.83 k	7.50 bc	185.67 j	8.50 f
		F	20.50 jk	9.17 a	350.50 g	9.00 f
		A	28.83 gh	7.00 cd	197.50 j	8.33 f
	750	C	23.17 i-k	5.83 ef	162.83 k	9.00 f
		F	24.00 ij	7.50 bc	282.17 h	11.00 e
		A	30.83 fg	5.67 ef	151.33 k	8.83 f
	1500	C	25.33 hi	6.17 e	186.00 j	9.00 f
		F	25.83 hi	6.83 d	257.83 i	11.17 e

A	32.67ef	5.33 f	160.00 k	9.67 ef

Means with same letter for each factor are not significantly different at 5% level based on Duncan's Multiple Range test.

Influence of triple interaction among shadow, paclobutrazol and turf grass genera on some growth quality characteristics

The results in Table (5) showed triple overlap among three factors had significant effects in those traits, and the biggest value for color degree, 7.48, was in Festuca genus grass growing under 75% shading and sprayed with 750 and 1500 mg.l^{-1} of paclobutrazol, while the lowest degree, 3.41, was for Cynodon genus grass grown under 75% shading and unsprayed with paclobutrazol. The results of coverage percentage showed a clear significant difference in the averages of this trait, and Festuca genus grass grown in an open field and sprayed with 750 and 1500 mg.l^{-1} of paclobutrazol gave highest significant values 82.69 and 83.52%, respectively, while the lowest value of 67.09% was for Cynodon genus grass grown under 75% shading and unsprayed with paclobutrazol. The highest significant values of total chlorophyll content 4.29 mg/gm and carbohydrate percent 0.66% were for Festuca genus grass sprayed with paclobutrazol at 1500 mg.l^{-1} and grown in open field, while this value of total chlorophyll content decreased to 2.57 mg/gm of fresh weight for Agrostis genus grass grown in the open field and unsprayed with paclobutrazol while for carbohydrate percent decreased to 0.51% for unsprayed cynodon genus grass with paclobutrazol and grown in an open field.

Table (5). Effect of triple interactions among shading levels, paclobutrazol concentrations and turf grass genera on different characteristics of turf grass genera.

Shading levels %	Paclobutrazol concentrations (mg.L^{-1})	Turf grasses genera	Characteristics			
			Color degree	Coverage percentage %	Total chlorophyll (mg.gm^{-1})	Carbohydrates %
		C	4.15 g	69.41 ef	2.98 e-h	0.51 f
	0	**F**	6.41 b	79.26 a-d	3.40 c-g	0.59 b-d
0		**A**	4.74 ef	69.54 ef	2.57 h	0.55 d-f
		C	4.30 fg	74.91 b-e	3.46 b-f	0.57 b-e
	750	**F**	7.04 a	82.69 a	4.05 ab	0.63 ab
		A	5.02 de	74.82 b-e	2.74 h	0.58 b-d
		C	4.48 fg	72.96 d-f	3.64 bc	0.59 b-d
	1500	**F**	7.00 a	83.52 a	4.29 a	0.66 a
		A	5.41 cd	75.76 b-e	2.93 f-h	0.58 b-d
		C	3.41 h	67.09 f	2.62 h	0.52 ef
75	**0**	**F**	6.41 b	74.72 b-e	3.00 d-h	0.57 b-e
		A	5.11 de	77.60 a-d	2.58 h	0.54 d-f
		C	4.11 g	73.37 c-e	2.79 gh	0.56 c-e
	750	**F**	7.48 a	80.47 ab	3.62 b-d	0.60 bc
		A	5.89 bc	82.50 a	2.80 gh	0.58 b-d

	C	4.11 g	73.43 c-e	2.83 f-h	0.58 b-d
1500	**F**	7.48 a	79.63 a-c	3.58 b-e	0.62 a-c
	A	6.37 b	81.05 ab	3.02 c-h	0.57 b-e

Means with same letter for each factor are not significantly different at 5% level based on Duncan's Multiple Range test.

Discussion

It can be shown in the final results during the study seasons that the two levels of shading significantly affected plant density, mowing number, cumulative dry weight, root dry weight, total chlorophyll content and carbohydrate percent where plants grown in the open (0% shading) were significantly superior to those grown in shade (75% shading) during the studied seasons and as in Tables (2 and 3). These results agree with what Douglas (13) and Mayasari *et al.* (23) stated that under shaded conditions the photosynthesis rate is decreased due to low light intensity, quantity, and quality and results in reduced turf quality. It may be that all turf grasses grow best in full-sun conditions. Furthermore, these results agree with what was presented by AL-Mizory (1) found that planting in open-air conditions with 0% shading resulting in a substantial increase in planting density (45.46 plant/100 m^2) and roots dry weight (19.06 g). Also, the results are similar to those reported by Jiang *et al.* (21) and Pessarakli (25) that *t*he leaves developing under low irradiance had fewer cells and chloroplasts, so chlorophyll content is less in shade than in full sun, and reduced shoot density as a result of light reduction may have adversely affected canopy physiological status such as photosynthesis, which in turn leads to limited carbohydrate synthesis.

Paclobutrazol has a considerable impact on the majority of characteristics. as shown in Tables (2 and 3) showed that the foliar spray of paclobutrazol on turf grass genera plants with concentrations of 750 and 1500 $mg.l^{-1}$ were significantly superior to unsprayed with paclobutrazol and led to increases in most studied characters including plant density, dry root weight, color degree, coverage percentage, total chlorophyll, and carbohydrate content and the contrast led to decreased mowing number and cumulative dry weight of clipping yield these findings are consistent with those reported by Dunne *et al.* (14) that the plant growth regulators such paclobutrazol have been demonstrated to boost leaf color and photosynthetic capability in addition to reducing clipping output, the high concentrations of paclobutrazol decrease the mowing number and cumulative dry weight for clipping yield, the main advantage of growth regulator use is a positive effect on turf grass growth and tolerance to various types of stress, thus, it is recommended for low-input maintenance turf grasses to reduce mowing expenses (27). Paclobutrazol also stimulates biosynthesis of endogenous cytokinins, maximising chloroplast differentiation, chlorophyll biosynthesis, and delaying degradation, as recorded by Arêde *et al*(6). Also, Volterrani *et al.* (35) recorded that the drop in mass manufacturing has been observed to increase over time 4 weeks following pacloburazol application, mass decrease in 'Patriot' Bermuda grass (*Cynodon dactylon* x *C. transvaalensis*) was observed to be up to 91 percent. The data in same tables for turf grasses genera indicated that fescue

grass was significantly superior to other turf grasses genera in mowing number, dry weight cumulative, root dry weight, color degree, coverage percentage, total chlorophyll content, and carbohydrate content. This may be due to the fact that this grass featured rough leaves and its ability to form turf with a rough texture (26). The highest values of plant density shown in Agrostis genus may be explained as a result of the increased density of vegetative growth in the spring and autumn seasons. The variation in these characters among genera might be due to the difference in the genetic potential (33).

The triple interaction among levels of the studied factors clarified, as in Tables (4 and 5), that there were significant differences in the averages of all traits. The growth of Festuca genus grass in an open field and spray with 1500 $mg.l^{-1}$ paclobutrazol gave highest significant values of root dry weight, total chlorophyll content, and carbohydrate percent were for Festuca genus grass sprayed with paclobutrazol at concentration 1500 $mg.l^{-1}$ and grown in open field, but the same treatment with sprayed 750 led to a significant increase in mowing number and cumulative dry weight of clipping yield. Also, the same genus of turf grass in the same condition without spray with paclobutrazol gave significant increase in coverage percentage; the results of the triple interaction can be explained by looking at the individual elements and their influences on the qualities being researched.

Conclusion

The shade levels had a substantial impact on plant density, mowing frequency, cumulative dry weight of clipping yield and root dry weight, total chlorophyll and carbohydrate percentage. The highest numbers were recorded for turf grasses grown in the open field and were superior to those grown under 75% shading, with no significant difference in degree of color and coverage percentage according to the different levels of shading. As for Paclobutrazol, the highest values of color degree, coverage percentage, total chlorophyll content, and carbohydrate percent were obtained when turf grasses were sprayed with concentrations of 1500 and 750 $mg.l^{-1}$ of paclobutrazol, respectively, in comparison with control treatment, except plant density, mowing number, and cumulative dry weight of clipping yield, which decreased. As for turf grass genera, fescue genera were significantly superior to Bermuda grass and Agrostis turf grass genera except plant density, whereas Agrostis genus was significantly superior to other turf grass genera. As for triple interaction, many characteristics, such as mowing number, cumulative dry weight of turf grass clipping yield, dry root weight, color degree, coverage percentage, total chlorophyll, and carbohydrate percentage, were found to be highest in *Festuca* genus sprayed with 750 and 1500 $mg.l^{-1}$ of paclpbutrazol planted in open fields and under shading.

Conflict of interest

The authors have no conflict of interest.

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