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Quality and Establishment of Some Water-Conserving Turfgrass Species for Sustainable Development and Some Ecosystem Services in Arid Urban Environments

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Abstract: Turfgrasses are essential landscape plants with social, environmental, and aesthetic services for urban ecosystems. However, more is needed to know how to establish them so that they can benefit from their ecosystem services in urban environments. This research examined some quality and morphological and physiological factors for the establishment and social and environmental service assessment of three warm-season turfgrasses, including Kikuyu grass (*Pennisetum clandestinum*), bermuda grass (*Cynodon dactylon*), and buffalo grass (*Buchloe dactyloides*), compared to the cool-season grass of tall fescue (*Festuca arundinacea* Schreb.). The experiment was split-plot in time, based on a randomized complete block design with eight replications. The main plot was the season with four levels, and the subplot was the four turfgrass species types. The results indicated that seasons and turfgrass types and their interaction significantly impacted most measured variables ($p \leq 0.01$). Some quality measurements like turf density, color, texture, coverage, and quality after clipping and establishment confirmed the superiority of *Buchloe dactyloides* over the other species. Also, kikuyu grass showed higher turfgrass density, more potential for weed control, and higher coverage and growth rate but also showed invasiveness features. Tall fescue had the lowest visual aesthetic compared with the other turfgrass species. Warm-season turfgrasses adaptable to the ecology of the region should be used compared to tall fescue to achieve better turfgrass quality and social and ecosystem services for the sustainable development of arid urban environments.

Keywords: warm-season grass; cool-season grass; green space; landscape; ecosystem services

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1. Introduction

Despite the water shortage in many cities worldwide, irrigation of urban landscapes, especially turfgrass species, accounts for a considerable percentage (between 40% and 70%) of urban water consumption [1]. Conversely, urban green spaces are a fundamental infrastructure that positively affects cities' sustainability through their ecological, social, and economic benefits [2,3]. The cities' main sustainability performances in ecology, biodiversity, urban heat island mitigation, and recreation depend on conserving and developing urban green spaces [4,5]. Turfgrasses are one of the essential components of urban green spaces [6,7], providing many ecosystem services that other vegetation types offer. Functional, aesthetic, recreational, social, and economic services, as well as physical and mental health effects, are among the ecosystem services of turfgrasses in urban environments previously receiving emphasis [7]. Turfgrasses have a special aesthetic significance and offer a unique surface for leisure sports and activities [7,8]. Based on the literature, if lawns are managed extensively, they have high capacities to prevent soil erosion due to their high soil coverage and density [9], reduction of surface runoff, contribution to carbon sequestration [10], and adding biodiversity values to urban environments [11,12]. Despite such benefits, significant debates exist about expanding and maintaining them in arid urban landscapes due to their high water consumption [7]. To achieve sustainability in urban turfgrass management, researching, establishing, and adapting water-conserving turfgrasses is very important. One of the most effective strategies to reduce water consumption in turfgrass species is to select varieties and cultivars adapted to the region's climatic conditions [13]. Turfgrasses used in urban green spaces belong to the Poaceae family, which includes many different species and ecotypes [6]. Such variation can provide high adaptability for the species to different climatic conditions. Despite this, turf breeders still try to develop cultivars that can grow satisfactorily in various climates, soils, and environmental conditions [14].

The warm- and cool-season grasses comprise the two main turfgrass categories. While cool-season grasses grow most actively in temperatures between 16 and 24 °C, warm-season turfgrasses sprout and grow best in warm months at temperatures between 27 and 35 °C [15]. The most prevalent warm-season grasses, which are more drought-resistant than cool-season grasses, include bermuda grass, buffalo grass, bahia grass, zoysia grass, and St. Augustine grass [16]. Water-restricted countries are more likely to create these types of lawns because warm-season turfgrasses use less water than cool-season turfgrasses in desert climates. In temperate climatic regions, warm-season turfgrass species undergo browning and winter dormancy due to low temperatures, causing a clear seasonal pattern [17]. Law et al.'s study [18] examined the growth rate, clipping practices, and environmental impacts of warm- and cold-season grass species, and the greenhouse gas fluxes from turfgrass systems. In comparison to C_4 turfgrasses, which had mean CO_2 flux rates ranging from 0.273 to 0.361 g CO_2-C m^{-2} h^{-1}, C_3 turfgrasses had the greatest mean CO_2 flux rates, varying from 0.373 to 0.431 g CO_2-C m^{-2} h^{-1}. Turfgrasses classified as C_4 were more likely to be CH_4 sources, whereas C_3 grasses were frequently CH_4 sinks. The drought resistance, salt tolerance, and fertilizer response of warm-season turfgrasses have all been examined [19,20]. Local study is necessary to find warm-season turfgrasses that can remain green for a long time throughout each region's cold seasons.

The grass industry in many countries relies on the National Turfgrass Evaluation Program (NTEP) developed by Morris and Shearman [21] for the quality assessment of turfgrass in urban landscapes. Grass reformers, researchers, and experts in this field use the data obtained based on the NTEP to determine the degree of adaptation of the cultivars [22]. However, image-based systems are also emerging [23]. The evaluation process of the lawns is based on the visual estimation of a set of qualitative indicators such as color, density, softness, growth habit, and uniformity of the texture by scoring the grasses by a number between 1 and 9 by a group of experts, and the numbers above six are considered acceptable lawn qualities [21–23]. Studies have been carried out on the establishment and quality of turfgrasses worldwide. For example, Mortazavi and Rabbi [24] examined the ecological adaptation of some exotic turfgrass cultivars (*Poa pratensis*, *Lolium perenne*, and *Festuca rubra*) in Zanjan, Iran. The results showed that these varieties had different germination rates, cover, uniformity, texture, seasonal colors, and growth rates under drought conditions. Their ecological adaptation in arid regions should be examined under drought conditions. Saeedi Pooya [22] examined the compatibility of *Lolium perenne* var. Yarand, *Lolium perenne* var. Chadegan, *Festuca arundinacea* var. Chadegan, and *Lolium multiflorum* var. Chadegan in pure and mixed sowings in different seasons under the climatic conditions of Mashhad. Salehi and Khosh-Khui [25] also made qualitative evaluations of color, density, and uniformity in single-seed and mixed plantings of cool- and warm-season turfgrasses. In this research, the turfgrasses—perennial rye grass, kentucky blue grass, common bermuda grass, and creeping red fescue—in monoculture or in mixtures of 1:1 (by weight) and 1:1:1:1 (by weight) and two sport turfgrasses—BAR 11 (Barenbrug Co., Dandenong, Australia) and MM (Mommersteeg Co., Hilvarenbeek. The Netherlands)—were used. According to their results, a mixture of kentucky bluegrass (*Poa pratensis*) and bermuda grass (*Cynodon dactylon*) was the most suitable lawn mixture for Shiraz climate conditions.

Akbarzadeh [26] investigated the growth responses of buffalo grass and tall fescue under three regulated deficit irrigation levels (40, 70, and 100% of the water requirement). Compared to tall fescue, the results showed that buffalo grass had better performance and minor damage to its morphological and physiological traits under drought stress. Buffalo grass varieties were more resistant to water stress and weeds than tall fescue. Therefore, tall fescue is recommended in water-limited and cold winter areas, especially for over-seeding purposes. In Mediterranean settings, Martiniello and Andrea [27] evaluated the quality and adaptation rate of cool-season turfgrasses, including creeping red fescue, tall fescue, perennial rye grass, and kentucky blue grass. Kentucky blue grass and creeping red fescue, compared with tall fescue and perennial rye grass, were less successful in quality, color, and turfgrass cover.

In contrast, perennial rye grass and tall fescue's rate of climate adaptability was much more than that of kentucky blue grass in Mediterranean conditions. Johnson [28] reported the differences in the growth speed of fescue and buffalo grass. He suggested that fine fescue (*Festuca rubra* ssp. *rubra* L. 'Vista', *F. ovina* var. glauca Lam. 'Minotaur', *F. rubra* ssp. *commutate* Gaud. 'Jamestown II') covered 100% of the plots and gradually prevailed on the buffalo grass. Volterrani [29] stated that bermuda grass cultivars showed good adaptability to the climatic conditions of Italy. Although these cultivars are yellow in winter, this problem could be solved by planting them mixed with cool-season turfgrasses. Some management techniques can increase the period of greenness, color, density, and cold tolerance of these cultivars. Whitman et al. [30] showed that the cultivation of mixed warm-season grasses significantly reduced maintenance needs such as lawn mowing and the use of pesticides compared to single cultivations of these grasses.

This study will investigate the establishment and quality of three single-seed water-conserving warm-season turfgrass species and their seed mixes compared with the cool-season grass of tall fescue during four seasons of a year to suggest the most suitable species for future sustainable urban landscaping.

2. Materials and Methods

2.1. Experimental Design and Site Description

This field experiment was performed in Mashhad, Iran (elevation 989 m; mean annual rainfall 255.2 mm) in an arid to semi-arid climate region. Long-term maximum and minimum temperatures average 22 °C and 8.9 °C, respectively (Table 1).

Table 1. Monthly meteorological parameters of the experimental area.

	2015									2016		
	July	**August**	**September**	**October**	**November**	**December**	**January**	**February**	**March**	**April**	**May**	**June**
Total precipitation (mm)	0	0	0.1	0	15.6	16.4	16.5	18.1	16.3	48	87.8	44.6
Average temperature (°C)	28.8	29.6	26.8	21.4	17	8.8	5.4	6.8	7.8	11.7	15	23
Maximum temperature (°C)	40	40.6	39.8	33.4	35.9	22.4	23.5	22.2	27.4	29.1	32.6	36.8
Minimum temperature (°C)	14.6	18.6	13.7	8.6	3.6	0.6	−5.6	−4.5	−5	0.7	2.2	13
Relative humidity (%)	13.5	15.5	20.6	45.9	68.1	98.1	72.6	34	33.2	69.5	53.8	40.4

This study was conducted as a split-plot arrangement based on a randomized complete block design experiment with eight replications. Seasons of the year (summer, autumn, winter 2015, and spring 2016) were considered as the main plot, and four turfgrass species, including kikuyu grass (*Pennisetum clandestinum*), bermuda grass (*Cynodon dactylon*), buffalo grass (*Buchloe dactyloides*), and tall fescue (*Festuca arundinacea*) (Figure 1) were considered as subplots. Also, a mixture of these three types of grass with similar seed percentages were considered as subplots. However, as kikuyu grass was highly invasive, the plots with a mixture of the three warm-season grasses were shortly over-dominated by kikuyu grass, and our turfgrass analysis only showed the characteristics of this grass species. Therefore, this study eliminated these mixed turfgrass plot data from further analyses to avoid biases. Over-domination of kikuyu grass was considered one of the measurements of the invasive nature of this turfgrass species.

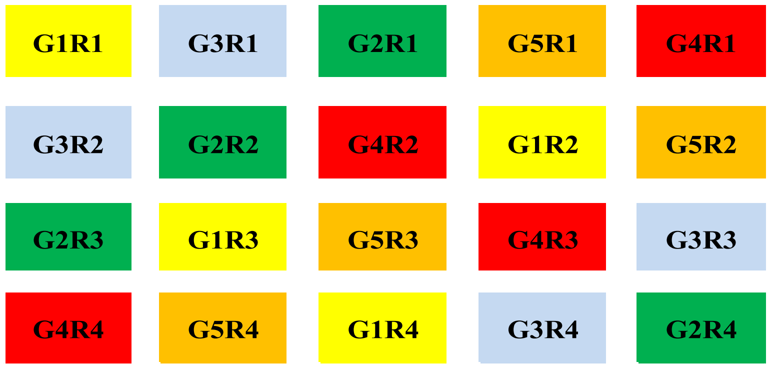

Figure 1. A schematic view of the experimental design (G1: kikuyu grass, G2: bermuda grass, G3: tall fescue, G4: buffalo grass, G5: mixture of the three warm-season grass types and R1–R4: Blocks or Replications).

2.2. Description of the Studied Species

2.2.1. Kikuyu Grass (*Pennisetum clandestinum*)

This grass species was introduced to Western Australia in the early 1920s. It is native to the central regions of Africa. However, the plant species now exists in many parts of the world, and in countries like Australia, New Zealand, and South Africa, it is considered one of the most popular grasses. This species is cultivated as a pasture plant for livestock grazing due to its high nutritional value (very digestible, low fiber, high protein, and good taste). However, it was initially considered a weed due to its fast coverage and aggressiveness [31]. Kikuyu grass spreads by large creeping fleshy rhizomes and stolons that sometimes grow up to 2 m. Its stolons produce a wide aerial section in each node, which sometimes reaches 60 cm in length. Among these features are fast regeneration power after picking or wear, high competition power with weeds, high growth rate and fully developed growth system, good tolerance to drought, heat, and salinity, covering power with high density, and stability. It is excellent for soil erosion control and is relatively shade-resistant [32,33]. This grass species, like bermuda grass, has a particular photosynthetic pathway that enables it to absorb carbohydrates at a high rate and grow rapidly during high solar radiation intensity and warm temperature periods. However, unlike bermuda grass, it maintains its constant growth rate under lower temperatures [33]. The optimal temperature for its growth is 18–30 °C, but it can maintain its active growth and color at lower (10 °C) and higher (38 °C) temperatures [33]. It is dormant in winter, starts growing in spring, and grows rapidly in summer and early autumn [31].

2.2.2. Bermuda Grass (*Cynodon dactylon*)

This grass is resistant to salinity, drought, and flooding stress and can compete with weeds. It quickly produces thatch and needs to be defoliated continuously [26]. This grass has a strong creeping and transverse growth feature, and its establishment speed is good. Its expansion range is extensive, and it shows excellent tolerance for environmental stresses [29]. Also, this grass is adaptable to a wide range of weather conditions and cannot only adapt to hot season areas but can also be established in areas where cold climate grasses are limited due to drought and salinity stress [26]. Its optimal growth temperature range is 27 to 35 °C. The grass leaves turn brown in winter. This species originates from the Middle East (Southwest Asia) [34].

2.2.3. Buffalo Grass (*Buchloe dactyloides*)

This species, native to semi-arid regions of North America [8,35], is a low-growth grass species with a soft texture that is remarkably resistant to hot and dry conditions [26]. It is an effective soil erosion controller, requiring minimal maintenance and surviving under low fertilization and watering regimes. It is worth noting that it will turn light brown if not watered during the summer, but its quality will be significantly improved when watering is resumed.

2.2.4. Tall Fescue (*Festuca arundinacea*)

This species is drought-tolerant and has deep and strong roots [36]. It is one of the cold-season perennial herbaceous grasses with high resistance to foot rot in optimal growth conditions (spring and autumn) [36]. It is a coarse-textured grass that grows in masses and remains green throughout the year. This grass has excellent resistance to heat, shade-sun, and drought and is compatible with a wide range of soil conditions [37]. It also shows a terrific response to increased irrigation and fertilization. Long grass is incompatible with other grasses and acts as a weed, especially in combination with fine-textured grasses [37]. The tall fescue used in this experiment was the variety native to Fereydon Shahr in the Isfahan province of Iran. This area is a mountain region with cold winters, cool summers, and an altitude of 2490 above sea level.

2.3. Planting and Maintenance

The turfgrass species' seeds were planted in plots of 1×1 m^2 covered with a thin layer of leaf compost and manure. Irrigation was carried out based on reference evapotranspiration (ET0). Reference evapotranspiration (ET0) was measured using an evaporation pan class A, which was installed within the experimental site. The amount of evaporation was calculated using the following formula:

$$\mathrm{ET0} = \mathrm{ECA} \times K_p \quad (1)$$

where ET0 was reference evapotranspiration (mm/day), ECA was the amount of evaporation from the Class A evaporation pan (mm/day), and K_p was the pan index, which was 0.77 for the Mashhad climate condition. The irrigation interval was once per day in the establishment stage, and it was then reduced to once every other day during the active growing period of the lawns.

The planting rate of the seeds was calculated considering their pure live seeds (PLS) by weight. Based on this calculation, the rate of the seedlings was 30 g/m^2 for buffalo grass, 10 g/m^2 for bermudagrass, 15 g/m^2 for Kikuyu grass, 50.5 g/m^2 for tall fescue, and 15.5 g/m^2 for the mixed turf according to the seed sizes, purity, and germination percentage. The mixture of the three warm-season grass types (kikuyu grass, bermuda grass, and buffalo grass) was sown with similar percentages of the species (based on 1000-seed weight and plot size, the quantity of seed used for the seed mixture was 7.8 g for buffalo grass, 3 g for bermuda grass, and 4 g for kikuyu grass).

The soil texture was loam, pH = 7.21, cation exchange capacity = 6.6 meq/100, and organic matter was 0.9%. The weed species, including narrow and broad leaves, were hand-pulled during the one year of this study. The soil was amended using 5% cow manure at the planting time. No chemical fertilizers were applied during the experiment as the aim was to identify the best established low-input turfgrass species for the study area.

2.4. Measured Factors

Visual quality was assessed using a visual scoring scale of 1–9, as introduced by the National Turfgrass Evaluation Program (NTEP) of the USA [21]. One was the lowest or poorest rating score, and nine was the highest or best rating score. A rating of six or greater was considered acceptable. Visual quality was evaluated 12 times during the experiment in monthly intervals. Chlorophyll and carotenoid content were measured in the laboratory in the middle of each season, and growth parameters were also measured in the field at the end of each month.

The overall plot color is represented by the seasonal color. On a scale of 1 to 9, 1 being straw brown and 9 being dark green, the ratings were given. Depending on the damage caused by diseases, insect pests, nutritional deficiencies, environmental stresses, and the capacity to retain color when seasonal changes occur, seasonal color can be utilized to successfully distinguish color variations in lawns (Figure 2). Assessing color is essential for measuring how warm-season grasses respond to cold stressors and how cool-season grasses respond to heat stressors [21]. Turfgrass density (visual estimate of living plants or tillers per unit area) was used using a 1–9 scaling system, with nine equaling maximum density [21]. The texture's visual rating was also based on the one to nine rating scale, with 1 equaling the coarse texture and 9 equaling the fine texture. Quality after clipping and general quality were also evaluated using the 1 to 9 scaling system (1 = poorest, 9 = best quality). A rating of six or above is generally considered acceptable.

(**A**) (**B**) (**C**)

Figure 2. Example images of scored color of buffalo grass based on NTEP method: (**A**) score 8, (**B**) score 5, (**C**) score 1.

Other traits such as uniformity, quality after clipping, resistance to weeds, and cold resistance were also evaluated using a 1 to 9 rating scale (1 = poorest, 9 = best) [21]. Visual ratings require consistency to ensure their merit. Therefore, total traits according to NTEP were measured every month, almost in the middle of the month. In the present study results, data from the three months in each season were averaged and reported as the seasonal effects. Four evaluators, including two men and two women, evaluated each plot in the measurement times, and the scores were averaged to enhance the accuracy of the results. To enhance the accuracy and consistency of the visual quality assessments using the NTEP method, a workshop on how to apply the method was held for the evaluators. The evaluators also reviewed the NTEP guideline and had access to example images of the different scored turfgrass species from our previous research work to use them as comparison images and references in their turfgrass evaluations and scorings. Some scored images for the color of buffalo grasses based on the NTEP method have been provided in Figure 2.

The coverage percentage can be quantified by the spread of stolon, rhizomes, and the primary tillering of the plants that occur after germination. A turfgrass is considered established if it covers more than 90% of the ground surface [23].

Also, to measure the leaves' chlorophyll content, 0.25 g of the fresh leaves were crushed in a mortar with 5 mL distilled water, and then they were mixed in balloons with distilled water. Then 0.5 mL of the resulting mixture was taken and mixed with 4.5 mL methanol and then was centrifuged for 15 min with 3500 rotations per minute. The solution was taken and used in a spectrophotometer, and the light absorbance at wavelengths of 470, 653, and 666 nm was red. The chlorophyll concentrations were obtained from the following equation [38].

$$\text{Chl a } (\mu\text{g/mL}) = (15/65 \times \text{A } 666) - (7/34 \times \text{A } 653) \tag{2}$$

$$\text{Chl b } (\mu\text{g/mL}) = (27/05 \times \text{A } 653) - (11/21 \times \text{A } 666) \tag{3}$$

$$\text{Carotenoid } (\mu\text{g/mL}) = (1000 \times \text{A } 470) - (2/860 \times \text{Chl a}) - (129/2 \times \text{Chl b})/245 \quad (4)$$

$$\text{Chl c } (\mu\text{g/mL}) = \text{Chl a} + \text{Chl b} \quad (5)$$

Growth parameters were also measured, including plant height with a ruler and leaf width with a caliper. The fresh weight of the leaves was measured with a digital scale, and their dry weight was also measured and recorded with the same scale after placing the leaves in an oven at 55 °C until a constant weight was obtained [5].

2.5. Statistical Analysis

JMP8 software was used to undertake analysis of variance (ANOVA) in the data. When an ANOVA revealed statistically significant treatment effects ($p \leq 0.05$), Tukey's test was used to compare the means. Excel package from Microsoft Office 365 was the program used to create the graphs.

3. Results

The results of the analysis of variance (Tables 2 and 3) indicated that season and turfgrass types significantly affected all the measured variables reported in these tables ($p \leq 0.05$). Also, the interaction effect of the season and turfgrass types was significant for all the measured traits ($p \leq 0.05$) except for total chlorophyll and carotenoids.

Table 2. Analysis of variances (mean squares) related to visual quality assessment of the turfgrasses in different seasons.

Source	d_f	Color	Density	Turf Texture	Uniformity of Turf	Weed Score	Resistance to Cold	General Quality	Coverage
Block	3	1.28	2.92	0.67	4.27	3.16 *	2.95	2	6.66 **
Season	3	141.79 **	11.25 *	22.28 **	11.51 *	11.78 **	123.38 **	158.59 **	21.83 **
Error a	9	1.55	2.45	3.27	3.37	1.25	1.26	0.98	1.02
Grass	3	69.94 **	69.49 **	9.02 *	79.22 **	51.11 **	24.60 **	21.97 **	188.74 **
Grass × season	9	22.15 **	14.68 **	19.88 **	12.25 **	8.26 **	23.01 **	30.25 **	23.13 **
Error b	36	1.78	3.2	2.13	2.53	2.16	1.59	1.09	2.48

**, *, significant at 1 and 5% probability levels, respectively.

Table 3. Analysis of variances (mean squares) related to morphological and physiological traits of the turfgrasses in four different seasons.

Source	d_f	Quality after Clipping	Height	Leaf Width	Fresh Weight of Clipping	The Dry Weight of Clipping	Chlorophyll a	Chlorophyll b	Total Chlorophyll	Carotenoids
Block	3	2.64	54.45 **	0.009	79.611 *	3.5	2.05	0.87	3.69	0.4
Season	3	5.57 *	568.24 **	0.1 **	12,520.8 **	1025.34 **	6.05 *	5.16 **	10.40 **	1.43 *
Error a	9	1.36	7.31	0.006	13.18	4.02	1.72	0.31	1.18	0.31
Grass	3	3.21 *	404.41 **	1.51 **	11,626 **	248.25 **	6.03 **	16.79 **	18.62 **	2.98 **
Grass × season	9	4.27 **	136.48 **	0.1 **	7165.38 **	236.42 **	1.83*	1.27 **	1.77	0.6
Error b	36	1.08	13.19	0.008	65.33	5.45	0.88	0.41	1.03	0.43

**, * show significant at 1 and 5% probability levels, respectively.

Tall fescue had a darker color than the other turfgrasses during the four seasons of this study (Figure 3a). Based on Figure 3b, the highest turfgrass density was related to kikuyu grass in the four seasons of the study except for spring, and the lowest density belonged to tall fescue in the summer season.

The uniformity of the turfgrasses was significantly affected by seasons (Table 2). The best and worst uniformity of the turfgrasses were observed in kikuyu grass, buffalo grass, bermuda grass, and tall fescue. The most uniform lawn type was buffalo grass in spring, and the least uniform grass was tall fescue in the summer season (Figure 3d).

The coarsest (worst) and the finest (best) leaf textures were observed in the winter and spring, respectively. Buffalo grass had the most delicate leaf texture among the four turfgrass types. However, the other turfgrasses had no significant difference in texture, although bermuda grass had a more acceptable texture than the other turfgrass species.

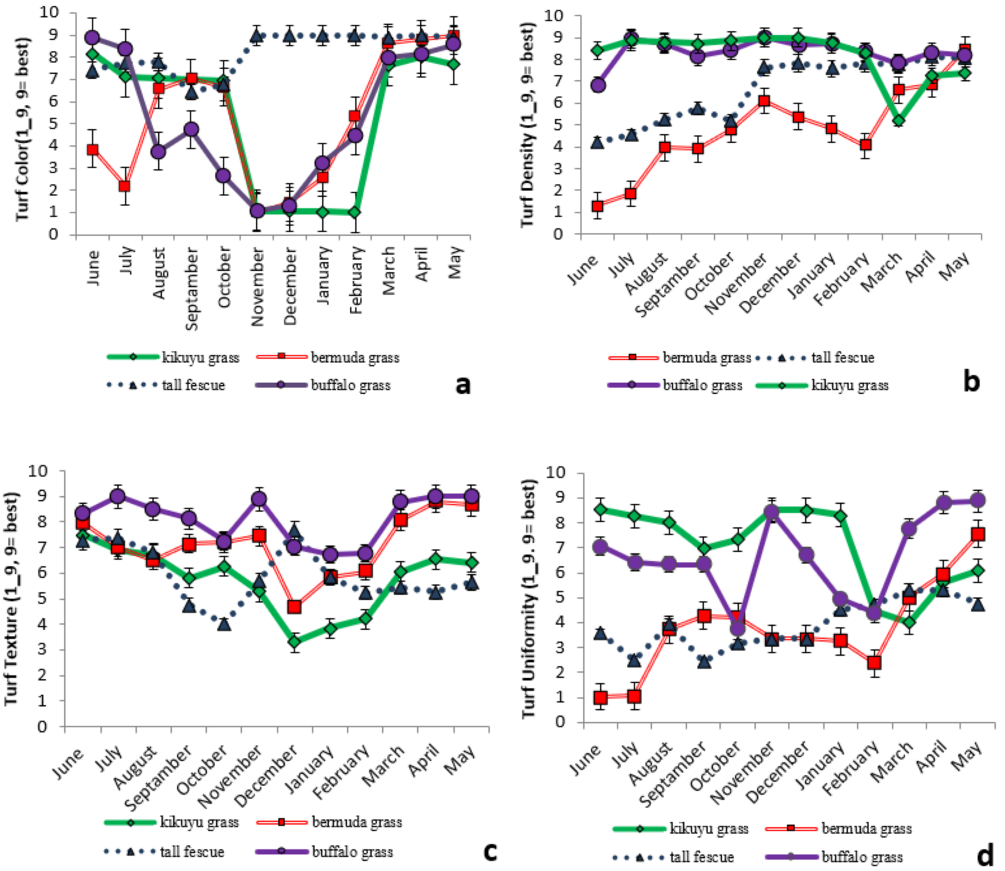

Figure 3. Monthly changes in color (**a**), density (**b**), texture (**c**), uniformity (**d**) in turfgrass species. Visual merit scores (1 = poorest, 9 = best) were measured according to NTEP, and during summer, autumn, winter 2015, and spring 2016. Error bars represent ± 1 standard error.

In this experiment, kikuyu grass and buffalo grass showed the fewest weeds compared to tall fescue and bermuda grass. The results showed that these four grass types were more robust against the weeds in the spring (Figure 4). The most common weeds included *Cyperus rotundus*, *Plantago major* L., *Datura stramonium* L., *Portulaca oleracea*, and *Chenopodium album*. In the winter, tall fescue was the most resistant to cold (maintaining plant color and active growth), and kikuyu grass was the most sensitive species. Buffalo grass was also a species minorly tolerant of autumn's cold weather (Figure 4).

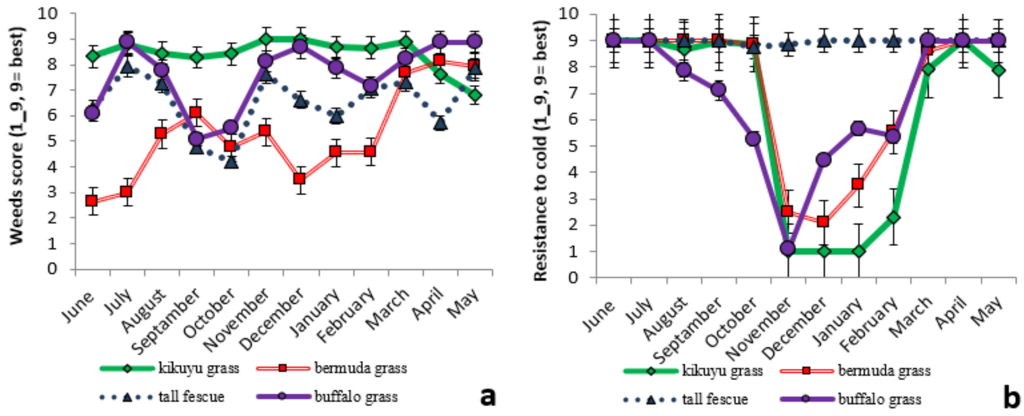

Figure 4. Monthly changes on weed attack score (**a**), cold resistance (**b**), in turfgrass species. Visual merit scores (1 = poorest, 9 = best) were measured according to NTEP and during summer, autumn, winter 2015, and spring 2016. Error bars represent ± 1 standard error.

The general quality of kikuyu grass was better than that of the other turfgrass species. Turf quality followed the sequence of kikuyu grass ≥ buffalo grass > tall fescue > bermuda grass. Generally, the quality of the turfgrasses was the best in the spring season. The seasonal effect on the turfgrasses' quality followed the order of spring > summer > autumn > winter. Results indicated that buffalo grass, kikuyu grass, and bermuda grass had higher visual attributes in the spring. All the turfgrass types had the lowest quality in winter except for tall fescue and buffalo grass, which had the most inferior quality in autumn. The turfgrass qualities in winter were tall fescue ≥ buffalo grass > bermuda grass > kikuyu grass (Figure 5a). The coverage percentage of the turfgrasses was generally higher in buffalo and kikuyu grasses. These two turfgrass types established and covered many plots during the summer, autumn, and winter. In the spring of the second year, buffalo grass had an excellent cover percentage, but kikuyu grass did not maintain an acceptable cover percentage. The other two turfgrass species, tall fescue and bermuda grass, had an increasing trend and reached an adequate coverage percentage level (in the spring of the second year) (Figure 5b).

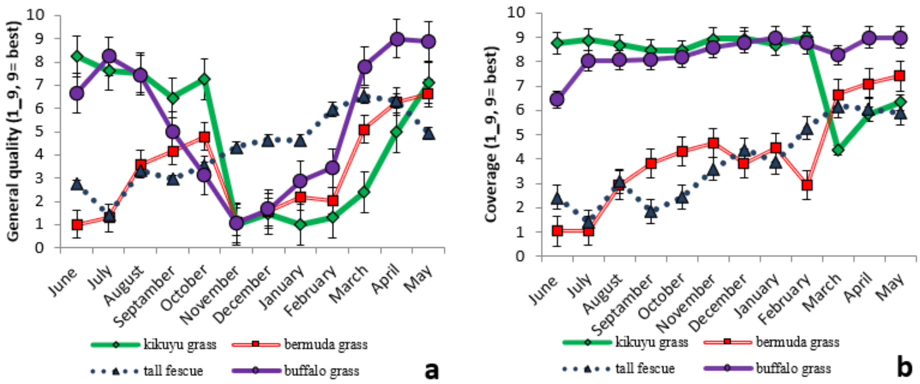

Figure 5. Monthly changes in general quality (**a**), coverage (**b**) in turfgrass species. Visual merit scores (1 = poorest, 9 = best) were measured according to NTEP, and during summer, autumn, winter 2015, and spring 2016. Error bars represent ± 1 standard error.

The mean quality after clipping was the lowest in tall fescue grass compared to the other turfgrasses, and buffalo grass had the best performance. According to Figure 6, among the seasons, autumn was the season in which the turfgrasses had the lowest quality after clipping.

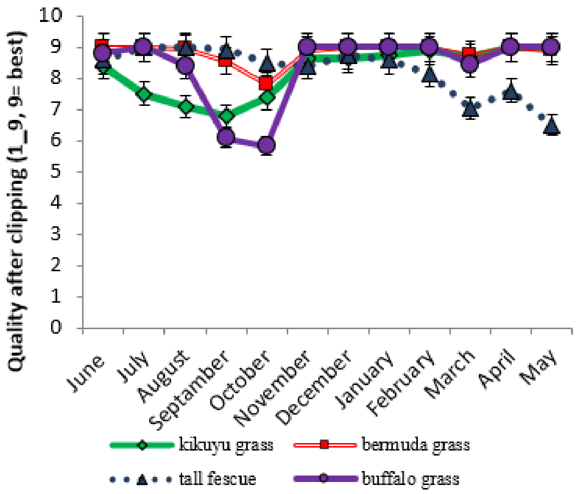

Figure 6. Monthly changes in quality after clipping in turfgrass species. Visual merit scores (1 = poorest, 9 = best) were measured according to NTEP, and during summer, autumn, winter 2015, and spring 2016. Error bars represent ± 1 standard error.

Among the studied plants in this experiment, kikuyu grass showed the highest values for plant height (21.04 cm), leaf width (0.58 mm), and fresh and dry weight (80.8 and 14.09 g, respectively). Also, bermuda grass showed the lowest plant height (12.72 cm), leaf width (0.19), and fresh and dry weight among the turfgrasses (23.22 and 8.48 g, respectively). There were significant differences in the growth of the plants in different seasons. The lowest height and width of the leaves were observed in summer, which might be due to the greater time required to establish the turf after planting. Also, the lowest clipping fresh and dry weight was achieved in the winter season (Figure 7).

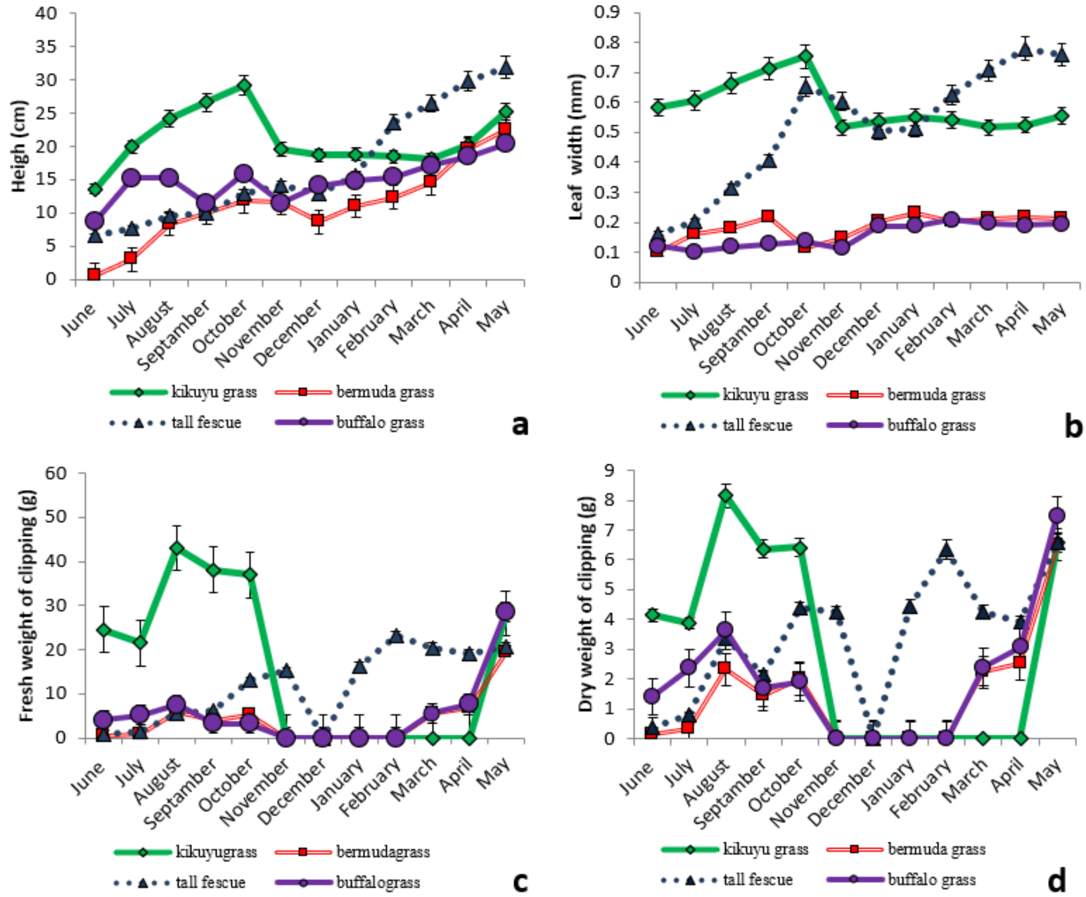

Figure 7. Monthly changes on height (**a**), leaf width (**b**), fresh weight of clipping (**c**), and dry weight of clipping (**d**) in turfgrass species. Visual merit scores (1 = poorest, 9 = best) were measured according to NTEP, and during summer, autumn, winter 2015, and spring 2016. Error bars represent ± 1 standard error.

The variance analysis on the chlorophyll a and b content showed that the interaction effect of the species and seasons was significant at a 1% probability level. However, there were no significant interactions between the species and the season's total chlorophyll in terms of chlorophyll content (Table 3). According to Figures 8 and 9, among the seasons, winter was the season when the species had the highest carotenoid content and the lowest amount of chlorophyll. Among the species, tall fescue had the highest amount of chlorophyll a, b, and total chlorophyll and the least amount of carotenoid.

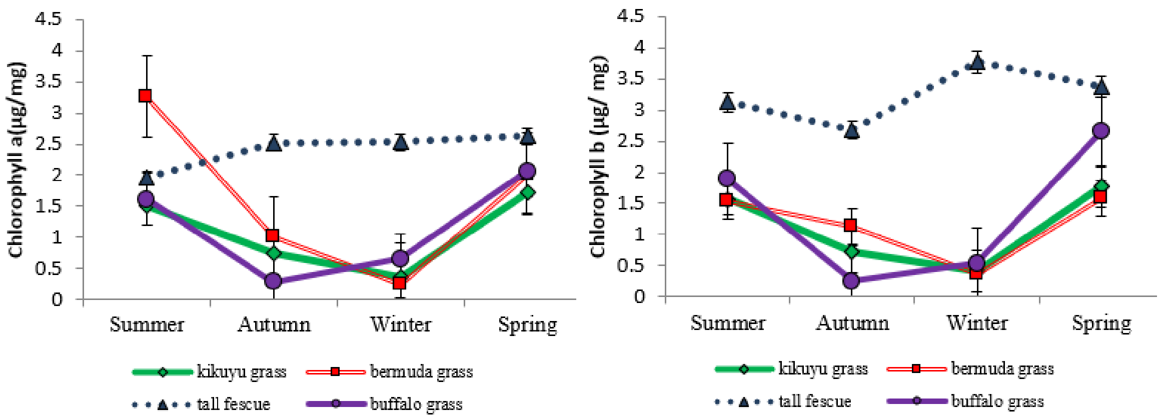

Figure 8. Interaction effect between the season and turfgrass types on chlorophyll a (**left**) and chlorophyll b (**right**). Error bars represent ± standard error.

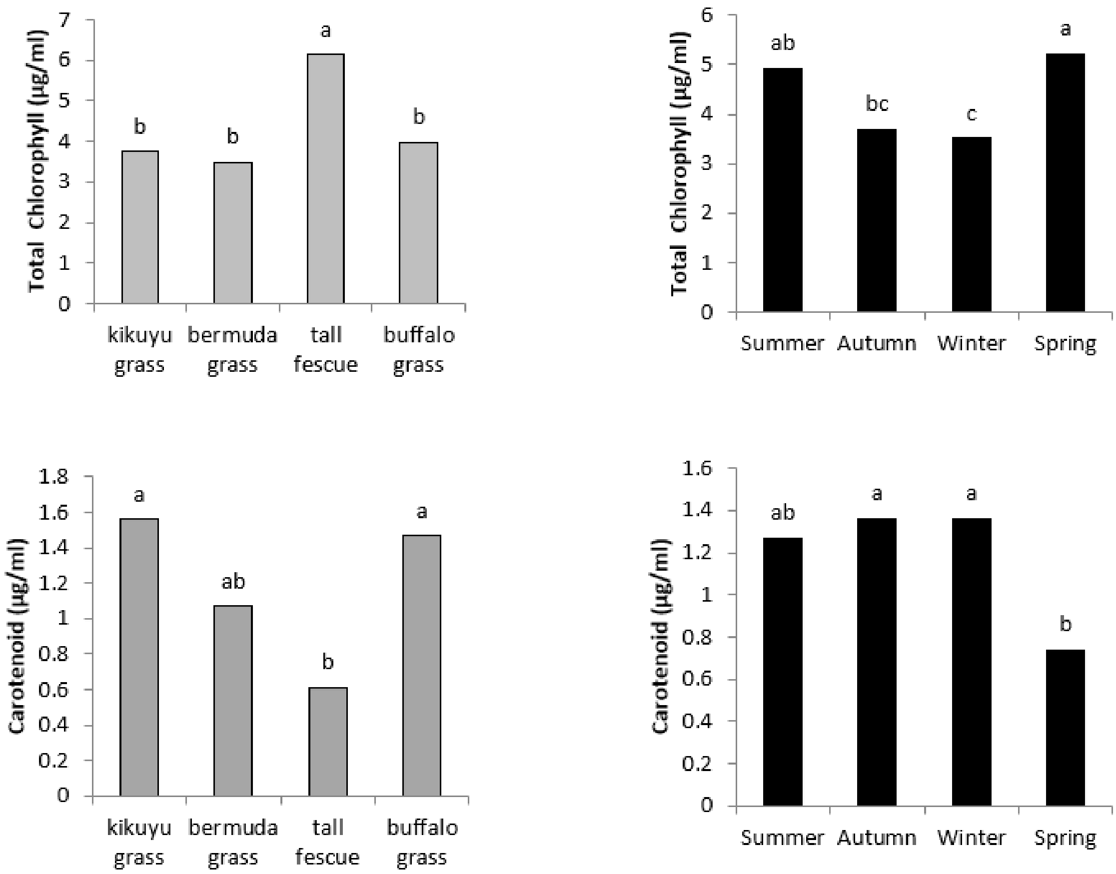

Figure 9. Differences in total chlorophyll and carotenoid contents of the examined turfgrass species in four seasons. The same letters indicate no significant differences at the probability level ($p \leq 0.05$) based on the Tukey test (a to c represents the highest and the lowest total chlorophyll and carotenoid contents, respectively).

Table 4 shows details of the qualitative assessment of the four turfgrass species studied in this study's four seasons.

Table 4. Qualitative assessment of the studied turfgrass species in four seasons.

	Color				Turf Density				Turf Texture				Uniformity of Turf				Amount of Weeds				Resistance to Cold				General Quality				Establishment of Turf				Quality after Clipping			
	s	a	w	p	s	a	w	p	s	a	w	p	s	a	w	p	s	a	w	p	s	a	w	p	s	a	w	p	s	a	w	p	s	a	w	p
Kikuyu Grass	*			*	*	*	*	*	*			*	*	*	*		*	*	*	*	*	*		*	*	*		*	*	*	*		*	*	*	*
Bermuda Grass	*			*		*		*	*	*		*				*				*	*	*		*				*	*			*	*	*	*	*
Tall Fescue	*	*	*	*			*	*	*		*						*	*		*	*	*	*	*			*	*	*			*	*	*		*
Buffalo Grass	*			*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*			*	*			*	*	*	*	*	*	*	*	*

*, means the attribute has received an acceptable grade (6 out of 9 or above based on NTEP) in the given season, (s) summer, (a) autumn, (w) winter, and (p) spring.

4. Discussion

In this study, visual quality measurements indicated the superiority of buffalo grass over the other studied grasses in a one-year study. Buffalo grass could establish quickly and produce an acceptable density, texture, and resistance to weeds during the four seasons of this experiment. However, it could not maintain an acceptable color and overall quality during winter and autumn and was not resistant to cold. It went to dormancy faster than the other species. Despite this species, kikuyu grass generated an acceptable turf density, low weed abundance score, and high quality after clipping in all four studied seasons, which could contribute to better social and ecological services of this turfgrass species [7]. Kikuyu grass did not show high-quality color, texture, and general turfgrass quality in autumn and winter. However, compared to the other warm-season grasses, it was resistant to the cold autumn weather conditions. The only problem for this species in spring was the lack of uniformity.

Based on this study's results, bermuda grass performed excellently in all the measured qualitative traits during the spring. This grass type had a good quality after clipping in all four studied seasons. This trait can be desirable for places where the lawn is constantly being clipped. However, compared to the other grass species in this experiment, it could have had a better quality in winter. Therefore, it is not recommended for the city of Mashhad, where a quality lawn is needed during the four seasons of the year. Bermuda grass survives the dormancy period using the reserves of non-structural carbohydrates and nitrogen compounds accumulated in its storage organs [39,40]. Also, the tall fescue's color and quality after clipping were high in all four study seasons. The best quality for this cool-season grass was observed during the spring season. The main problem with the quality of this grass species was the lack of uniformity, which is directly related to the aesthetic performance of the turfgrass species [22].

Color is one of the best indicators of the turfgrasses' general quality conditions [40]. Beard [38] stated that most individuals prefer dark green turfgrasses. In this study, all the visual quality measurements were the best in summer and the poorest in winter, disregarding the type of turfgrass. The turf color was lighter in winter and turned into a greener color in the spring. The highest color quality in buffalo grass was observed in spring and summer. In this study, tall fescue was darker than the three warm-season grass species during the four seasons. In a survey by Martiniello and Andrea [27], the effect of season on the color of different species, including perennial ryegrass, kentucky bluegrass, and tall fescue, was significant. Other researchers have also studied the color differences among lawn genotypes [25]. Genetic color differences among the grass species such as buffalo grass, blue grama, tall fescue, kentucky bluegrass, and agropyron and their mixtures were also reported by Bunderson et al. [41] based on the qualitative assessment scoring of 1 to 9. They also confirmed the color differences between the different grasses. In a study by Martiniello and Andrea [27] on cool-season species of perennial ryegrass, kentucky bluegrass, and tall fescue, the best coverage rate of the grass was in the spring and summer, and the lowest density was reported in winter, which corresponds with the results of our current experiment. Many researchers studied the density of different genotypes of turfgrasses using visual assessment methods. For example, Salehi and Khosh-Khui [25] looked at mixtures of various grasses. They suggested that varieties of native fescue and bermuda grass had the least coverage. A mix of kentucky and bermuda grass had the highest coverage rate in Shiraz, Iran. In the present experiment, buffalo grass maintained a similar density during the four seasons. However, kikuyu grass showed a greater density during the three seasons of summer, autumn, and winter than the other species, while at the beginning of the spring, it could not reach its initial density. As a cool-season grass, tall fescue increased its density continuously during the four seasons of the study so that the highest density was observed in the last season of the study, spring. The density in bermuda grass decreased much more by cold than in other warm-season grasses, but at the beginning of spring, this grass increased its density like the other grass types. It seems bermuda grass reached an acceptable density and visual quality in the second year after planting. Regarding the texture of the grasses, buffalo grass showed the narrowest leaves. Although the other three types of grass were ranked statistically similarly, kikuyu grass and tall fescue had coarser leaves than bermuda grass. Further, all three warm-season types of grass had the coarsest leaves in winter, and the spring's finest leaves (Figure 7). The differences in leaf texture among the turfgrass species have also been previously reported by Saeedi Pooya [22] and Akbarzadeh [26]. An important point that should be carefully considered in turfgrass planting is not to plant a mixture of narrow and broad-leaf grasses. High density requires a high-quality lawn, as the fundamental function of grass is to cover the soil [42]. In sports field, high density is needed to cover the soil and form a cushion to reduce injury to players and provide a smooth platform for sports activities [43]. While high density is a positive turfgrass attribute for aesthetic and sports applications of lawn species, very high density negatively affects other turfgrass ecosystem services, causing low water flow, which lowers the flow's velocity, gives infiltration more time, and reduces the erosion control capacity of the turfgrass species [44].

In terms of uniformity in the grasses, the most uniformity was related to the spring, and the lowest uniformity was observed in the winter. As the planting time increased, the uniformity of buffalo grass, bermuda grass, and tall fescue increased during the four seasons of the study, and the highest uniformity among the three species was observed in the spring. Kikuyu grass had the highest uniformity in the summer, and this uniformity continued to decline and reach its lowest level in the spring. The differences in texture, density, competition between the species, color, and clipping height may affect the uniformity rate [26]. This reduction in uniformity of kikuyu grass in the spring can be related to its late growth start in the spring compared to that in the other species and can lead to weed growth and non-uniformity of the plots. Akbarzadeh [26] reported different uniformities among tall fescue, bermuda grass, and buffalo grass in Mashhad weather conditions and showed the superiority of buffalo grass compared to the other two turfgrass species in this city. Having a uniform and less weed-grown lawn will contribute to the lawn's aesthetic and low maintenance. However, it should be noted that alternatives to natural lawns, such as ground cover plant species and artificial lawns, have similar maintenance needs. Therefore, selecting the best turfgrass species should be based on multicriteria decision-making approaches by considering all lawns' aesthetic, social, recreational, functional, and ecosystem services [7].

At the beginning of the cold season in autumn in this study, the three warm-season species' reactions started with varying degrees. The most sensitive species to cold in autumn was buffalo grass, which went to dormancy at the beginning of September and began its growth earlier than the other species and showed signs of growth in winter from mid-December, indicating that its dormancy period is in autumn. This phenomenon differed in kikuyu grass and bermuda grass, which went to dormancy in winter. In contrast, tall fescue was the most resistant species in all four seasons of the year and had no dormancy period. Liu et al. [45] showed that tall fescue had higher heat and cold resistance than bermuda grass. The reason might be that tall fescue accumulates higher proline and H_2O_2 content as an antioxidant than bermuda grass after heat treatment.

According to this experiment's results, buffalo grass species, compared to other species, had a significantly higher rate of deployment and coverage during the four studied season (Table 4) The coverage rate of kikuyu grass was also acceptable, and the same was true in the experiment's first three seasons. However, kikuyu grass could not reach its initial establishment after passing the cold weather of winter, and its coverage rates were the lowest in the spring among the turfgrass types. The establishment and coverage rate of bermuda grass and tall fescue increased as the experiment passed. This study also showed that after the mixed planting of the three warm-season types of grass at the early stages of the planting, kikuyu grass was the fastest-growing species and became a dominant species compared to the other species in the plots. This species did not allow the other species to grow. The species should be selected to have the most color and growth rate similarity if an acceptable quality in the mixture of grasses is desired. In addition, none of the species should prevail over the other species and show signs of invasiveness [44]. Invasive grasses are not visually pleasant. Some are very pale and weak-looking and will grow outwards and sideways rather than straight upwards. Invasive grasses generally do not have a perfect color and will often grow more quickly than the more desirable grass types. They can quickly shadow out the desirable grasses, causing bare patches and allowing them to expand further into the available spaces. While the feature of fast grass coverage can be an essential factor in the restoration and over-seeding of the grass, particularly in sports lawns, it is neither visually aesthetic nor ecologically sound when it comes to an invasiveness feature and fast domination of one species over the other turfgrass species. Johnson [28] reported the differences in the growth rates of tall fescue and buffalo grass so that tall fescue gradually covered 100% of the plots and dominated the buffalo grass.

5. Conclusions

Turfgrasses are considered an integrated and crucial component of urban green spaces in the study area, the city of Mashhad. Therefore, the outcomes of this experiment on water-conserving turfgrass species selection are of great help to urban policymakers and landscape professionals of this region and other regions with similar climate conditions worldwide. Kikuyu grass was an invasive turfgrass species in this experiment for the studied area. It did not allow the minimal growth of other turfgrasses in the mixed cultivation. It had a very high stolon growth rate even in single species plantings, which is considered a biodiversity threat to the region's ecology. In addition to being invasive, this species did not have an optimum growth and color in the four seasons of the experiment. Therefore, it is not recommended for the region's urban landscaping. Despite the warm-season grasses in this study that all showed dormancy and periods of yellowness in cold seasons, tall fescue, as a cold-season grass species, did not show a dormancy period by being almost green in the four studied seasons. In addition, tall fescue was a native species that did not bring ecological invasiveness or threat to the region. However, it represented low visual quality attributes such as low coverage, coarse texture, and low quality after clipping. Among the studied turfgrass species in this experiment, buffalo grass (*Buchloe dactyloides*) was superior for most of the studied traits, such as turf density, color, texture, and quality after clipping and establishment in the city of Mashhad's climatic conditions. We recommend it as a suitable species for water-wise turfgrass establishment in this city. However, the species is non-native to the region. This study and our other studies (yet to be published) showed the current practice of planting this turfgrass species in controlled areas such as sports fields or urban landscape planting beds with edges together with applying turfgrass management actions such as regular mowing has represented this species as non-invasive with favorable ecosystems services. However, further research may require quantifying its effect on the long-term biodiversity, ecology, and ecosystem services it can bring to the studied city and to other urban environments worldwide.

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References

1. Nazemi Rafi, Z.; Kazemi, F.; Tehranifar, A. Effects of various irrigation regimes on water use efficiency and visual quality of some ornamental herbaceous plants in the field. *Agric. Water Manag.* **2019**, *21*, 78–87. [CrossRef]
2. Kazemi, F.; Mohorko, R. Review on the roles and effects of growing media on plant performance in green roofs in world climates. *Urban For. Urban Green.* **2017**, *23*, 13–26. [CrossRef]
3. Nazemi Raf, Z.; Kazemi, F.; Tehranifar, A. Public Preferences Toward Water-wise Landscape Design in a Summer Season. *Urban For. Urban Green.* **2020**, *48*, 126563. [CrossRef]
4. Shi, Y.; Guofu, Y.; Du, Y.; Ren, Y.; Lu, Y.; Fan, L.; Chang, J.; Ge, Y.; Bao, Z. Estimating irrigation water demand for green spaces in humid areas: Seeking a sustainable water management strategy. *Urban Water J.* **2017**, *15*, 16–22. [CrossRef]
5. Kazemi, F.; Beecham, S.; Gibbs, J. Streetscape biodiversity and the Role of bioretention swales in an Australian urban environment. *Landsc. Urban Plan.* **2011**, *101*, 139–148. [CrossRef]
6. Rabbani, M.; Kazemi, F. Investigating strategies for optimum water usage in green spaces covered with lawn. *Desert* **2015**, *12*, 217–230.
7. Monteiro, J.A. Ecosystem services from turfgrass landscapes. *Urban For. Urban Green.* **2017**, *26*, 151–157. [CrossRef]
8. Hedblom, M.; Lindberg, F.; Vogel, E.; Wissman, J.; Ahrne, K. Estimating urban lawn cover in space and time: Case studies in three Swedish cities. *Urban Ecosyst.* **2017**, *20*, 1109–1119. [CrossRef]
9. Dong, Y.; Lei, T.; Li, S.H.; Yuan, C.; Zhou, S.H.; Yang, Z. Effects of rye grass coverage on soil loss from loess slopes. *Int. Soil Water Conserv. Res.* **2015**, *3*, 170–182. [CrossRef]
10. Bretzel, F.; Gaetani, M.; Vannucchi, F.; Caudai, C.; Grossi, N.; Magni, S.; Caturegli, L.; Volterrani, M. A multifunctional alternative lawn where warm-season grass and cold-season flowers coexist. *Landsc. Ecol. Eng.* **2020**, *16*, 307–317. [CrossRef]
11. Winkler, J.; Pasternak, G.; Sas, W.; Hurajová, E.; Koda, E.; Vaverková, M.D. Nature-Based Management of Lawns—Enhancing Biodiversity in Urban Green Infrastructure. *Appl. Sci.* **2024**, *14*, 1705. [CrossRef]
12. Chou, M.; Pavlou, D.; Rice, P.J.; Spokas, K.A.; Soldat, D.J.; Koch, P.L. Microbial diversity and soil health parameters associated with turfgrass landscapes. *Appl. Soil Ecol.* **2024**, *196*, 105311. [CrossRef]
13. Mirabile, M.; Bretzel, F.; Gaetani, M.; Lulli, F.; Volterrani, M. Improving aesthetic and diversity of bermuda grass lawn in its dormancy period. *Urban For. Urban Green.* **2016**, *18*, 190–197. [CrossRef]
14. Pessarakli, M.; Kopec, D. Comparing growth responses of selected cool- season turf grasses under salinity and drought stresses. *Turfgrass Landsc. Urban IPM Res. Summ.* **2008**, *158*, 55–60.
15. Du, H.; Wang, Z.; Huang, B. Differential Responses of Warm-season and Cool-season Turfgrass Species to Heat Stress Associated with Antioxidant Enzyme Activity. *J. Am. Soc. Hortic. Sci.* **2009**, *134*, 417–422. [CrossRef]
16. Romero, C.; Dukes, M. *Turfgrass and Ornamental Plant Evapotranspiration and Crop Coefficient Literature Review*; Agricultural and Biological Engineering Department, University of Florida: Gainesville, FL, USA, 2009. Available online: https://abe.ufl.edu/faculty/mdukes/turfgrass (accessed on 19 December 2018).
17. Croce, P.; De Luca, A.; Mocioni, M.; Volterrani, M.; Beard, J. Adaptability of warm season turfgrass species and cultivars in a Mediterranean climate. *Acta Hortic.* **2004**, *61*, 365–368. [CrossRef]
18. Law, Q.; Trappe, J.; Patton, A. Greenhouse gas fluxes from turfgrass systems: Species, growth rate, clipping management, and environmental effects. *J. Environ. Qual.* **2021**, *50*, 547–557. [CrossRef] [PubMed]
19. Fuentealba, M.; Zhang, J.; Kenworthy, K.; Erickson, J.; Kruse, J.; Trenholm, L. Transpiration responses of warm-season turfgrass in relation to progressive soil drying. *Sci. Hortic.* **2016**, *198*, 249–253. [CrossRef]
20. Pompeiano, A.; Giannini, V.; Gaetani, M.; Vita, F.; Guglielminetti, L.; Bonari, E.; Volterrani, M. Response of warm–season grasses to N fertilization and salinity. *Sci. Hortic.* **2014**, *177*, 92–98. [CrossRef]
21. Morris, K.N.; Shearman, R.C. NTEP Turfgrass Evaluation Guidelines Beltsville (MD): National Turfgrass Evaluation Program. 2008. Available online: http://www.ntep.org/cooperator.htm (accessed on 15 January 2013).
22. Saeedi Pooya, E.; Tehranifar, A.; Shoor, M.; Selahvarzi, Y.; Ansari, H. The use of native turf mixtures to approach sustainable lawn in urban landscapes. *Urban For. Urban Green.* **2013**, *12*, 532–536. [CrossRef]

23. Kazemi, F.; Golzarian, M.; Nematollahi, F. Quality assessment of turfgrasses using NTEP method compared to an image-based scoring system. *J. Ornam. Plants* **2020**, *10*, 177–178.
24. Mortazavi, S.M.; Rabbi Angurany, H. Evaluation of ecological compatibility of five external grass varieties conditions of Zanjan. In Proceedings of the First National Congress of Science and New Technologies in Agriculture, Zanjan, Iran, 9 September 2011. (In Persian).
25. Salehi, H.; Khosh-Khui, M. Turf monoculture cool-cool and cool-warm season seed mixture establishment and growth responses. *Am. Soc. Hortic. Sci.* **2004**, *39*, 1732–1735.
26. Akbarzadeh, M. The Effect of Deficit Irrigation on Traits and Growth Buffalo Grass, Fescue and Bermuda Grass. Master's Thesis, Ferdowsi University of Mashhad Iran, Mashhad, Iran, 2013. (In Persian)
27. Martiniello, P.; D'Andrea, E. Cool-season turf grass species adaptability in Mediterranean environments and quality traits of varieties. *Eur. J. Agron.* **2006**, *25*, 234–242. [CrossRef]
28. Johnson, P. Mixtures of Buffalograss and Fine fescue or Streambank Wheatgrass as a Low-maintenance Turf. *HortScience* **2003**, *38*, 1214–1217. [CrossRef]
29. Volterrani, M.; Gross, N.; Pardine, G.; Miele, S.; Gaetani, M.; Magni, S. Warm season turfgrass adaptation in Italy. *Int. Turfgrass Soc. Res. J.* **1993**, *8*, 1298–1309.
30. Whitman, B.; Iannone, B.; Kruse, J.; Unruh, B.; Dale, A. Cultivar blends: A strategy for creating more resilient warm season turfgrass lawns. *Urban Ecosyst.* **2022**, *25*, 797–810. [CrossRef]
31. Wilen, C.A.; Cudney, D.W.; Elmore, C.L.; Gibeault, V.A. Kikuyu Grass, Integrated Pest Management for Home Gardeners and Landscape Professionals (PEST NOTES), University of California Statewide Integrated Pest Management Program Agriculture and Natural Resources. 2011. Available online: www.ipm.ucdavis.edu (accessed on 15 May 2024).
32. Muscolo, A.; Panuccio, M.R.; Eshel, A. Ecophysiology of *Pennisetum clandestinum*: A valuable salt tolerant grass. *Environ. Exp. Bot.* **2013**, *92*, 55–63. [CrossRef]
33. Moore, G.; Sanford, P.; Wiley, T. *Perennial Pastures for Western Australia (Bulletin 4690)*; Department of Agriculture and Food Western Australia: Perth, Australia, 2006.
34. Nasrasafhani, M.; Razmjo, J. Comparison of drought tolerance of African grass cultivars for use in green spaces. In Proceedings of the First National Conference of Low-Water Green Spaces, Kashan, Iran, 5 May 2015. (In Persian)
35. Huff, D.R.; Peakall, R.; Smouse, P.E. RAPD variation within and among natural populations of outcrossing buffalo grass [*Buchloe dactyloides* (Nutt.) Engelm.]. *Theor. Appl. Genet.* **1993**, *86*, 927–934. [CrossRef]
36. Ghasemi Gahsare, M.; Kafi, M. *Scientific, and Practical Floriculture (Volume II)*, 3rd ed.; Day Negar Publishing: Isfahan, Iran, 2010. (In Persian)
37. Turgeon, A.J. *Turf Grass Management*; Reston Publishing: Reston, VA, USA, 1985.
38. Arnon, D.S. Copper enzyme in isolated chloroplast polyphenol oxidase in Beta Vulgaris. *J. Plant Physiol.* **1940**, *24*, 1–15. [CrossRef]
39. Giolo, S.; Macolino, M.; Barolo, E.; Rimi, F. Stolons reserves and spring green-up of seeded bermudagrass cultivars in a transition zone environment. *Hortic. Sci.* **2013**, *48*, 780–784. [CrossRef]
40. Trudgill, S.; Jeffery, A.; Parker, J. Climate change and the resilience of the domestic lawn Stephen. *Appl. Geogr.* **2010**, *30*, 177–190. [CrossRef]
41. Bunderson, L.; Johnson, P.; Kopp, K.; Dyke, A.V. Tools for evaluating native grasses as low maintenance turf. *Technol. Prod. Rep.* **2009**, *19*, 626–632.
42. Janakiram, T.; Namita, A. Genetic divergence analysis in turfgrasses based on morphological traits. *Indian J. Agric. Sci.* **2014**, *84*, 1035–1039.
43. Agnihotrl, R.; Chawla, S.L.; Patil, S. Evaluation of warm-season turfgrasses for various qualitative and quantitative traits under Gujarat agro-climatic conditions. *Indian J. Agric. Sci.* **2017**, *87*, 83–91.
44. Beard, J.B.; Green, R.L. The role of turfgrasses in environmental protection and their benefits to humans. *J. Environ. Qual.* **1994**, *22*, 452–460. [CrossRef]
45. Liu, M.; Sun, T.; Liu, C.; Zhang, H.; Wang, W.; Wang, Y.; Xiang, L.; Chan, Z. Integrated physiological and transcriptomic analyses of two warm- and cool-season turfgrass species in response to heat stress. *Plant Physiol. Biochem.* **2022**, *170*, 275–286. [CrossRef]