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Determination of Some Agronomic Proporties of Mixtures of Newly Developed Rhizome Tall Fescue and Some Turfgrass Species

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ABSTRACT

This study was conducted to determine the turfgrass performance of the mixtures newly developed Rhizome *Festuca arundinacea* Schreb. together with *Lolium perenne* L. and *Poa pratensis* L. cultivars in different ratios in Sakarya/Pamukova ecological conditions between 15 October 2016 and 15 October 2020. The experiment, 100% Fa, 100% Lp, 100% Pp lean sowing plots as well as mixtures of *Festuca arundinacea* in different ratios (90% Fa + 5% Lp + 5% Pp, 80% Fa + 10% Lp + 10% Pp, 70% Fa + 15% Lp + 15% Pp, 60% Fa + 20% Lp + 20% Pp, 50% Fa + 25% Lp + 25% Pp, 40% Fa + 30% Lp + 30% Pp, 30% Fa + 35% Lp + 35% Pp, 20% Fa + 40% Lp + 40% Pp, 10% Fa + 45% Lp + 45% Pp) was established in the randomized block design with four replications. In the study were measured; shoot length (cm), herbage yield (g m^{-2}), dry matter ratio (%), hay yield (g m^{-2}), root yield (g $m^{-2)}$ and visual turf quality (1-9 point) characteristics. According to the results of the research, the highest numerical values in terms of turfgrass quality were obtained from 50% Fa + 25% Lp + 25% Pp and 60% Fa + 20% Lp + 20% Pp mixtures and that, generally speaking, the other cultivars could be used in turf establishment in the region and in similar ecological conditions.

Keywords: *Cool season turfgrasses, shoot length, herbage yield, hay yield, root yield, turf quality.*

Yeni Geliştirilen Rizomlu Kamışsı Yumak ve Bazı Çim Türlerinin Karışımlarının Bazı Agronomik Özelliklerinin Belirlenmesi

ÖZ

Bu araştırma; yeni geliştirilmiş Rizomlu *Festuca arundinacea* Schreb. ile birlikte *Lolium perenne* L. ve *Poa pratensis* L. çeşitlerinden oluşan farklı oranlardaki karışımların yeşil alan performanslarının belirlenmesi amacıyla, Sakarya/Pamukova ekolojik koşullarında 15 Ekim 2016 - 15 Ekim 2020 döneminde yürütülmüştür. Deneme, %100 Fa, %100 Lp, %100 Pp yalın ekim parsellerin yanısıra; *Festuca arundinacea*'nın farklı oranlarda karışımları (%90 Fa + %5 Lp + %5 Pp, %80 Fa + %10 Lp + %10 Pp, %70 Fa + %15 Lp + %15 Pp, %60 Fa + %20 Lp + %20 Pp, %50 Fa + %25 Lp + %25 Pp, %40 Fa + %30 Lp + %30 Pp, %30 Fa + %35 Lp + %35 Pp, %20 Fa + %40 Lp + %40 Pp, %10 Fa + %45 Lp + %45 Pp) kullanılarak Tesadüf Blokları Deneme Deseni'nde 4 tekrarlamalı olarak kurulmuştur. Araştırmada; sürgün boyu (cm), yeşil ot verimi (g/m^2), kuru madde oranı (%), kuru ot verimi (g/m^2), kök verimi (g/m^2) ve çim kalitesi (1-9 puan) özellikleri incelenmiştir. Araştırma sonuçlarına göre çim kalitesi açısından en yüksek rakamsal değerler %50 Fa + %25 Lp + %25 Pp ve %60 Fa + %20 Lp + %20 Pp karışımlarından alınmış, ancak diğer karışımların da aldıkları tatminkâr puanlarla bölgede ve benzer ekolojik koşullarda çim alan tesisinde kullanılabileceği sonucuna varılmıştır.

Anahtar kelimeler: *Serin iklim çim buğdaygilleri, sürgün boyu, yeşil ot verimi, kuru ot verimi, kök verimi, çim kalitesi*

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1. Introduction

It is possible to see many different plant species and varieties that make up the green area texture around us. Among the ground cover plants used in landscaping, the largest share belongs to the turfgrasses plants. Turfgrass plants are the most common ground cover plants used in areas used for sports purposes, recreation areas and erosion prevention [1, 2, 3].

Turfgrass areas used for sportive purposes in the world are primarily football, golf and tennis fields. The establishment of these areas is very costly. In addition, this sector, which has very high costs and earnings for players, has become a large global market. For these reasons, these sports fields should be planned very well, they should be established with the highest quality and their subsequent maintenance should be done professionally.

In order for a lawn to reveal its functions and benefit from its potential, the plant material to be used; it is necessary to know the origin, characteristics, way of growing, and control techniques against diseases and pests and to choose accordingly. Wrong choice of plant material causes both the failure of the work and a great economic loss [1, 2, 3]. More important than the establishment of the green area facility is to ensure the long-term sustainability of the green cover in a quality that will meet the expectations. It is the use of different mixtures, especially the selection of the right plant material, for a long-term green area facility. Because it is known that mixtures are much more successful than lean sowings. In areas with variable environmental conditions and many different diseases and pests, it is more beneficial to use several compatible varieties together instead of a single variety.

Especially in regions with continental and transitional climates, triple-quadruple mixtures should be preferred. Because mixtures affect green spaces in a versatile and positive way, from their beautiful appearance to their resistance to diseases and pests [1, 2, 3, 4, 5]. Mixing ratios vary according to the genetic characteristics of the plants used, ecological conditions and intended use. The most important point to be considered here is the selection of plants that will best cover the soil and plants that can be in harmony in terms of life forms.

Tall Fescue (*Festuca arundinacea* Schreb.), perennial rygrass (*Lolium perenne* L.) and Kentucky bluegrass (*Poa pratensis* L.) plants are perennial cool climate plants and are the plants most used both alone and as a mixture in the establishment of grass fields all over the World [2, 3, 4, 5, 6]. Several researchers working with the turfgrass plants used as material in this study [3, 7-27] evaluated the plant's quantitative characteristics and the visual turf quality between 3-9 points, and also provided explanatory information about the green field and quantitative characteristics performance of the plant. Furthermore, among researchers who studied the topics of shoot height, herbage yield, dry matter content, hay yields and root yield; the best indicators of whether plants adapted well to their cultivation area, Klapp [28] 1.200, Jung and Baker [29] 429-523, Fiala [30] 1.400-1.700, Genckan [31] 100-4.500 (mean: 800), Birant [32] 128, Yilmaz [33] 688, Yilmaz and Avcioglu [34] reported a root yield of 315-1.200 g m^{-2}. Tarman [35], on the other hand, stated that root dry matter amounts were approximately 80% of hay yield yield.

In this research, it was aimed to determine the turfgrass performances of with the newly developed rhizome *Festuca arundinacea* and the mixtures of *Lolium perenne* and *Poa pratensis* varieties, which are the most widely used in the lawn plant, in different ratios, which were created to close each other's weaknesses and exhibit their superior properties, in Sakarya and similar cool climate regions.

2. Materials and methods

2.1. Site description

The research was carried out in the field belonging to the Sakarya Applied Sciences University Pamukova Vocational School district in the Sakarya province, which is situated in the eastern Marmara region (N 40° 30' 20.462, E 30° 10' 9.263 and 80 m above altitude) for 4 years between 15 October 2016 and 15 November 2020.

The climate data of the research area between October 2016 and November 2020 and for long term averages are given in Table 1.

Table 1. *The climate dates of Pamukova district for the 2016-2020 years and Long Term Average (L.T.A.)*[(*)]

	Years				
Climatic factors	1. Year	2. Year	3. Year	4. Year	LTA[(*)]
Total precipitaion (mm)	762.0	696.0	605.0	509.4	621.0
Average temperature (ºC)	15.4	15.0	15.0	15.4	15.0
Moisture (%)	77.5	77.6	77.5	76.7	77.4

(*): Meteorological Bulletin for Pamukova/Sakarya.

In terms of total precipitation amounts, the first two years in which the research was conducted were higher than the long term average, the third year was close, and the fourth year was lower. Average temperatures and relative humidity values are close to long term averages.

Soil samples taken from 0-20 and 20-40 cm depths of the research area soil were analyzed in Sakarya Applied Sciences University Pamukova Vocational School laboratories [36] and the results are presented in Table 2.

Table 2. *Soil properties of the research area*

Sample Depth (cm)	Properties							
	Structure	pH	Total Salt (%)	$CaCO_3$ (%)	Organic matter (%)	Nitrogen (kg ha^{-1})	P_2O_5, (kg ha^{-1})	K_2O (kg ha^{-1})
0-20	loamy	6.71	0.025	5.61	1.61	1.11	10.7	211.0
20-40	loamy	7.61	0.024	7.53	1.15	0.61	8.4	261.0

According to the results of the analysis, it was determined that the soil at a depth of 0-20 cm was loamy textured, moderately acidic, moderate in salinity, lime and organic matter, insufficient in total nitrogen and available phosphorus, and rich in available potassium. It was determined that the soil at a depth of 20-40 cm was slightly alkaline and in the same group in terms of other values.

2.2. Experimental design and treatments

In the research; *Festuca arundinacea* "Titan RX", *Lolium perenne* "Esquire" and *Poa pratensis* "Evora" cultivars were used as seed material.

The research was carried out for 4 years between 15 October 2016 - 15 October 2020. In the research, as control 3 lean sowing plot (%100 Fa, %100 Lp, %100 Pp) and 9 different mixtures sowing plot (%90 Fa + %5 Lp + %5 Pp, %80 Fa + %10 Lp + %10 Pp, %70 Fa + %15 Lp + %15 Pp, %60 Fa + %20 Lp + %20 Pp, %50 Fa + %25 Lp + %25 Pp, %40 Fa + %30 Lp + %30 Pp, %30 Fa + %35 Lp + %35 Pp, %20 Fa + %40 Lp + %40 Pp, %10 Fa + %45 Lp + %45 Pp) were used.

The dimensions of the parcel are 2×1 m = 2 m^{-2} and there are 50 cm gaps between the parcels and the blocks. Sowing was done on 15 October 2016 according to the 25 g m^{-2} sowing norm [2, 3], taking into account the germination percentages.

In fertilization, as annual 25-15-15 m^{-2} NPK fertilizer dose was used, which is also supported by the results of some studies [22, 24, 25, 26, 37] which is the appropriate amount for Sakarya ecological conditions and suggested by Acikgoz [2] and Avcioglu [3]. In the fertilization process, as a fertilizer source Palmorganic fertilizer (20% organik humus, 12 N, 12 P, 12 K, Fe 0,1%, Zn 0,1, Mn 1%) and as for additional nitrogen source Ammonium Nitrate fertilizer (26%) were used. The total amount of fertilizer was divided into 14 equal parts and given every 15 days between in April-October. Irrigation was done with automatic rotary sprinkler. When necessary, weed plants were combated with mechanical methods. The plots were cut 22 times each year (spring 8, summer 6, autumn 8 and winter 0) with a gasoline lawnmower from a height of 4 cm when the plant height reached an average of 6-10 cm.

2.3. Measurements and observations

In the study, shoot length (cm), herbage yield (g m^{-2}), dry matter ratio (%), hay yield (g m^{-2}) (each year in Spring 15 April, Summer 15 July, Autumn 15 October), root yield (g m^{-2}) (each year in 15 October, obtained from 20×20×20 cm area) by measuring, and visual turf quality data such as uniformity, flatness, weed density and winter endurance (each year in four seasons: Spring 15 April, Summer 15 July, Autumn 15 October, and Winter 15 January) were reported by Beard [1], Evans [5], Mehall et al. [38] and Sills and Carrow [39] scored according to the 1-9 (1: very bad, 9: very good) scale was determined by observing. An archive was created by taking photographs of all stages of the research.

2.4. Statistical analysis

The experiment was carried out according to the random blocks design with four replications. In the trial; mixtures, seasons and mixtures × seasons interactions were investigated. Statistical analyzes of the data obtained at the end of the research were made in the JUMP statistical program. All investigated properties showed statistically significant differences in terms of mixtures, seasons and mixtures × seasons interactions, and LSD (5%) and coefficient of variation (cv) values are given below the Tables.

3. Results of the research

Since the aim of this research is to establish a good green area by using different mixing ratios of plants with different life forms, no comment on lean sowings has been made. Lean sowings were tested in observations that were not made, the winter season was excluded from the evaluation and were not included in the average and total. Among all the features examined in the study, statistically; significant differences were determined between mixture, season and mixture × season interactions.

3.1. Shoot length

The average values of the shoot length obtained in three seasons each year and their total values are given in Table 3.

Table 3. *Shoot length of mixtures by seasons (cm)*

Mixtures	Shoot length				Total
	Spring	Summer	Autumn	Winter	
100% *Pp*	34.6	15.3	32.2	0.0	82.1
100% *Lp*	50.2	26.4	45.4	0.0	122.0
100% *Fa*	65.4	36.3	61.0	0.0	162.7
90% *Fa* + 5% *Lp* + 5% *Pp*	49.6	41.3	46.7	0.0	137.6
80% *Fa* + 10% *Lp* + 10% *Pp*	46.5	38.9	43.8	0.0	129.2
70% *Fa* + 15% *Lp* + 15% *Pp*	43.6	36.7	41.5	0.0	121.8
60% *Fa* + 20% *Lp* + 20% *Pp*	41.2	34.7	37.4	0.0	113.3
50% *Fa* + 25% *Lp* + 25% *Pp*	38.6	32.8	36.4	0.0	107.8
40% *Fa* + 30% *Lp* + 30% *Pp*	35.4	29.7	33.6	0.0	98.7
30% *Fa* + 35% *Lp* + 35% *Pp*	33.2	27.7	31.3	0.0	92.2
20% *Fa* + 40% *Lp* + 40% *Pp*	31.4	26.8	29.7	0.0	87.9
10% *Fa* + 45% *Lp* + 45% *Pp*	30.5	25.8	28.6	0.0	84.9
Means	41.7	31.0	39.0	0.0	
LSD 5%	*Mixture: 1.61*	*Season:0.54*	*Mikture x Season:3.36*		*CV: 1.54*

The highest shoot length values were obtained from 90+5+5 and the lowest 10+45+45 mixtures. The highest shoot length among the seasons occurred in the spring season. When the data is analyzed in terms of mixture × season interactions, the highest shoot length was obtained from the 90+5+5 mixture in spring.

When the shoot length data are evaluated in terms of mixtures; the reason for the highest shoot length data to be obtained in the 90+5+5 mixture is that the total of tall plants (Fa, Lp) in the mixture is the highest (95%). On the other hand, with the increase in the ratio of the shorter plant (Pp), it is seen that the shoot length data gets shorter. When the shoot length data are evaluated in terms of seasons; ıt is seen that the spring season comes to the fore. The reason for this is that the spring season is the most ideal season for the development of cool climate grasses.

3.2. Herbage yield

The average values of the herbage yield were taken in three seasons each year and their averages are given in Table 4.

Table 4. *Herbage yield of mixtures by seasons (g m^{-2})*

Mixtures	Herbage yield				Total
	Spring	Summer	Autumn	Winter	
100% *Pp*	1861	1254	1461	0	4576
100% *Lp*	3555	2233	3156	0	8944
100% *Fa*	3912	2402	3682	0	9995
90% *Fa* + 5% *Lp* + 5% *Pp*	3905	2385	3601	0	9892
80% *Fa* + 10% *Lp* + 10% *Pp*	3855	2256	3522	0	9634
70% *Fa* + 15% *Lp* + 15% *Pp*	3754	2168	3478	0	9401
60% *Fa* + 20% *Lp* + 20% *Pp*	3642	2078	3371	0	9091
50% *Fa* + 25% *Lp* + 25% *Pp*	3533	1965	3285	0	8784
40% *Fa* + 30% *Lp* + 30% *Pp*	3462	1881	3167	0	8510
30% *Fa* + 35% *Lp* + 35% *Pp*	3319	1768	3082	0	8170
20% *Fa* + 40% *Lp* + 40% *Pp*	3200	1661	2964	0	7826
10% *Fa* + 45% *Lp* + 45% *Pp*	3117	1555	2875	0	7546
Means	3426	1967	2565	0	
LSD 5%	*Mixture: 36.54*	*Season:21.61*	*Mikture x Season:54.44*		*CV: 3.61*

When the herbage yield figures are considered in terms of mixtures, it is seen that the highest values are obtained from 90+5+5, and the lowest values are obtained from 10+45+45 mixtures. The highest values among the seasons occurred in the spring season. When the data were analyzed in terms of mixture × season interactions, the highest herbage yield was determined from the 90+5+5 mixture and in the spring season. When evaluated in terms of mixtures; the reason why the highest herbage yield was obtained from the 90+5+5 mixture is that the total of tall and coarse plants (Fa, Lp) in the mixture is the highest (95%). In addition, it is seen that the herbage yield decrease with the increase in the shorter and thinner plant (Pp) ratio. When the herbage yield figures is evaluated in terms of seasons; it is seen that the spring season comes to the fore. This is because the spring season is the most suitable season for the development of cool climate grasses.

3.3. Dry matter ratio

The average values of the dry matter ratio obtained in three seasons each year and their averages are given in Table 5. Among the mixtures, the highest dry matter ratio was obtained from 90+5+5, and the lowest was obtained from 10+45+45 mixture. The highest dry matter ratio among the seasons occurred

in summer. In terms of mixture × season interactions, the highest dry matter ratio was determined in the summer season from the 90+5+5 mixture.

Table 5. *Dry matter ratio of mixtures by seasons (%)*

Mixtures	Dry matter ratio				Means
	Spring	Summer	Autumn	Winter	
100% *Pp*	31.11	31.61	31.34	0.00	31.35
100% *Lp*	27.25	27.73	27.41	0.00	27.46
100% *Fa*	29.15	29.68	29.38	0.00	29.40
90% *Fa* + 5% *Lp* + 5% *Pp*	31.04	31.58	31.26	0.00	31.29
80% *Fa* + 10% *Lp* + 10% *Pp*	30.69	31.15	30.86	0.00	30.90
70% *Fa* + 15% *Lp* + 15% *Pp*	30.34	30.83	30.51	0.00	30.56
60% *Fa* + 20% *Lp* + 20% *Pp*	29.98	30.44	30.15	0.00	30.19
50% *Fa* + 25% *Lp* + 25% *Pp*	29.64	30.12	29.81	0.00	29.86
40% *Fa* + 30% *Lp* + 30% *Pp*	29.29	29.78	29.44	0.00	29.50
30% *Fa* + 35% *Lp* + 35% *Pp*	28.94	29.44	29.12	0.00	29.17
20% *Fa* + 40% *Lp* + 40% *Pp*	28.61	29.11	28.78	0.00	28.83
10% *Fa* + 45% *Lp* + 45% *Pp*	28.25	28.74	28.41	0.00	28.47
Means	29.52	30.02	29.71	0.00	
LSD 5%	*Mixture: 0.09*	*Season:0.07*	*Mikture x Season:0.14*		*CV: 1.12*

When evaluated in terms of mixtures; the reason why the highest dry matter ratio figures are obtained from the 90+5+5 mixture is that the total of coarse and hard plants (Fa, Lp) in the mixture is the highest (95%). When the dry matter ratio figures are evaluated according to the seasons; it has been determined that the water in the plant is partially reduced in the summer season.

3.4. Hay yield

The average values of the hay yield were taken in three seasons each year and their averages are given in Table 6.

Table 6. *Hay yield of mixtures by seasons (g m^{-2})*

Mixtures	Hay yield				Means
	Spring	Summer	Autumn	Winter	
100% *Pp*	579	396	458	0	1433
100% *Lp*	969	619	865	0	2453
100% *Fa*	1140	713	1082	0	2935
90% *Fa* + 5% *Lp* + 5% *Pp*	1212	753	1126	0	3091
80% *Fa* + 10% *Lp* + 10% *Pp*	1183	703	1087	0	2973
70% *Fa* + 15% *Lp* + 15% *Pp*	1139	669	1061	0	2869
60% *Fa* + 20% *Lp* + 20% *Pp*	1092	633	1016	0	2741
50% *Fa* + 25% *Lp* + 25% *Pp*	1047	592	979	0	2619
40% *Fa* + 30% *Lp* + 30% *Pp*	1014	560	932	0	2506
30% *Fa* + 35% *Lp* + 35% *Pp*	960	521	898	0	2379
20% *Fa* + 40% *Lp* + 40% *Pp*	916	484	853	0	2252
10% *Fa* + 45% *Lp* + 45% *Pp*	880	447	817	0	2144
Means	1012	591	762	0	
LSD 5%	*Mixture: 11.04*	*Season:8.12*	*Mikture x Season:16.61*		*CV: 2.44*

When the figures in hay yield are examined, the highest and lowest values are similar to the same mixture (90+5+5), same season (spring) and interactions (90+5+5; spring) depending on the herbage yield and dry matter ratios appears to have emerged. The hay yield values obtained by multiplying the herbage yield with the dry matter ratios were also found in the same mixture ratio and in the same season, depending on the herbage yield.

3.5. Root yield (g m^{-2})

Root yields taken in the autumn season every year (October 15) and the numbers obtained with their averages are presented in Table 7.

Table 7. *Root yield of mixtures by years (g m^{-2})*

Mixtures	Root yield				Means
	1. Year	2. Year	3. Year	4. Year	
100% *Pp*	1001	1105	1134	1166	1101
100% *Lp*	1772	1891	1921	1942	1882
100% *Fa*	2184	2307	2328	2366	2296
90% *Fa* + 5% *Lp* + 5% *Pp*	2219	2391	2428	2452	2372
80% *Fa* + 10% *Lp* + 10% *Pp*	2139	2285	2328	2365	2280
70% *Fa* + 15% *Lp* + 15% *Pp*	2061	2215	2245	2275	2199
60% *Fa* + 20% *Lp* + 20% *Pp*	1965	2121	2152	2176	2104
50% *Fa* + 25% *Lp* + 25% *Pp*	1851	2025	2061	2092	2008
40% *Fa* + 30% *Lp* + 30% *Pp*	1745	1945	1972	2022	1921
30% *Fa* + 35% *Lp* + 35% *Pp*	1642	1855	1886	1919	1825
20% *Fa* + 40% *Lp* + 40% *Pp*	1562	1754	1784	1821	1730
10% *Fa* + 45% *Lp* + 45% *Pp*	1485	1672	1697	1725	1645
Means	1802	1964	1995	2027	----
LSD 5%	*Mixture: 22.44*	*Season:18.11*	*Mikture x Season:26.54*		*CV: 3.54*

When the four-year average data is evaluated in terms of mixtures, it is seen that the highest yield is obtained from the 90+5+5 mixture, as in the herbage and hay yield. When the figures are considered in terms of years, the lowest values were reached in the first year and the highest values in the fourth year. When the data were analyzed in terms of mixture × season interactions, the highest root yield values were obtained from the mixture and the fourth year from the 90+5+5 mixture as in the years.

Root yield values reached the highest values in the 90+5+5 mixture, depending on the herbage yield. The data obtained; "the rate of root yield can be up to 80% of herbage yield" confirms Tarman [35]. This shows that the selected plants adapt well to ecology.

3.6. Sowing ratio in mixtures and seed counts

The average values of the sowing ratio in mixtures and seed counts are given in Table 8. Sowing was done using 25 g m^{-2} sowing norm. This ratio is accepted as an ideal sowing norm when a good seed bed is prepared by Beard [1], Acikgoz [2], Avcioglu [3], Hubbard [4] and Evans [5]. One of the most important issues to be considered while preparing the mixtures is to keep the ratios of the varieties with big seeds higher and the ratios of varieties with small seeds to be lower. Because here, the total number of seeds to be sowing in the soil is as important as the sowing rate. The optimum number of seeds to be sowing is suggested as 3-4 per cm^{-2} [1, 2, 3]. When the mixing ratios, seed amounts and especially the number of seeds per cm^{-2} are examined in the table, it is seen that the ideal number is 3.30 and 3.84 at 60+20+20 and 50+25+25 ratios, respectively. Sowing more seeds than this number causes both excessive competition among plants due to too frequent planting and waste of seeds. Plant density in

green areas should be adjusted not by sowing more seeds, but by ensuring the tillering of the plants. When green areas are created using varieties containing different life forms such as fescue, rhizom and stolon, they can be more resistant to environmental and usage conditions [1, 2, 3].

Table 8. *The sowing ratio in mixtures (%) and seed counts (25 g m^{-2})*

Mixtures (%)	Sowing rate (g m^{-2})	*Fa + Lp + Pp* (Seed counts)	Total (Seed counts)	In cm^{-2} (counts)
100% Pp	25	0+0+118.750	118.750	11.88
100% Lp	25	0+12.500+0	12.500	1.25
100% Fa	25	11.250+0+0	11.250	1.13
90% *Fa* + 5% *Lp* + 5% *Pp*	22.5+1.25+1.25	10.125+625+5.938	16.688	1.67
80% *Fa* + 10% *Lp* + 10% *Pp*	20+2.5+2.5	9.000+1.250+11.875	22.125	2.21
70% *Fa* + 15% *Lp* + 15% *Pp*	17.5+3.75+3.75	7.875+1.875+17.813	27.563	2.76
60% *Fa* + 20% *Lp* + 20% *Pp*	15+5+5	6.750+2.500+23.750	33.000	3.30
50% *Fa* + 25% *Lp* + 25% *Pp*	12.5+6.25+6.25	5.625+3.125+29.688	38.438	3.84
40% *Fa* + 30% *Lp* + 30% *Pp*	10+7.5+7.5	4.500+3.750+35.625	43.875	4.39
30% *Fa* + 35% *Lp* + 35% *Pp*	7.5+8.75+8.75	3.375+4.375+41.563	49.313	4.93
20% *Fa* + 40% *Lp* + 40% *Pp*	5+10+10	2.250+5.000+47.500	54.750	5.48
10% *Fa* + 45% *Lp* + 45% *Pp*	2.5+11.5+11.5	1.125+5.750+54.625	61.500	6.15

Average number of seeds in 1 gram: Pp (4750), Lp (500), Fa (450) ([1,2,3])

3.7. Visual turf quality

The four year visual average turf quality data, in which properties such as uniformity, flatness, weed density and winter endurance are evaluated together are presented in Table 9.

Table 9. *Visual turf quality scores of mixtures by seasons (1-9 point)*

Mixtures	Visual Turf Quality (1-9 Point)				Means
	Spring	Summer	Autumn	Winter	
100% *Pp*	8.32	8.12	8.24	7.86	8.14
100% *Lp*	7.80	7.50	7.60	7.22	7.53
100% *Fa*	8.66	8.44	8.52	7.82	8.36
90% *Fa* + 5% *Lp* + 5% *Pp*	8.54	8.36	8.42	7.80	8.28
80% *Fa* + 10% *Lp* + 10% *Pp*	8.72	8.42	8.54	7.86	8.39
70% *Fa* + 15% *Lp* + 15% *Pp*	8.75	8.55	8.64	7.90	8.46
60% *Fa* + 20% *Lp* + 20% *Pp*	8.84	8.55	8.66	7.94	8.50
50% *Fa* + 25% *Lp* + 25% *Pp*	8.84	8.54	8.68	7.95	8.50
40% *Fa* + 30% *Lp* + 30% *Pp*	8.72	8.44	8.52	7.76	8.36
30% *Fa* + 35% *Lp* + 35% *Pp*	8.42	8.18	8.22	7.38	8.05
20% *Fa* + 40% *Lp* + 40% *Pp*	7.96	7.54	7.72	7.26	7.62
10% *Fa* + 45% *Lp* + 45% *Pp*	7.84	7.44	7.64	7.14	7.52
Means	8.44	8.17	8.28	7.66	----
LSD 5%	*Mixture: 0.04*	*Season:0.06*	*Mikture x Season:0.03*		*CV: 1.36*

When the numbers were evaluated according to the averages of the mixing ratios, it was determined that the visual turf quality was more balanced at the ratios of 60+20+20 and 50+25+25. According to seasonal averages, the visual turf quality values were highest in spring and lowest in winter.

When the obtained data were analyzed according to the mixture × season interactions, the highest values were obtained in the spring season, when the mixtures were more balanced, at the ratios of 60+20+20 and 50+25+25.

4. Conclusion

The highest of the measurements and observations in this research; shoot length, herbage and dry matter yield values were obtained from the 90+5+5 mixture, and the visual turf quality values were obtained from the 60+20+20 and 50+25+25 mixtures in the spring season. Dry matter ratio values were taken from the 90+5+5 mixture in the summer season. Root yield values gave the highest results in the 4th year and the lowest in the 1st year. When the figures obtained from all measurements and observations are evaluated together, it can be said that optimum ecological conditions have emerged for the plants included in the mixture and that the varieties have exhibited their true potential.

The highest shoot length, herbage and hay yield values obtained in the research were obtained from the mixture at the ratio of 90+5+5 in the spring and autumn seasons, where the cool climate plants develop best. In the summer, growth and yields decreased, partly due to high temperatures. This was confirmed by mowing 8 times in two months (weekly in April-May) spring and in two months (weekly in September-October) autumn seasons, and 6 times in the summer three months (biweekly in June-July-August) seasons. Dry matter ratio values were higher in summer than in other seasons, when plants lost more water and the amount of dry matter increased. When the root yield values are examined, it is seen that the biggest differences are between the first year data and the second year data, while the differences between the other years are lower. This can be explained by the fact that the first year is the year of the plants holding on to the vegetation, so they cannot complete their root development. The increase in root yield, especially from the second year, showed that the plants were well adapted to the location and showed their real performance. Root yield values confirm Tarman [35], who said that root yields of well-grown grass crops can be up to 80% of hay yield. One of the main reasons for the high root yields is that there are rhizome plant varieties in mixing ratios. Sowing rates and seed numbers Beard [1], Acikgoz [2], Avcioglu [3] and Genckan [6] suggested as the ideal number per cm^{-2}, the closest values to 3-4 seeds are 60+20+20 (3.30 units) and 50+25+25 (3.84 units) mixtures. The fact that the sowing norm is 25 g m^{-2} means that it is both suitable for the ideal plant density and not wasting the seed. When the visual turf quality values, which are one of the most important parameters for green areas and include features such as uniformity, flatness, weed density and winter resistance, are examined, it is seen that the highest and positive values are obtained from 60% Fa + 20% Lp + 20% Pp and 50% Fa + 25% Lp + 25% Pp mixtures.

The plant species used in research are among the plant species that are called ideal turfgrass plants by some researchers [1, 2, 3, 4, 5, 6]. When the data and observations obtained in the research are evaluated together, it has been seen that they have very close values with the results of some researches [8, 10, 11, 12, 16, 22, 23, 24, 25, 26, 37] made in cool climate ecological conditions. However, the results are partially higher than some research [17, 18, 19, 20, 21, 32] results in warm climate conditions.

5. Suggestions

This research was carried out in Sakarya/Pamukova ecological conditions for four years in order to determine at which mixing ratios the performance of the turfgrass created with *Festuca arundinacea, Lolium perenne* and *Poa pratensis* varieties, which are most commonly used in lawns, will reach the highest quality. Since this research is the first study in the region, it can be considered as an important start for turfgrass areas.

When the data obtained in the research are evaluated in terms of mixing ratios; shoot length (137.6 cm), herbage (9892 g m^{-2}), hay (3091 g m^{-2}) and root yield (2372 g m^{-2}), and dry matter content (31.29%) values were the highest from a mixture of 90% Fa + 5% Lp + 5% Pp. The visual turf quality values, which is one of the most important parameters for green areas, together with the sowing rates and seed numbers, were obtained from 60% Fa + 20% Lp + 20% Pp and 50% Fa + 25% Lp + 25% Pp mixtures.

When the data obtained in the research is evaluated in terms of seasons; in order of the most positive results; it has been determined that it is moderate in spring, autumn and summer seasons. Some measurements and observations were not made in the winter season when there is no growth and development. The results are quite satisfactory, showing that the mixture used as a material is compatible with ecology.

When all the properties and mixing ratios examined in this study are interpreted together, the rhizome *Festuca arundinacea* Schreb., *Lolium perenne* L. and *Poa pratensis* L. cultivars and the mixtures formed with them are 60% Fa + 20% Lp + 20% Pp and 50% Fa + 25% Lp + it has been concluded that 25% Pp ratios give the most appropriate results, and turfgrass areas consisting of these mixtures can be established in the region and in similar ecological conditions. However, it is thought that it is necessary to ensure the continuity of studies to be carried out using different mixtures and different plant species in order to reveal much more detailed results in this type of research.

Author Contribution

The author is responsible for all parts of this article.

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