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Optimizing lawn grass species for turf establishment as mono-stand and mixtures under mid hill conditions

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Abstract

Lawn performs best with minimum inputs when grown in mixtures using more than a single grass specie. A study was conducted under open field conditions to evaluate the performance of four lawn grass species as mono-stand and in mixtures under mid-hill conditions at the Experimental Farm of the Department of Floriculture and Landscape Architecture, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during March, 2020 to March, 2021. The experiment was laid out in a randomized block design with twelve treatments and three replications. Data was recorded at fortnight intervals for total weed count, chlorophyll content, number of mowing, and overall presentability just after turf establishment. It was observed that all turf grass mixtures, performed better than the monostands, during the entire course of the study. Turf grass mixture (50% *'Agrostis stolonifera'* + 20% *'Festuca rubra'* + 20% *'Lolium perenne'* + 10% *'Cynodon dactylon)'* required least number of mowing and was presentable throughout the year attaining highest presentability score of 22.98.

Key words: *Festuca rubra* L., *Lolium perenne* L., *Cynodon dactylon* [L] Pers., *Agrostis stolonifera* L., mono-stand, mixture, establishment, texture, diseases, presentability

Introduction

The beauty of the ornamental plants and garden features are best enjoyed with the lawn as a foreground. As centre of the garden for major activities, lawn is considered the soul/heart of the garden. Private gardens, public landscapes and parks are allocated with certain areas as lush green lawn providing satisfaction to the owner. Turf grasses are members of family Poaceae, which comprise 600 genera and 9000 species, of which about 20-25 species are used for turf production (Vengris, 1973). Ground covers, sedges, low-growing herbs, and wildflowers can also be incorporated into lawns as needed. Most lawns are typically established using a mix of cool-season grasses, warm-season grasses, and grass alternatives (Haravandi *et al.,* 2001). Coarse textured grasses with high wear and tear tolerance are used for playgrounds, whereas fine textured grasses are used in garden lawns (Randhawa and Mukhopadhyay, 2001).

Lawns appear best when made up of as many different species or kinds of grasses as feasible. Turf grass stands, composed of multiple species, are better able to withstand environmental conditions and pest stresses than mono-stands. Mixture performs somewhat better in shade, wear and tear tolerance, disease resistance, drought resistance, and other factors, ensuring that the entire lawn looks excellent even if one species is not performing well or has died. This practice reduces the overall input cost required for lawn maintenance, including irrigation, fertilizers, pesticides, number of mowings and weeding, etc. Therefore, mid hill zone experiencing extreme weather conditions ranging from -4 to 34˚C, requires mixtures of warm and cool season grasses for better turf establishment.

Hence, the present study was planned to compare and optimize lawn grass species for turf establishment as mono-stand and in mixtures under mid hill conditions.

Material and methods

The experiment was carried out under open field conditions at the Experimental Farm of the Department of Floriculture and Landscape Architecture, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) from March 2020 to March 2021. The 4 grass species evaluated for mixture were *'Agrostis stolonifera'*L. (Creeping Bentgrass), *'Cynodon dactylon'* [L.] Pers. (Bermuda grass), *'Festuca rubra'* L. (Creeping Red Fescue), *'Lolium perenne'* L. (Perennial ryegrass), and their seeds were procured from DLF Pickseed, Halsey, Oregon USA. The experiment was laid out in a randomized block design with twelve treatments and three replications *i.e.*,

T_1= *'Festuca rubra'* L. (A)
T_2= *'Lolium perenne'* L. (B)
T_3= *'Cynodon dactylon'* [L] Pers. (C)
T_4= *'Agrostis stolonifera'*L. (D)
T_5 = 40% (A) + 20% (B) + 20% (C) + 20% (D)
T_6= 40% (B) + 20% (A) + 20% (C) + 20% (D)
T_7 = 40% (C) + 20% (A) + 20% (B) + 20% (D)
T_8 = 40% (D) + 20% (A) + 20% (B) + 20% (C)
T_9 = 50% (D) + 20% (A) + 20% (B) + 10% (C)
T_{10} = 50% (D) + 20% (B) + 20% (C) + 10% (A)
T_{11}= 50% (D) + 20% (A) + 20% (C) + 10% (B)
T_{12}= 50% (D) + 15% (A) + 20% (C) + 15% (B)

Raised beds of one-meter square were prepared with proper drainage channels. Seed sowing was done on 17th March, 2020. The application of 2% urea was done 45 days after planting. Standard cultural practices like irrigation, weeding, hoeing, mowing and plant protection were followed during investigations. Observations recorded were:

Days taken to germination (days from sowing of seeds till 75%

Table 1. Score allotted to various parameters for evaluating presentability

Parameter	Description	Points alloted
Turf colour	Green group-137-A, 137-B, 137-C,137-D	5
	Green group-143-A	4
	Yellow Green Group-147-B	3
	Orange White Group-159-B	2
Turf texture (Hand feel method)	Fine	5
	Fine to medium	4
	Medium to coarse	3
	Coarse	2
Visual texture	Fine	5
	Fine to medium	4
	Medium to coarse	3
	Coarse	2
Turf spread	Uniform grass growth throughout the area	5
	Area showing uneven growth without any	4
	Area showing uneven growth with patch up to 20%	3
	Area showing uneven growth more than 20% patch	2
Disease and insect-pest incidence	Nil	5
	< 250 cm² (low)	4
	250-500 cm²(medium)	3
	> 500cm²(high)	2

of the seeds germinated), Days taken to turf establishment (days from sowing till the entire bed was completely covered), Mowing frequency (by maintaining 3cm culm length), Total weed count (weeds were identified and their number per m² was recorded at monthly interval), Chlorophyll content (recorded quarterly, as per the method described by Hiscox and Israelstam (1979); Presentability (based on turf colour (colour chart of "The Royal Horticulture Society", London), texture of leaf *i.e.* hand feel method and visual texture, turf spread, the occurrence of diseases and insect-pest incidence, each parameter carried 5 points making the total to be of 25 points (Table 1) (Verma, 2007)

Results and discussion

Days taken to germination and turf establishment: Among different treatments evaluated for days taken to germination (Table 2), the earliest germination occurred in T_2, *i.e.*, *'Lolium perenne'* (9.00 days). In contrast, delayed germination was observed in T_3 *i.e.*, *'Cynodon dactylon'* (59.33 days). Similar findings were made by Charif *et al.* (2021) who observed that *'Lolium perenne'* took the shortest germination time with a germination rate of 92% in 7 days. Germination of *'Cynodon dactylon'* at a constant temperature, *i.e.* at 35°C, was recorded in 42 days after sowing as per the studies conducted by (Loddo *et al.*, 2019). During the experiment, temperature conditions were favorable for '*Cynodon dactylon'* germination only after mid May with an average temperature of 29.7°C (Table 4).

The minimum number of days for turf establishment (Table 2) was taken by treatment T_2 *i.e.*, *'Lolium perenne'* (44.66 days). In contrast, the maximum number of days for turf establishment were taken by treatment T_3 *i.e. 'Cynodon dactylon'* (99.00 days). *'Loilum perenne'* had most rapid emergence rate along with the greatest cumulative height as observed by (Volterrani *et al.,* 1997). 100% monostand of perennial ryegrass (*'Lolium perenne'*) and mixtures of Kentucky bluegrass: perennial ryegrass in the ratio of 50:50, 70:30, or 80:20 had the highest percentage turf cover after 6 weeks of sowing during the studies conducted by (Proctor *et al.,* 2015). Highest turf cover percentage *i.e.*, 96.03% at 120 days after sowing, was recorded in *'Cynodon dactylon'* (Dhanalakshmi, 2015), which suggests that '*Cynodon dactylon'* may take a while to germinate, but once germinated, it spreads well and has a better turf cover percentage owing to its spreading type growth pattern.

Mowing frequency and total number of mowing: The data presented in Table 3 reveals the number of mowing required, which depend upon the monthly increase in growth of the culms. Treatments T_2 , T_1 and mixtures with more ratio of T_2 required more mowings because this species had a faster establishment rate. Treatment T_9 and T_{12} required less number of mowings throughout the year. It was observed that *'Lolium perenne'* showed a faster establishment rate (Newell, 1997) and Volterrani *et al.* (1997) reported *'Lolium perenne'* to be the most rapidly emerging grass with the greatest cumulative height and thus requiring more number of mowings. Mixture with a high percentage of *'Lolium perenne'* eventually dominated both tall fescue and Kentucky bluegrass in mixtures (Dunn *et al.,* 2002) and hence, more mowings were required.

Table 2. Days taken to germination and turf establishment, total weed count and chlorophyll content (mg/100g) for different treatments from April 2020 to March 2021

Treatments	Days taken to germination (Days)	Days taken to turf establishment (Days)	Total weed count (weeds/m²)	Chlorophyll content (mg/100g)			
				June 2020	September 2020	December 2020	March 2021
T_1= *'Festuca rubra'* (A)	14.00	48.00	145.83	0.84	0.17	0.88	0.44
T_2= *'Lolium perenne'* (B)	9.00	44.66	133.33	1.80	0.47	0.77	0.52
T_3= '*Cynodon dactylon'* (C)	59.33	99.00	126.00	2.36	0.54	0.20	0.17
T_4= '*Agrostis stolonifera'* (D)	16.33	59.00	121.50	2.29	0.54	0.79	0.14
T_5 =40% (A) + 20% (B) + 20% (C) + 20% (D)	13.00	50.33	139.83	1.41	0.52	0.70	0.39
T_6=40% (B) + 20% (A) + 20% (C) + 20% (D)	10.33	48.00	140.83	1.55	0.58	0.70	0.49
T_7=40% (C) + 20% (A) + 20% (B) + 20% (D)	20.00	60.00	111.83	1.54	0.60	0.67	0.58
T_8=40% (D) + 20% (A) + 20% (B) + 20% (C)	14.00	49.66	139.66	1.33	0.61	0.75	0.31
T_9=50% (D) + 20% (A) + 20% (B) + 10% (C)	15.66	52.00	132.16	1.49	0.49	0.70	0.24
T_{10}=50% (D) + 20% (B) + 20% (C) + 10% (A)	16.66	50.00	129.33	1.68	0.62	0.63	0.57
T_{11}=50% (D) + 20% (A) + 20% (C) + 10% (B)	15.33	51.00	141.00	2.00	0.82	0.72	0.39
T_{12}=50% (D) + 15% (A) + 20% (C) + 15% (B)	16.00	50.33	122.33	2.08	0.81	0.61	0.71
$CD_{0.05}$	2.97	4.33	7.14	0.18	0.17	0.16	0.03

Table 3. Monthly mowing frequency and total number of mowing

Treatments	May, 2020	June, 2020	July, 2020	August 2020	September, 2020	October, 2020	November, 2020	December, 2020	January, 2021	February, 2021	March, 2021	Total mowings
T_1= *'Festuca rubra'* (A)	3	2	2	2	1	1	1	1	1	2	2	18
T_2= *'Lolium perenne'* (B)	3	2	2	3	2	2	2	2	2	2	2	24
T_3= *'Cynodon dactylon'* (C)	0	1	2	2	2	2	2	1	1	1	1	15
T_4= *'Agrostis stolonifera'* (D)	0	2	2	1	1	1	1	1	2	2	2	15
T_5=40% (A) + 20% (B) + 20% (C) + 20% (D)	3	2	2	2	2	2	2	2	2	2	2	23
T_6=40% (B) + 20% (A) + 20% (C) + 20% (D)	3	2	2	2	2	2	2	2	2	2	2	23
T_7=40% (C) + 20% (A) + 20% (B) + 20% (D)	2	2	2	2	2	2	1	1	1	1	1	17
T_8=40% (D) + 20% (A) + 20% (B) + 20% (C)	3	2	2	2	2	2	2	2	2	2	2	23
T_9=50% (D) + 20% (A) + 20% (B) + 10% (C)	2	2	2	1	1	1	1	1	1	1	1	14
T_{10}=50% (D) + 20% (B) + 20% (C) + 10% (A)	3	2	2	2	2	2	1	1	1	1	1	18
T_{11}=50% (D) + 20% (A) + 20% (C) + 10% (B)	3	2	2	2	2	2	1	1	1	1	1	18
T_{12}=50% (D) + 15% (A) + 20% (C) + 15% (B)	2	2	2	1	1	1	1	1	1	1	1	14

Total weed count: During the entire course of observations, the prominent weeds that were found growing in the experimental plots were *Axonopus compressus*, *Euphorbia maculate*, *Oxalis dillenii*, *Digitaria sanguinalis*, *Euphorbia hirta* and *Cyperus rotundus*. The data pertaining to total weed count has been detailed in Table 2 which shows that among different treatments, maximum weed count was observed in treatment T_1 (145.83 /m^2) whereas, minimum weed count was observed in treatment T_7. Busey (2003) stated that various abiotic (drought, unnecessary aeration, excessive mowing) and biotic (nematode, insect-pest, diseases) stresses contribute to weed infestation. Fine fescue used in mixtures had significantly fewer weeds than the monoculture (Miller *et al.,* 2013) as other species covered the barren soil surface in a mixture—Bermuda grass var. 'Tif dwarf' with lower weed infestation and the ability to spread quickly excludes weeds, as reported by Mathew *et al.* (2020).

Chlorophyll content (mg/100g): Chlorophyll content was observed quarterly during the year *i.e.*, in the month of June, 2020, September 2020, December 2020 and March 2021 and is presented in Table 2. During June (summer season) 2020, maximum chlorophyll content was recorded in treatment T_3 *'Cynodon dactylon'* (2.36 mg/100g) and was at par with treatment T_4 (2.29 mg/100g) whereas, minimum chlorophyll content was recorded in treatment T_1 (0.84 mg/100g). During September 2020 (monsoon season), minimum chlorophyll content was recorded in treatment T_1 (0.17 mg/100g) whereas, maximum chlorophyll content was recorded in treatment T_{11} (0.82 mg/100g) and was at par with treatment T_{12} (0.81 mg/100g). During March (spring season), 2021 minimum chlorophyll content was recorded in T_4 (0.14 mg/100g) and was at par with treatment T_3 (0.17mg/100g) whereas, maximum chlorophyll content was recorded in treatment T_{12} (0.71 mg/100g). The highest chlorophyll content is associated with more turf cover area and has been reported in cool season turf grass species during winters (Chestnut, 2018). Warm season turf grass species *i.e.*, *'Cynodon dactylon'* and their seed mixtures and cool season turf grass species *i.e.*, *'Lolium perenne'* and *'Festuca rubra',* had higher chlorophyll content. However, *'Festuca rubra'* monoculture was reported to be very sensitive to high temperatures and reduced humidity and had the lowest chlorophyll content in summer (Salehi and Kosh-Khui, 2004). Hence it was observed that in general, *'Cynodon dactylon',* which is considered to be a warm-season grass species, had minimum chlorophyll content during the winters and *'Festuca rubra'*, the cool-season grass species, had minimum chlorophyll content during the summer season *i.e.*, June 2020. This depicts that the chlorophyll content is directly related to the nature of the species, thereby being presentable as per the season of their active growth. A similar finding concerning chlorophyll content was reported in *'Cynodon dactylon'* along with cool season turf grass species, *i.e.*, the highest chlorophyll content during the summer month, whereas the lowest chlorophyll content after winter in *'Cynodon dactylon'* monocultures because it undergoes dormancy experiencing chlorophyll loss and recovers at a slow rate during spring as reported by Akbari *et al.* (2011).

Presentability: The data pertaining to presentability (Table 4), which was recorded from May 2020 to March 2021 by taking into consideration the turf colour, texture of leaf *i.e.*, hand feel method and visual texture, turf spread, the occurrence of diseases and insect-pest incidence, each carrying 5 points making the total to be 25 points (Table 1). It was observed that all mixtures, namely, T_5, T_6, T_7, T_8, T_9, T_{10}, T_{11}, and T_{12} performed better than the mono-stands, namely, T_1, T_2, T_3, and T_4 during the entire course of the study. Among mixtures, treatment T_9 was the most presentable with a maximum score of 22.98 whereas, treatment T_1 mono-stand had least presentability with a minimum score of 17.90.

Table 4. Total presentability score of different treatments from May 2020 to March 2021

Treatments	Presentability (Score out of 25)
T_1= *Festuca rubra* (A)	17.90
T_2= *Lolium perenne* (B)	19.72
T_3= *Cynodon dactylon* (C)	18.86
T_4= *Agrostis stolonifera*(D)	20.13
T_5 = 40% (A) + 20% (B) + 20% (C) + 20% (D)	20.77
T_6= 40% (B) + 20% (A) + 20% (C) + 20% (D)	20.83
T_7 = 40% (C) + 20% (A) + 20% (B) + 20% (D)	22.36
T_8 = 40% (D) + 20% (A) + 20% (B) + 20% (C)	21.34
T_9= 50% (D) + 20% (A) + 20% (B) + 10% (C)	22.98
T_{10}= 50% (D) + 20% (B) + 20% (C) + 10% (A)	21.42
T_{11}= 50% (D) + 20% (A) + 20% (C) + 10% (B)	22.37
T_{12}= 50% (D) + 15% (A) + 20% (C) + 15% (B)	22.31
$CD_{0.05}$	1.33

Mixtures of bermudagrass (*'Cynodon dactylon'* [L.] Pers.) with other species resulted in better visual quality after winter and summer and established a good turf (Akbari *et al.,* 2011). Agnihotri and Chawla (2017) reported similar results about color rating and aesthetic appearance. Bonos *et al.* (2021) found that combinations of several turf grasses (blend of *Festuca*, *Poa*, *Lolium* and *Cynodon*) produced superior visual quality than individual species. These results were near the findings of the present study.

The data about presentability shows that among different treatments treatment T_9 was most presentable with a maximum score of 22.98 and was found to be statistically at par with treatments T_{11} (22.37), T_7 (22.36) and T_{12} (22.31) whereas, treatment T_1 had least presentability with a minimum score of 17.90 and was found to be statistically at par with treatment T_3 (18.86).

The study revealed that mixtures containing four lawn grass species performed better, attaining higher presentability scores than mono-stands of the four species individually, suggesting that the use of mixtures may result in low input costs by reducing the number of mowing, pesticides, and other resources.

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Declaration: The authors declare that there is no conflict of interest.

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Appendix 1. Mean monthly meteorological data of Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) for the year 2020-2021

Months	Temperature (°C)			Relative Humidity (%)	Rainfall (mm)
	Max.	Min.	Mean		
February, 2020	20.26	4.06	12.16	57	38.50
March, 2020	21.22	7.23	14.22	62	171.80
April, 2020	26.80	10.70	18.75	51	47.70
May, 2020	29.70	14.44	22.07	53	74.80
June, 2020	30.75	17.38	24.06	64	58.70
July, 2020	30.20	19.91	25.10	76	278.10
August, 2020	29.24	20.70	24.97	81	148.60
Sept., 2020	30.63	17.56	24.09	68	6.00
October 2020	29. 80	11.0	20.40	55	-
Nov., 2020	23.68	5.55	14.61	55	37.70
Dec., 2020	21.90	2.53	12.21	50	23.8
Jan., 2021	20.50	2.34	11.42	58	21.3
Feb., 2021	23.00	4.80	13.90	62	59.7
March, 2021	27.30	9.00	18.15	43	14.8

Source: Meterological Observatory, Department of Environmental Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) 173230

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