

Rooting characteristics of turf grass species planted under different methods of establishment

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Abstract

The present investigation was aimed to evaluate the rooting characteristics of turf grass species planted with two different methods of establishment. A two factorial experiment with two methods of establishment and four turf grass species was laid out in a randomized block design replicated thrice during the year 2014-2015. The rooting characteristics, such as number of roots per stolon, root length and distribution, root diameter, root fresh weight (RFW), root dry weight (RDW), root length density (RLD) and root mass density (RMD) were studied during the course of investigation. The results showed that Bermuda grass planted with dibbling method of establishment recorded significantly higher number of roots, root length and distribution, RFW, RDW, RLD and RMD, whereas lowest rooting characteristics were exhibited by Korean grass planted with turf plastering method of establishment. The differences in RLD and RMD among different turf grass species observed to be related to the method of establishment adopted. Deep rooting species may have an advantage in absorbing the soil moisture from the deeper layers of the soil particularly during the water deficit periods thereby resulting in higher quality turf throughout the year.

Key words: Turf grass species, establishment, root length density, root mass density.

Introduction

Turf grass species, which belong to the family Graminae are considered as monocotyledonous plants used in the establishment of lawn. In fact, the evapotranspiration rate for warm season turf grasses, such as Bermuda grass (*Cynodon dactylon*) and Zoysia grass (*Zoysia japonica*) ranges from 2 to 5 mm d⁻¹ compared with 3 to 8 mm d⁻¹ for cool season grasses (Beard, 1994). However, the differences in water use rates among warm season grasses have been further described and large variation has been observed between cultivars within species (Huang, 2008). Efficiency of the turf grass canopy in using water is influenced by several epigeal traits including leaf morphology, growth habit, turf grass density and also by rooting characteristics (Beard, 1973; Shearman, 1986). Rooting depth and root density are considered as critical for an efficient plant capacity of water supply from soil especially under non-irrigated conditions. It is widely recognized that roots of various turf grasses are able to spread in lower soil profiles as a response to loss of soil moisture in the upper layers (Beard, 1973; Huang *et al.*, 1997; Huang, 1999). Drought resistance mostly depends on the ability of plants to deepen roots for taking up water in the lower soil layers where moisture is more reliable (Huang, 2008). The differences in root system architecture among turf grasses have been investigated with regard to drought avoidance and turf quality (Carrow and Duncan, 2003). The use of warm-season grasses can significantly contribute for reducing turf grass irrigation requirement in these areas. Warm-season grasses such as Bermuda grass (*Cynodon dactylon* (L.) Pers.) provide high quality turf with minimal cost and low water inputs. There is a significant demand for turf grasses in aesthetic display in landscaping sectors and a prompt

functional usage in sports domain have set a tone for developing futuristic research modules in turf grass breeding, production and maintenance. The main objective of the present investigation was to evaluate the rooting characteristics of turf grass species with different methods of establishment.

Materials and methods

The present investigation was carried out during the year 2014-2015 at Horticultural College and Research Institute, Venkataramannagudem which is situated in West Godavari district of Andhra Pradesh at an elevation of 34 m above mean sea level. During the investigative period *i.e.*, from October, 2014 to February, 2015 the area received rainfall of about 150 mm. The experimental field was laid out in a Factorial Randomized Block Design (FRBD) with three replications with a net plot size of 3 × 3 m by leaving a spacing of 1 m between the plots and replications. The plots were dug out in a manner to bring the down layer of soil to up and moving the top layer of soil to down to a depth of about 60 cm. Then the plots were uniformly levelled with a mixture of sand, red soil, river soil and compost in 2:1:1:1 ratio. Later the soil was drenched with chlorpyrifos @ 2.5 mL L⁻¹ per square metre area to control white ants *i.e.*, before turf grass planting. Rooted slips of four grass species Bermuda grass (*Cynodon dactylon* (L.) Pers.), Korean grass (*Zoysia japonica* Steud.), St. Augustine grass (*Stenotaphrum secundatum* (Walter) Kuntze) and Centipede grass (*Eriochloa ophiuroides* (Munro) Hack.) were collected from Hortus Consultants (I) Pvt. Ltd, Pune, Maharashtra and planted with dibbling (small pieces of grass roots are dibbled at 10-15 cm apart on a levelled ground in zig-zag rows when the soil was wet after irrigation) and turf plastering

(turf grass slips were chopped into small bits of 5-7 cm long. Two baskets of chopped grass pieces were mixed well with one basket each of garden soil and fresh cow dung and also added a shovel full of wood ash along with adequate amount of water to form a thick paste like substance. This mixture was then spread uniformly on the surface of a previously levelled and perfectly wetted ground to a thickness of at least 2.5 cm and watering done gently with a rose can) methods of establishment. The treatment details were as listed below:

- T₁ : Bermuda grass planted with dibbling method of establishment
 T₂ : Korean grass planted with dibbling method of establishment
 T₃ : St. Augustine grass planted with dibbling method of establishment
 T₄ : Centipede grass planted with dibbling method of establishment
 T₅ : Bermuda grass planted with turf plastering method of establishment
 T₆ : Korean grass planted with turf plastering method of establishment
 T₇ : St. Augustine grass planted with turf plastering method of establishment
 T₈ : Centipede grass planted with turf plastering method of establishment

Irrigation was applied to the established grass at regular intervals every day. Hand weeding was carried out at fortnightly interval commencing from 30 days after planting to control both annual and perennial weeds during the course of establishment of lawn grass species. The data were collected on various vegetative growth parameters at 20, 40, 60, 80, 100 and 120 days after planting. Five randomly selected plants in each plot were uprooted and the roots were washed thoroughly under tap water to remove the soil particles adhered to the root system. The roots of individual plants were separated and the fresh weight of roots was recorded after removing excess moisture from the roots with blotting paper. The average root fresh weight was calculated

and then roots of individual plants were separated and kept in a brown paper bag after thorough drying in sun light. The brown paper bags were placed in hot air oven at 70 °C for 48 hours then the dry weight of roots of individual plants was recorded. Roots were analysed for total root length (cm) measured from the base of nodal region of shoot to the tip of the longest root by using scale and root diameter (mm) measured by using digital vernier callipers in between base to tip of the roots. For each core section RLD and RMD were respectively calculated as the ratio of total root length and total root mass to the volume of soil as described by Baldwin *et al.* (2009). Data were analyzed statistically by adopting the procedures outlined by Panse and Sukhatme (1985).

Results and discussion

Significant differences were observed between different methods of establishment, turf grass species and their interaction effects for number of roots per stolon and root length (Table 1). A gradual increase was observed in the number of roots formed per stolon and root length in the methods of establishment, turf grass species and their interaction effects with passage of time. Dibbling method of establishment recorded significantly more number of roots per stolon and maximum root length compared to that of turf plastering method of establishment. Dibbling method of establishment also recorded significantly the highest number of roots formed and root length distribution due to the presence of more number of leaves per stolon thereby an increase in the photosynthetic activity of the grass species which helped in the diversion of photo assimilates towards the root system of the dibbled grass. Further, the root length which was recorded significantly the highest in dibbling method of establishment could be attributed to less soil compaction, more bulk density, more pore space availability, proper gaseous exchange and an increased supply of photo assimilates towards root system there

Table 1. Effect of methods of establishment, turf grass species and their interaction effects on number of roots per stolon and root length distribution at different days after planting

Treatment	Number of roots per stolon						Root length distribution (cm)					
	20	40	60	80	100	120	20	40	60	80	100	120
Establishment methods												
Dibbling (E ₁)	85.25	95.16	107.10	118.33	129.72	142.08	8.57	11.72	12.15	12.61	13.05	13.45
Turf plastering (E ₂)	75.52	85.63	95.84	107.25	118.33	128.50	6.51	10.55	10.89	11.20	11.58	11.86
SEm±	1.61	0.42	0.51	0.30	0.69	0.19	0.11	0.05	0.09	0.06	0.07	0.05
LSD (P=0.05)	4.87	1.29	1.54	0.91	2.09	0.58	0.33	0.17	0.28	0.19	0.22	0.16
Turf grass species												
Bermuda grass (G ₁)	109.83	118.83	130.57	145.67	158.17	172.00	9.88	14.40	15.00	15.43	15.94	16.34
Korean grass (G ₂)	49.40	63.38	74.90	84.83	95.00	103.00	3.75	7.25	7.43	7.67	7.88	8.12
St. Augustine grass (G ₃)	91.32	103.71	112.77	123.83	136.17	149.33	9.79	12.70	13.00	13.34	13.76	14.12
Centipede grass (G ₄)	71.00	75.67	87.67	96.83	106.17	116.83	6.73	10.22	10.65	11.17	11.68	12.04
SEm±	2.27	0.61	0.71	0.43	0.98	0.27	0.15	0.08	0.13	0.09	0.10	0.07
LSD (P=0.05)	6.89	1.83	2.18	1.29	2.96	0.83	0.46	0.24	0.39	0.28	0.31	0.23
Establishment methods x Turf grass species												
E ₁ ×G ₁	110.00	120.00	134.00	151.33	165.33	180.67	11.93	14.84	15.49	16.02	16.48	16.93
E ₁ ×G ₂	50.33	67.33	79.33	89.33	99.00	109.00	4.21	8.21	8.42	8.71	8.99	9.33
E ₁ ×G ₃	93.67	105.67	114.10	124.67	136.00	150.67	10.20	13.34	13.76	14.11	14.50	14.88
E ₁ ×G ₄	87.00	87.67	101.00	108.00	117.33	128.00	7.94	10.50	10.93	11.60	12.24	12.67
E ₂ ×G ₁	109.67	117.67	127.13	140.00	151.00	163.33	7.84	13.92	14.51	14.85	15.39	15.77
E ₂ ×G ₂	48.47	59.43	70.47	80.33	91.00	97.00	3.30	6.29	6.44	6.64	6.79	6.91
E ₂ ×G ₃	88.97	101.77	111.44	123.00	136.33	148.00	9.39	12.06	12.25	12.58	13.03	13.36
E ₂ ×G ₄	55.00	63.67	74.33	85.67	95.00	105.67	5.53	9.94	10.38	10.74	11.12	11.41
SEm±	3.21	0.85	1.02	0.60	1.38	0.38	0.22	0.11	0.18	0.13	0.14	0.11
LSD (P=0.05)	9.75	2.59	3.15	1.83	4.18	1.18	0.65	0.35	0.56	0.40	0.44	0.34

by maintenance of optimum soil moisture content in the soil favoured the development of longer roots and more penetration into the deeper depths of soil horizons.

Bermuda grass recorded highest number of roots per stolon and root length. Korean grass recorded significantly the lowest number of roots per stolon and root length. St. Augustine and Centipede grasses were found to be intermediate for number of roots per stolon and root length on many of the days of observation.

Bermuda grass planted with dibbling method of establishment recorded significantly highest number of roots per stolon and root length distribution, followed by St. Augustine grass planted with dibbling method of establishment and Bermuda grass planted with turf plastering method. At 20 and 40 DAP the number of roots per stolon in Bermuda grass planted with dibbling method of establishment was at par with Bermuda grass planted with turf plastering method. Korean grass planted with turf plastering method showed significantly the lowest number of roots per stolon and root length distribution. Koski (1983) reported that formation of number of roots and length distribution was dependent on the age of the grass species, season of planting and method of establishment. The formation of number of roots depends upon the soil physical characteristics and prevailing weather conditions in the locality. Formation of more number of roots leads to greater biodiversity in the root zone. Rooting density of turf grass species with different methods of establishment was found decreased with an increase in soil depth. The present findings were in confirmation with the results of Jinmin and Dernoeden (2009) in their earlier studies on turf grass species. The differences in root length among different turf grass species could be attributed to the inherent genotypic character. Chen *et al.* (2012) observed an increase in root length distribution due to increased absorption of water and nutrients with minimum energy consumption. Deeper root distribution was associated with drought avoidance and

tolerance in many turf grass species (Carrow, 1996). Grass species which have recorded higher root length distribution showed the drought avoidance in the present study. Baldwin *et al.* (2008) and Aimilia-Eleni *et al.* (2012) also reported similar observations earlier in various turf grass species.

Significant differences were observed between different methods of establishment, turf grass species and their interaction effects for root fresh and dry weights (Table 2). Dibbling method of establishment recorded significantly the maximum root fresh weight and root dry weight when compared with turf plastering method of establishment. Less compaction, availability of more pore space, soil moisture content and proper gaseous exchange in the soil might have led to early establishment of root system there by increased the water and nutrient uptake from the soil. Further, an increase in the stolon length, number of leaves per stolon and leaf area thereby an increase in the photosynthetic activity of the leaves led to translocation of more photo assimilates towards the root system which helped an increase in root length and formation of more number of new roots. Finally, it may be concluded that accumulation of more photo assimilates in roots increased the root thickness there by increased the root fresh weight, finally which led to an increase in root dry weight.

Bermuda grass recorded highest root fresh weight and root dry weight followed by St. Augustine grass, whereas Korean grass recorded lowest root fresh and dry weights on all the days of observations recorded. The differences in the root fresh and dry weights among turf grass species might be due to inherent variation in the genetic constitution of different turf grass species (Juncker and Madison, 1967).

Bermuda grass planted with dibbling method of establishment recorded significantly the highest root fresh weight and root dry weight followed by Bermuda grass planted with turf plastering method of establishment which was at par with St. Augustine

Table 2. Effect of methods of establishment, turf grass species and their interaction effects on root fresh weight and dry weight at different days after planting

Treatment	Root fresh weight (g)						Root dry weight (g)					
	20	40	60	80	100	120	20	40	60	80	100	120
Establishment methods												
Dibbling (E_1)	4.08	4.70	5.54	6.38	6.94	7.95	1.51	2.03	2.41	2.74	3.13	3.62
Turf plastering (E_2)	3.54	4.31	4.90	5.50	6.30	7.17	1.33	1.54	1.92	2.22	2.53	2.62
SEm±	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.03
LSD ($P=0.05$)	0.03	0.04	0.03	0.03	0.04	0.03	0.06	0.04	0.03	0.03	0.03	0.09
Turf grass species												
Bermuda grass (G_1)	5.10	5.83	6.81	7.72	8.45	9.74	2.10	2.78	3.21	3.67	4.12	4.32
Korean grass (G_2)	2.25	2.76	3.15	3.65	4.22	4.93	0.61	0.82	1.12	1.38	1.81	2.24
St. Augustine grass (G_3)	4.45	5.32	6.11	7.01	7.60	8.54	1.91	2.25	2.51	2.76	3.02	3.40
Centipede grass (G_4)	3.46	4.10	4.81	5.40	6.24	7.01	1.10	1.30	1.82	2.12	2.35	2.57
SEm±	0.01	0.02	0.02	0.01	0.02	0.01	0.03	0.02	0.01	0.01	0.02	0.04
LSD ($P=0.05$)	0.04	0.06	0.50	0.04	0.06	0.04	0.08	0.06	0.04	0.04	0.05	0.13
Establishment methods x Turf grass species												
$E_1 \times G_1$	5.28	6.13	7.29	8.20	8.66	10.14	2.11	3.09	3.46	3.97	4.56	5.09
$E_1 \times G_2$	2.41	2.97	3.33	3.82	4.41	5.39	0.68	1.00	1.34	1.75	2.07	2.53
$E_1 \times G_3$	4.82	5.38	6.25	7.58	8.05	8.82	1.96	2.42	2.74	2.88	3.19	3.86
$E_1 \times G_4$	3.84	4.32	5.28	5.96	6.64	7.44	1.31	1.61	2.11	2.37	2.68	3.01
$E_2 \times G_1$	4.92	5.54	6.32	7.25	8.23	9.35	2.09	2.47	2.96	3.38	4.08	4.29
$E_2 \times G_2$	2.09	2.55	2.96	3.49	4.04	4.48	0.54	0.65	0.91	1.03	1.54	1.94
$E_2 \times G_3$	4.09	5.27	5.97	6.43	7.10	8.27	1.86	2.09	2.29	2.64	2.85	2.91
$E_2 \times G_4$	3.08	3.87	4.34	4.82	5.84	6.59	0.84	0.93	1.54	1.87	2.03	2.14
SEm±	0.02	0.03	0.02	0.02	0.03	0.02	0.04	0.03	0.02	0.02	0.02	0.06
LSD ($P=0.05$)	0.06	0.09	0.07	0.06	0.09	0.05	0.11	0.09	0.05	0.05	0.07	0.19

grass planted with dibbling method of establishment except at 80 DAP. Korean grass planted with turf plastering method of establishment recorded lowest root fresh weight and root dry weight on all the days of observations recorded. Further, an increase in the root fresh and dry weights helped in better root penetration and absorption of more water and nutrients from the soil thereby an increase in the rate of photosynthetic activity was observed in the plants. The increased photosynthetic activity in the plant further helped in the translocation of reserved carbohydrates towards the root system there by an increase in the root growth both in terms of root length as well as in terms of formation of more number of new roots was observed which increased the root fresh and dry weights. Zhenping *et al.* (2008), Macolino *et al.* (2012) and Ubendra (2014) reported similar findings in different turf grass species.

Significant differences were observed between the establishment methods, turf grass species and their interaction effects for root length and mass densities (Table 3). A gradual increase in root length and mass density were observed in the methods of establishment of turf grass species and their interaction effects with passage of time. Dibbling method of establishment recorded highest root length density and root mass density when compared with turf plastering method of establishment. It could be attributed to early establishment of grass slips and easy penetration of root system due to less soil compaction and availability of more pore space, optimum soil moisture content and proper gaseous exchange in the soil horizon. Early establishment of grass slips in the dibbling method of establishment was also responsible for more water and nutrients absorption from the soil. This resulted in improved grass coverage on the ground by development of more number of roots (mass and length wise).

Bermuda grass planted with dibbling method of establishment

recorded highest root length density and root mass density followed by St. Augustine grass planted with dibbling method of establishment. Korean grass planted with turf plastering method of establishment recorded lowest root length and mass densities on all the days of observations recorded. The reason might be the relatively lower root exploration capacity of other grass species when compared with Bermuda grass indicated its inherent genetic character towards the root development. The root length and mass densities of grass species were positively correlated with root exploration capacity. Macolino *et al.* (2012) and Rimi *et al.* (2012) reported similar findings earlier in different turf grass species which are in agreement with the present results.

Based on overall observations, it could be concluded that dibbling method of Bermuda grass establishment is better for getting higher number of roots per stolon, root length distribution, root fresh and dry weights and root length and mass densities. However, Korean grass has low growth and mass density as compared to other grass species under the coastal humid tropical conditions of Andhra Pradesh.

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Table 3. Effect of methods of establishment, turf grass species and their interaction effects on root length density and root mass density at different days after planting

Treatment	Root length density (RLD) (cm g ⁻³)						Root mass density (RMD) (g g ⁻³)					
	20	40	60	80	100	120	20	40	60	80	100	120
Establishment methods												
Dibbling (E ₁)	8.62	8.89	9.10	9.34	9.75	10.26	3.41	3.62	3.81	3.90	4.22	4.43
Turf plastering (E ₂)	7.05	7.34	7.57	7.80	8.06	8.45	2.83	3.06	3.25	3.45	3.62	3.93
SEm±	0.02	0.03	0.03	0.03	0.02	0.02	0.05	0.05	0.05	0.05	0.06	0.05
LSD (P=0.05)	0.07	0.08	0.09	0.10	0.06	0.06	0.15	0.16	0.15	0.16	0.18	0.15
Turf grass species												
Bermuda grass (G ₁)	9.18	9.31	10.15	10.68	11.20	11.94	5.11	5.31	5.43	5.55	5.80	6.12
Korean grass (G ₂)	5.54	5.73	5.98	6.12	6.43	6.72	1.01	1.30	1.48	1.58	1.83	2.06
St. Augustine grass (G ₃)	8.95	9.19	9.35	9.53	9.75	10.21	3.81	4.08	4.30	4.46	4.72	4.92
Centipede grass (G ₄)	7.54	7.71	7.88	7.95	8.23	8.54	2.56	2.70	2.91	3.10	3.35	3.62
SEm±	0.03	0.04	0.04	0.04	0.03	0.03	0.07	0.08	0.07	0.08	0.09	0.07
LSD (P=0.05)	0.10	0.11	0.13	0.14	0.09	0.08	0.22	0.23	0.22	0.23	0.26	0.22
Establishment methods x Turf grass species												
E ₁ ×G ₁	10.09	10.43	10.71	11.35	12.14	12.99	5.50	5.71	5.82	5.84	6.16	6.45
E ₁ ×G ₂	6.18	6.40	6.58	6.70	7.07	7.41	1.17	1.40	1.62	1.62	2.01	2.20
E ₁ ×G ₃	9.83	10.15	10.32	10.51	10.68	11.23	3.95	4.22	4.45	4.61	4.88	5.05
E ₁ ×G ₄	8.38	8.59	8.81	8.80	9.10	9.42	3.04	3.15	3.36	3.54	3.87	4.04
E ₂ ×G ₁	8.54	9.20	9.58	10.01	10.27	10.90	4.72	4.90	5.04	5.27	5.44	5.79
E ₂ ×G ₂	4.90	5.08	5.38	5.56	5.79	6.04	0.85	1.20	1.34	1.55	1.66	1.93
E ₂ ×G ₃	8.07	8.24	8.38	8.55	8.82	9.20	3.68	3.93	4.15	4.32	4.56	4.79
E ₂ ×G ₄	6.70	6.84	6.96	7.10	7.36	7.67	2.08	2.22	2.47	2.66	2.83	3.20
SEm±	0.05	0.05	0.06	0.06	0.04	0.04	0.10	0.11	0.10	0.11	0.12	0.10
LSD (P=0.05)	0.15	0.16	0.19	0.20	0.14	0.12	0.31	0.32	0.31	0.32	0.37	0.30

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