International Journal of Agricultural Sciences
Volume 14 | Issue 2 | June, 2018 | 354-361 ■ e ISSN-0976-5670
DOI:10.15740/HAS/IJAS/14.2/354-361
Visit us : *www.researchjournal.co.in*

RESEARCH PAPER

Influence of physiological responses on the establishment of turfgrass species under different methods of planting

R. Dhanalakshmi, V. Vijaya Bhaksar* **and** P. Subbaramamma[1]
College of Horticulture, Dr. Y.S.R. Horticultural University, Anantharajupeta, Kadapa (A.P.) India
(Email : vijayabaachi@gmail.com)

Abstract : The present investigation was carried out at College of Horticulture, V.R. Gudem, West Godavari district of Andhra Pradesh during the year 2014-15. Aim of the experiment was to find out physiological responses of turfgrass species to different methods of planting under humid tropical coastal conditions of Andhra Pradesh. The experiment was laid out in a factorial randomized block design with 4 turf grass species *viz.*, Bermuda grass (*Cynodon dactylon*), Korean grass (*Zoysia japonica*), St. Augustine grass (*Stenotaphrum secundatum*) and Centipede grass (*Erimochloa ophiuroides*) planted with dibbling and turf plastering methods. Based on the results obtained it was concluded that dibbling method of planting and Bermuda grass species individually recorded significantly highest amounts of chlorophyll pigments, but their interaction effect was found non-significant. St. Augustine grass planted with dibbling method recorded significantly highest stolon fresh and dry weights (65.27 and 13.97 g, respectively). Bermuda grass planted with dibbling method of establishment recorded significantly highest values for root fresh and dry weights (10.14 and 5.09 g, respectively), root length density (12.99 cm/g^{-3}) and root mass density (6.45 g/ g^{-3}). Korean grass planted with turf plastering method recorded significantly lowest stolon fresh and dry weights (26.53 and 6.34 g, respectively), root fresh and dry weights (4.48 and 1.94 g, respectively), root length density (6.04 cm/g^{-3}) and root mass density (1.93 g/g^{-3}).

Key Words : Bermuda grass, Korean grass, St. Augustine grass, Centipede grass, Chlorophyll, Stolon, Root

View Point Article : Dhanalakshmi, R., Bhaksar, V. Vijaya and Subbaramamma, P. (2018). Influence of physiological responses on the establishment of turfgrass species under different methods of planting. *Internat. J. agric. Sci.*, **14** (2) : 354-361, **DOI:10.15740/HAS/IJAS/14.2/354-361.**

Article History : Received : 03.03.2018; **Revised :** 26.04.2018; **Accepted :** 12.05.2018

INTRODUCTION

A change in the life style brought a change in the environment posing a challenge. Deforestation, proliferation of industrial development, urbanisation, increased vehicle trafficking, indiscriminate usage of electronic gadgets, all have led to a change in the environment causing difficulties in different forms to the living organisms with particular reference to the humanity. Conversion of millions of acres of productive agricultural land into real estate or industrial purposes causing downfall in the agricultural production apart from the dwindling natural resources. Maintenance of equilibrium in the ecosystem versus modern development

*** Author for correspondence:**
[1]Department of Floriculture and Landscape Architecture, College of Horticulture, Dr. Y.S.R. Horticultural University, Venkataramannagudem, West Godavari (A.P.) India
[2]Department of Plant Physiology, College of Horticulture, Dr. Y.S.R. Horticultural University, Venkataramannagudem, West Godavari (A.P.) India

should go hand in hand without causing harm to the environment and ecological systems. Upon realizing alarming situation with regard to challenging changes in the climate, the governments started enacting several Acts related to protection of environment. The gravity of this issue in India has urged from common man to policy makers to develop and establish gardens as per the law established *i.e.*, mandatory for the corporate sectors to maintain at least 33% greenery around their establishments. Millions of acres of turfgrass established in the home gardens, commercial landscapes, road sides, parks, athletic fields and golf courses improved the quality of life by providing open space, recreational facilities and business opportunities apart from reducing the pollutants thereby enhanced the property value and finally led to the conservation of natural resources.

Lawn grasses reduce the problem of mud and reduce the problem of pollutants *viz.*, dust, absorb the noise, control the soil erosion, protect the ground water, filter the water, produce lot of oxygen and the comprehensiveness of all these environmental benefits improve the quality of life. Lawn is not only enhances the value and beauty of our lives but also contribute towards the improvement in our physical and mental health because of its great therapeutic value.

Grasses are considered as mono-cotyledonous weeds belonging to the family poaceae. Domestication of these weed grasses has become the dollar business in the recent times. Value of grasses has long been recognized from pre-historic times, but within the past 100 years the aesthetic value of grasses has gained lot of importance for pleasure purposes as well as establishment of sports grounds. A lawn is an area where grass is grown as a green carpet for landscapes. Lawn is considered as 'heart of landscape' and it is the basic feature for any type of garden. Having a garden with beautiful lawns at home is considered as an aesthetic prestige and it is the dream of many people. A community with a high percentage of attractive home lawns and with a ready access to maintain healthy turf in parks and play grounds enhanced the quality of living for its inhabitants (Sprague, 1982). Lawn apart from the functional value has an excellent play surface and the quality of the play has a direct correlation with the turf established in the playing area. The contemporary living concepts in urban agglomeration has witnessed the apartments, individual villas, townships, gated communities, urban extension, etc., and on the other side Multi-National Companies, Corporate companies demand for uniform development of open green spaces with ornamental plants and lawns to balance the global warming phenomenon.

Proper establishment and maintenance are essential for any lawn to be healthy and to look at its best. A lawn laid out in a scientific way will remain good enough for a reasonably longer period with lower maintenance. When we try to understand the scientific attempts and research issues related to the establishment of turfgrass species in India, the answer is deprived. There is a significant demand of turfgrass species for their aesthetic display in the landscape designs as well as for a prompt functional usage in the sports domain, have set a tone for developing futuristic research modules in turfgrass breeding, production, establishment and maintenance. For initiating a sound turf research and development program will begin with the identification of genetic resources in turfgrass species and cultivars should be given prime importance apart from the method of establishment. Keeping all these things in view, the present investigation was planned to generate research evidence on the establishment of turfgrass species with different methods of planting and evaluating their performance based on certain physiological implications.

MATERIAL AND METHODS

The present experiment was carried out at College of Horticulture, Venkataramanna Gudem, West Godavari district of Andhra Pradesh during the year 2014-2015. The experimental field was laid out in a Factorial Randomized Block Design (FRBD) with three replications. The net plot size was of 3 m × 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 earth, tank silt and compost in 2:1:1:1 ratio. Later the soil was drenched with chlorpyriphos @ 2.5 ml l^{-1} to control white ants before turfgrass planting. Rooted slips of four turfgrass species *viz.*, Bermuda grass (*Cynodon dactylon*), Korean grass (*Zoysia japonica*), St. Augustine grass (*Stenotaphrum secundatum*) and Centipede grass (*Erimochloa ophiuroides*) were collected from Hortus Consultants (I) Pvt. Ltd., Pune, Maharashtra and planted with dibbling (small pieces of grass roots are dibbled at 10 cm apart on a levelled ground in *zig-zag* manner 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 was done gently with a rose can). The treatment details were: T_1: Bermuda grass with dibbling method; T_2: Korean grass with dibbling method; T_3: St. Augustine grass with dibbling method; T_4: Centipede grass with dibbling method; T_5: Bermuda grass with plastering/slurry method; T_6: Korean grass with plastering/slurry method; T_7: St. Augustine grass with plastering/slurry method; T_8: Centipede grass with plastering/slurry method. After planting, the turf grass species were provided sufficient moisture by applying water every day through rose can at regular interval to promote germination as early as possible. Hand weeding was carried out regularly at fortnight interval commencing from 30 days after planting to control both annual and perennial weeds during the course of establishment of turfgrass species.

Data were collected on various physiological parameters at 120 days after planting from five randomly selected plants and the average values were worked out for scientific interpretation of the results. Chlorophyll-a,b and total contents were estimated as per the procedure explained by Arnon (1949). Stolon fresh and dry weights were measured by collecting 5 plants randomly in each plot. An upright shoot producing adventitious root was considered as an individual plant. Five randomly selected plants in each plot were uprooted from the soil and washed thoroughly under tap water to remove the soil particles adhered to the roots and shoots. Later the roots and shoots of individual plants were separated and recorded the stolon fresh weight by removing the excess moisture from the stolon by using blotting paper. Then stolon was placed in to a brown paper bag and dried in sun light for two days. Later the brown paper bag was placed in a hot air oven at 70°C for 48 hours. Remove the brown paper bag from oven and record the dry weight of stolons of individual plant. The average fresh and dry weights of stolon was recorded and expressed in grams. Root fresh and dry weights of turfgrass species were measured by uprooting five randomly selected plants from the plot and washed thoroughly under tap water to remove the soil particles adhered to the root system. Separated roots of the individual plant and recorded fresh weight of roots after removing excess moisture from the roots by using blotting paper. The average root fresh weight was calculated and expressed in grams. 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 and then recorded dry weight of roots. The average root dry weight was calculated and expressed in grams.

Root length density (RLD) was calculated as ratio of total root length to volume of soil and the averages are expressed in cm/gm^{-3} as described by Baldwin *et al.* (2009) through the formula given below.

$$\text{RLD} = \frac{\text{Total root length (cm)}}{\text{Volume of soil } (g^3)}$$

Root mass density (RMD) was calculated by analysing the total root length (cm) and then root mass and finally ratio of total root mass to volume of soil and the averages are expressed in g/gm^{-3} (Baldwin *et al.*, 2009).

$$\text{RMD} = \frac{\text{Total root mass (g)}}{\text{Volume of soil } (g^3)}$$

The data arrived was analysed statistically by following standard statistical methods outlined by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Chlorophyll pigments :

Significant differences were observed in the data pertaining to chlorophyll pigments of turfgrass species planted with different methods (Table 1). Dibbling method of planting recorded significantly highest a, b and total chlorophyll pigments (1.80, 0.84 and 2.34 mg/g, respectively) in comparison to turf plastering (1.50, 0.70 and 1.97 mg/g, respectively) method at 120 days after planting. Apparently quantity of all the chlorophyll pigments were observed more in dibbling method of planting than in turf plastering method which could be attributed to early establishment of turfgrass species in dibbling method might have helped to better supply of water and nutrients essential for the formation of chlorophyll in leaves. Significant differences were observed among turf grass species for different constituents of chlorophyll pigments. Bermuda grass recorded significantly highest content of chlorophyll pigments a, b and total chlorophyll (2.34, 1.00 and 3.24 mg/g, respectively) at 120 days after planting, whereas, St. Augustine grass recorded significantly lowest quantities of chlorophyll pigments (1.05, 0.50 and 1.23 mg/g of chlorophyll a, b and total, respectively). The interaction effect between methods of planting and turfgrass species was found non-significant with regard to different pigments of chlorophyll. Based on the results obtained it could be concluded that Bermuda grass recorded significantly highest amount of chlorophyll pigments a, b and total chlorophyll when compared with other turf grass species. Bermuda grass and Korean grass species used in the present study were considered as dark green coloured turf grass species. St. Augustine grass has been considered as light green coloured species, hence, might have recorded significantly lowest chlorophyll pigments. Johnson (1973) reported that darker the leaf colour, more is the chlorophylls content. Bermuda grass recorded significantly highest quantity of chlorophyll pigments which indicated its potentiality to tolerate high temperatures prevailing in the tropical regions. Liu and Huang (2000) reported that possession of higher quantities of chlorophyll pigments in leaves might have been considered as an indicator of heat tolerance under warm season conditions. Variation in chlorophyll-a, chlorophyll-b and total chlorophyll contents among different turf grass species could be attributed to their genetic nature. Verhoeven *et al.* (2005) reported that photosynthetic activities of evergreen plants decline when temperatures drop down. However, chlorophyll continues its light-absorbing properties even under lowered temperature conditions thereby growth and development continues.

Stolon fresh weight and dry weight :

Significant differences were observed in the data pertaining to stolon fresh and dry weights influenced by turfgrass species planted under different methods (Table

Table 1: Influence of physiological parameters on the establishment of turfgrass species planted under different methods

Treatments	120 Days after planting								
	Chl-a (mg/g)	Chl-b (mg/g)	Total Chl (mg/g)	Stolon Fresh Wt. (g)	Stolon Dry Wt. (g)	Root Fresh Wt. (g)	Root Dry Wt. (g)	RLD (cm/g^{-3})	RMD (g/g^{-3})
Methods of planting									
Dibbling (M_1)	1.80	0.84	2.34	46.30	12.49	7.95	3.62	10.26	4.43
Turf plastering (M_2)	1.50	0.70	1.97	40.70	10.16	7.17	2.62	8.45	3.93
S.E.±	0.03	0.02	0.05	0.36	0.09	0.01	0.03	0.02	0.05
C.D. (P=0.05)	0.08	0.07	0.14	1.10	0.26	0.03	0.09	0.06	0.15
Turf grass species									
Bermuda grass (G_1)	2.34	1.00	3.24	40.54	9.60	9.74	4.32	11.94	6.12
Korean grass (G_2)	1.80	0.82	2.32	27.72	7.11	4.93	2.24	6.72	2.06
St. Augustine grass (G_3)	1.05	0.50	1.23	60.62	16.13	8.54	3.40	10.21	4.92
Centipede grass (G_4)	1.40	0.75	1.84	45.10	12.45	7.01	2.57	8.54	3.62
S.E.±	0.04	0.03	0.07	0.51	0.12	0.01	0.04	0.03	0.07
C.D. (P=0.05)	0.15	0.10	0.21	1.56	0.37	0.04	0.13	0.08	0.22
Methods of planting x Turf grass species									
$M_1 \times G_1$	2.47	1.08	3.32	42.63	10.29	10.14	5.09	12.99	6.45
$M_1 \times G_2$	1.94	0.93	2.57	28.91	7.88	5.39	2.53	7.41	2.20
$M_1 \times G_3$	1.17	0.53	1.41	65.27	18.30	8.82	3.86	11.23	5.05
$M_1 \times G_4$	1.56	0.84	2.08	48.34	13.48	7.44	3.01	9.42	4.04
$M_2 \times G_1$	2.21	0.88	3.16	38.44	8.91	9.35	4.29	10.90	5.79
$M_2 \times G_2$	1.61	0.71	2.07	26.53	6.34	4.48	1.94	6.04	1.93
$M_2 \times G_3$	0.92	0.41	1.04	55.97	13.97	8.27	2.91	9.20	4.79
$M_2 \times G_4$	1.22	0.65	1.59	41.83	11.43	6.59	2.14	7.67	3.20
S.E.±	0.05	0.05	0.10	0.73	0.17	0.02	0.06	0.04	0.10
C.D. (P=0.05)	NS	NS	NS	2.20	0.53	0.05	0.19	0.12	0.30

NS=Non-significant

1). Dibbling method of planting recorded significantly highest stolon fresh and dry weights (46.30 and 12.49 g, respectively) in comparison to turf plastering (40.70 and 10.16 g, respectively) method. Significant increase in the stolon fresh and dry weights planted with dibbling method could be attributed to early establishment of turfgrass species thus helped to increase the stolon length, thickness, number of leaves per stolon, leaf length, leaf width, leaf area and photosynthetic activity which might have helped to accumulate more dry matter in the stolons. Significant differences were observed among different turfgrass species for stolon fresh and dry weights. St. Augustine grass recorded significantly highest stolon fresh and dry weights (60.62 and 16.13 g, respectively), whereas, Korean grass recorded significantly lowest stolon fresh and dry weights (27.72 and 7.11 g, respectively) at 120 days after planting. Significant differences were observed in the interaction effect between methods of planting and turfgrass species with regard to stolon fresh and dry weights. St. Augustine grass planted with dibbling method of establishment recorded significantly highest stolon fresh and dry weights (65.27 and 18.30 g, respectively) followed by St. Augustine grass planted with turf plastering (55.97 and 13.97 g, respectively) method. Korean grass planted with turf plastering method recorded significantly lowest stolon fresh and dry weights (26.53 and 6.34 g, respectively) at 120 days after planting. Based on the results obtained it could be concluded that St. Augustine grass recorded significantly highest stolon fresh and dry weights which could be attributed to an increase in the stolon length, thickness, leaf length, leaf width and leaf area per stolon which might have contributed to an increase in the leaf photosynthetic activity. Korean grass recorded significantly the lowest stolon fresh and dry weights which could be attributed to formation of lowest number of leaves, leaf length, leaf width, leaf area, stolon length, stolon thickness thus leading to lower activity of photosynthesis recorded in leaves. Further, variation in stolon fresh and dry weights could also be attributed to their inherent genetic constitution of turfgrass species. Zhenping *et al.* (2008); Venugopal (2012) and Ubendra (2014) reported similar kind of observation in their earlier studies with different turfgrass species.

Root fresh weight and dry weight :

Significant differences were observed in the data pertaining to root fresh and dry weights influenced by turfgrass species planted under different methods (Table 1). Dibbling method of planting recorded significantly highest root fresh and dry weights (7.95 and 3.62 g, respectively) in comparison with turf plastering (7.17 and 2.62 g, respectively) method. Significantly highest root fresh and dry weights of turfgrass species planted with dibbling method might be attributed to increased soil pore space due to lower soil compaction and availability of optimum soil moisture content and proper gaseous exchange helped to early establishment of root system of turfgrass slips thereby an increase in the uptake of water and nutrient from the soil observed thus leading to an increase in the stolon length, number of leaves per stolon and leaf area which has contributed to increased photosynthetic activity of leaves. Availability of more photo-assimilates were translocated towards the development of root system which helped to record an increase in the root length and formation of more number of newer roots. Further accumulation of more photo-assimilates in the roots led to an increase in the root thickness there by increased the root fresh and dry weights. Significant differences were observed among different turfgrass species for root fresh and dry weights. Bermuda grass recorded significantly highest root fresh and dry weights (9.74 and 4.32 g, respectively) followed by St. Augustine grass (8.54 and 3.40 g, respectively). Korean grass recorded significantly lowest root fresh and dry weights (4.93 and 2.24 g, respectively). Interaction effect between methods of planting and turfgrass species with regard to root fresh and dry weights was found significant variation. Bermuda grass planted with dibbling method recorded significantly highest root fresh and dry weights (10.14 and 5.09 g, respectively) followed by Bermuda grass planted with turf plastering (9.35 and 4.29 g, respectively) method. Korean grass planted with turf plastering method recorded significantly lowest root fresh and dry weights (4.48 and 1.94 g, respectively). Based on the results obtained it could be concluded that Bermuda grass recorded significantly highest root fresh and dry weights whereas, Korean grass recorded significantly lowest root fresh and dry weights. Maximum per cent sprouting of grass slips *i.e.*, 80.17% (data not shown) in Bermuda grass species might have helped for early establishment of turfgrass species. Early establishment further helped in better root penetration and absorption of more water and nutrients from the soil thereby increased formation of more number of newer shoots and number of leaves per stolon (1089.50 – data not shown) there by increased the ground cover percentage (96.03 – data not shown). Increased photosynthetic activity in leaves might have helped in the translocation of carbohydrates towards the root system thereby increased root growth both in terms of root length as well as formation of more number of newer roots thus increased root fresh and dry weights. The differences in root fresh and dry weights among the turfgrass species might be due to inherent genetic constitution of plant species (Junker and Madison, 1967). Macolino *et al*. (2012) and Ubendra (2014) reported similar kind of observation in their earlier investigation while studying different turfgrass species.

Root length density (RLD) :

Significant differences were observed in the root length density of turfgrass species planted under different methods of planting (Table 1). Dibbling method of planting recorded significantly highest root length density (10.26 cm/g^{-3}) when compared with turf plastering (8.45 cm/g^{-3}) method. The reason could be attributed to early establishment and easy penetration of root system of turfgrass slips due to lower soil compaction and availability of more pore space with optimum soil moisture content as well as proper gaseous exchange in the soil horizon. Early establishment of grass slips with well developed root system was found responsible for absorption of more water and nutrients from the soil there by improved the grass coverage on the ground by development of more number of roots in length wise has led to increased root length density with dibbling method of planting than turf plastering. Turfgrass species have expressed significant differences in the root length density. Bermuda grass recorded significantly highest root length density (11.94 cm/g^{-3}) followed by St. Augustine grass (10.21 cm/g^{-3}). Korean grass recorded significantly lowest root length density (6.72 cm/g^{-3}). Interaction effect between methods of planting and turfgrass species with regard to root length density was found significant. Bermuda grass planted with dibbling method recorded significantly highest root length density (12.99 cm/g^{-3}) followed by St. Augustine grass planted with dibbling (11.23 cm/g^{-3}) method. Korean grass planted with turf plastering method recorded significantly lowest root length density (6.04 cm/g^{-3}). Based on the results obtained it could be concluded that Bermuda grass recorded significantly

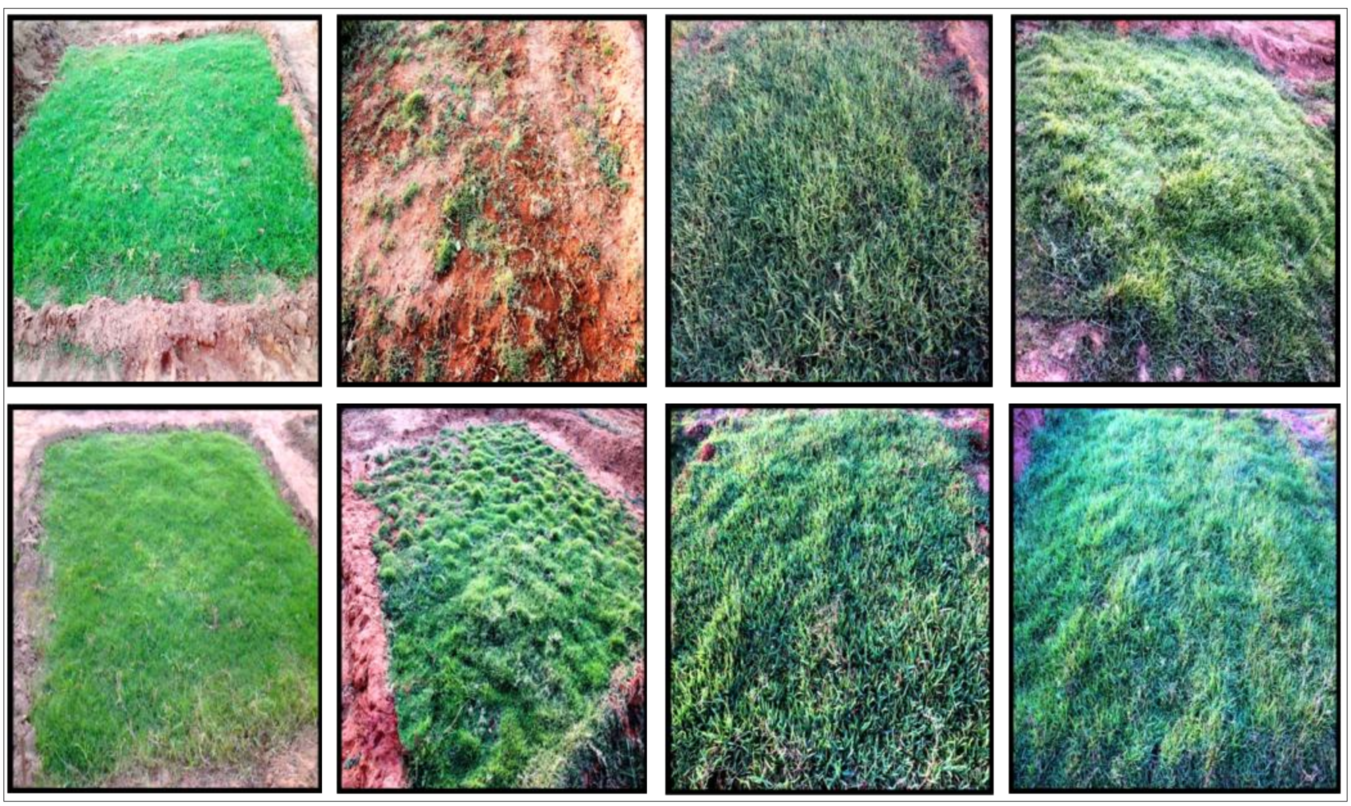

Fig. 1 : Establishment of Bermuda, Korean, St. Augustine and Centipede grass species (left to right) planted with Turf plastering (top row) and Dibbling method (bottom row) of planting at 120 days after planting

highest root length density when compared with other grass species. The reason might be due to relatively lower root exploration capacity of other grass species when compared to Bermuda grass species. Huang *et al*. (1997) opined that increased root length density might be due to the inherent genetic character of a particular species. Root length density of turfgrass species was found positively correlated with root exploration capacity. Further, increased root length density was also found correlated with Bermuda grass species which had darker green leaves. Macolino *et al*. (2012) observed variations in the root length density of turfgrass species of darker and lighter green in colour.

Root mass density (RMD) :

Significant variation was observed in the root mass density of turfgrass species planted under different methods (Table 1). Dibbling method recorded significantly highest root mass density (4.43 g/g^{-3}) when compared with turf plastering (3.93 g/g^{-3}) method. Early establishment of turfgrass species planted with dibbling method increased the ground cover percentage through easy penetration of root system thus increased the uptake of water and nutrients from the soil which might have helped to record an increase in the stolon length, number of leaves per stolon and leaf area. Increased photosynthetic activity of leaves led to an increase in the production of photo-assimilates which were translocated to the root system. Further, it led to development of roots either in terms of length or in terms of an increase in the number of roots per stolon and an increase in the root diameter due to accumulation of more photo-assimilates which led to increased root mass density planted with dibbling method than in turf plastering method. Significant variation was observed in the root mass density of different turfgrass species. Among the turfgrass species, Bermuda grass recorded significantly highest root mass density (6.12 g/g^{-3}) followed by St. Augustine grass (4.92 g/g^{-3}), whereas, Korean grass recorded significantly lowest root mass density (2.06 g/g^{-3}). Interaction effect between methods of planting and turfgrass species has created significant variation with regard to root mass density. Bermuda grass planted with dibbling method of planting recorded significantly highest root mass density (6.45 g/g^{-3}) followed by Bermuda grass planted with turf plastering (5.79 g/g^{-3}). Korean grass planted with turf plastering method recorded significantly lowest root mass density (1.93 g/g^{-3}). Based on the results obtained it could be concluded that Bermuda grass planted with dibbling method of planting recorded significantly highest root mass density due to higher root exploration capacity under lower soil compaction. Further, inherent genetic character of the species towards the root development might have led to increased root mass density. Huang *et al*. (1997) reported similar observation while working with different turfgrass species. McCauley (2009) and Rimi *et al*. (2012) reported similar kind of observation while working with different turfgrass species.

REFERENCES

Arnon, D.I. (1949). Copper enzymes in isolated chloroplasts. Polyphenoloxidases in *Beta vulgaris*. *Plant Physioogy,* **24**: 241-249.

Baldwin, C.M., Liu, H., McCarty, L.B., Luo, H., Wells, C.E. and Toler, J.E. (2009). Impacts of altered light spectral quality on warm-season turf grass growth under greenhouse conditions. *Crop Sci*., **49** : 1444 -1453.

Huang, B., Duncan, R. and Carrow, R. (1997). Drought resistance mechanisms of seven warm-season turf grasses under surface soil drying: II. Root Aspects. *Crop Sci*., **37**: 1863-69.

Johnson, G.V. (1973). Simple procedure for quantitative analysis of turf grass color. *Agron. J.,* **66**: 457–459.

Junker, P.H. and Madison, J.J. (1967). Soil moisture characteristics of sand peat mixes. *Proceed. Soil Sci. Soc. America,* **31**: 5-8.

Liu, X. and Huang, B. (2000). Carbohydrate accumulation in relation to heat stress tolerance in two creeping bent grass cultivars. *J. American Soc. Hort. Sci.,* **125** : 442-447.

Macolino, S., Ziliotto, U. and Leinauer, B. (2012). Comparison of turf performance and root systems of Bermuda grass cultivars and 'Companion' Zoysia grass. *International Symposium on Environmental, Edaphic and Genetic Factors Affecting Plants, Seeds and Turf Grasses. Acta Hort.,* 938.

McCauley, K.R. (2009). Over seeded Bermuda grass spring transition response to mowing height, nitrogen rate, sulfonylurea herbicide and allelopathy. M.S. Thesis, Clemson University, USA.

Panse, V.G. and Sukhatme, P.V (Revised by Sukhatme, P.V. and Amble, V.N.) (1985). Statistical Methods for Agricultural Workers. ICAR, New Delhi. pp. 187-202.

Rimi, F., Macolino, S. and Ziliotto, U. (2012). Rooting characteristics and turf grass quality of three Bermuda grass cultivars and a zoysia grass. *Acta Agriculturae Scandinavica,* *Section B-Soil & Plant Sci.*, **62**(1): 24-31.

Sprague, H.B. (1982). Turf Management Handbook. Third Edition. *The Interstate Printers and Publishers, Inc.* Illinois.

Ubendra, S. (2014). Evaluation of turf grasses for tropical conditions. M.Sc. (Hort.) Thesis, Tamil Nadu Agricultural University, Coimbatore (T.N.) India.

Venugopal, G. (2012). Studies on the performance of lawn grasses under different soil and shade conditions. M.Sc. (Hort.) Thesis, Dr. Y.S.R. Horticultural University, Venkataramannagudem, India.

Verhoeven, A.S., Swanberg, A., Thao, M. and Whiteman, V. (2005). Seasonal changes in leaf antioxidant systems and xanthophyll cycle characteristics in Taxus media growing in sun and shade environments. *Physiologia Plantarum*, **123** : 428–434.

Zhenping, Z., Herong, G. and Xiaoliang, L. (2008). Effects of photoperiod on winter re-growth of *Zoysia japonica* cv. Lanyin No. III. *Proc. II International Conference on Turfgrass, Acta Hort.*, **1**(783): 169-174.