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Growth performance evaluation of Bermuda grass (*Cynodon dactylon* L. Pers. x *Cynodon transvaalensis*) under different nitrogen application methods and sprigging intensities

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Abstract
Cynodon dactylon (L.) Pers, commonly called Bermuda grass is one among the most commonly used warm season grasses which can withstand drought stress and produce quality turf. Establishing high quality turf is a key management concern. The selection of suitable method of its establishment and precise nutrient management are the first and most important factors for a well-established lawn. N has the greatest impact on grass growth of all the nutrients, and an appropriate N fertiliser can quicken up the development of high-quality mats. Hence a field trial was conducted at Tamil Nadu Agricultural University, Coimbatore to study the growth response of Bermuda grass to 4 different sprigging intensities: S_1- 10×10 cm, S_2- 15×15 cm, S_3- 20×20 cm, S_4- 25×25 cm and 3 different methods of N application at fortnight intervals: N_1- Granular application at 4g/m^2, N_2- 2% Foliar spray and N_3- IFFCO Nano Urea at 5ml/l of water. Morphological parameters including leaf length, internodal length, shoot length, root length, percent cover and physiological parameters including total chlorophyll content, relative greenness and proline content for drought estimation have been evaluated at 90 days after planting. Plots treated with nano urea showed improved growth response rather plots treated with granular urea. Closer and medium spacing showed quick grass spread compared to wider spacing. Among 12 treatments, Treatment S_1N_3 (10 X 10 cm spacing with 5 ml/ l of water Nano Urea Foliar Spray) recorded the highest values for almost all the morphological (Leaf length 3.43 cm, Internodal length 3.63 cm, Shoot length 52.46 cm, Root length 11.51 cm and Percent cover 101.25%) and physiological parameters (TCC 3.42 mg/ g fresh wt., Relative greenness 13.86 and Proline content 2.52 mg/ g of fresh wt.). Future thrust can be relied on such encapsulated slow-release N fertilizer to ease out nitrogen loss concern and improved turf quality.

Keywords: Bermudagrass, nitrogen, nano urea, sprigging

1. Introduction
A lawn is a crucial component of a landscape garden since it contributes significantly to the beauty of the surrounding area. The aesthetic value of any garden depends largely on the verdure of the lawn. Apart adding aesthetic value, they are used in bowling greens, tennis courts, golf courses and home lawns. The right kind of grass chosen according with soil and climate conditions, including the right cultural practises and management approaches are vital to a lawn's success. The selection of appropriate grass species and techniques of establishment are the first and most important criteria for a well-established and pleasant lawn. Good ground cover is accomplished with an appropriate planting technique. Therefore, choosing the proper method that works for certain species of grass is more essential when establishing a lawn. Yet, the basis for establishment is the growth pattern of the grass species.
Cynodon dactylon, commonly known as Bermuda grass is one amongst the most popular warm-season turf grasses used globally in lawns, parks, play areas, athletic fields and golf courses where dense turf is preferred (Le to *et al.*, 2008) [8]. Its Stoloniferous nature ensures rapid spread and ground cover. The spacing between planted sprigs has a significant impact on plant spread. In addition to establishment method, fertilisation is another major element of turf culture that influences turf grass growth rate and aids in establishing a pest and disease-free healthy lawn. Compared to other turf species, Bermuda grass has relatively higher N requirement and it may not be able to survive lower N inputs under shade, particularly in cases where the athletic turf is heavily used (Cisar *et al.*, 2007) [4].

The quantity and method of N application greatly influences the growth rate of lawn grasses. To maximise NUE, it is crucial to optimise the rate, source, timing and technique of application of N fertiliser. (Hopkins *et al.*, 2008) [7]. Therefore, it would be of interest to examine which type of N fertilizer could be employed to achieve optimal turf quality and rapid spread.

2. Materials and Methods

The present study was carried out at Department of Floriculture and Landscape Architecture, Tamil Nadu Agricultural University, Coimbatore from February to June 2022. The experiment was laid out in a factorial randomised block design (FRBD) consisting of 12 treatments and 2 factors: Spacing and Nitrogen application replicated thrice. Bermuda grass sprigs were collected from Botanical Garden, Coimbatore and were planted at 4 different sprigging intensities: S_1- 10×10 cm, S_2- 15×15 cm, S_3- 20×20cm and S_4- 25×25 cm. Nitrogen was supplied as urea in 3 different forms at fortnight intervals: N_1- Granular application at 4g/m^2, N_2- 2% Foliar spray and N_3- IFFCO Nano Urea at 5ml/l of water. Each experimental plot was 2×2 m^2. Morphological parameters including Leaf length (cm), Internodal length (cm), Shoot length (cm), Root length (cm) and Percent ground cover (%) were assessed. Physiological parameters including Total Chlorophyll Content was estimated using Acetone method (Yoshida *et al.*, 1949) and expressed in mg/ g of fresh weight. Relative greenness was measured with Konica Minolta SPAD- 502 Plus. Proline content of the leaves was estimated by the method described by Bates *et al.*, 1973 [1] and expressed in mg/ g of fresh weight. Parameters were evaluated 90 DAP. To test the significance, the data were analysed for variance using AGRIS (International System for Agricultural Science and Technology) and Turkey test (t-test) was used to compare the means at 5% probability level.

3. Results and Discussion

3.1 Morphological Parameters

3.1.1 Leaf length

Data from Table 1 revealed that there was significant difference in leaf length under different spacing and methods of nitrogen application. Among spacing levels closest spacing S_1- 10×10 cm recorded the longer leaves, medium spacing S_2- 15×15 cm and S_3- 20×20 cm being on par with each other and wider spacing 25×25 cm recorded shorter leaves. Plots that received nitrogen applied through nano urea recorded longer leaves while 100% granular urea treated plots recorded shorter leaves. The interactive effect of spacing and nitrogen resulted in significantly shorter leaves (1.93 cm) in treatment S_4N_1 and significantly longer leaves (3.43 cm) in S_1N_3. This concurs with the fact that the slow release formulation of liquid fertilizers is able to penetrate the trans cuticular pores on foliage (Wesley *et al.*, 1985) [14].

3.1.2 Internodal Length

One of the metrics for determining the density of turf grass is internode length. The effect of spacing and different methods of nitrogen application on internodal length was represented in Table 1. Treatment S_1N_3 with closer spacing of 10×10 cm applied with nano urea exhibited longest internodal length (3.63 cm) whereas treatment S_4N_1 showed shortest internodal length (2.26 cm). At spacing level, treatments with S_1 recorded longest internodal length followed by S_2, S_3 and S_4 respectively. At nitrogen application level, N_3 recorded highest values followed by N_2 and N_1. The current study's findings regarding the internodal length of Bermuda grass are consistent with (Prine and Burton, 1956) [10], who observed that Bermuda grass's internodal and stem length increased as N fertilisation levels increased. Maximum values in the optimum dosage of nitrogen showed positive influence due to the role in cell division as well as protein synthesis.

3.1.3 Shoot and Root Length

Various levels of spacing and nitrogen application methods had significant difference on shoot and root length which are represented in Table 1. Among the treatments, S_1N_3 recorded highest shoot and root length (52.46 cm and 11.51 cm) respectively. Treatment S_4N_1 recorded lowest shoot and root length (31.3 cm and 6.91 cm) respectively. This is in accordance with findings of (Bilgilli *et al.*, 2005) [2] that with an optimum dose of nitrogen, Kentucky blue grass showed positive effects on shoot length and creeping bent grass showed positive effects on root length (Totten *et al.*, 2007) [13].

3.1.4 Percent Cover

Significant difference between spacing and nitrogen application methods can be well understood from Table 1. At spacing levels, closest spacing, S1 had highest coverage followed by medium, S_2 and S_3 and wider spacing, S_4 whereas in nitrogen application methods N_3 recorded highest spread followed by N_2 and N_1. However, interaction effect showed highest percent cover in S_4N_1 (101.25%) followed by S_2N_3 (97.34%) and lowest spread in S_4N_1 (83.58%). This may be because, in addition to the effects of nitrogen, the closely spaced sprigs contributed to maximum shoot density, ensuring the highest ground cover percentage. Foliar nitrogen might have accelerated the mechanism of absorption and may have accelerated photosynthetic rate. These findings support those of Guertal and Evans (2006) [6] in the case of Bermuda grass, Razmjoo and Kaneko (1993) [11] in the case of perennial rye grass and Zhao *et al*. (2008) [16] in the case of tall fescue grass.

Table 1: Effect of spacing and different methods of nitrogen application on morphological characters of Bermuda grass (*Cynodon dactylon* L. Pers. x *Cynodon transvaalensis*)

Treatment	Leaf Length (cm)	Internode Length (cm)	Shoot Length (cm)	Root Length (cm)	Percent Cover (%)
S_1N_1	2.96	3.16	39.03	8.61	89.09
S_1N_2	3.03	3.43	45.51	10.42	92.12
S_1N_3	3.43	3.63	52.46	11.51	101.25
S_2N_1	2.46	2.93	33.53	7.43	87.65
S_2N_2	2.5	3.2	41.27	9.11	91.23
S_2N_3	2.56	3.4	43.51	9.6	97.34
S_3N_1	2.43	2.6	32.42	7.15	82.09
S_3N_2	2.53	3.1	36.33	8.02	88.18

S_3N_3	2.66	3.46	40.17	8.86	90.24
S_4N_1	1.93	2.26	31.3	6.91	83.58
S_4N_2	2.1	2.4	33.27	7.34	87.62
S_4N_3	2.23	2.5	38.52	8.51	89.14
Mean	2.57	3.01	38.94	8.62	89.96
S.Ed	0.05	0.06	0.9	0.17	1.78
Cd (P= 0.05)	0.11	0.12	1.87	0.36	3.69
S Mean					
S_1	3.14	3.41	45.67	10.18	94.15
S_2	2.51	3.12	39.43	8.71	92.07
S_3	2.54	3.05	36.31	8.01	86.83
S_4	2.09	2.39	34.36	7.59	86.78
S.Ed	0.03	0.03	0.52	0.11	1.03
Cd (P= 0.05)	0.07	0.07	1.08	0.21	2.14
N Mean					
N_1	2.44	2.74	34.07	7.53	85.6
N_2	2.54	3.03	39.1	8.72	89.79
N_3	2.72	3.25	43.66	9.62	94.49
S.Ed	0.02	0.02	0.45	0.09	0.89
Cd (P= 0.05)	0.06	0.06	0.93	0.18	1.85

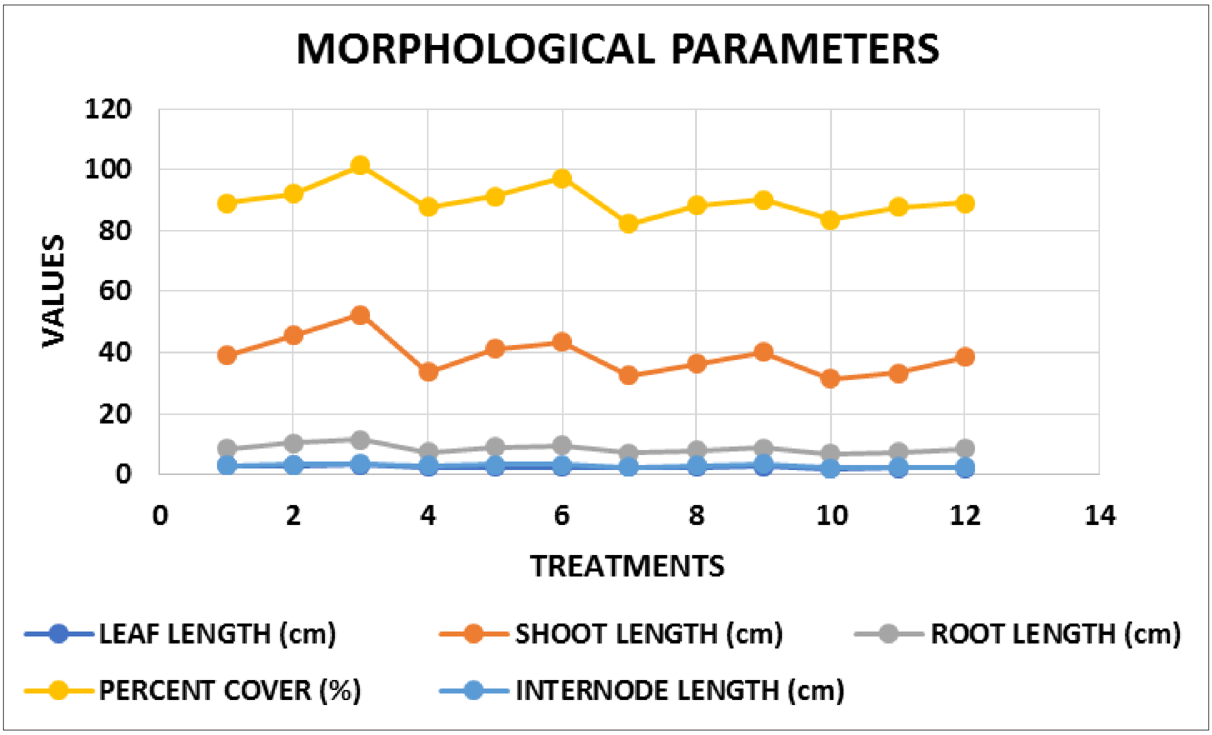

Fig 1: Effect of Sprigging intensities and methods of nitrogen application on morphological parameters of Bermuda grass

3.2 Physiological Parameters

3.2.1 Total Chlorophyll Content (TCC) and Relative Greenness

Spacing levels did not have any effect on TCC and Relative greenness whereas Nitrogen application methods had a significant different on TCC. Highest TCC was noted in S_1N_3 (3.42 mg/ g) with SPAD reading (13.32) followed by S_2N_3 (3.39 mg/ g) with SPAD reading (13.86), S_3N_3 (3.31mg/ g) with SPAD reading (12.93) and S4N3 (3.30 mg/ g) with SPAD reading (11.89). Lowest TCC was recorded in S_4N_1 and S_2N_1 (2.42 mg/ g) with SPAD reading (8.63 and 8.64) respectively. Increased fertilizer rates assured ample availability of nutrient for utilising in growth and development. Nitrogen has a vital role in chlorophyll production in turf grasses (Christian, 2004). This is further substantiated by Machahary and Paswan (2003) [9] where in Doob and Bahia grasses they found that increasing the nitrogen content from 0 to 40 g/m^2 led to an increase in the amount of chlorophyll in the leaves.

3.2.2 Proline Content

The proline accumulation accounts for reduced osmotic potential by maintaining plant turgor pressure and also it protects protein configuration during stress and dehydration (Fernandez *et al.*, 2006) [5]. From Table 2, significant differences were observed between different methods of nitrogen application rather different spacing levels. The highest proline content was observed in S_1N_3 (2.52 mg/g) followed by S_2N_3 (2.40 mg/g), S_3N_3 (2.28 mg/g) and S_4N_3 (2.20 mg/g). The lowest value was recorded in S_4N_1 (0.80 mg/ g). This observation finds agreement with that of Shi *et al.*, (2012) [12] who have reported about the drought tolerance mechanism promoted in Bermuda grass by its high proline content.

Table 2: Effect of spacing and different methods of nitrogen application on physiological characters of Bermuda grass (*Cynodon dactylon* L. Pers. x *Cynodon transvaalensis*)

Treatment	Total Chlorophyll Content (mg/ 100g fresh wt)	Relative Greenness (SPAD)	Proline Content (mg/ g of fresh wt)
S_1N_1	2.49	8.98	1.16
S_1N_2	2.80	10.73	1.60
S_1N_3	3.42	13.86	2.52
S_2N_1	2.43	8.63	1.00
S_2N_2	2.78	10.64	1.52
S_2N_3	3.39	13.32	2.40
S_3N_1	2.46	9.74	0.92
S_3N_2	2.72	11.35	1.48
S_3N_3	3.31	12.93	2.28
S_4N_1	2.43	8.64	0.80
S_4N_2	2.73	10.84	1.40
S_4N_3	3.30	11.89	2.20
Mean	2.85	11.16	1.61
S.Ed	0.07	0.20	0.03
Cd (P= 0.05)	0.15	0.42	0.05
S Mean			
S_1	2.9	11.01	1.76
S_2	2.87	10.73	1.64
S_3	2.83	11.65	1.56
S_4	2.82	11.23	1.47
S.Ed	0.04	0.12	0.01
Cd (P= 0.05)	0.09	0.24	0.03
N Mean			
N_1	2.45	9.29	0.97
N_2	2.76	10..89	1.5
N_3	3.36	13.29	2.35
S.Ed	0.04	0.1	0.01
Cd (P= 0.05)	0.07	0.21	0.03

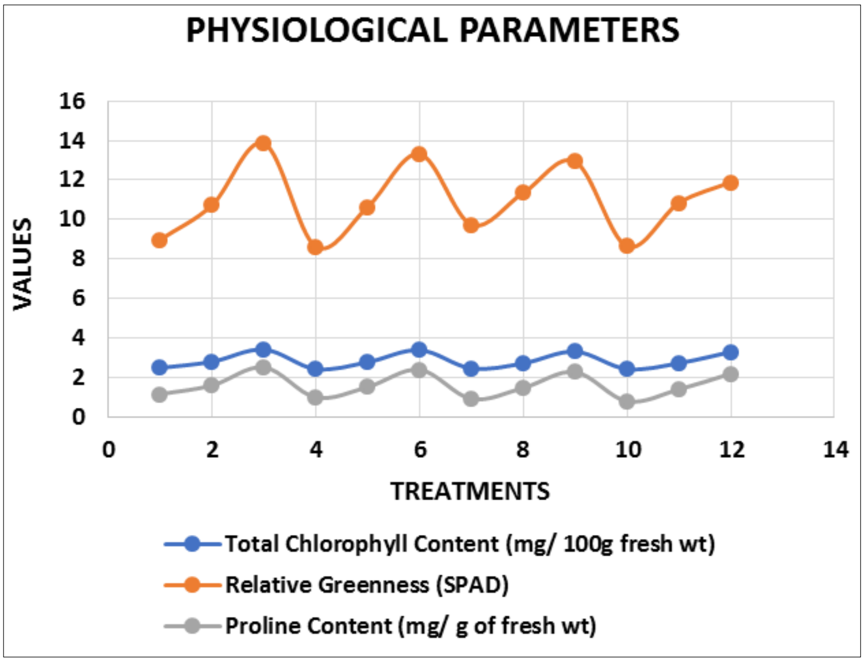

Fig 2: Effect of Sprigging intensities and methods of nitrogen application on physiological parameters of Bermuda grass

4. Conclusion

Increased sprigging intensity along with nano urea application simulated great response for most of the turf quality parameters. From the above results, it is evident that reliable characters of a high-quality lawn including highest ground cover, leaf length, shoot length, root length and greenness is exhibited by the treatment S_1N_3 (10 X 10 cm spacing and 5 ml/ l of water Nano Urea Foliar Spray) established through sprigs.

5. Future Thrust

For all levels of turfgrass maintenance and management, including golf courses, sports fields, and residential lawns, capsulated slow release fertilisation can be the best alternative to granular urea which loses almost three times as much nitrogen through ammonia volatilization. And also, this method of fertilization allows for fast utilization of the nutrient by the plant, less energy exerted for uptake, greater uniformity of application and can provide fast spread. Hence in addition to optimum spacing future thrust can be relied on method of nitrogen application where the leaves can absorb N in ionic form and translocate in plants without any loss which can lead to significant increase in the turf quality characters.

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