www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2020; 9(3): 56-60

www.thepharmajournal.com
Received: 16-01-2020
Accepted: 18-02-2020

Kanda Jena
Department of Floriculture and Landscaping, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

CR Mohanty
Department of Floriculture and Landscaping, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

Corresponding Author:
Kanda Jena
Department of Floriculture and Landscaping, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

Effect of nitrogen and phosphorus on growth and quality of Bermuda lawn grass (*Cynodon dactylon*) cv. selection-1

Kanda Jena and CR Mohanty

Abstract
A field trial was conducted during the period from October, 2013 to January, 2015 to study the effect of nitrogen and phosphorus on growth and quality of Bermuda lawn grass (*Cynodon dactylon*) cv. Selection-1 and to determine the most suitable dose for establishment and maintenance of a quality lawn. In the present investigation three levels of nitrogen viz., 10, 20 and 30 g/m^2, three levels of phosphorus *viz*., 5, 10 and 15 g/m^2 and a fixed dose of potassium viz., 5 g/m^2 were tried along with untreated control (viz., N 0, P 0 and K 0) comprising of 10 different combinations. Nitrogen, phosphorus and potassium were applied as urea (46.0 % N), single super phosphate (16.0 % P_2O_5), and muriate of potash (60.0 % K_2O) respectively. The textural class of the soil of the experimental site was sandy loam with a pH of 5.82. The chemical analysis of the soil indicated that it contained 80 kg/ha available nitrogen 51 kg/ha available phosphorus, 517 kg/ha, exchangeable potassium and 1.34 % organic carbon. Stem cuttings of Bermuda turf were planted in the experimental plots with basal application of 200 g/m^2 vermicompost. Phosphorus was applied in a single dose along with 25 % each of N and K after three months of planting. Rest N and K were applied in three equal splits @ 25 % at three months interval. Observations were recorded on various growth and quality parameters. The result of the study revealed that significant differences existed among various treatments with respect to most of the parameters which recorded lowest values under untreated control *viz*., N_0, P_0 and K_0 and increased with increasing doses of fertilizer and the maximum values were recorded with the highest dose of fertilizer treatment viz., 30-15-5 g of NPK/m^2. Parameters like clipping shoot length, stem thickness, internodal length, leaf length, shoot density and leaf chlorophyll content showed significant improvement under the highest dose of fertilizer viz., 30-15-5 g NPK/m^2 over control *viz*., N_0, P_0 and K_0 during all the observations and other lower doses of fertilizer during most of the observations recorded at different times. In case of stem thickness except the highest dose of fertilizer treatment which recorded the maximum value, no significant difference was noticed among control and other lower doses of fertilizer treatments. Based on the result it was concluded that a dose of 30-15-5 of NPK/m^2 was the most suitable dose for establishment and maintenance of a quality lawn developed from Bermuda lawn grass, cv.Selection-1.

Keywords: Bermuda lawn grass, clipping shoot length, stem thickness, internodal length, leaf length, shoot density, chlorophyll content.

Introduction
Among various management practices, fertilization is an important aspect of turf culture which influences the growth rate of turf grass and helps in maintenance of a healthy turf/lawn that are free from pest and diseases. Nutritional deficiency leads to susceptible turfs that are not of good appearance and wear out easily which lack the recuperative capacity from damage. On the other hand excess fertilization is also harmful which contaminates the ground water, causes environmental pollution and makes the turf susceptible to pest and diseases. It also leads to excess shoot growth at the expense of roots involving extra maintenance cost in the form of frequent manuring and application of fungicides and insecticides. Hence, balanced fertilization is most important as well as necessary for maintaining the quality of turf/lawn at the same time decreasing the maintenance cost. Response of fertilizer rate differs among the grass species and cultivars (Carroll and Petrovic, 1991) [4]. Therefore, it is important to standardize the fertilizer rate for cultivars that are popular in local public and professional domain.
Cynodon dactylon popularly known as Bermuda grass is one of the most widely used warm season turf grasses all over the world in lawns, parks, play grounds, athletic fields and golf courses; where dense turf is desired (Le to *et al*., 2008) [9]. Bermuda grass cv. Selection-1 is one of the popular cultivars which is widely used for making lawn under Odisha condition.

But, unfortunately no authentic information is available on its nutritional management for development and maintenance of a healthy and quality lawn under local climatic condition. Therefore, it was felt useful to conduct the present study on nutritional management of Bermuda lawn grass cv. Selection-1.

Materials and Methods

The present investigation was undertaken in the form of a field experiment in the Ornamental garden of College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar during 2013-2015. Prior to conducting the experiment the soil of the experimental site was analyzed which was found to be sandy loam in texture with a pH of 5.82. Chemical analysis of the soil indicated that it contained 80 kg/ha available nitrogen, 51 kg/ha available phosphorus, 517 kg/ha exchangeable potassium and 1.34 % organic carbon. Bermuda grass (*Cynodon dactylon*), cv. Selection-1 was used in the present investigation. The experiment was conducted following Randomized Block Design with four replications. Nitrogen at 10, 20 and 30 g/m^2 and phosphorus at 5, 10 and 15 g/m^2 were applied as treatments with a fixed dose of potassium (*viz*., 5 g/m^2) which were compared with an untreated control. In total there were 10 treatment combinations which were T_1 - N_0 P_0, K_0 (control), T_2 - N_{10}, P_5 K_5, T_3 – $N_{10}P_{10}K_5$, T_4- N_{10} P_{15} K_5, T_5 – N_{20} P_5 K_5, T_6- N_{20} P_{10} K_5, T_7- N_{20} P_{15} $K_{5,}$ $_T8$ – N_{30} P_5 K_5, T_9- N_{30} P_{10} K_5 T_{10}- N_{30} P_{15} K_5.

During land preparation, after final ploughing and prior to levelling, vermicompost @ 200 g/m^2 was thoroughly incorporated into the soil. Stem cuttings of cv. Selection-1 of Barmuda lawn grass were planted continuously in shallow groves drawn at a distance of 10 cm in the prepared plots on 30th October, 2013. Various doses of nitrogen and phosphorus along with fixed dose of potassium in different combinations as per the treatment schedule were applied in four splits. First application was done on 30th January, 2014 with full dose of phosphorus and 25 per cent each of nitrogen and potassium. The rest 75 per cent of nitrogen and potassium were applied in three equal splits @ 25 per cent each during 30th April, 30th July and 30th October, 2014. The fertilizers were applied each time after clipping of grasses in the experimental plots. The nutrients N, P and K were applied in the form of urea (46 % N), single super phosphate (16 % P_2O_5) and muriate of potash (60 % K_2O) respectively. On the other hand control plots *viz.*, $N_0P_0K_0$ received only vermicompost without application of any chemical fertilizers. Usual management practices like irrigation, weeding and plant protection measures were taken up at regular intervals. Grasses were mowed at a height of 5.0 cm from the ground level by means of a Falcon rotary lawn mower. The first mowing was done during the last week of January, 2014 after all the plots attained full coverage. Subsequent mowing was done at an interval of three months.

Observations on various growth and quality parameters such as clipping shoot length, stem thickness, internodal length, leaf length, shoot density and chlorophyll content of leaves were recorded four times during the experimental period at trimonthly interval, the first one commencing from April, 2014. For determination of these parameters the grasses which were not mowed during previous three months were clipped by means of a grass cutting shear at a height of approximately 5.0 cm above the ground level from a sub sample area of 0.1 m^2 in each plot and collected in polythene bags. Twenty shoots were randomly selected from the fresh clipping to determine the shoot length, stem thickness and internodal length. Clipping shoot length was determined by measuring the length of clipped shoot by means of a meter scale and expressed in cm. Stem thickness was measured by a slide caliper at the base of third leaf from the tip of those twenty randomly selected shoots as mentioned above and the average was calculated and expressed in cm. The basal internodes of the clipped shoots were measured and expressed in cm. For determination of leaf length a sub sample of twenty leaves was taken from the fresh clipping. The third leaf from the tip of twenty individual shoots were sampled for this purpose and the length of individual leaves was measured from the base to tip and the mean of twenty readings was recorded and expressed in cm. The total number of shoots which constituted verdure (i.e. the mass of grass remaining on the ground after clipping/mowing) was counted to find out the shoot density per 0.1 m^2 area. For determination of chlorophyll content, the third leaf from the tip of individual shoot was sampled to obtain leaves of approximately the same physiological age and chlorophyll from leaf was extracted by DMSO method (Hiscox and Isralistam, 1979) [7] and the chlorophyll content was calculated by the equation given by Arnon (1949) [3] and expressed in mg/g of fresh weight of leaves.

Results and Discussion

Clipping shoot length

Data presented in Table 1 revealed that there was significant difference in clipping shoot length due to combined application of various doses of nitrogen and phosphorus along with a fixed dose of potassium. During April and October, 2014. Significantly lower shoot length was recorded under control (i.e. $N_0P_0K_0$) which had 5.50 cm and 7.65 cm respectively, on the other hand significantly higher shoot length was recorded under T_{10} receiving the highest dose of fertilizer i.e., 30-15-5 g NPK/m^2 which had 9.07 cm and 15.23 cm respectively during the same observation period. The result of the present study is in conformity with the findings of Trenholm *et al.* (2001) [17] who reported that higher nitrogen rate of 392 kg/ha increased shoot growth as compared to 196 kg N/ha in Sea Shore Paspalum turf grass. Machahary and Paswan (2003) [10] also observed increase shoot length of doob and bahia grass with increased nitrogen levels from 0-40 g/m^2 vegetative growth increased with nitrogen application may be ascribed to the fact that nitrogen is an essential part of nucleic acid which plays a vital role in promoting plant growth (Acharya and Dasora, 2004) [1]. On the other hand turf grass response to P fertilizer is expressed as improved root growth (Stewart, 2008) [14] and shoot growth is dependent on root growth. Hence, higher clipping shoot growth was observed due to higher P rates in the present study.

Stem Thickness

As indicated in Table 1 significant difference was noticed in stem thickness due to treatment with various doses of fertilizers. It was minimum in control ($N_0P_0K_0$) which increased with increasing doses of fertilizer and the maximum was recorded under T_{10} i.e., the highest dose of fertilizer (30-15-5 g NPK/m^2). However, during April, 2014 the stem thickness under control (T_1) as well as T_2 (10-5-5 g NPK/m^2) was identical which was 0.013 cm in each case. On the other hand stem thickness of 0.019 cm was recorded under T_{10} receiving the highest dose of fertilizer. However, it was followed by and at par with T_9 (30-10-5 g NPK/m^2) and T_8 (30-5-5 g NPK/m^2) which recorded similar stem thickness (0.017 cm) in each case. During October, 2014 the same trend was observed. The minimum stem thickness (0.011 cm) was also recorded under untreated control. However, it was statistically comparable with same recorded under various fertilizer treatments (from T_2 to T_9) except T_{10} which recorded significantly higher thickness of stem of 0.021 cm. Increased stem diameter of tillers of Bermuda grass due to application of higher nitrogen rate was also reported by Alderman *et al*. (2011) [2] and Premazzi *et al*. (2003) [12].

It was found that lower doses of fertilizer treatments were not effective in bringing significant improvement in stem thickness. Application of the highest dose of fertilizer treatment i.e., T_{10} comprising of 30-15-5 g NPK/m^2 was the most effective treatment to bring significant change in this growth parameter.

Internodal length

So far as internodal length was concerned significant variation was also noticed due to various fertilizer treatments (Table 2). It was the shortest under control (T_1) and increased with fertilizer application rates and the longest internode was observed under T_{10} (30-15-5 g NPK/m^2). During April, 2014 it was found that internodal length under control ($N_0P_0K_0$) was 0.79 cm. However, it was at par with T_2 (10-5-5 g NPK/m^2) and T_3 (10-10-5 g NPK/m^2) which recorded internodal length of 0.86 cm and 0.93 cm respectively. On the other hand the longest internode of 1.11 cm was recorded under T_{10} receiving the highest dose of N and P followed by T_9 (30-10-5 NPK/m^2) which recorded an internodal length of 1.05 cm without showing significant variation from each other. During October, 2014 internodal length was also observed to be significantly shorter (0.98 cm) under control while the longest internode of 2.09 cm was noticed under T_{10} which was followed by and at par with T_9 (2.0 cm), T_8 (1.97 cm), T_7 (1.89 cm), T_6 (1.81 cm) and T_5 (1.79 cm) treatments. It was found that there was linear increase in intermodal length with increase in fertilizer rates and the longest internode length was observed under T_{10} which differed significantly from other treatments including control. The result of the present study with respect to internodal length of Bermuda grass is in agreement with the earlier workers (Prine and Burton, 1956) [13] who noted that increasing N fertilization increased stem length and internodal length in Bermuda grass. Improvement in stem thickness and internodal length due to increase rate of N and P fertilizers may be attributed to the fact that vegetative growth increases with nitrogen application because nitrogen is an essential part of nucleic acid, which plays a vital role in promoting plant growth (Acharya and Dashora, 2004) [1]. On the other hand phosphorus is a constituent of many energy rich compounds in plants and also involved in active root growth which helps in uptake of other nutrients (Marshner, 1986) [11].

Leaf length

As observed from Table 2 various levels of fertilizer treatments significantly influenced the length of leaves in Bermuda turf grass. During April, 2014 significantly shorter leaves (2.10 cm) was recorded under control which increased with increasing doses of fertilizer and the longest leaves (2.82 cm) was recorded under T_{10} receiving the highest dose of fertilizer (30-15-5 g NPK/m^2) treatment. However, it was statistically comparable with lower doses like T_9 (30-10-5 g NPK/m^2), T_8 (30-5-5 g NPK/m^2), T_7 (20-15-5 g NPK/m^2), T_6 (20-10-5 g NPK/m^2) and T_5 (20-5-5 g NPK/m^2) which recorded 2.74 cm, 2.60 cm, 2.58 cm, 2.58 cm and 2.52 cm long leaves respectively. During October, 2014 the same trend with respect to this parameter was also observed significantly shorter leaves (1.97 cm) was recorded under control and it increased with increase in each level of fertilizer. On the other hand significantly longer leaves (3.39 cm) were recorded under T_{10} receiving the highest dose of nitrogen and phosphorus fertilizer. Present findings are in conformity with Prine and Burton (1956) [13] who also observed increased leaf length due to increase fertilization with nitrogen. Role of nitrogen in improving vegetative parameters have been reported earlier workers. Nitrogen is used largely in synthesis of protein and it is a part of chlorophyll molecules (Tisdale and Nelson, 1966) [15] thus increasing vegetative parameters at higher concentration. Role of phosphorus may be attributed to the fact that, it is involved in active root growth and helps in uptake of other nutrients (Marshner, 1986) [11].

Shoot density

Shoot density or number of shoots per unit area is an important parameter that improves the compactness of turf thus producing a dense turf. In the present study significant influence of various levels of N and P application with a fixed dose of K was observed on the shoot density of Bermuda grass (Table 3). During April, 2014 minimum number of shoots (255.00/0.1m^2) was recorded under control ($N_0P_0K_0$) and it increased with increasing dose of fertilizer and the maximum number (455.00/0.1m^2) was recorded under T_{10} receiving the highest dose of fertilizer (30-15-5 g NPK/m^2) treatment which differed significantly from control and other fertilizer treatments. During October 2014 more or less same trend was observed. Significantly less number of shoots (219.75 nos.) were recorded under control while the highest number (388.25 nos.) was recorded under T_{10} and it was closely followed by and at par with T_9 (30-10-5 g NPK/m^2) which recorded 377.00 shoots per 0.1 m^2 area. Shoot density is an indicator of nitrogen response in turf grasses (Turgeon, 1980) [18]. Higher the fertilizer rate, more are the nutrients available to the plants for utilizing in growth which contributed to increase in shoot density with increasing fertilizer rates. Turfs having high shoot densities with the increase in nitrogen fertilizer rate was observed by many workers in various turf grasses/species like tall fescue, Bermuda, Joysia and Centipede grass (Cazato *et al*., 2004, Johnson, 1997, Yin *et al*., 2014 and Toler *et al*., 2007) [8, 19, 16]. Higher tiller density in high N treatments is a result of a large number of active meristems stimulated by N availability (Alderman *et al*., 2011) [2]. Application of phosphorus also improves rooting and cell division. Shoot growth is dependent on root growth and vice versa. Hence, higher rates of phosphorus was also a contributing factor for higher shoot density next to nitrogen.

Chlorophyll content of leaves

It was noticed (Table 3) that various levels of fertilizer treatments significantly influenced the chlorophyll content of turf grass leaves. During April, 2014 it was significantly lower (0.91 mg/g of fresh weight of leaves) under control which increased with increase in dose of fertilizer and significantly higher chlorophyll content was noted under T_{10} (1.28 mg/g of fresh weight of leaves) receiving the highest dose of fertilizer (30-15-5 g NPK/m^2). During October, 2014 although the lowest content of chlorophyll (0.64 mg) was recorded under control it was at par with T_2 (10-5-5 g NPK/m^2) and T_3 (10-10-5 g NPK/m^2) which recorded 0.67 mg and 0.68 mg respectively. On the other hand the maximum chlorophyll content of 0.89 mg was recorded under T_{10}. Higher fertilizer rates ensured availability of ample nutrient for utilizing in growth and development. Nitrogen plays an important role in chlorophyll production in turf grasses (Christian, 2004) [6], Machahary and Paswan (2003) [10] observed that increase in nitrogen content from 0 to 40 g/m^2 resulted in increase in chlorophyll content of leaf in doob and Bahia grasses.

Based on the study it was concluded that Bermuda lawn grass cv. Selection-1 responded well to various doses of nitrogen and phosphorus along with a dose of 5 g potassium per sq. metre which exhibited better performance in terms of growth and quality parameters. Various parameters were appreciably improved with increased dose of nitrogen and phosphorus and the best performance was observed with the highest dose of nitrogen and phosphorus i.e., 30 g N and 15 g P with 5.0 g K per sq. metre.

Table 1: Interaction effect of nitrogen and phosphorus on clipping shoot length and stem thickness of Bermuda lawn grass cv. Selection-I during April and October, 2014

Treatment (NPK g/m^2)	Clipping shoot length (cm)		Stem thickness (cm)	
	April	October	April	October
T_1 ($N_0P_0K_0$) (Control)	5.50	7.65	0.013	0.011
T_2 ($N_{10}P_5K_5$)	7.38	10.13	0.013	0.011
T_3 ($N_{10}P_{10}K_5$)	7.62	10.28	0.014	0.011
T_4 ($N_{10}P_{15}K_5$)	7.77	10.61	0.014	0.011
T_5 ($N_{20}P_5K_5$)	7.95	11.36	0.016	0.011
T_6 ($N_{20}P_{10}K_5$)	8.06	12.17	0.016	0.012
T_7 ($N_{20}P_{15}K_5$)	8.10	13.09	0.016	0.012
T_8 ($N_{30}P_5K_5$)	8.16	13.35	0.017	0.012
T_9 ($N_{30}P_{10}K_5$)	8.21	13.41	0.017	0.013
T_{10} ($N_{30}P_{15}K_5$)	9.07	15.23	0.019	0.021
SEm (±)	0.08	0.02	0.001	0.002
CD at 5%	0.23	0.07	0.003	0.005

Table 2: Interaction effect of nitrogen and phosphorus on internodal length and leaf length of Bermuda lawn grass cv. Selection-I during April and October, 2014

Treatment (NPK g/m^2)	Internodal length (cm)		Leaf length (cm)	
	April	October	April	October
T_1 ($N_0P_0K_0$) (Control)	0.79	0.98	2.10	1.97
T_2 ($N_{10}P_5K_5$)	0.86	1.57	2.42	2.49
T_3 ($N_{10}P_{10}K_5$)	0.93	1.58	2.44	2.54
T_4 ($N_{10}P_{15}K_5$)	0.96	1.71	2.49	2.60
T_5 ($N_{20}P_5K_5$)	0.99	1.79	2.52	2.70
T_6 ($N_{20}P_{10}K_5$)	0.99	1.81	2.58	2.88
T_7 ($N_{20}P_{15}K_5$)	1.00	1.89	2.58	3.03
T_8 ($N_{30}P_5K_5$)	1.01	1.97	2.60	3.12
T_9 ($N_{30}P_{10}K_5$)	1.05	2.00	2.74	3.16
T_{10} ($N_{30}P_{15}K_5$)	1.11	2.09	2.82	3.39
SEm (±)	0.02	0.10	0.11	0.03
CD at 5%	0.07	0.30	0.31	0.10

Table 3: Interaction effect of nitrogen and phosphorus on shoot density and leaf chlorophyll content of Bermuda lawn grass cv. Selection-I during April and October, 2014

Treatment (NPK g/m^2)	Shoot density (Nos./0.1m^2)		Chlorophyll content (mg/g fresh weight)	
	April	October	April	October
T_1 ($N_0P_0K_0$) (Control)	255.00	219.75	0.91	0.64
T_2 ($N_{10}P_5K_5$)	316.25	282.00	1.04	0.67
T_3 ($N_{10}P_{10}K_5$)	324.00	315.75	1.05	0.68
T_4 ($N_{10}P_{15}K_5$)	331.50	332.75	1.09	0.74
T_5 ($N_{20}P_5K_5$)	338.75	342.00	1.11	0.75
T_6 ($N_{20}P_{10}K_5$)	342.75	345.25	1.14	0.77
T_7 ($N_{20}P_{15}K_5$)	359.50	356.00	1.16	0.80
T_8 ($N_{30}P_5K_5$)	368.75	367.50	1.18	0.80
T_9 ($N_{30}P_{10}K_5$)	397.75	377.00	1.22	0.81
T_{10} ($N_{30}P_{15}K_5$)	455.00	388.25	1.28	0.89
SEm (±)	9.33	5.51	0.016	0.017
CD at 5%	27.07	15.98	0.048	0.052

References

1. Acharya MM, Dashora LK. Response of graded levels of

nitrogen and phosphorus on vegetative growth and flowering in African marigold (*Tagetes erecta* Linn.). J of Ornamental Hort. 2004; 7(2):179-183.
2. Alderman PD, Boote KJ, Sollenberger LE. Regrowth dynamics of ‘Tifto 85’ Bermuda grass as affected by nitrogen fertilization. Crop Science. 2011; 51:1716-1726.
3. Arnon DI. Copper enzymes in isolated chloroplasts, polyphenol oxidase in Beta vulgaris. Plant Physiology, 1949; 24:1-15.
4. Carroll MJ, Petrovic AM. Wear tolerance of Kentucky blue grass and creeping bent grass following nitrogen and potassium application. Hort Science. 1991; 26(7):851-853. Corleto
5. Cazzato E, Annese V, Corleto A. Effects of clipping management on some aspects of tall fescue (*Festuca arundinacea* Schreb) turf. Acta Horticulturae. 2004; 661:301-307.
6. Christians N. Fundamentals of Turfgrass management. New Jersey: John Wiley & Sons Inc. 2004, 359.
7. Hiscox JD, Isralistam GF. A method for extraction of chlorophyll from leaf tissue without maceration. Canadian J Botany, 1979; 57:1332-1334.
8. Johnson BJ. Growth of Tifway Bermuda grass following application of nitrogen and iron with trinexapac- ethyl. Hort. Science. 1997; 32(2):241-242.
9. Leto C, Sarno M, Tuttolomondo T, Bella SI, Licata M. Two year studies into native Bermuda grass (*Cynodon spp.*) germplasm from Sicily (Italy) for the constitution of turf cultivars. Acta Horticulturae, 2008; 7100:39-48.
10. Machahary RK, Paswan L. Effect of nitrogen on growth performance of two lawn grass species. Proceedings of the Abstract: National Symposium on Recent Advances in Indian Floriculture, 2003; 15p.
11. Marshner H. Mineral nutrition of higher plants. Academic Press Inc. London, U.K, 1986.
12. Premazzi LM, Monterio FA, Corrente JE. Tillering of ‘Tifton 85’ Bermuda grass in response to nitrogen rates and time of application after cutting. Sci. Agric., 2003; 60:565-571.
13. Prine GM, Burton GW. The effect of nitrogen rate and clipping frequency upon their yield, protein content and certain morphological characteristics of coastal Bermuda grass. Agron. J. 1956; 48:296-301.
14. Stewart Mike. Best management practices for turf and lawn fertilization. A publication of International Plant Nutrition Institute (IPNI), Georgia, USA, 2008, 1-8.
15. Tisdale S, Nelson W. Soil fertility and fertilizers. Third edition, Collier Mac Millan International Editions, Mac Millan Publishing Company Inc. New York (USA), 1966.
16. Toler JE, Higingbottom K, McCarty LB. Influence of fertility and mowing height and performance of established centipede grass. Hort Science. 2007; 42(3):678-681.
17. Trenholm LE, Carrow RN, Duncan RR. Wear tolerance, growth and quality of Seashore Paspalum in response to nitrogen and potassium. Hort. Science, 2001; 36(4):780-783.
18. Turgeon AJ. Turf grass management. Virginia: Reston publishing company. 1980, 391.
19. Yin S, Li Q, Liu W, Li D. Managing tall fescue and Zoysia grass mixtures as turf grass in the transition zone. Agronomy Journal. 2014; 106(1):1-6.