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A review of turfgrass on growth, nutrient and mowing practices

Medha Saha and Pooja Gupta

Abstract
Turf grasses are the plants which form a continuous ground cover that persist under regular mowing and traffic (Turgeon, 1980) [23] Turf grasses are increasingly gaining popularity and importance in India. The demand for turf grasses is rising as more and more people are opting for turfs and lawns, at home, offices, landscapes, parks, in sports field etc. Acceptable turf quality is defined as meeting the appearance and expectations for a particular area and includes traits such as green colour, fine leaf texture, high tiller density, and overall aesthetic appeal (Hanks *et al*., 2005) [7]. Fertilization is another important aspect of turf culture which influences the growth rate of the turf grass and helps in maintenance of healthy turfs that are free from diseases and pest. One cannot maintain good quality turfgrasses without mowing. It is indispensable in turf culture. Mowing can increase or decrease the cost of maintenance.

Keywords: Turf grass, fertilization, growth and mowing

Introduction
Turf grasses are the primary vegetative covers on airports, athletic fields, cemeteries, churches, commercial buildings, golf courses, home lawns, schools, parks, and roadsides. Turfgrass provides at least three major benefits to human activities: functional, recreational and ornamental (Beard 1973, Christians 2004, Wiecko 2006, Turgeon 2008, Bell 2011) [3, 5, 26, 23, 28]. Turfgrass is used in many different ways and under many different conditions. As a result, the multi-billiondollar industry is many-faceted, and encompasses diverse facilities and services. It consists of a remarkably diverse group of species which are selectively used on the basis of applications and/or climatic conditions (Janakiram and Namita 2014) [8]. They are grown primarily for utility turf, provide functional value including dust control, erosion control, and glare reduction, and, thus can serve as a safety factor on air fields and highway rights-of way (DiPaola *et al*., 1986) [6]. The modern turf grass industry has grown rapidly in the past three decades. It contributes substantially to the national economy, with numerous employment opportunities. Turf cover plays an integral role in various ecosystem services like soil carbon sequestration, and mitigation of urban heat island effect Carbon Sequestration and Regulation of the water cycle.
Balance fertilization is important as well as necessary for maintaining the quality of turf while decreasing the maintenance cost at the same time. Response to fertilizer rate differs between the grass species and cultivars (Carroll *et al.* 1991) [4]. Nutritional deficiency leads to susceptible turfs that are not good in appearance and wear easily and lack the capacity to recuperate from damage. On the other hand, excess fertilization is also harmful as it contaminates groundwater, causes environmental pollution and also makes the turf susceptible to Pest sand diseases. Mowing may be defined as the practice of cutting turfgrass at particular height and at certain frequency interval to maintain quality turf. Mowing can increase or decrease the cost of maintenance. It is actually a stress that has to be applied on the grasses. It is necessary to maintain the turf at particular heights, so that they are useful to mankind. One cannot maintain good quality turfgrasses without mowing. It is indispensable in turf culture. Mowing influences the appearance and quality of the turfgrass by affecting leaf densities, shoot densities, uniformity, colour, rhizome growth, root and shoot growth of the grasses.

Review of Literature
Growth parameters of turfgrasses
Wadekar *et al.* (2018) [25] studied nine turfgrass species Argentine grass, Pensacola grass, Weeping Love grass, Korean grass, Bermuda grass, American Blue grass, Taiwan grass, Phosphelone grass and St. Augustine grass and concluded that the highest grounds cover

(100%) was observed in American blue grass and Bermuda grass at 60 DAT. The significantly maximum chlorophyll content 69.59 mg/100g was recorded by Bermuda grass when was significantly superior over rest of treatments. Performance for morphological traits indicated, the maximum shoot length was recorded in Phosphelone grass (80.82 cm), Argentine grass (6.95 mm) exhibited maximum stem thickness DAT. The maximum leaf length range between (45.07-50.43 cm) recorded in Weeping love grass and Taiwan grass recorded shortest leaf length (2.70 cm). Phosphelone grass recorded maximum leaf width (13.48 mm). Weeping love grass showed maximum root length (21.74 cm). After 120 days of transplanting maximum root shoot ratio (1.11) was recorded in Argentine grass. The maximum fresh weight of shoot and dry weight of roots was recorded in Weeping love grass whereas, the maximum fresh weight of roots was recorded in Argentine grass. Agnihotri *et al*. (2017) [1] evaluated 13 different turfgrass species and varieties for the morphological characters under south Gujarat agro-climatic condition. Among the various characters, minimum days to 90 per cent establishment(14.00 days) and deepest root (24.50 cm) were observed in *Cynodon dactylon* 'Local', which was at par with *C. dactylon* × *C. transvaalensis* 'Tifdwarf'. Lowest canopy height (43.87 cm), shortest average stolon internodal diameter (0.35 mm), highest shoot density (227.14/ 25 cm^2), narrowest leaf width (1.05 mm) and slowest VLGR (0.05 mm/day) were recorded in *Zoysia tenuifolia*. Maximum cumulative fresh clipping yield (3492.98 g/m^2) and minimum value of stolon internodal length (0.99 cm) were registered in 'Tifdwarf'. *Z. tenuifolia*, *Z. matrella* and 'Tifdwarf' showed very fine texture of leaves whereas the later also showed consistently good average turf quality rating and chlorophyll content in the whole period of experimentation. Under south Gujarat agro-climaticcondition, *C. dactylon* L. × *C. transvaalensis* 'Tifdwarf' performed best in most of turf quality parameters and can be subjected to further functional quality trials for sports and athletic turf.

Sangma *et al*. (2015) [18] evaluated for suitability of turfgrass under Delhi conditions of six varieties (*viz*. Selection 1, Bargusto, Panama, Panam, Palma and Tifdwarf 419) and *Paspalum notatum* species Out of evaluated varieties and species, Tifdwarf 419 exhibited better performance with respect to shoot dry weight (2.03 g/100 cm2), shoot fresh weight (5.78 g/100 cm2), root length (17.17 cm), root density (35.00 number/100 cm3), relative water content (86.96%), chlorophyll a (2.63 mg/g fresh weight), chlorophyll b (0.53 mg/g fresh weight) and total chlorophyll (3.24 mg/g fresh weight) when compared to other varieties. Apart from these characteristics, short shoot length of 6.07 cm and high shoot density (331.27 number/100 cm2 area), along with good colour throughout the growing season was observed in Tifdwarf 419. Selection 1 also showed desirable shoot fresh weight (5.07 g/100 cm2), root length (16.10 cm), root density (28.87 number/100 cm3) and shoot density (395.40 number/100 cm2 area). The *Cynodon dactylon* varieties Tifdwarf 419 and Selection1 were found to be most suitable to be used as turfgrasses in Delhi conditions.

Ubendra *et al*. (2015) [24] investigated the performance of twelve native turfgrasses under tropical condition. Morphological, physiological parameters and visual quality (shoot color, shoot density and shoot uniformity) were also recorded. It was found that temperature has significant effect on the performance of turfgrasses. Bermuda grass which had the highest root length (41.59 cm), root density (8.08), dry weight of root (5.04), turf quality (8.53 / 9), total chlorophyll (1.24 mg g^{-1}), relative water content (85.62%) and stomatal index (upper) (26.94%) was found to be most drought tolerant followed by Zoysia japonica which is best suitable for stress tolerant conditions. Malik *et al.* (2014) [14] evaluated quality, growth and physiological potential of various turfgrass cultivars for shade gardens and found that during the growth period of six months, all cultivars exhibited variations in color, texture and visual quality. Maximum quality scores (8.2) for color was achieved in cultivar 'Fine Dacca'. Stolon diameter was maximum (2.1 mm) in the ecotype Khabbal in the month of December. Maximum fresh clipping weight of 4.2 g was noted in the cultivar Fine Dacca in the month of April followed by the ecotype Khabbal. Similarly, the rate of photosynthesis was higher in the cultivar Fine Dacca (7.23 μmole $m^{-1}S^{-1}$) in the month of March followed by Tifway. Maximum chlorophyll content (2.73 mgs g^{-1} fresh weight) was observed in the cultivar 'Tifway' in the month of December. Janakiram *et al.* (2014) [8] evaluated twelve turfgrass genotypes. All of them under study exhibited fine leaf texture, except *Eragrostis curvula* had medium coarse texture, both *Paspalum notatum* and Argentine bahia had coarse texture and *Poa pratensis* L. exhibited medium fine leaf texture. *Agrostis palustris* L. exhibited maximum mean performance for shoot density (277.33) in 25 cm-2 area, whereas minimum value (57.67) was exhibited by *Cynodon dactylon* L. var. Panama.

Severmutlu *et al.* (2011) [20] studied warm-season turf grass species *viz.*, Bermuda grass (*Cynodon dactylon*), buffalograss (*Buchloedäctyloides*), zoysiagrass (*Zoysia japonica*), bahiagrass (*Paspalum notatum*), seashore paspalum (*Paspalum vaginatum*) and centipedegrass (*Eremochloa ophiuroides*). Twenty cultivars belonging to these species were evaluated for their establishment, turfgrass, quality, spring green-up and fall color retention. Bermudagrass, bahiagrass and seashore paspalum established 95% or better coverage at1095 growing degree days [GDD]. 'Sea Spray' seashorepaspalum; 'SWI-1044', 'SWI-1045', 'Princess 77' and 'Riviera' bermudagrass; 'Cody' buffalograss and 'Zenith' zoysiagrass exhibited acceptable turfgrass quality for 7 months throughout the growing season. 'Argentine' and 'Pensacola' bahiagrass, 'Sea Spray' seashore paspalum and 'SWI-1044' and 'SWI-1045' bermudagrass extended their growing season by retaining their green color upto 15 days or longer than the rest of the warm season cultivars and/or species in the fall.

Nutrient requirement of turfgrass

Bermudagrass (*Cynodon dactylon*) cultivar Tifdwarf was studied by Aishah *et al.*, 1997 [2] under three types of organic material (chicken dung, peat and palm oil mill effluent) and combinations of nitrogen: potassium ratios. The N:K ratios used for the study were 0.6:1.2 kg/ 100 m2/month and 0.6:1.8 kg/ 100 m2/ month. Growth, length of internode, chlorophyll content and tissue nutrient content were affected by the application of fertilizers. Highest nitrogen, phosphorus, soluble carbohydrate and chlorophyll content were observed when treated with chicken dung. Potassium was found to be highest when palm oil mill effluent was used. N:K combinations were more effective in promoting vegetative growth than organic materials. Use of chicken dung supplemented with N:K ratio of 0.6: 0.6 kg/ 100 m2/ month in

Tifdwarf cultivar of (*Cynodon dactylon*) for maximum nitrogen uptake is recommended. McCrimmon (2004) [15] studied the effects of mowing height, nitrogen rate and potassium rate on palmetto and Raleigh St. Agustine grass under high and low combinations of two mowing heights (5.00 cm and 7.50 cm), two N rates (227 g/ 93 m2/ month and 454 g/ 93 m2/ month), two K rates (227 g / 93 m2 / month and 454g/93 m2/ month) and observed differences for both the mowing height as well as macronutrient and micronutrient effect on the cultivars under all the treatments. Effect of compost on turfgrass was studied by Petrovic *et al.*, (2008) [16]. Dairy and poultry compost at the rate of 6 mm and 12 mm thickness was applied once in the first year and two times in the second and third year. Short term benefits was not apparent due to compose application and fertilizer applied plots perform better in the first years. However, at the end of three years the poultry and dairy compost exhibited higher turfgrass quality than both the nitrogen fertilized and unfertilized plots suggesting potential of compost application in the long run.

Rodriguez-Fuentes *et al.* (2009) [17] studied mineral nutrition requirements for bermudagrass grown on professional soccer field. They found that N (1.74 g/ m2/ week), P (0.18 g/ m2/ week), K (0.83 g/ m2/ week), Ca (0.58 g/ m2/ week), Mg (0.27 g/ m2/ week), Cu (0.36 g/ m2/ week), Fe (1.87 g/ m2/week), Mn (1.53 g/ m2/ week) and Zn (2.25 g/ m2/ week) should be applied per m2 per week in three equal split fractions with the first three irrigations each week, for maintaining the soccer field. Treanholm *et al.*, (2012) [21] studied turf response to various nitrogen rates. Nitrogen was applied at the rate of 32.00 kg N/ ha, 64.00 kg N/ ha, 128.00 kg N/ ha and 196.00 kg N/ ha in 2005 and 49.00 kg N/ ha, 196.00 kg N/ ha, 343.00 kg N/ ha and 490.00 kg N/ ha in 2006 and 2007 on St. Augustine grass and zoysia grass. Turf quality was acceptable at all nitrogen levels except the lowest rate in St. Augustine grass and zoysia grass applications of higher nitrogen rates resulted in susceptibility to diseases. Sangma (2015) [18] Tifdwarf 419 evaluated under six fertilizer doses recommended dose (54:18:27 g/m2 N:P:K), out of which 1½ of recommended dose recorded highest shoot density (562.22/100 cm^2), shoot fresh weight (11.35 g/ 100 cm^2), shoot dry weight (3.86 g/100 cm^2), root density (20.06/ 100 cm^3), chlorophyll a (3.87 mg/ g fresh weight), chlorophyll b (0.55 mg/ g fresh weight), total chlorophyll (4.41 mg/ g fresh weight), fertilizers were applied in three methods, Highest shoot density (501.17numbers/ 100 cm^2), shoot fresh weight (10.25 g/ 100 cm^2), shoot dry weight (3.98 g/ 100 cm^2), clipping yield (2.30 g/ 100 cm^2), root density(19.31 numbers/100 cm^3), chlorophyll a (3.84 mg/ g fresh weight), chlorophyll b (0.50 mg/ g fresh weight), total chlorophyll (4.34 mg / g fresh weight), were all recorded with the third method of fertilizer application(¹/3 of N, full dose of P & K at the time of planting, remaining Nin two equal doses after every 4 months) in Tifdwarf 419, indicating that applying nitrogen in splits of three is more beneficial to turfgrasses than either single application as basal dose or two split applications. Studies revelead that increase in fertilizer rate increased in turf quality parameter and best quality turf was noticed with highest dose of fertilizers i.e. 1½ of recommended dose (81g N, 27g P and 40g K/m^2).

Mowing requirement of turfgrass

Law *et al.* (2016) [9] revealed that the one-third rule decreased mowing requirements by 31% (approximately eight mowing events yr^{-1}) and returning grass clippings added approximately two additional mowing events yr^{-1}. Tall fescue [*Schedonorus arundinaceus* (Schreb.) Durmort., nom. cons.; *Festuca arundinacea* Schreb.] required more annual mowing events than Kentucky bluegrass (*Poa pratensis* L.) (nine and three more in 2012 and 2013, respectively). Tall fescue had a greater 2-yr cumulative DMY than Kentucky bluegrass (875 vs. 522 g m^{-2}). Growth rate (i.e., cultivar) also affected annual mowing requirements and yield: the faster the growth rate, the more annual mowing events. Leaf tissue N concentrations were higher when clippings were returned and with slower-growing cultivars. Mowing by the one-third rule and selecting slower-growing cultivars of turfgrass species adapted to a particular location can reduce annual mowing requirements and subsequent mower emissions. Macolino *et al.*, (2014) [12] studied the effect of three mowing heights (20.00 mm, 32.00 mm, 62.00 mm), on Kentucky blue grass, two rhizomatous and two non rhizomatous tall fescue cultivars. They found that the mixtures containing rhizomatous tall fescue exhibited higher turfgrass quality and turfgrass density than non rhizomatous types. Turfgrasses mowed at lower mowing heights (20.00 mm and 32.00 mm), was found to perform better. Mowing heights was also found to influence species composition in the mixtures. Yin *et al.*, (2014) [27] studied Tall fescue and zoysiagrass mixtures that were maintained at 5.00 cm and 7.00 cm mowing height with fertilizer rate of 100 kg N/ ha/ year, 200 kg N/ ha/ year and 400 kg N/ ha/ year and were evaluated for various parameters like turf visual quality, shoot density and ground cover. 5.00 cm mowing heights and low nitrogen application produced high shoot density in zoysiagrass but it was indifferent in tall fescue with regards to mowing height. Higher nitrogen rate produced higher shoot density and ground coverage in tall fescue. Li *et al*. (2008) [10] studied Zoysiagrass and tall fescue mixture at three mowing heights of (3.50 cm, 5.00 cm and 6.50 cm) with fertilizer rates of 0.00 kg N/ ha, 50.00 kg N/ ha and 100 kg N/ ha. Significant interactions between nitrogen fertilization rates and mowing heights were observed. Zoysia coverage was favoured under low mowing heights and lower nitrogen rates. Shoot density of zoysiagrass was higher at more mowing heights and lower nitrogen rates. TifEagle bermudagrass was studied by Tucker *et al.*, (2006) [22] at three mowing heights (3.20 mm, 4.00 mm and 4.80 mm) and three nitrogen rates (12.00 kg N/ ha/week, 24.00 N/ ha/ week and 48.00 N/ ha/ week). Observations were taken for root length density, root surface area, thatch layer depth and turf quality. It was observed that mowing height and nitrogen rate influenced turf quality, root surface area and root length density. Other than the lowest nitrogen rate other nitrogen rates produced acceptable turf quality. They observed that higher mowing heights favoured root growth than lower mowing heights.

Liu *et al*. (2003) [11] studied the effect of mowing height on summer growth and physiological activities of two bentgrass cultivars used in putting green. The grasses were mowed daily at 3.00 mm and 4.00 mm mowing height and turf quality. Turf quality, net photosynthetic rate, leaf phytochemical activity, canopy temperature and soil temperature were examined. They found that compared to higher mowing heights, turf quality, net photosynthetic rate, leaf phytochemical activity decreased and canopy temperature and soil temperature increased at lower mowing height (3.00 mm). They concluded that mowing at higher heights of 4.00 mm for certain bentgrass cultivars like Penncross and Crenshaw during the summer results in better quality golf greens as they are able to maintain higher photosynthetic activities and lower respiration rates. Maitre *et al*., (2004) [13] studied to describe and quantify the effect of mowing height on ground cover of turf grass growing in pure stand and various binary mixtures. Mowing was done at 10.00 mm, 25.00 mm and 40.00 mm height. For all the mixture a better ground cover was observed with 10.00 mm mowing height for creeping bent grass, 25.00 mm for smooth meadow grass and 40.00 mm for perennial ryegrass.

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