REVIEW ARTICLE

ROLE OF TURFGRASS IN URBAN LANDSCAPES

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Abstract: Lawns occupy a significant proportion of green spaces in manycities worldwide. Despite of aesthetic and ornamental benefits, turfgrass also possess many inevitable functional benefits. It helps in maintaining ecological balance and reclamation of polluted environments due to profuse exploitation of nature in urban landscape. The major benefits include controlling soil erosion and improving soil quality, water purification and noise reduction, mitigating air pollution and dust. Turfgrass plays a major role in carbon sequestration which reduce the atmospheric temperature. Apart from these functional benefits, turfgrass is also used in various medical therapies as a tool for reducing mental stress and by various entrepreneurs as a billion-dollar industry with high returns per unit area.

Keywords: Turfgrass, Urban landscape, Air pollution, Water quality

INTRODUCTION

The 2010 UN projections envisage global population to rise from 6.9 billion in 2010 to 8.1, 9.3 and 10.6 billion by mid-century under the low, medium or high assumptions (UN Population Division 2011, John, C., 2013). The increasing urban area has afforded permanent negative alterations on human life, and it may magnify the risk of environmental hazards. The most considerable impact of rapid urban expansion is reducing the area of green space coverages (Alireza and Mohammad, 2019). This rapid urbanization has promoted social and economic development, but has also accelerated the exploitation of limited resources, causing many environmental pollution problems (Wu *et al.*, 2014). These are mainly wastewater pollution caused by the daily activities of urban residents(Ng *et al.*, 2014), Carbon emissions from urban expansion (Lai *et al.*, 2016), industrial wastewater pollution (Nedved and Jansz, 2006), industrial smoke and dust pollution (Lamb, 2010), industrial solid waste pollution caused by industrial production(Cai *et al.*, 2018) and atmospheric pollution caused by fuel combustion, such as SO_2 (Liu and Wang, 2017), PM_{10} (Chen *et al.*, 2018), $PM_{2.5}$ (Wang and Fang, 2016), and CO_2 (Zeng *et al.*, 2008, Longwu., *et al.* 2019).Inorder to mitigate the problems arisen by this we need to move towards healthy urbanization in which urban landscape plays a major role.

According to the European landscape convention, there are two major classes when talking about landscape: natural landscape and anthropic landscape, the second being plainly represented by the urban landscape. Today, more urban planners and architects emphasize the idea of compact cities to limit the effects of urbanization over the surrounding landscape and local environment (Athanasios *et al.*, 2016). Urban landscapes, which include residential lawns, have been suggested to cover 2 per cent of the land area in the United States alone (Milesi *et al.*, 2005, Thompson and Kao-Kniffin, 2019, Manish *et al.*, 2021).Also, for many centuries turfgrasses have played a vital role in protecting our environment (Beard and Robert 1994). Theperennial nature of turfgrass facilitates soil organic matter accumulation associated with increased microbial production (Fontaine *et al.*, 2003, Shi *et al.*, 2006, Yao *et al.*, 2006).

Lawns occupy a significant proportion of green spaces in manycities worldwide today (Stewart *et al.*, 2009). According to the mostrecent EU study "Green Surge – A typology of urban green spaces,ecosystem provisioning services and demands" and the green spaces are defined as "Any vegetated areas foundin the urban environment, including parks, forests, open spaces,lawns, residential gardens, or street trees" (Maria *et al.* 2017).

Previous research from golf course management zones suggested moderate management in fairways resulted in highest soil organic carbon and microbial biomass when compared to intensively managed putting greens or minimal management in rough (Wang *et al.*, 2014). Residential lawns experience minimal to intense management that may alter urban soil quality or health (Cheng *et al.*, 2008, Gu *et al.*, 2015).

Functional benefits of turf grasses

Controlling soil erosion

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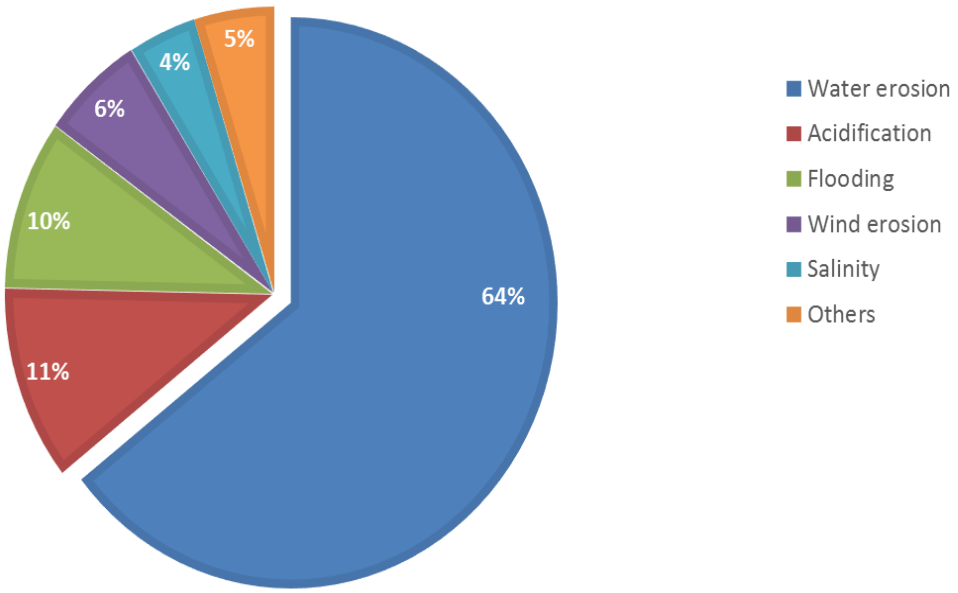

Fig. 1. Status of soil erosion or land degradation in India

Figure 1 shows the status of soil erosion or land degradation in India out of which 64% of land degradation occurring due to water erosion, 11% due to acidification, 10% due to flooding, 6% due to wind erosion, 4% due salinity and 5% due other factors (Source: Central Soil Water Conservation Research and Training Institute (CSWCRTI), Dehradun) which points the finger towards the efficient management aspects need to be taken. Turf grasses with its dense fibrous root system offers a very effective soil erosion control in urban ecosystem.

Gross *et. al*. (1991) reported sediment losses of 10-60 kg /ha from turfgrass plots during a 30 min storm that produced 76 mm/h of rainfall, whereas, soil loss from bare soil plots averaged 223 kg/ha. Grass binds the soil more effectively than any other plant. A key characteristic of mowed turfgrasses that contributes to this very effective erosion control is a dense ground cover (Figure 2) with a high shoot density ranging from 75 million to more than 20 billion shoots per hectare (Beard, 1973, Lush, 1990, Gross *et al.* 1991). Table 1 shows the effectiveness of various organic and io-organic ground covers in controlling soil erosion. Among them grass sod recorded the least soil loss of 0.04 tons per acre compared to all other ground covers (Brady and Weil, 1999).

Figure 2. Root and shoot growth of turfgrasses which forms the barrier for eroding soil particles.

Table 1. Effectiveness of various groundcovers in reducing runoff and soil erosion for simulated rain event (3.78in/ha) at university of Maryland's turf grass research station.

Material	Soil loss (tons/acre)	% of Rainfall Runoff
• Bare soil with partial cover	2.97	83
• Woven mesh	0.18	61
• Wood shaven in non-woven polyester netting	0.36	69
• Coconut fiber mat	0.48	58
• Straw	0.26	76
• Grass sod	0.04	NA

(Brady and Weil,1999)

The perennial grasses can be effectively utilized in restoration of highly eroded rural areas, burnt over lands, garbage dumps, mined areas and in rain garden (Figure 3). Rain gardens are shallow depressions in the landscape that are planted with trees and/or shrubs, and covered with a bark mulch layer or ground cover. They allow stormwater to infiltrate, recharge aquifers, and reduce peak flows. In addition, they are expected to provide pollutant treatment, which has been attributed to several processes including adsorption, decomposition, ion exchange, and volatilization (Michael and John, 2005). Studies shown that surface-water runoff losses from a cultivated tobacco (*Nicotiana tabacurn* L.) site averaged 6.7 mm/ha/month during the tobacco-growing season (May-September), whereas, the surface-water runoff loss from perennial turfgrass averaged only 0.6 mm/ha/month (Angle, 1985, Gross *et al.*, 1990, Beard and Robert, 1994).

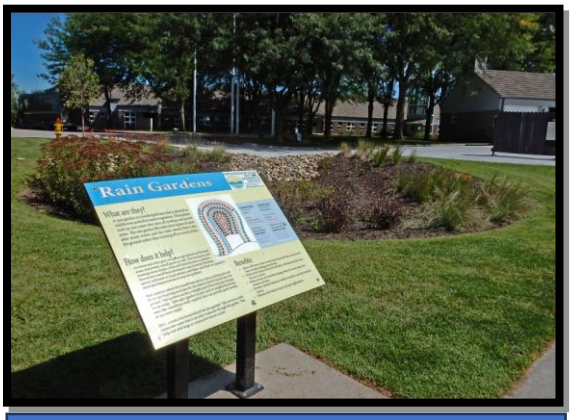

Figure 3. Restored land from mining areas by turfgrass and rain garden establishment

Lawns improve the soil quality structure:
Grass keeps the soil structure loose and open, with plenty of pores for water to soak down into. High proportion of the world's most fertile soils has been developed under vegetative cover grass (Gould, 1968). Vegetation improves soil quality as it is promoted in agriculture by the use of cover crops. Cover crops ameliorate soil chemical, physical and biological properties, including soil organic carbon content, cation exchange capacity, aggregate stability, and water permeability, as revised by Dabney *et al.* 2001 and Jose, 2017. It is evident from figure 4 that turfgrass enhanced the soil organic carbon accumulation considerably compared to the land previous to turf establishment.

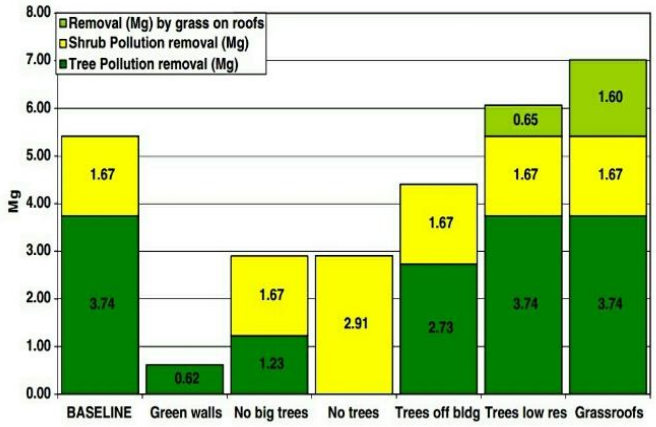

Fig 5. Total NO_2 (a) and O_3 (b) removal(Mg) by trees, shrubs and grass in Midtown per annum

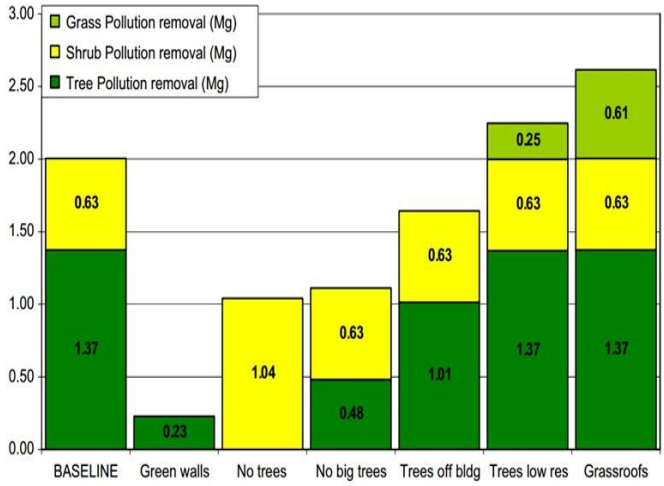

Fig 6: Total PM10 (a) and SO_2 (b) removal (Mg) by trees, shrubs and grass in Midtown per annum

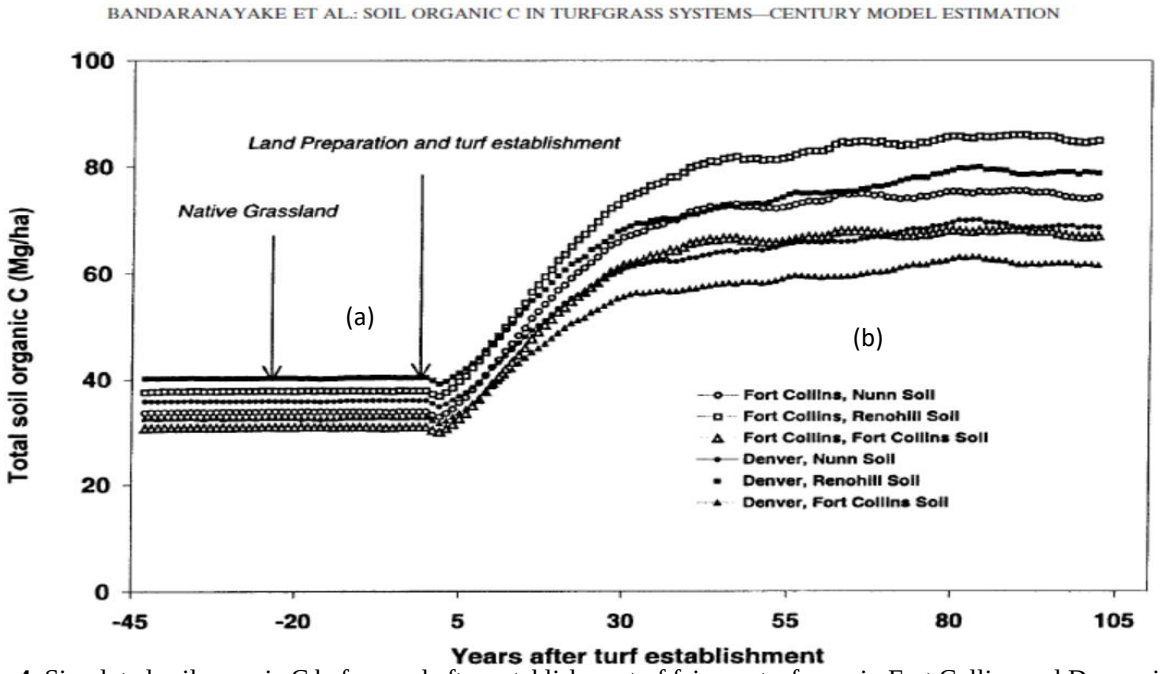

Fig 4. Simulated soil organic C before and after establishment of fairway turfgrass in Fort Collins and Danver in three different soils

Turfgrass and Air pollution

It is well known that trees, shrubs and other natural vegetation in urban areas reduce air contaminant levels.By extensions like green wall and green roof, air quality and the overall experience of health and well-being of humans living in urban areas can be increased (Nowak *et al.*, 1998). Johnson and Newton (1996) estimated that 2,000 m^2 of un-mowed grasson a roof could remove as much as 4,000 kg of particulates from their leaves and stems. One meter square of uncut grass on a roof would provide enough oxygen to meet the needs of one person over one year (Minke and Witter, 1982). Grass also takes in hydrogen fluoride and peroxyacetyl nitrate which are the worst group of atmospheric pollutants. The toxic gas (NO_2, O_3, PM_{10} and SO_2) removal by different vegetation from green roof and green wall (Figure 5 & 6) indicated that grass surfaces removed highest milligram of toxic gases (Currie and Bass, 2008).

Turfgrass and Carbon sequestration

One of the best ways to reduce carbon dioxide concentration in the environment is carbon sequestration. Carbon sequestration is the process through which atmospheric carbon dioxide is absorbed by plants through photosynthesis and stored as carbon in growing shoots. This form of stored carbon is carbohydrates (Jain, 1983, Sharma et al 2014). Turfgrasses act as a Carbon sink, absorbing more CO_2 than they release, resulting in C-sequestration. Turf grasses are classified into C_3 and C_4 grasses according to their photosynthetic pathways (Ehleringerand Cerling, 2002, Linlin *et al.*, 2012). C_3 grasses have an adaptive advantage where minimum temperatures are low during the winter growing season. At the same time the occurrence of C_4 species increases with decreasing rainfall and they dominate in those areas where temperatures are high throughout the year (Vogel *et al.*, 1986,Ghannoum *et al.* 2000, Schulze et al 1996, Keeley *et al.* 2005). The century modelsimulations in scenarios of this research indicate that turfgrass systems serve as a sink for atmospheric Carbon for approximately 30 to 40 year after establishment at approximately 0.9 to 1.2 Mg/ha/yr (Figure 7). Organic carbon change in the soil is a slow process and it needs many years and decades to access carbon content changes in soil. So, century model provides opportunity to predict long term carbon change by using mathematical equations (Parton *et al.* 1988).

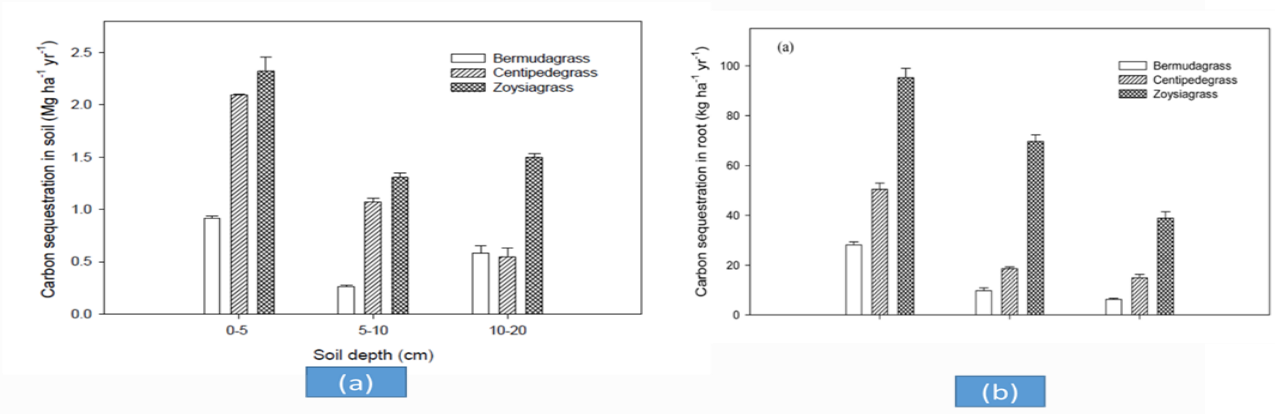

Fig 7. (a) Carbon sequestration(Mg/ha/yr) in soil as affected by turfgrass species and soil depth, (b)Effect of grass species and soil depth on carbon sequestration (Kg/ha/yr) in grass root

Dust prevention

Grasses in the United States traps an estimated 12 million tons of dust and dirt released annually into the atmosphere. Grassed areas significantly lower the levels ofatmospheric dust and pollutants. Perennial turfgrasses offer one of the most cost-efficient methods to control water and wind erosion of soil. Such control is very important in eliminating dust and mud problems around homes, factories, schools, and businesses (Beard and Robert 1994).

Urban heat Island

The temperature of the urban area is highest compared to the surrounding areas (Figure 8) because of less vegetation (Beard and Robert 1994). Hence the term Urban heat island is coined for city areas. Turfgrass can used as a remedy for reducing the temperature in these areas. Turfgrass plays an important part in controlling our climate (Johns and Beard, 1985). Turf cools itself and its surroundings by the evapo-transpirationprocess(Beard and Johns, 1985). Roughly 50% of the sun's heat striking the turf may be eliminated through this transpirational cooling process. The transpirational cooling effect of green turfs and landscapes can save energy by reductions in the energy input required for interior mechanical cooling of adjacent homes and buildings.

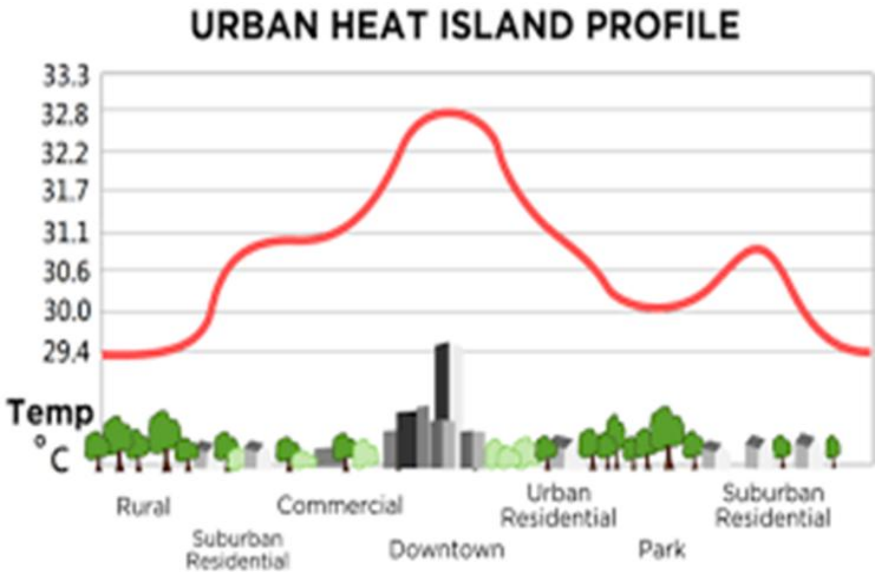

Figure 8. Temperature variations of different living environments

Influence on surface water quality and ground water recharge

Turfgrasses have superior capacity to trap and hold runoff, which results in more water infiltration through the soil-turfgrass ecosystem (Bennett, 1939, Morton *et al.*, 1988, Watschke and Mumma, 1989, Angle, 1985, Gross *et al.*, 1990). Rain water filtered through turfgrass is found to be 10 times less acidic than water running off a hard surface. Turfgrass ecosystems can support abundant populations of earthworms (*Lumbricidae*) of from 200 to 300/m^2 (Potter *et al.*, 1985). Earthworm activity increases the amount of macropore space within the soil that results in higher soil water infiltration rates and water-retention capacity (Lee, 1985, Beard and Robert., 1994).

Water purification and noise reduction

The runoff water and sediment that occurs from impervious surfaces in urban areas carries many pollutants, including metals such as Pb, Cd, Cu, and Zn, hydrocarbon compounds and household and industrial hazardous wastes (Artina *et al.*, 1999, Lee and Bang, 2000, Kim *et al.*, 2005, Zhao *et al.*, 2006). Turfgrasses can be designed for the catchment and filtration of these polluted runoff waters (Schuyler, 1987). Turfgrass ecosystem microflora constitute the largest proportion of the decomposers. These organisms offer one of the most active biological systems for the degradation of trapped chemicals and pesticides (Alexander, 1977). Ten percentof United States golf courses are already using effluent water for their turfgrass irrigation. Lawn acts like a blanket or insulation panel, absorbing sounds from vehicles, people, and animals. The surface characteristics of turfgrasses function in noise abatement as well as in multi-directional light reflection that reduces the glare. Studies have shown that turfgrass surfaces absorb harsh sounds significantly better than hard surfaces such as pavement, gravel, or bare ground (Cook and Van Haverbake, 1971, Robinette, 1970). These benefits are maximized by an integrated landscape of turfgrasses, trees, and shrubs. Unfortunately, the proper use of turfgrasses, trees, and shrubs in concert to maximize noise abatement has received little attention within the scientific community.

Aesthetic and recreational role

Lawn is the heart of any landscape and is an essential feature for any type of garden (Sithin *et al.*, 2020a). Lawn is considered as the soul of garden, because the lush green lawn provides a great satisfaction to the owner and becomes a centre of the garden for major activities. Turf grasses beautifies millions of home lawns, provides safe playing surfaces on over 700,000 athletic fields, outdoor recreation for nearly 26 million golfers on over 17,000 golf courses and economic opportunities for thousands of seed and sod producers, lawn care operators and landscapers (Janakiram *et al.*, 2015). Lawn acts as a background for any garden feature and some time it acts as a focal point in case of large areas. It is an inevitable part in English gardens and it comprises of 70 % of the total area of the garden.Turfgrass acts as a low-cost cushioning surface for sports players in football, cricket, hockey, rugby and many other games (Sithin *et al.* 2021). It provides surface to do exercise and meditation in urban areas which is very much essential to cop up with the urban stressed life. Also, the cool green colour of turf grasses helps to provide a mental relief which is widely used in Yoga. The green large pieces of land are always a pleasing sight for everyone. It also offers space to spend leisure time for family members and playing surface for children.

Monitory value

As part of a well-designed and maintained landscape, turfgrass increases a house's property value by 15 to 20 %.They are part of a larger "Green Industry", which is regarded as a million-dollar industry as the selling price of a unit turf when compared with any

other ornamental for a unit area is very high (Roshini *et al*. 2017). Turf grasses beautifies millions of home lawns, provides safe playing surfaces on over 700,000 athletic fields, outdoor recreation for nearly 26 million golfers on over 17,000 golf courses and economic opportunities for thousands of seed and sod producers, lawn care operators and landscapers. Among diverse avenue of floriculture, turf grass is an upcoming avenue to flourish the floriculture and landscaping trade. The turf grass industry is often called as "Hidden Agricultural Industry" because it is not routinely surveyed like other agricultural commodities by the various agencies (Janakiram *et al.*, 2015). Grasses are marketed at 100 Rs. Per m^2in India hence for one hectare area total gross income of Rs. 20,00,000 is obtained. In tropical countries like India, highest benefit to cost ratio was obtained when Mexican grass is chosen for planting and weeds in the grasses are managed chemically along with seed sowing method of establishment is practiced (Sithin *et al.*, 2020b).

The Health Benefits

Walking through turf grasses in bare foot improves nervous system balance. While walking on turf grasses, the nerve endings situated in the foot gets activated from the stimulus. These stimuli are created by the contact of rough surface of grasses with the sensitive under foot skin. It also promotes cardiovascular health by increasing the blood circulation by activating the nerve receptors. Which ultimately reduce the risk of Cardiac arrest or heart attack (Janakiram *et al.*, 2015). When the circulation of blood gets augmented it decreases the blood viscosity which boost ups the brain functioning. Some reports suggest that walking through the lawn grasses improve the eyesight. The acupuncture field of medical therapy uses lawn-walking as an important tool for treating a number of diseases. A good walk on the grass stabilizes the circadian rhythm of the body by which, it helps to have a better sleep at night. Also, the cool green colour of turf grasses helps to reduce the stress and provide a mental relief which is widely used in Yoga.

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