EFFECTS OF USING DIFFERENT CONCENTRATION OF SEA WATER FOR GRASSY WEED CONTROL IN BERMUDA TURFGRASS (*Cynodon dactylon*)

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ABSTRACT

Long term use of herbicide can pose serious threat to environment. Alternative strategies to chemical herbicide in weed control have received increasing attention now a days. Sea water could be used to control weed in salt tolerant turfgrass areas. The experiment was conducted in the rain shelter at Faculty of Sustainable Agriculture, Sandakan Campus, UMS in pots under a sand culture system to examine the response of turfgrass and common local weed species. The sandy soil had electrical conductivity (EC) of 0.24 dSm^{-1}, organic carbon 0.09%, nitrogen 0.34%, with pH 5.23. Eight grassy weed species were used namely *Axonopus compressus*, *Chrysopogon aciculatus*, *Dactyloctenium aegyptium*, *Digitaria ciliaris*, *Digitaria fuscescens*, *Digitaria sanguinalis*, *Poa annua*. L, *Sporobolus diander*. The objectives of this experiment were to evaluate the effect of different concentration of sea water application for grassy weed control in *Cynodon dactylon* turfgrass and to categorise grassy weed species according to its susceptibility to sea water. All weed species and the control *C. dactylon* (Bermuda) were subjected to five different salinity treatments, namely 0 dS m^{-1} (distilled water), 12.2 dS m^{-1}, 24.4 dS m^{-1}, 36.5 dS m^{-1} and 48.7 dS m^{-1}. The EC of collected sea water was 48.7 dS m^{-1}. Pots were arranged in a Completely Randomised Design (CRD) with four replications. The treatment means were compared by Least Significance Differences (LSD) at the 5% probability level. The parameters measured were injury level, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight, and total dry matter. Injury symptoms were visually evaluated as an indicator of current conditions of weeds and bermudagrass at 3, 7, 14, 21 and 28 day after initial sea water exposure. At the end of the experiment shoots and roots were harvested. Results showed that the response to salinity varied among species. Based on the present study weeds could be categorized as highly susceptible, moderately susceptible and highly tolerant. Highly susceptible weeds include some grassy weeds (*Axonopus compressus*, *Chrysopogon aciculatus*, *Digitaria ciliaris* and *Digitaria fuscescens*). Moderately susceptible weed species was *Digitaria sanguinalis*. Besides *Cynodon dactylon*, *Poa annua*. L and *Sporobolus diandrus* was found to be moderately tolerant to salt water treatments (48.7 dS m^{-1}). Among the weed tested at day 21 *D. ciliaris* was completely killed at 48.7 dS m^{-1} with 100% injury level. *Poa annua*. L, *S. diander* and *C. dactylon* (control) was the least sensitive grass at all higher concentration of sea water with injury level of 45%, 47% and 6% respectively at 48.7 dS m^{-1} on day 28. These results conclude that sea water could be used for selected grassy weed (*A. compressus, C. aciculatus, D. ciliaris* and *D. fuscescens*) control in turf species *C. dactylon* turfgrass field. This option would be particularly attractive to managers of turf located near coastal areas where brackish or sea water can be readily made available for irrigation at the same time reduce weed populations. As for the tolerant weed species which experienced less than 50% injury level further research should be done to identify the minimum amount of sea water needed over complete control of the weeds and maybe mixture of sea water and herbicides application can be used to control tough weeds and indirectly reduce the amount of herbicide use.

KESAN PENGGUNAAN KEPEKATAN AIR LAUT BERLAINAN TERHADAP KAWALAN RUMPAI BERDAUN TIRUS DI KAWASAN RUMPUT TURF
Cynodon dactylon

ABSTRAK

Penggunaan racun rumpai secare berpanjang boleh menimbulkan ancaman yang serius kepada alam sekitar. Strategi alternatif kepada racun kimia dalam kawalan rumpai telah menerima perhatian yang semakin meningkat pada masa kini. Air laut boleh digunakan untuk mengawal rumpai di kawasan rumput turf yang bersifat toleran garam. Eksperimen ini dilakukan dibawah rumah lindungan hujan, Fakulti Pertanian Lestari, Kampus Sandakan, UMS di dalam pasu menggunnakan sistem kultur pasir bagi mengkaji tindakbalas rumput turf dan spesies rumpai yang didapati di kawasan FPL. Tanah berpasir mempunyai konduktur elektrik (KE) 0.24 dsm^{-1}, karbon organik 0.09%, nitrogen 0.34 %, dan pH 5.23. Lapan spesies rumpai berdaun tirus telah digunakan antaranya Axonopus compressus, Chrysopogon aciculatus, Dactyloctenium aegyptium, Digitaria ciliaris, Digitaria fuscescens, Digitaria sanguinalis, Poa annua. L, Sporobolus diander. Objektif eksperimen ini adalah untuk menilai kesan penggunaan kepekatan air laut berlainan terhadap kawalan rumpai berdaun tirus di rumput turf C. dactylon dan untuk mengkategorikan species rumpai berdaun tirus berdasarkan tahap kerentanan terhadap air laut. Semua spesies rumpai dan kawalan C. dactylon (Bermuda) tertakluk kepada lima rawatan yang berbeza kemasinan, iaitu 0 dS m $^{-1}$ (air suling), 12.2 dS m $^{-1}$, 24.4 dS m $^{-1}$, 36.5 dS m $^{-1}$ dan 48.7 dS m $^{-1}$. KE air laut yang dikumpul adalah 48.7 dS m $^{-1}$. Pasu telah diatur dalam reka bentuk (CRD) dengan empat replikasi. Purata rawatan dibandingkan dengan (LSD) pada peringkat kebarangkalian 5%. Parameter yang diukur ialah tahap kecederehan, berat basah pucuk, berat basah akar, berat kering pucuk, berat kering akar dan jumlah berat kering pokok. Tanda-tanda kecederaan telah dinilai secara visual sebagai petunjuk keadaan semasa rumpai dan bermudagrass pada hari ke 3, 7, 14, 21 dan 28 selepas aplikasi air laut. Pada akhir ekperiment pucuk dan akar telah dituai. Hasil kajian menunjukkan bahawa tindak balas kepada kemasinan berubah antara spesies yang berlainan. Berdasarkan kajian dilakukan, rumpai boleh dikategorikan sebagai sangat mudah terdedah , sederhana mudah dan sangat bertoleransi terhadap kemasinan air laur. Rumpai sangat mudah terdedah termasuk beberapa rumpai berumput (Axonopus compressus , Chrysopogon aciculatus , Digitaria ciliaris dan fuscescens Digitaria). Spesies rumpai Agak mudah terdedah adalah sanguinalis Digitaria . Selain Cynodon dactylon , Poa annua . L dan Sporobolus diandrus didapati sederhana toleran kepada rawatan air garam (48.7 dS m^{-1}). Antara rumpai yang diuji D. ciliaris mati pada kepekatan air laut 48.7 dS m^{-1} dengan tahap kecederaan 100% pada hari ke 28. Poa annua. L, S. diander dan C. dactylon (kawalan) adalah rumput yang paling toleran pada semua kepekatan air laut dengan tahap kecederaan masing-masing sebanyak 45% , 47% dan 6%. Dengan keputusan yang diperolehi, ia boleh disimpulkan bahawa air laut boleh digunakan untuk kawalan rumpai berumput tirus terpilih (A. compressus, C. aciculatus, D. ciliaris dan D. fuscescens) dalam kawasan rumput turf C. dactylon. Ini boleh menjadi satu cara yang sangat menarik kepada pengurus rumput di kawasan berhampiran dengan pantai, di mana air laut mudah diperolehi untuk pengairan pada masa yang sama mengurangkan populasi rumpai. Bagi spesies rumpai toleran penyelidikan lanjut harus dilakukan untuk mengenal pasti jumlah minimum air laut yang diperlukan bagi mencapai kawalan sepenuhnya dan mungkin penggunaan campuran air laut dan racun rumpai boleh digunakan untuk mengawal rumpai yang sukar dikawal dan secara tidak langsung mengurangkan jumlah penggunaan racun rumpai.

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CHAPTER 1

INTRODUCTION

1.1 Background

Turf can be defined as a surface layer of vegetation, consists of earth and a dense stand of grasses and roots. Other terms used synonymously with turf include sod, which is a piece cut from vegetative material plus it's adhering soil or sward, which is the grassy vegetation often used in association with pasture. Turf grass falls under the largest angiosperm families, the Poaceae, contains approximately 785 genera and 10000 species. Sixteen genera are found within the subfamilies of *Eragrostoigeae*, *Festucoideae* and *Panicoideae*, containing world's principal turfgrasses (Aldous, 1999).

A turfgrass has various, vital functional purposes, as well as being attractive. Healthy, properly maintained turf has positive impacts on quality of lives and environment in a way that anything else would not do. A dense turf area prevent soil erosion, cools by enhancing heat dissipation via the process of evapotranspiration and cleans the air, filters surface water and enhance ground water recharge, cushions falls thus help reduce injuries and improve playability, act as a noise and glare control, decreases noxious pest and allergy related pollen, and add great value to our homes and provide a pleasant eye sight (Beard and Watschke, 2008).

Common bermudagrass (*Cynodon dactylon*) is a warm season turfgrass species used for athletic fields, lawn and golf course tees, fairways and roughs. It was first available by seed in U.S around 1940, but the first improved cultivar, Arizon common was introduced in 1960s. The use of bermudagrass in high value turfs has increased in recent years due to the release of new cultivars with improved turfgrass quality similar to hybrid bermudagrass (Patton, 2009). In Tennessee, bermudagrass (*Cynodon* spp.) is commonly selected for use on athletic fields and golf courses for its aggressive growth and tolerances to heat, drought and traffic stress. In general, bermudagrass is a mat forming perennial grass that aggressively spreads by both rhizomes and stolons.

This extensive network of rhizomes (below ground) and stolon (above ground) vegetative propagules makes bermudagrass extremely tough to control. Many times, bermudagrass can be desiccated on the soil surface with certain herbicide applications only to regenerate from below ground rhizome over the time. Additionally, aggressive above growth from stolon allows bermudagrass to advance into additional areas of desired turf over time (Breeden *et al.*, 2010). While in Malaysia, popular cultivars of Bermuda grass are Tifgreen, Tifway and Tifdwarf, which were used in golf courses and it is also high quality turfs (Gobilik *et al.*, 2013).

Weed is a plant that is objectionable or interferes with the activities or welfare of man (Pessarakli, 2008). It is competitive, persistent, pernicious, and interferes negatively with human activities. There are approximately 250,000 species of plants throughout the world, of those, about three percent, or 8,000 species, behave as weeds. Of those 8,000, only 200 to 250 are major issues in worldwide cropping systems. A plant is considered a weed if it has certain characteristics that set it apart from other plant species (PennState, 2015). Weeds in turfgrass may grow more than the turfgrass intended by competing with desired turfgrass for water, nutrients, space and light eventually prevent the turfgrass from looking its best. Besides that, weeds reduces the aesthetic value of turfgrass area, decreases revenue, property value, and functional quality of the turfgrass. This causes turf manager to invest more on weed management to repair and reinstall the original quality of the turfgrass. In maintenance of turf quality general characteristics such as density, uniformity, leaf texture, smoothness, growth habit, and colour are measured (Leinauer *et al.,* 2014). However, the occurrence of weeds in turfgrass community disrupts the turf quality and may result in a substantial reduction in shoot density, variability in leaf width, colour and growth habit.

Herbicide may control a broad spectrum of weeds. However, perennial grass weeds are practically difficult to control as the roots and underground parts survive and the foliage re-emerges (Anonymous, 2009). Alternative approaches to weed control with minimal use of herbicides or other non-chemical methods have received increasing attention in the past decade because of environmental concerns. To minimize the herbicide effects, there is a possibility that salty water can be used to develop sustainable weed control methods in salt tolerant turfgrass areas.

There are number of potential turfgrass species that may be appropriate at various salinity level of seawater. New generation of turf varieties allow landscape development in saline environments. Such type of several grasses have now been developed and selected to produce plant varieties that can be utilized as turf. The current available turf variaties come from seashore paspalum (*Paspalum vaginatum*), manilagrass (*Zoisia matrella* (L.) Merr.), St. Augustinegrass (*Stenotaphrum secundatum* (Walt.) Ktze, Tifway bermudagrass, Japanese lawngrass (*Zoisia japonica* Steud) are common examples of warm season turfgrass with salinity tolerance (Pool, 2005).

Global warming is one of the greatest threats now facing the planet. Climate change is expected to influence crop production and other components of agricultural systems. Melting of masses of ice around the world has been one of the most pronounced effects of climate change. Over the past century, most of the world's mountain glaciers and the ice sheets in both Greenland and Antarctic have lost mass. The melting back of the glaciers and ice sheets has two major impacts. First, as the glaciers disappear areas that rely on the runoff from the melting of mountain glaciers are very likely to experience severe water shortages. Less runoff will lead to a reduced capability to irrigate crops as freshwater dams and reservoirs more frequently go dry. According to the Intergovernmental Panel on Climate Change (IPCC), even the best case scenarios indicate that a rising sea level would have a wide range of impacts on coastal environments and infrastructure. Effects are likely to induce massive environmental issues include salinization of aquifers and soils (Nicholls *et al.,* 2007).

Therefore, weed control strategies are needed that would reduce the use of synthetic herbicides, reduce cost of weed management and save the environment as well.

1.2 Justification

Millions of acres of lawn and landscapes around homes, businesses, roadsides, parks, athletic fields, and golf courses improve our quality of life by providing open spaces, recreation facilities, enhanced property values and the conservation of important natural resources. Healthy turf grass filters groundwater, absorbs pollutants, hinders the spread of fire and acts as a cooling agent around buildings and also providing space for outdoor activities, allowing individuals to enjoy green spaces.

Weed is a major problem faced in every turfgrass area. As turfgrass plays a very crucial role in our landscape environment, uniformity in turf field is a very important aspect in a turf industry. However, the present of weed disrupts the uniformity and took a step forward to compete for nutrient space and light, eventually suppressing the growth of the turfgrass in the field. Poor growth and development has been a definite eyesore to everyone.

While most modern herbicides are designed to kill only plants and have little or no toxicity to humans, many still have extreme consequences in the environment, changing habitats in ways that affect insects and wildlife. These consequences extend to water courses where they may kill beneficial aquatic plants and fish.

Paraquat, one of the most widely used herbicides in the world, is so toxic it's frequently used in third-world countries as a means of suicide. Large, unintentional exposure to paraquat almost always leads to death. Smaller exposures, usually through inhalation, have been linked to lung damage, heart and kidney failure, Parkinson's disease and eye damage. There was an outcry in 2003 when the Environmental Protection Agency decided not to limit the sale of the weed killer atrazine amid charges that the chemical industry had undue influence in the decision. The EPA's own research had shown that atrazine was toxic to some water borne species in extremely low parts-per-billion. A few years ago France ordered the withdrawal of atrazine and related weed killers, saying the chemicals were building up in water supplies and threatening human health. Some herbicides continue to be toxic to animals and plants. One study showed dogs who play in herbicide treated yards have three times the risk of cancer. A Swedish study linked herbicides with non-Hodgkin's lymphoma cancer in humans.

Usage of herbicides to control weed in turfgrass community is not healthy, environmentally friendly and moderately expensive. Usage of readily available sea water as a substitute of post emergence herbicides to control weeds in turfgrass is not only cost effective but more sustainable. Furthermore, report on response of weed and turfgrass species to salt water (post emergence) treatments is limited in Malaysia. Therefore, the present study is designed to evaluate the effect of salt water for the control of weed species in the turf which will benefit to turfgrass areas in Malaysia.

1.3 Objectives

The objectives of this study were:

i. To evaluate the effects of different concentration of sea water application for grassy weed control in *C. dactylon* turfgrass.

ii. To categorise grassy weed species according to its susceptibility to sea water.

1.4 Hypothesis

H_O: There was no significant difference in effects of different concentration of sea water application for grassy weed control of *C. dactylon* turfgrass.

H_A: There was significant difference in effects of different concentration of sea water application for grassy weed control of *C. dactylon* turfgrass.

CHAPTER 2

LITERATURE REVIEW

2.1 Turfgrass

2.1.1 Biology, Botany and Ecology

Turfgrasses evolved from forage and pasture grasses in various different ways. In livestock agriculture grasses were the foundation from the beginning. From play on rough pasture to finer-textured meadows many sports has evolved, as rules, skills and goal also evolved together. Turfgrass cultivation were developed from germ plasm used largely for forage and fodder uses (FAO, 2011). The turfgrass are incredibly diverse and versatile group of species. It existence is a result of unique combination of forces that have driven genetic evolution, including climatic and soil factor (disease, insects, and ungulates), domestic livestock and human. Thousand years of natural evolution, grazing pressure, and human domestication events have formed this germ plasm that is so valuable to the mankind. As human recreation and reclamation needs increase and evolve, so too will turfgrass continue to evolve as its phenotypes are highly plastic and adaptable, leading themselves to modification by breeding and selection in relatively short periods of time (Casler and Duncan, 2003).

Turf grass falls under the largest angiosperm family, the Poaceae formerly known as Gramineae, contains approximately 785 genera and 10000 species. Sixteen genera are found within the subfamilies of Eragrostoigeae, Festucoideae and Panicoideae, containing world's principal turfgrasses under the class Monocotyledoneae (Aldous, 1999). Each species may contain a number of cultivars or varieties. Most cultivars are produced by hybridization followed by natural selection and also artificial selection.

In consideration of life cycle, annual and perennial turfgrasses are available throughout the ecosystems (Uddin and Juraimi, 2013). Over the climatic regions of the world, differences in ecological adaptation of turf determine their distinctive geographical distribution. Bermudagrass, Cowgrass, Serangoongrass, Zoysiagrass St. Augustinegrass, Bahiagrass, Seashore Papalum, and Centipedegrass have established their position in the list of warm season turfs. On the other hand, Kentucky bluegrass, Rough Bluegrass, Canada Bluegrass, Annual Bluegrass, and Annual Ryegrass are highly appreciated as tropical cool season turfgrasses.

2.1.2 Economic Value

The turfgrass industry in the USA is valued somewhere between $40 and $60 billion, with over 50 million acres of turf. In Ohio alone, according to a 2007 survey conducted, the turfgrass industry accounts for $4.6 billion in total economic impact ($3 billion in annual expenditure) with 42,000 people employed in the industry and over four million acres of turf grown in the state (Sherratt *et al.*, 2011).

In Malaysia, turf production is an emerging industry (Uddin *et al.*, 2009). Turfgrasses are among the most important commodities in our country because of an increased interest in landscape industry as well as in the participation in recreational activities played on turf surface (Uddin and Juramai, 2013). Due to their importance, the sports turf and landscaping industry are expected to expend further under the clear policies and current guidelines enforced by the Ministry of Housing And Local Government (New Straits Times, 2001). Hence, excellent turfgrass cultivation becomes crucial to sustain the associated industries and job opportunities in Malaysia.

2.2 *Cynodon dactylon*

2.2.1 Taxonomy and Nomenclature

Cynadon is a genus of nine species (Assefa *et al.*, 1999) and the genus name Cynodon was derived from the Greek *kuon*, dog, and *odous*, a tooth is geographically widely distributed and genetically diverse (Mudau, 2006).The name *Cynodon dactylon* is universally accepted for this common, widespread weed. It is highly variable and various subspecies have been distinguished (Harlan *et al.*, 1970). It is normally tetraploid (2n=36) but diploid, triploid and pentaploid forms also occur (Kissmann, 1991). Although it is not native to Bermuda, *C. dactylon* is an abundant invasive species there. It is presumed to have arrived in North America from Bermuda, resulting in its common name of Bermuda grass. The taxonomy of Cynadon is shown in Table 2.1.

Table 2.1 Taxonomy of *Cynodon dactylon*

Domain	Eukaryota
Kingdom	Plantae
Phylum/ Subphylum	Spermatophyta/ Angiospermae
Class	Monocotyledonae
Order	Cyperales
Family	Poaceae
Genus	Cynodon
Species	*Cynodon dactylon*

Source: CABI, 2015. Invasive Species Compendium Datasheet

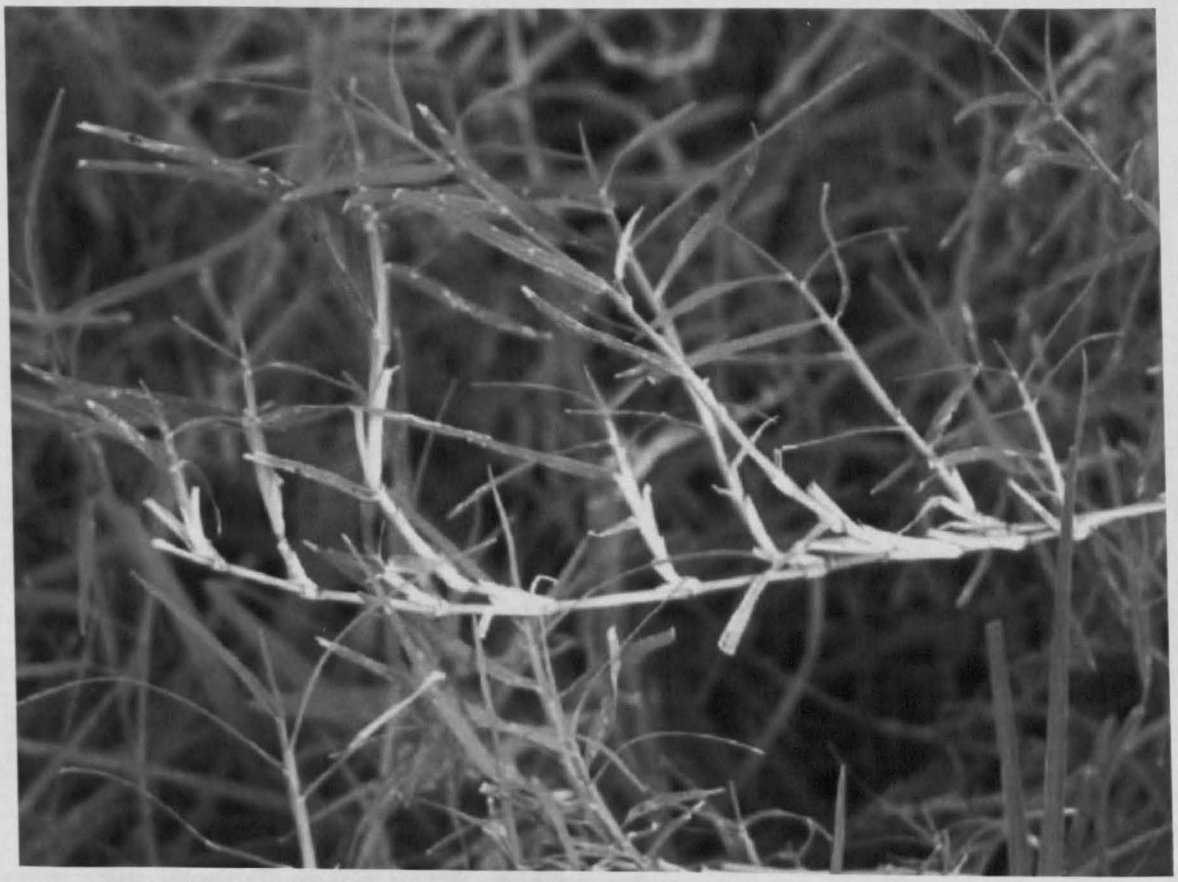

Figure 2.1 Photo of *Cynodon dactylon*

Source: CABI Datasheet

2.2.2 Description

Cynodon dactylon is a perennial grass, spreads quickly by surface and underground runners (Breeden *et al.*, 2010). The horizontally spreading runners bears nodes with internodes of about 10 cm length. They are mostly hairless and may be flattened or cylindrical. Each node roots in the soil and produces short culms (tillers), up to 25 cm high which develop into prostrate runners under less dense conditions. The almost unique character of the Cynodon genus of at least two and often three leaves at each node can be seen on the extended runners. This immediately distinguishes it from other perennial weeds with comparable growth pattern such as *Panicum repens* and *Paspalum distichum* (FAO, 1999).

The rhizomes are mainly in the top 10 cm of the soil but may penetrate to a depth of 35 cm (CABI, 2015) .They may be twice as wide as the runners and this is one of the variable characters in populations (0.2-0.9 cm). Each node is covered by a white cataphyl. Runner or rhizome nodes may bear up to three viable buds.

Leaves have an alternate distal pattern of distribution along the runners. Leaf blades are open up to the base, unhaired, similar or shorter than the length of the internode. The ligule is very short but with a conspicuous white fringe hairs. Leaf blades colour range between green to dull-green, from 1 to 15 cm depending on node, lanceolate, and forming almost a 90° angle with the leaf blade, finely parallel-ribbed on both surfaces, without a conspicuous midrib (CABI, 2015).

The inflorescence is supported on a culm up to 25 cm high and consists of a single whorl of 3-7 narrow racemes, each 3-8 cm long. Spikelets are 2-2.5 mm long in two rows, closely appressed to the rachis. Glumes are one-nerved, the lower almost as long as the spikelet, the upper half to three-quarters as long. The lemma is silky pubescent on the keel, palea glabrous. Caryopses are sub-eliptical, compressed and brownish, brilliant coloured (Kissmann, 1991). The seedling has a hairy ligule, bears 0.5 mm hairs. Pilosity increases as the seedling grows.

2.2.3 Distribution

Cynodon dactylon is thought to have originated in Africa but now occurs worldwide in both tropical and subtropical regions including Asia, North, Central and South America, the Caribbean, and islands in the Pacific Ocean (Beard, 2012). It also spreads into temperate areas of Europe and North America but is limited by sensitivity to prolonged frost. *Cynodon dactylon* invades almost all kinds of crops and modified ecosystems, including urban areas and circulation paths in many regions. (CABI, 2015).

2.2.4 Economic Importance

A valuable pasture and excellent fodder grass, staying green during hot weather. It can grow in very diverse conditions of soil and moisture, withstanding drought well and also has the tendency to eliminate other plants. Provides more and better grazing for horses and cattle than any other grass. It is also used for hay and ensilage. The rhizomes are given to horses. It has high value in soil conservation due to its long runners that root at the nodes. It has a potential of becoming a serious weed in cultivated land because it is hard to eradicate. *Cynodon dactylon* is a valuable lawn grass of wide adaptability (FAO, 1990).

Bermudagrass is reported to be alterative, anecbolic, antiseptic, aperient, astringent, cyanogenetic, demulcent, depurative, diuretic, emollient, sudorific, and vulnerary (Animesh *et al.*, 2012) photosensitizing in animals, to cause contact dermatitis and cure hay fever (CABI, 2015). It is a folk remedy for anasarca, calculus, cancer, carbuncles, convulsions, cough, cramps, cystitis, diarrhea, dropsy, dysentery, epilepsy, headache, hemorrhage, hypertension, hysteria, insanity, kidneys, laxative, measles, rubella, snakebite, sores, stones, tumors, urogenital disorders, warts, and wounds (Animesh *et al.*, 2012).

Silage made from heavily fertilized 'Coastal', properly ensilaged before 35 days old, can produce as much milk as corn silage at a cheaper cost. Dehydrated, this cultivar may be substituted for alfalfa as a source of vitamin A and xanthophyll for poultry feeds. Processors producing pellets for poultry, manage the grass for hay but apply 672 kg N/ha/year plus P and K, and cut the grass every 21-24 days, giving yields of 15.7 MT pellets/ha/season. Most commercial seed is produced in Arizona and southern California.

With one or two crops harvested annually, seed yields range from 112-224 kg/ha (James, 1983). In a Texas survey, bermudagrass was identified to fix nitrogen at a rate of 33 kg/ha/100 days in the rhizosphere, 26 for *Paspalum urvillei*, 20 for Brachiaria sp., and 20 for *Andropogon gerardi*. Bermudagrass is an extensively used in temperate and sub-tropical areas for forage, hay, ensilage, turf, and as a soil binder. In the US, it is widely used from Maryland to Florida and west to irrigated areas of the Southwest. However, it can become a serious pest in cultivated lands due to its thick network of runners can starve out crops and vast areas of land may become unfit for cultivation.

2.3 Turfgrass Importance

Turfgrasses have been utilized by humans to improve their environment for more than 10 centuries. The distinguishing characteristic of turfgrasses is the ability to withstand close mowing and still provide a functional, dense and healthy ground cover and that is what sets it apart from other plants by carrying various benefits (Sherratt *et al.*, 2011). Turfgrass benefits may be divided into three main components called functional, recreational, and aesthetic benefits (Beard and Green, 1994).

2.3.1 Carbon Storage (Sequestration)

Firstly, turfgrass systems is very suitable as sequester Carbon (C) in urban areas. Turfgrasses like other plants, capture atmospheric carbon dioxide and use it via photosynthesis to create usable energy in the form of sugars and carbohydrates. With increasing levels of atmospheric CO_2 associated with the greenhouse effect (global warming), turfgrasses serve as a source of carbon storage, or sequestration. Most of the turf volume, or biomass is below ground. Given the perennial nature of turf, the storage of carbon in root mass and organic matter development in the soil, turf is a significant carbon sink. Overall, a healthy lawn can sequester as much as 300 lbs. carbon/year or 1,500 lbs. carbon/acre/year (Huh *et al.*, 2008).

Research has also concluded that carbon storage in turf is comparable to the rate of carbon storage in land situated in the Conservation Reserve Program. A practical example of carbon sequestration is that one soccer field can offset the carbon produced by a car driving 3,000 miles (Zirkle *et al.*, 2011). Research over the last few years has concluded that practices like mowing, returning clippings, feeding and watering actually increases the turf's ability to sequester carbon. Basically, the healthier the turf, the more carbon it can store (Beard and Green, 1994).

2.3.2 Soil, Water and Nutrient Stabilization

Turfgrasses also play a vital role in soil erosion, dust control and water runoff by holding the soil in place. Turfgrasses has fibrous root systems that form excellent soil "netting" that reduces dust and stabilizes soil on both flat and sloping areas. Healthy turf are capable of absorbing and conserving water, filter water and prevent run-off, which is why turf is often used around parking lots, on slopes and roadsides. Since turf is a perennial and stable ground cover that is not cultivated, it slows storm water runoff reducing erosion potential and also improves the frequency of the water infiltrating down through the soil. Run-off and erosion of soil is considered to be one of the prime causes of nutrient contamination in the water systems. Reducing storm water run-off from impregnable surfaces is a relatively new concept in landscape design, with rain gardens being introduced in some residential region. Some researchers are also recommending designing turf areas to serve as catchments and filtration zones for polluted runoff water. Turf systems are not only efficient at catching and filtering water, but are also very efficient at holding on to nutrients. Nutrients like phosphorus are fixed onto soil particles or taken up by the plant and they do not leach out easily. The bottom line is that fertilizers applied to a healthy lawn are held in the soil and utilized by the turf plants (Beard and Green, 1994).

2.3.3 The Cooling Effect

An increase in temperature happens as communities grow from a village to a town and to a city. In metropolitan areas the term urban heat island is used to characterize the temperature increase. On warm summer days, the temperature can elevate ranging from 3°C-10°C in an urban area compared to the surrounding area (Shahmohamadi *et al.*, 2011). Every individual turf shoots carries a cooling process called transpiration. Transpiration helps reduce temperatures in the urban environment by dissipating high levels of radiation. To that end, turf is considerably cooler than other common surfaces. Research at Brigham Young University has recorded temperatures on turf twenty degrees cooler than bare soils and forty degrees cooler than synthetic turf (Shahmohamadi *et al.*, 2011). Transpirational cooling is dependent on an adequate supply of water. In turf areas, water is provided by rainfall and sometimes supplemented by irrigation, depending on length of the growing season, temperature, evapotranspiration rates, soil type, turf species and management practices (Beard and Green, 1994).

2.3.4 Sport and Recreation

In addition to environmental benefits, turf is used extensively for recreation and sport. Lawns and other recreational areas are places where adults, kids and pets can spend time outside of the home. Turf is used for play, for places to relax and for entertaining friends. This all contributes to the quality of one's life. With over 34,000 acres of athletic field turf and more than 700 golf courses in Ohio, sports are important not just to the economy but also to people's health and wellbeing. Per the census, there are 267 million people in the United States at seven years of age and older. Of those 267 million people, around 80 million people (30% of the population) play sports on turfgrasses. In the top five sports played on turf, it is estimated that golf courses have the most activity at 25.6 million and baseball and soccer have around 15 million regular participants. The importance of encouraging people to play sports and offering them places to play those sports cannot be down-played, particularly when the Centre for Disease Control estimates that 17% of American children and adolescents are obese. Also, and just as important, it is an outlet for children and adults to spend their leisure time in a positive and safe environment (Beard and Green, 1994).

2.3.5 Turf in the Urban Landscape

The last role that turf plays in society is in value to the landscape and urban environment. Turfgrasses help provide a pleasing urban environment through noise abatement, glare reduction, fire protection, and pest reduction. Turf areas like golf courses and parks also protect and foster wildlife. The natural state of these landscapes, coupled with the addition of trees, ponds, lakes and wetlands support a diverse population of birds, animals and plants. Studies looking at landscaping & house values have found that there is a positive relationship between a home's value and the existence of trees, up to a certain threshold. A more recent study suggests that the existence of a lawn also has a positive effect on the value of a home, with a lawn 1/4 -1/3 of an acre in size associated with the greatest effect on selling price (Beard and Green, 1994).

2.4 Grassy Weed

Any plant that is growing where it is not wanted can be called a weed (Pessarakli , 2008). Grassy weed species can be divided in annuals, biennials, and perenials. They falls under monocot family which poses narrow leaf and fibrous root systems.

The annual grasses are common weed in turf grass and landscape. Annuals complete their life cycle in a 12 month period. In temperate countries it can be further narrowed down into summer annuals and winter annuals. Examples of annual grasses are annual bluegrass, barnyardgrass and others (Turgeon *et al.,* 2009).

Perennial grass weeds live two years or more. Some reproduce by seed and some reproduce by creeping stems that can be either above-ground (stolons) or below-ground (rhizomes) (McAfee and Baumann, 2008). Also commonly infest lawns and other landscape areas and return every year. These weeds are the most difficult species to control in turf because they are so similar to the lawn grasses that they infest (Turgeon *et al.,* 2009). The management practices that favour the lawn grasses also favour these species. In many cases, perennial grasses that are themselves useful turfgrasses in one situation become weeds when they infest other turf species (Turgeon *et al.,* 2009).

Biennial weeds complete their life cycle in two years, germinating and forming rosettes their first year and producing flowers and seeds their second year. These are the least commonly found weed species in turf area.

2.5 Weed Control Methods

A turfgrass area may grow more than the intended beautiful grass. It may also grow weeds, which prevent your lawn from looking its best. In addition to reducing the aesthetics of turf area, weeds compete with the desired turfgrass for water, nutrients, and light. So, weed control involving both removing the weeds and correction the conditions are necessary.

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