UNIVERSITI PUTRA MALAYSIA

GROWTH PERFORMANCES OF SELECTED TURF GRASSES UNDER DIFFERENT LIGHT CONDITIONS

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GROWTH PERFORMANCES OF SELECTED TURF GRASSES UNDER DIFFERENT LIGHT CONDITIONS

By

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To my beloved parents;

Shukran bin Hj. Abdullah and Aminah binti Awang.

And sisters;

Nur Hanna Shahida and Nur Hanna Amira.

Thank you for eveything...

ABSTRACT

The experiment was carried out at the Horticulture Unit, Universiti Putra Malaysia Bintulu Campus to study the growth performance of grasses species namely *Axonopus compressus* cv. Pearl, *Cynodon dactylon* cv. Tif Dwarf and *Zoysia matrella* under three levels of light intensity which were 70% shade, 50% shade and under full sunlight as control. These grasses were grown in polythene bags of 12 cm x 8 cm filled with soil mixed of top soil, sand and organic matter of ratio 3: 2: 1 respectively. Experimental design used in this experiment was completely randomized design. The treatments were replicated three times with 30 samples in each replicate, and the grasses were watered twice daily. The experiment was conducted from November 2007 until February 2008. Parameters observed were number of blades, root length, inflorescences and wet weight of the clumps for four months. There was no significant difference in parameters of *Axonopus compressus* cv. Pearl and *Zoysia matrella* except for wet weight. For *Cynodon dactylon* cv. Tif Dwarf, only control treatment showed significant difference as compared to other treatments. Both *Axonopus compressus* cv. Pearl and *Zoysia matrella* can adapt heavy shading but *Cynodon dactylon* cv. Tif Dwarf requires full sunlight for proper growth.

ABSTRAK

Eksperimen dijalankan di Unit Hortikultur, Universiti Putra Malaysia Kampus Bintulu untuk mengkaji perkembangan pertumbuhan spesis-spesis rumput *Axonopus compressus* cv. Pearl, *Cynodon dactylon* cv. Tif Dwarf dan *Zoysia matrella* di bawah tiga tahap pencahayaan iaitu naungan 70%, naungan 50% dan bawah cahaya matahari langsung sebagai kawalan. Rumput-rumput ini ditanam di dalam beg polythene bersaiz 12 cm x 8 cm yang diisi dengan campuran tanah yang terdiri daripada tanah permukaan, pasir dan bahan organik pada nisbah 3: 2: 1. Rekabentuk eksperimen yang digunakan adalah rawak sepenuhnya. Rawatan direplikasi sebanyak tiga kali dengan 30 sampel dalam setiap replikasi dan rumput-rumput disiram dua kali sehari. Ujikaji dijalankan dari November 2007 hingga Feruari 2008. Parameter yang dilihat adalah bilangan daun, panjang akar, bunga dan berat basah tangkai untuk empat bulan. Tiada perbezaan bererti bagi semua parameter untuk *Axonopus compressus* cv. Pearl dan *Zoysia matrella* kecuali berat basah. Bagi *Cynodon dactylon* cv. Tif Dwarf, hanya rawatan kawalan menunjukkan perbezaan bererti berbanding rawatan-rawatan lain. Kedua-dua *Axonopus compressus* cv. Pearl dan *Zoysia matrella* mampu bertahan pada tahap naungan yang tinggi tetapi *Cynodon dactylon* cv. Tif Dwarf memerlukan cahaya matahari langsung untuk pertumbuhan sempurna.

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I certify that this research project report entitled "***Growth Performances of Selected Turf Grasses under Different Light Conditions***" has been examined and approved as a partial fulfillment of the requirement for the degree of Bachelor of Bioindustry Science in the Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Campus.

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LIST OF ABBREVIATIONS

C_3	three carbons users' plants
C_4	four carbons users' plants
cm	centimeter
CO_2	carbon dioxide
cv.	variety
DNMRT	Duncan New Multiple Range Test
ft	feet
g	gram
lux	light intensity
m	meter
SAS	Statistical Analysis System
spp.	species
°C	degree Celsius
°F	degree Fahrenheit
<	less than or equal to
%	percent

CHAPTER I

INTRODUCTION

1.1 Background

Grass is a common word that generally describes a monocotyledonous green plant in the family Poaceae (Langer, 1972). This includes most plants grown as cereals, pasture and lawns. There are also some more specialized crops such as lemongrass, many ornamental plants and some weeds, as well as plants often not considered to be grass, such as bamboos.

Grasses belong to a larger group of plants called monocotyledons or simply called monocots. The monocots are flowering plants that have only one seed leaf (cotyledon) in their seeds. They usually have parallel veins in their leaves, stems with vascular bundles, and flower part in multiples of three.

Sedges and rushes are monocots that always be mistaken for grasses. Grasses however can be distinguished by the two-ranked arrangement of their leaves; each successive leaf of a grass aid attached at a 180-degree angle from the previous leaf. The leaves of sedges are three-ranked, and the leaves of rushes are round in cross section (Pohl, 1968).

Grasses are an incredibly diverse group of more than 10 000 individual species (Watson and Dallwitz, 1992). They ranged from the small, fine-textured plants that attained a mature height of 1 in. (Hitchcock and Chase, 1950) to the giant bamboos, which may reach a height of 100 ft and have a stem diameter of up to 1 ft (Pohl, 1968).

A very small number of the grasses are suited for use as turfgrass. They are generally the more compact members of the group, which are able to form a high density under continuous defoliation caused by mowing. There are less than 50 grass species that fit this creation in the world (Christians, 2004).

The turfgrass are divided into cool-season and warm season species. As the names indicate, the cool-season species are best adapted to the cooler times of the year. They thrive in temperatures from 65° to 75°F. This species emerged from dormancy and grow very rapidly in the spring. The green color remains green into the fall and through the winter. Jones (1985) stated that cool-season grass species belong to C_3 group, regarding their carbon compound usage. Examples of this species are bluegrass (*Poa* L.), fescues (*Festuca* L.), bentgrass (*Agrostis* L.) and ryegrass (*Lolium* L.)

Warm-season species best adapted at temperatures between 80° to 95°F (Beard, 1973). Warm-season species emerged from dormancy more slowly and do not reach maximum growth rate until midsummer. Their growth rate slows in the fall, and they go dormancy in regions where soil temperatures are below 50°F (Beard, 1973).

Warm-season grasses lose their chlorophyll when they go dormant, and remain brown until spring (Christians, 2004). Some examples of warm-season grasses are Bermuda grass (*Cynodon* spp. Rich.), Zoysiagrass (*Zoysia* spp. Willd.), Bahia grass (*Paspalum notatum* Flugge.) and carpetgrass (*Axonopus compressus* cv. Beauv.).

Axonopus compressus cv. Pearl is locally called Rumput Mutiara. This perennial grass is often used as permanent pasture, ground cover and turf in moist, low fertility soils, particularly in shaded situations (Emmons, 2000). Like most plants, it performs best in fertile areas but also grows remarkably well on poor sandy soils if moisture is present.

Zoysia matrella is known locally as Rumput Siglap, a species of mat-forming, perennial grass that forms extensive, velvety green mats, spreading virgiously by stolons or occasionally by rhizomes. Engelke and Anderson (2003) agreed that this Zoysia grass can grow in low evaluation preferring sandy soils where other grasses established poorly. In addition to this, it tolerates high salinity, making it ideal for erosion control and lawns in coastal areas. Emmons (2000) stated that this grass also tolerate shade and draught.

Cynodon dactylon cv. Tif Dwarf is a hybrid of common *Cynodon dactylon* (L.) Pers. and *Cynodon transvaalensis*. Known as Royal Blue or locally referred as Rumput Minyak, the hybrid requires higher degree of maintenance, but can produce fine-textured, dense and vigorous turfs (Emmons, 2000).

Turgeon (2005) concerned its intolerance of shade may necessitates the use of alternative warm-season species on sites where trees and other structure restricts sunlight penetration. Besides, it is often used to feed livestock, as cover crop in orchards and control erosion (McCarty, 2002) in steep areas due to a long-rapid growth that forms dense turf on soil surface.

This study is very important because turf industry is very promising. Besides being used as roadside beautification and natural land buffer, golf course demand for turfs contribute to their major demand. These importances make turfs study more complex, with more cultivars and cross-breeding be made for the past 30 years (Turgeon, 2000). In the future, turfs are believed to be one part that will make up the distribution for urban landscaping.

1.2 Objectives

The goal of the proposed study is to determine how shading affects growth performances of *Axonopus compressus* cv. Pearl, *Zoysia matrella* and *Cynodon dactylon* cv. Tif Dwarf as well as to observe their growth performances in each light regime.

CHAPTER 2

LITERATURE REVIEW

2.1 Turfgrass Cultivation

According to Emmons (2000), the true grasses are in the family Poaceae. However, ancient grass cannot tolerate certain properties to be cultivated at home or other usages. Therefore breeding researches were greatly carried out since early 1930's (Muntzing, 1951).

Final subdivision then becomes necessary today to obtain different cultivars of grasses. Some cultivars are considered to be of the same species because they have similarity in structure and physiology but they differ in traits such as shade tolerance, leaf width, color and drought tolerance (Emmons, 2000).

The general goal on the plant breeding of turf species is to modify plant genotype through appropriate breeding procedures that will better fit the plants to the environment (Long, 1972). Initial programs in variety improvements were the selection of desirable biotypes that already present in nature (Brittingham, 1943; Funk, 1969). Breeding of grasses started where research to breed selected Bermuda grass, *Cynodon dactyion* (L.) Pers., for improved winter hardiness (Dorrance, 1930).

2.2 Shading

Various kinds of shades, such as tree shade or shade of structures, can influence turf quality, persistence, and the traffic tolerance of turf grasses. Bews (1973) estimated that the US has the widest shaded area of grass cultivation, which is estimated to be 25% of total national grass.

Shade reduces light intensity or/and effects light quality, resulting in morphological and physiological changes in turf grasses (Bell and Danneberger, 1999). The likelihood of injury from stresses such as cold, heat and draught increased when the plant have insufficient supplies of food stored (Christians, 1998).

Pritchett and Nelson (1951) were concerned with the effects of oats shading young brome grass grown with the oat. Turfs grasses become weakened, etiolated, and have enhanced susceptibility to disease under shade; therefore, management of turf grasses in shaded environments is challenging.

Turfgrass responses to different artificial shade conditions have been reported for a number of species. 'Diamond' zoysiagrass [*Zoysia matrella* (L.). Merr.] maintained acceptable quality under 73% shade but not under 86% shade (Qian and Engelke, 1997). Van Huylenbroeck and Bockstaele (2001) found significant differences in photosynthetic capacity and growth between the species perennial ryegrass (*Lolium perenne* L.), chewings fescues (*Festuca rubra* L.) and creeping red fescues (*Festuca rubra* spp. rubra) under 65% shade.

The response of grain crops to shading is more complex than that of forage crops. and a number of studies on the effects of shading have been conducted, mostly on maize and sorghum (Langer 1972).

According to Bews (1979), the amount of light available to an individual plant is reduced when it is shaded by taller plants, grown at high population densities or placed under artificial shaded elements. For example, the growth of weeds germination below the crop canopy is often limited by shading, and individual plants grown at high population densities are usually smaller than those grown at lower populations.

Plants adapt to shading and competition for light in several ways. Cunningham (1981) stated that the gross structure of the plants as well as leaf morphology and biochemistry adjust to changes in the light regime.

As many experiments were done using grain such as maize and rye which have better economic value, very little is known about the effects of light and shading towards the growth of turf grasses. There are, however, several approaches to determine the relationship for turfs. as stated by Langer (1972) where ryegrass cv. Manawa to compare the effect of light intensity (lux) to number of leaves per week.

Meanwhile, Vasey (1999) conclude that some turf species are known to be tolerated with shading, such as Switch grass (*Panicum virgatum*) that can either grow under full sun or shady areas while other species like meadow foxtail (*Alopecurus pratensis*) may need long exposure to direct sunlight to continue its growth.

Watsons (2001) suggests that better understanding to determine the growth performance of turf grasses should be approached, in which these characteristics; color choices, grooming response, pests and diseases resistance, environmental stresses tolerance and desirability, can be possessed.

2.3 Effects of Shade on the Turf Microclimate

Shade limits turfgrass growth not only by altering irradiance but also by modifying other micro-environmental conditions. Water transpired from trees and grasses in enclosed, shaded areas leads to high relative humidity (Fry and Huang, 2004).

The shade canopy moderates temperature fluctuations by lowering temperatures during daytime and increasing temperatures during night time by retaining heat. Shade from trees and other structures usually have little influence on grass canopy temperature, but soil temperature is typically much lower under shade than areas exposed to full sun during summer months.

Reduced soil temperatures are beneficial to cool-season turfgrass growing in hot, dry environments. However, lower soil temperatures under heavy shade may restrict growth earlier in fall and delay recovery in spring.

Shaded areas may maintain longer dew coverage than exposed, sunny areas, which promote diseases. The concentration of carbon dioxide often increased in shaded areas with restricted air movement, which may increase photosynthesis.

2.4 Physiological, Morphological and Anatomical Responses to Shade

Typical shoot and root characteristics of shaded turfgrass plants include shortened roots, reduced shoot density, erect and elongated growth of stems and leaves, thin leaves and decreased plant vigor (Fry and Huang, 2004).

Dudeck and Peacock (1992) and Beard (1997) presented extensive reviews of previous research on growth and physiological responses of turfgrass to shading. Van Huylenbroeck and Van Bockstaele (2001) reported that average leaf elongation was 35 percent higher under reduced irradiance (65%) compared to full light in several grass species, and perennial ryegrass had the highest plant height and lowest relative grass cover under shade.

The enhanced shoot growth under shade was most likely due to increased endogenous gibberellin (GA1) levels found in Kentucky bluegrass (Tan and Qian, 2003). Jiang, Duncan and Carrow (2004) reported that canopy height of Bermuda grass under low light conditions increased over 100 percent relative to plants exposed to full light; the reduced shoot density was paralleled with diminished canopy coverage (density).

Turf density declined in shade is likely due to decreased tiller of leaf areas (Fry and Huang, 2004). Maintaining high photosynthetic capacity under low light is important for turfgrass performance because leaves are removed due to regular mowing. For grasses adapted to full sunlight, the photosynthetic rate decreased with increasing shade, especially in C_4 grasses.

Cool-season grasses approach light saturation at only moderate intensity. Jiang, Duncan and Carrow (2004) reported that net photosynthetic rate decreased with 70 percent to 90 percent of full light for seashore paspalums and Bermuda grass respectively. Seashore paspalums generally had a higher photosynthetic rate than Bermuda grass, particularly under 90 percent light. This suggested that higher photosynthetic rate contributed to tolerance of low light in seashore paspalums.

Van Huylenbroeck and Van Bockstaele (2001) also demonstrated significant differences in photosynthetic rates among perennial ryegrass, red fescue and crested hairgrass (*Koeleria macrantha* L.) and relationship between tolerance of low light and photosynthetic features of the species. However, leaf anatomical and physiological responses to shade were both shown to influence photosynthesis in tall fescue leaves (Allard, Nelson and Pallardy, 1991).

A reduced respiration rate is often considered a major physiological adaptation, allowing plants to conserve carbohydrates in shade. Reduced leaf respiration at low light levels has been well documented (Givnish, 1988). The photosynthetic-respiratory balance is a critical factor in shade tolerance, and a positive CO_2 balance contributed to shade adaptation in red fescue (Wilkinson, Beard and Krans, 1975).

A low ratio of photosynthesis to respiration in response to stress conditions may result in a reduced total nonstructural carbohydrate content and inferior turf recovery from stress.

2.5 Light

Turfgrass absorbs and converts to chemical energy, through photosynthesis, only about 1% to 2% of the incident radiation (Turgeon, 2005). Most of the energy is reradiated at longer wavelengths with the release of heat that significantly affects atmospheric temperature.

The amount of reflected radiation varies among plants and is affected significantly by moisture conditions. Glossy or wet leaf surfaces are more reflective than dry and dull leaves. The amount of radiation absorbed by the leaves varies from about 50% to 80% of isolation, depending on leaf orientation.

The amount of light received by turfgrass is influenced by many factors in the environment. Clouds, buildings, trees, and other features can reduce light intensity through shading. Turfgrass responses to variations in the intensity of light ranges; from a relatively horizontal orientation of the leaf blades at high intensities, to a failure of the turf to persist under extremely low light (Turgeon, 2005).

2.6 Germination

In the grasses, what is usually called the seed or grain is really a fruit, known as caryopsis (Langer, 1972). It is composed of a comparatively large store of carbohydrates, the endosperm that separated from the embryo by a shield-like structure, the scutellum (Thomas and Davies, 1964).

During germination, the caryopsis absorbs water and swells. Growth can be indicated by the appearance of the primary root, the radicle (Langer, 1972). The energy for germination of early growth must come from metabolites stored in endosperm.

Working with germinating barley seeds, Paleg (1960) has shown that the embryos appeared to play a vital part in this process. He stated that the embryo provides a hormonal signal that stimulates enzyme synthesis in the aleurone layer called gibberellin. The seeds of many grass species germinate readily as soon as they are ripe, but others may remain dormant (Langer, 1972).

2.7 Leaf Appearance

Measurement of leaf growth on a tiller can be done under two consequences; determining the rate of initiation as leaf primordial appear on the stem apex and the rate of appearance as leaves become visible externally and unfold (Langer. 1972).

Sharman (1947) examined comparable tillers of several species and suggested that there are three groups, ranging from those with long apices, pasture grasses and cereals which commonly have only few primordia.

Leaf growth can be affected by controlling light intensity, as done by Aspinall and Paleg (1963) using barley under 14 to 24 hours of direct light intensity. Beside light, temperature may also relate to leaf growth. Silsbury (1970) has summarized results obtained by several workers with perennial ryegrass at temperature between 18°C to 23°C. Width and thickness of the leaf may response to temperature, which Friend (1966) noticed by using wheat.

2.8 Stem and Roots

During their early development the successive leaf primordia produced by the stem apex are inserted closely above each other without being separated by internodes. Separation occurs later through cell division in the region between adjoining primordia (Langer, 1972). Initially this involved all cells but, as the internodes grow, merismetic becomes restricted to the basal portion. More recently formed internodes may elongate, but there appears to be a curious pattern whereby long and short internodes adjoin together or one long internodes alternate with several very short ones (Barnard, 1964).

Grasses have two root systems, the seminal and the adventitious or nodal roots. The seminal roots arise from primordia that are present in the embryo (Langer, 1972). They are much more highly branched than adventitious roots and thus exploit a greater soil volume their small size suggests. Williams (1962) have calculated that they absorb fifty times more nutrients per unit weight than the nodal roots.

It is agreed by Bews (1973) that in temperate species the optimum temperature for root growth tends to be lower than for the growth of the shoots. These grasses grow best when soil temperature is relatively low, and under these conditions they can tolerate above optimal air temperature. *Cynodon dactylon*, a tropical species however, was shown to adversely affect by relatively low soil temperature even if the air temperatures were high (Langer, 1972).

2.9 Weed, Pest and Disease

Specific weeds are often good indicators of unfavorable environment conditions for turfgrass (Turgeon, 2005). Hall *et al.* (1994) reflected this to the existence of knotweed where severe compaction limit turfgrass growth. Ground ivy often invades under trees where insufficient sunlight always is the major problem (Engel, 1969).

Broadleaf weeds are very noticeable in turf area because their appearance is much different for that of grasses (Engel and Ilnicki, 1969). Besides, these weeds have a particularly disruptive aesthetic effect if they produce flowers and seed heads. Certain grass species, as stated by Emmons (2000), are called weeds because they destroy the uniformity of the turf. They may grow in unattractive clumps, coarser and have different growth habit of desirable grass.

A disease could result from many causes, including such abiotic factors as traffic and nutritional deficiencies (Britton, 1969). However, most disease occurs when infectious microorganisms called pathogens enter the life complexity and produce characteristic symptoms of diseases.

Almost all infectious diseases in turfgrass are caused by fungi (Smith and Woolhouse, 1989). Vargas (1994) noted that until recent time, no bacteria disease on turfgrass is recognize. Common symptoms of fungi attack are leaf spots. If a spore lands on the foliage, germinates and penetrates the leaf, a dead spot will appear where the fungus has fed (Schurtleff and Randell, 1974).

Disease control can be achieved by several intolerant methods. Disease development must be a susceptible host, a virulent pathogen and favorable environment conditions (Vargas, 1994). So, by reducing any of these reasons, disease can be removed.

Where disease-resistance cultivars are available; these can be substitute for susceptible ones. Direct control of pathogens usually involves the application of fungicides. A specific set of environmental conditions can favor both host susceptibility and activity of the pathogens. For example, water mold, *Pythium aphanidermatum* is favored by warm humid weather and high soil moisture. Under these same conditions cool-season turfgrass may be under considerable stress and therefore less resistance to these fungi (Smith and Woolhouse, 1989).

CHAPTER 3
MATERIALS AND METHODS

3.1 Background

Experiments were conducted at Horticulture Unit, Universiti Putra Malaysia Bintulu Campus (**Plate 3.1**) from November 2007 till February 2008. Grasses were planted in three planting units.

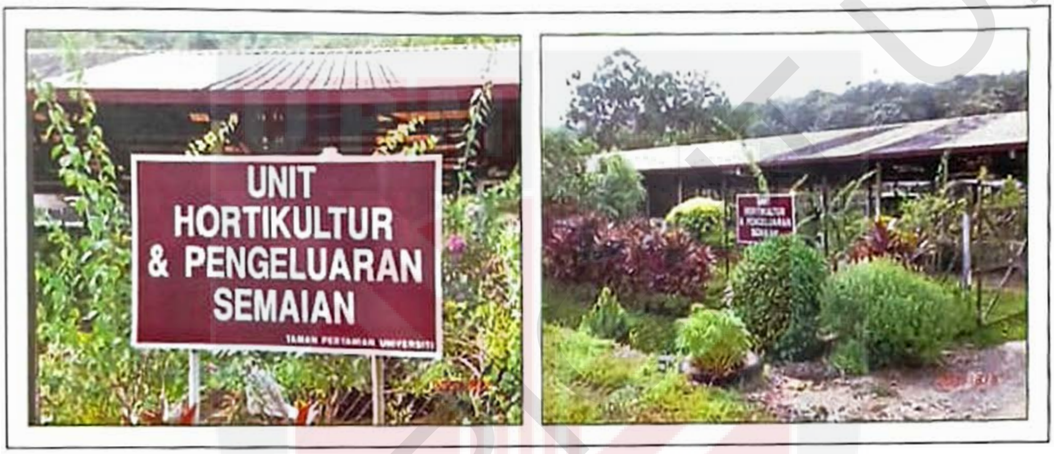

Plate 3.1: Horticulture Unit, Universiti Putra Malaysia Bintulu Campus.

Sods of *Axonopus compressus* cv. Pearl and *Zoysia matrella* were supplied by local suppliers near Bintulu area, while *Cynodon dactylon* cv. Tif Dwarfs' sods were sponsored by Bintulu Golf Club. Experimental design used was completely randomized design with three replications.

3.2 Materials

3.2.1 Turf species

Three species of turf grasses were used in this experiment (**Plate 3.2**):

Axonopus compressus cv. Pearl

Cynodon dactylon cv. Tifdwarf

Zoysia matrella

Plate 3.2: Sods of *Zoysia matrella* (left) and *Axonopus compressus* cv. Pearl (right).

3.2.2 Medium

The potting media were 3:2:1; consists of topsoil, sand and organic matter. The soil was taken from rehabilitated forest area of Hutan Nirwana in Universiti Putra Malaysia Bintulu Campus. Sand was taken from riverbanks in Bintulu region. Organic matter used was chicken promoter fertilizer labelled $B_{12}A$. 15N15P15K granular fertilizer was added at the rate of 0.5 g/pot depending on current turf condition. To control fungi development, Mas Tiram fungicide was applied accordingly.

3.3 Methods

3.3.1 Preparation of Growing Medium

All of the growing media were mixed together using machinery mixer and a little amount of water. If small amount was to be made, manual mixing was done using scopes.

3.3.2 Shading and Placing

Each sod was measured at 10 cm x 7.5 cm (4 inches x 3 inches). Turf grasses selected were grown in polythene bags (12 cm x 8 cm), placed under shades of 70%, 50% and full sunlight.

Plate 3.3: Turf grass planted on the platforms under different shades.

Three platforms were built in Horticulture Unit, and these platforms were equipped with proper drainage and water sprinkler and tied with two types of net, Butterfly 50% and Butterfly 70% which allows certain selected density of light to pass through, mimic shading of plant canopy. The height of net was 1 meter. The third platform was left without net for control treatment (**Plate 3.3**).

Every species were replicated three times (R_1, R_2, R_3), with every replicate contains 30 sods. Initial size area must be small to allow the grass to spread. Every plant within the same replicate was arranged side by side, and distance between each replicate was 30 cm.

Although the plants were left to grow naturally, watering was done twice a day. If the weather is unfavorable, rain water was left to water the plant. Sprinkler unit was used if the water pressure was too low for manual watering.

3.4 Data Sampling

3.4.1 Period of Sampling

Sampling started from 24th November to 24th February. Sampling was taken every month for four months, giving each parameter four readings. Each sampling took approximately 4 to 5 days to be completed.

3.4.2 Sampling Parameters

Four parameters were taken in this study to evaluate growth performances of selected turf grasses which are: number of blades that represent photosynthesis success of plant, inflorescences which was the emergence of flowers, root length that showed water uptake activity and wet weight basis. Both root length and weight were measured using plastic ruler and electronic balance respectively.

3.4.3 Data Analysis

Data from the experiment was run using SAS. The experimental design was completely randomized to observe light effect on growth of each species independently. Data was obtained from Duncan's New Multiple Range Test (DNMRT) at $p \leq 0.05$.

CHAPTER 4

RESULTS

Means for each species were calculated independently and were compared amongst related species. They were obtained from Duncans' New Multiple Range Test (DNMRT) using SAS at $p \leq 0.05$.

4.1 Growth Performance of *Axonopus compressus* cv. Pearl

4.1.1 Second Months' Growth Performance

Table 4.1.1: Mean for growth performance of *Axonopus compressus* cv. Pearl during the second month.

Treatment	Blade	Inflorescences	Root	Weight
30%	7.57^{a}	0.03^{a}	3.36^{a}	28.37^{b}
50%	7.20^{a}	0.66^{a}	3.38^{a}	30.74^{b}
Control	6.81^{a}	0.66^{a}	3.46^{a}	35.15^{a}

Means within the respective with the same letter are not significantly different at $p \leq 0.05$

In **Table 4.1.1**, it was observed that among all parameters, only weight gain showed significant effects of the treatments. For blade growth however, performance of *Axonopus compressus* cv. Pearl under control treatment declined from the most number of blades in the first month (7.14 cm) to the lowest mean (6.81 cm). In contrast, blades of grass under 30% sunlight rose from 6.31 to 7.57. As only small amount of flower emerged during the period, no significant difference detected within each treatment.

Root growth of every treatment showed no significant difference; they only vary from 3.36 cm (30% treatment) to 3.46 cm (control). During the first month, it was observed that weight of 30% sunlight and 50% sunlight was not significantly different at 28.37 g and 30.74 g respectively as compared to control (35.15 g).

4.1.2 Fourth Months' Growth Performance

Table 4.1.2: Mean for growth performance of *Axonopus compressus* cv. Pearl during the fourth month.

Treatment	Blade	Inflorescences	Root	Weight
30%	8.77^{a}	0.07^{a}	4.44^{a}	34.76^{b}
50%	8.68^{a}	0.14^{a}	4.15^{a}	38.45^{ab}
Control	7.14^{a}	0.11^{a}	4.36^{a}	42.68^{a}

Means within the respective with the same letter are not significantly different at $p \leq 0.05$

Means for each parameter increased but grasses grown under 30% light condition showed the highest mean for blades' growth (8.77) and root growth (4.44 cm). There were not much differences among each data except for weight where there was significant difference between 30% light treated grasses at 34.76 g and control (42.68 g).

4.2 Growth Performance of *Cynodon dactylon* cv. Tif Dwarf

4.2.1 Second Months' Growth Performance

Table 4.2.1: Mean for growth performance of *Cynodon dactylon* cv. Tif Dwarf during the second month.

Treatment	Blade	Inflorescences	Root	Weight
30%	3.41^{b}	0.00^{a}	3.34^{a}	21.61^{a}
50%	4.68^{b}	0.00^{a}	3.38^{a}	19.11^{a}
Control	8.24^{a}	0.00^{a}	3.39^{a}	22.67^{a}

Means within the respective with the same letter are not significantly different at $p \leq 0.05$

For the blade growth, *Cynodon dactylon* cv. Tif Dwarf grown under full sunlight (control) still show differences compared to the other two treatments. Mean recorded increased slightly from 7.14 to 8.24. The lowest mean came from treatment under 30% light condition at 3.41. There was no growth of inflorescence observed after two months.

Root lengths were slightly even amongst all treatments with the highest mean was recorded under control treatment at 3.39 cm and the shortest was 30% light at 3.34 cm. There was also no significant difference in weight, where 50% treatment showed the lowest mean at 19.11 g as compared to control treatment at 22.67 g.

4.2.2 Fourth Months' Growth Performance

Table 4.2.2 Mean for growth performance of *Cynodon dactylon* cv. Tif Dwarf during the fourth month.

Treatment	Blade	Inflorescences	Root	Weight
30%	4.30^{b}	0.00^{a}	3.61^{a}	25.84^{a}
50%	6.46^{b}	0.00^{a}	3.88^{a}	25.31^{a}
Control	10.22^{a}	0.00^{a}	3.95^{a}	27.60^{a}

Means within the respective with the same letter are not significantly different at $p \leq 0.05$

In the fourth month, numbers of blade in control treatment still differ significantly as compared to two other treatments. This reflects to their means of 10.22 as compared to 30% and 50% treatments at 4.30 and 6.46 respectively. At the end of experiment, there was no inflorescence recorded after four months.

Root growth and weight were not significantly different in every treatment. The highest means were under control treatment at 3.95 cm and 27.60 g as compared to the other two treatments; 30% light treatment at 3.61 cm and 25.84 g, and 50% light treatment at 3.88 cm and 25.31 g respectively.

4.3 Growth Performance of *Zoysia matrella*

4.3.1 Second Months' Growth Performance

Table 4.3.1 Mean for growth performance of *Zoysia matrella* during the second month.

Treatment	Blade	Inflorescences	Root	Weight
30%	13.85 ^{a}	0.00 ^{a}	6.77 ^{a}	45.83 ^{a}
50%	11.70 ^{b}	0.01 ^{a}	7.42 ^{a}	44.59 ^{a}
Control	12.88 ^{ab}	0.01 ^{a}	5.54 ^{b}	44.58 ^{a}

Means within the respective with the same letter are not significantly different at $p \leq 0.05$

In **Table 4.3.1**, it was noted that the number of new blade did not increased in all treatments. In contrast, inflorescences value decreased in all treatments. Flowers in 30% treatment declined to 0.00 after two months.

Mean for root growth in control treatment differ significantly to the other two treatments; at 5.54 cm compared to 6.77 cm and 7.42 cm respectively. Every value however increased from previous months' means. No significant difference was observed in weight, as every mean shows slight different between each other. The highest mean was under 30% light treatment at 45.83 g and the lowest mean was control at 44.58 g.

4.3.2 Fourth Months' Growth Performance

Table 4.3.2 Mean for growth performance of *Zoysia matrella* during the fourth month.

Treatment	Blade	Inflorescences	Root	Weight
30%	13.85 ^{a}	0.04 ^{a}	8.32 ^{a}	53.33 ^{a}
50%	11.70 ^{b}	0.03 ^{a}	8.58 ^{a}	54.61 ^{a}
Control	12.88 ^{ab}	0.04 ^{a}	7.65 ^{a}	51.21 ^{a}

Means within the respective with the same letter are not significantly different at $p \leq 0.05$

Table 4.3.2 shows the fourth month data for *Zoysia matrella* growth. Still, there was no increase in blade numbers in all treatments, and flowers's growth was also remaining the same, except for 50% treatment which increased from 0.02 to 0.03.

Root growth of control treatment was not significantly different from two other treatments, as happened in the first and second month. It increased from 5.54 cm to 7.65 cm, the highest increase among all treatments. Grasses treated under 50% light remained the longest at mean of 8.58 cm. For 30% treatment, the mean was 8.32 cm.

Weight for each treatment increased almost at the same rate, with the highest mean was recorded under 50% light at 54.61 g, followed by 30% light at 53.33 g and control at 51.21 g.

4.4 Blade Performance

4.4.1 *Axonopus compressus* cv. Pearl

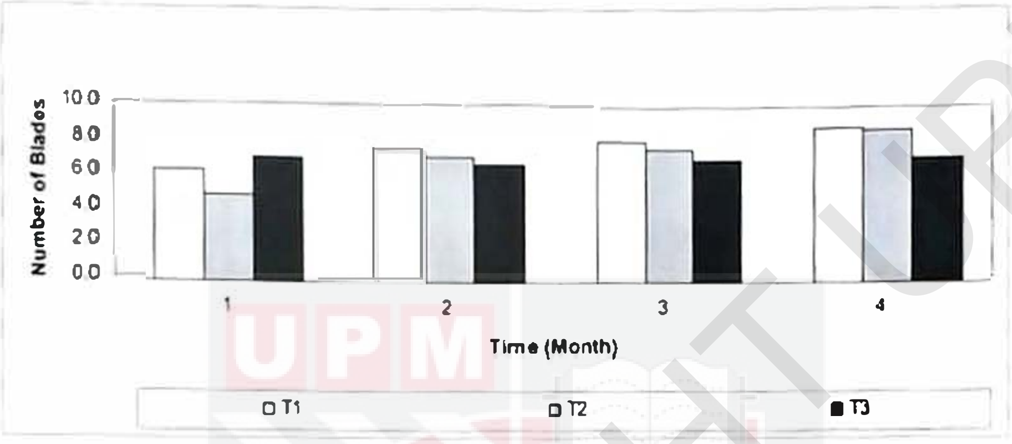

Figure 4.1.1 Blades performance of *Axonopus compressus* cv. Pearl under T_1: 30% light, T_2: 50% light, T_3: control treatment, for four months.

Table 4.4.1 Mean for blade performance of *Axonopus compressus* cv. Pearl after 4 months.

Treatment	1st Month	2nd Month	3rd Month	4th Month
30%	6.31 ^{a}	7.57 ^{a}	8.10 ^{a}	8.77 ^{a}
50%	4.90 ^{a}	7.20 ^{a}	7.66 ^{a}	8.68 ^{a}
Control	7.14 ^{a}	6.81 ^{a}	7.00 ^{a}	7.14 ^{a}

Means within the respective with the same letter are not significantly different at $p \leq 0.05$

Figure 4.1.1 shows blade performance of *Axonopus compressus* cv. Pearl during the four months of experiment. It was noted that in the first month, the most growing grasses were under control condition, which had the highest mean of 7.14. The least successful grasses were under 50% light condition with a mean of 4.90. However, in the second month, the mean of blades for control treatment decreased from 7.14 to 6.81. Grasses treated under 30% light had the highest with a mean of 7.57, followed by 50% treatment at 7.20.

After three months, each treatment increased in number of blades; but still there was no significant difference recorded among data. In the fourth month, it was noted that grasses treated under 30% sunlight was the best performer with a mean of 8.77, followed by 50% sunlight (8.68) and control (7.14).

4.4.2 *Cynodon dactylon* cv. Tif Dwarf

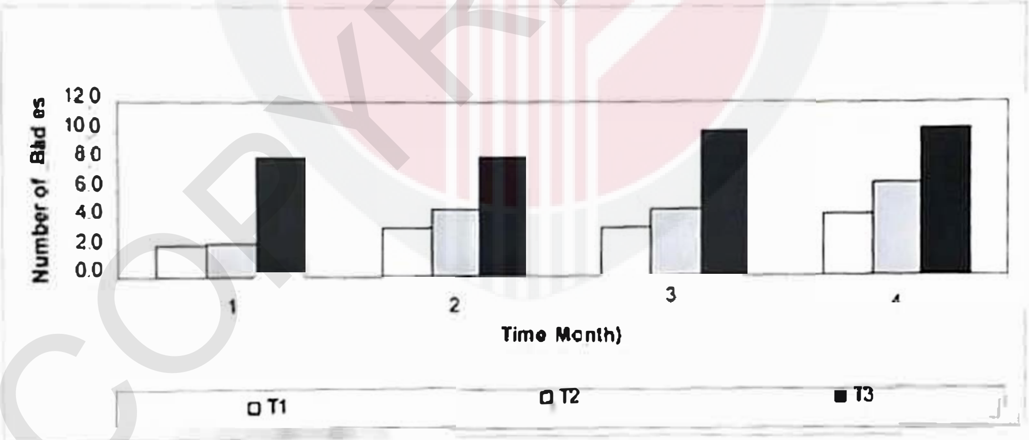

Figure 4.1.2 Blades performance in *Cynodon dactylon* cv. Tif Dwarf under T$_1$; 30% light, T$_2$: 50% light, T$_3$; control treatment, for four months.

Table 4.4.2 Mean for blade performance of *Cynodon dactylon* cv. Tif Dwarf after four months.

Treatment	1st Month	2nd Month	3rd Month	4th Month
30%	2.18 b	3.41 b	3.30 b	4.30 b
50%	2.37 b	4.68 b	4.69 b	6.46 b
Control	8.24 a	8.24 a	10.06 a	10.22 a

Means within the respective with the same letter are not significantly different at $p \leq 0.05$

Figure 4.1.2 and **Table 4.4.2** show blade performance of *Cynodon dactylon* cv. Tif Dwarf. In the first month, it was clearly noted that there was significant difference of blades between control and treated grasses. Mean for control treatment was 8.24 while means for the other treatments were 2.18 (30% sunlight) and 2.37 (50% sunlight) respectively. For the second month, there were still having significant difference between control treatment and the other two treatments.

In the third month, mean for treatment under 30% light decreased from 3.41 to 3.30. Control treatment was the highest value at 10.06. This treatment remained insignificant the following month; mean increased to 10.22 compared to 4.30 (30% light treatment) and 6.46 (50% light treatment).

4.4.3 *Zoysia matrella*

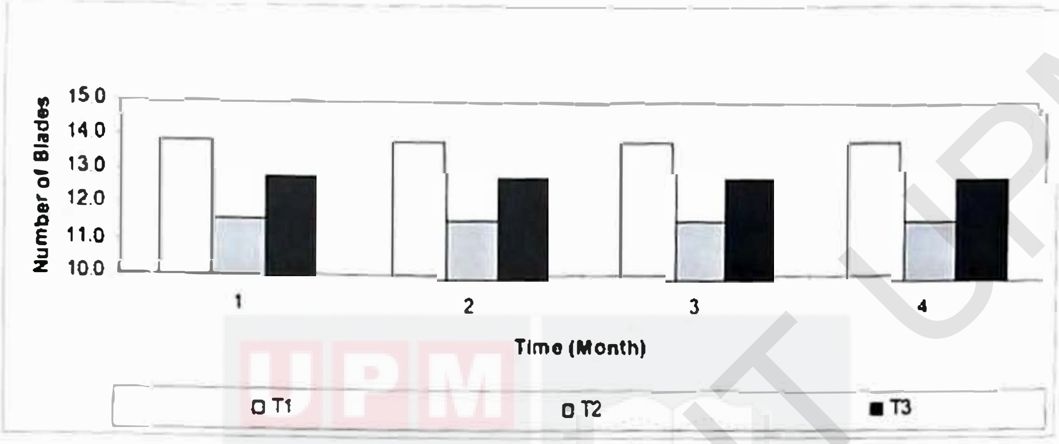

Figure 4.1.3 Blades' performance in *Zoysia matrella* under T_1; 30% light, T_2; 50% light, T_3; control treatment, for four months.

Table 4.4.3 Mean for blade performance of *Zoysia matrella* after four months.

Treatment	1st Month	2nd Month	3rd Month	4th Month
30%	13.85^{a}	13.85^{a}	13.85^{a}	13.85^{a}
50%	11.70^{b}	11.70^{b}	11.70^{b}	11.70^{b}
Control	12.88^{ab}	12.88^{ab}	12.88^{ab}	12.88^{ab}

Means within the respective with the same letter are not significantly different at $p \leq 0.05$

There were significant difference between 30% light (13.86) and 50% light (11.70), but the control treatment was slightly differ from each other (12.88). There was no increase in the number of blades in each treatment.

4.5 Inflorescences

4.5.1 *Axonopus compressus* cv. Pearl

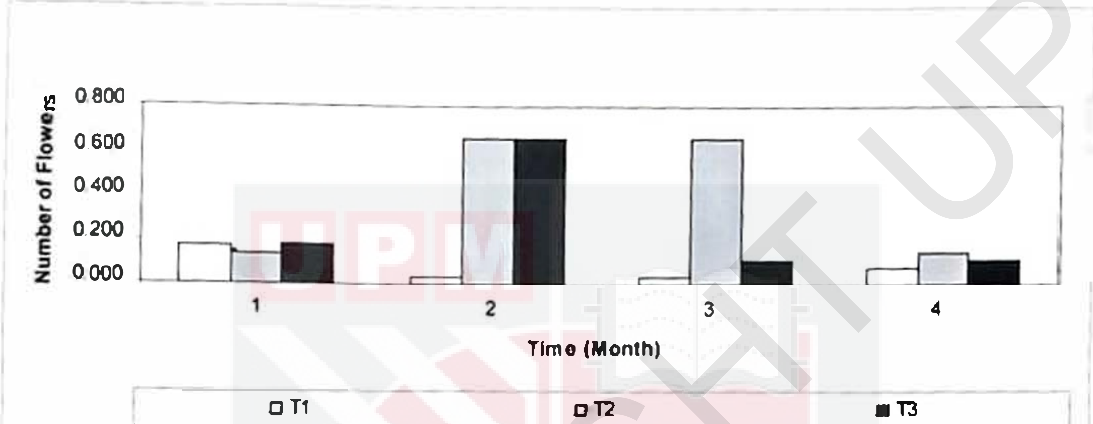

Figure 4.2.1 Inflorescences of *Axonopus compressus* cv. Pearl under T_1; 30% light, T_2; 50% light, T_3; control treatment, for four months.

Table 4.5.1 Mean for inflorescences of *Axonopus compressus* cv. Pearl after four months.

Treatment	1st Month	2nd Month	3rd Month	4th Month
30%	0.16 ^{a}	0.03 ^{a}	0.03 ^{a}	0.07 ^{a}
50%	0.13 ^{a}	0.66 ^{a}	0.66 ^{a}	0.14 ^{a}
Control	0.17 ^{a}	0.66 ^{a}	0.11 ^{a}	0.11 ^{a}

Means within the respective with the same letter are not significantly different at $p \leq 0.05$

Figure 4.2.1 shows inflorescences of *Axonopus compressus* cv. Pearl for four months. Inflorescences were recorded as number of flowers. The data range was very small, ranging from 0.00 to 1.00 due to lacks of flowers. For the first month, there was no significant different between each treatment where the control grasses had the most flowers; 0.17, followed by 30% light treatment (0.16) and 50% light treatment (0.13).

In second month, both control and 50% light treatment showed increase number of flowers at 0.66. However, for treatment 30% light treatment, the value decreased to 0.03 as shown in **Table 4.5.1**. No difference was recorded in 30% light treatment and 50% light treatment in the following month, but in control the flowers were reduced to 0.11. Finally, there were changes in means for 30% treatment from 0.03 to 0.07 and 50% treatment from 0.66 to 0.14. No change was recorded in control treatment.

4.5.2 *Cynodon dactylon* cv. Tif Dwarf

Table 4.5.2 Mean for inflorescences of *Cynodon dactylon* cv. Tif Dwarf after four months.

Treatment	1st Month	2nd Month	3rd Month	4th Month
30%	0.00 ^{a}	0.00 ^{a}	0.00 ^{a}	0.00 ^{a}
50%	0.00 ^{a}	0.00 ^{a}	0.00 ^{a}	0.00 ^{a}
Control	0.00 ^{a}	0.00 ^{a}	0.00 ^{a}	0.00 ^{a}

Means within the respective with the same letter are not significantly different at $p \leq 0.05$

Table 4.5.2 shows inflorescences growth of *Cynodon dactylon* cv. Tif Dwarf for the experiment. However, no inflorescence was recorded during the four months period.

4.5.3 *Zoysia matrella*

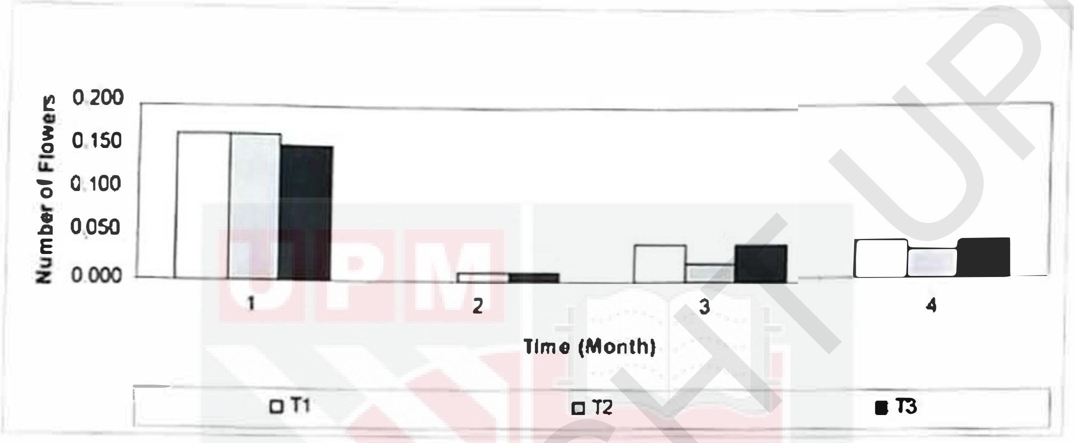

Figure 4.2.2 Inflorescences of *Zoysia matrella* under T_1; 30% light, T_2: 50% light, T_3; control treatment, for four months.

Table 4.5.3 Mean for inflorescences of *Zoysia matrella* after four months.

Treatment	1st Month	2nd Month	3rd Month	4th Month
30%	0.16 ^{a}	0.00 ^{a}	0.04 ^{a}	0.04 ^{a}
50%	0.16 ^{a}	0.01 ^{a}	0.02 ^{a}	0.03 ^{a}
Control	0.15 ^{a}	0.01 ^{a}	0.04 ^{a}	0.04 ^{a}

Means within the respective with the same letter are not significantly different at $p \leq 0.05$

From Figure 4.2.2, all three treatments had very good flowers emergence in the first month where both 30% light treatment and 50% light treatment means were 0.16 while control treatment was 0.15.

In the following month, the means decreased in every treatment where the value for 50% treatment and control treatment were 0.01, and no flowers was recorded in 30% treatment. For the third month, means for all treatments increased. The value for the fourth month was same in both 30% sunlight and control treatment (0.04) but increased slightly for 50% sunlight (0.02 to 0.03).

4.6 Root Growth

4.6.1 *Axonopus compressus* cv. Pearl

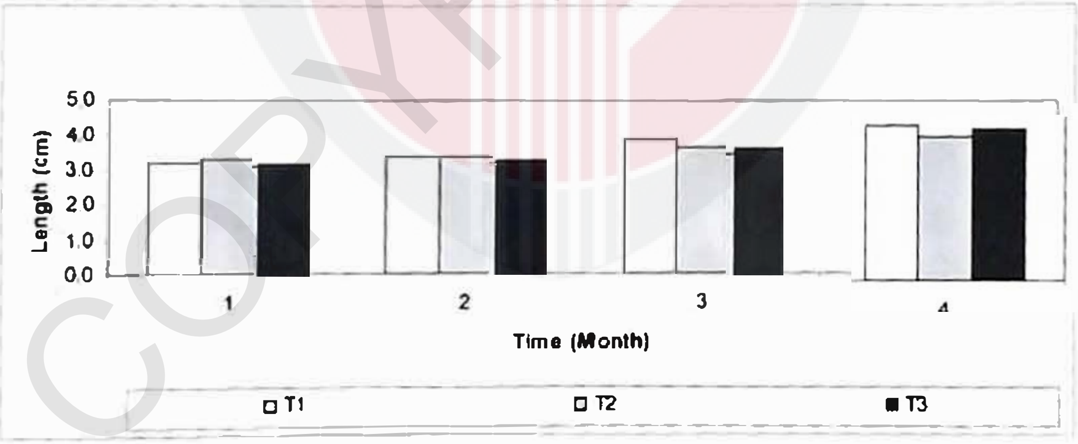

Figure 4.3.1 Root growth of *Axonopus compressus* cv. Pearl under T_1; 30% light, T_2; 50% light, T_3; control treatment, for four months.

Table 4.6.1 Mean for root growth of *Axonopus compressus* cv. Pearl after four months, (cm).

Treatment	1st Month	2nd Month	3rd Month	4th Month
30%	3.19^{b}	3.36^{a}	3.87^{a}	4.44^{a}
50%	3.29^{ab}	3.38^{a}	3.63^{a}	4.15^{a}
Control	3.35^{a}	3.46^{a}	3.77^{a}	4.36^{a}

Means within the respective with the same letter are not significantly different at $p \leq 0.05$

Figure 4.3.1 and **Table 4.6.1** show root growth performance of *Axonopus compressus* cv. Pearl for the four months period of study. In the first month, there were significant difference between growth performance of grasses in control treatment and in under 30% light condition, reflecting the value of 3.35 cm compared to 3.19 cm. Mean for grasses under 50% light condition were not significantly differ to each other.

In the second month, all means in the data increased, but differences cannot be identified. Three months after the experiment, the length of grasses under 30% light conditions increased and became highest at 3.87 cm as compared to control treatment (3.77 cm). Longest root lengths were 30% sunlight at 4.44 cm, followed by control (4.36 cm) and 50% sunlight (4.15 cm) respectively.

4.6.2 *Cynodon dactylon* cv. Tif Dwarf

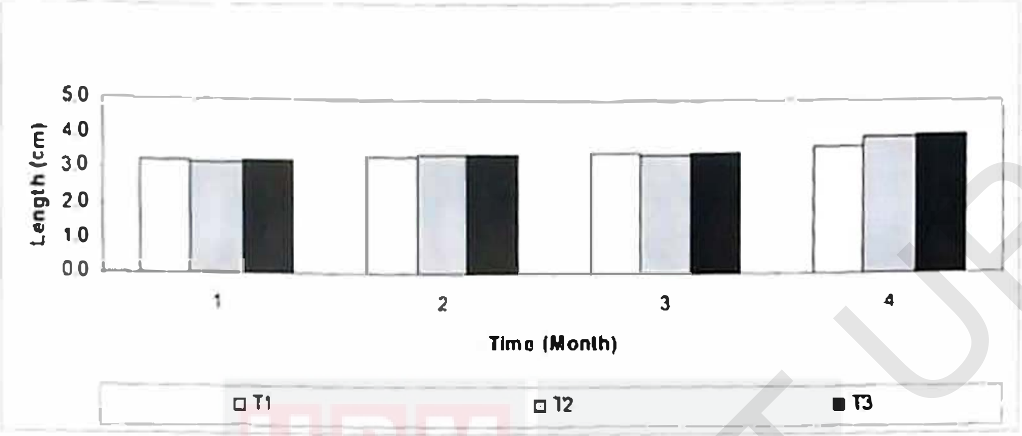

Figure 4.3.2 Root growth of *Cynodon dactylon* cv. Tif Dwarf under T_1: 30% light, T_2: 50% light, T_3: control treatment, for four months.

Table 4.6.2 Mean for root growth of *Cynodon dactylon* cv. Tif Dwarf after four months, (cm).

Treatment	1st Month	2nd Month	3rd Month	4th Month
30%	3.22 a	3.34 a	3.46 a	3.61 b
50%	3.20 a	3.38 a	3.42 a	3.88 a
Control	3.24 a	3.39 a	3.46 a	3.95 a

Means within the respective with the same letter are not significantly different at $p \leq 0.05$

No significant difference was noted for the first three months of root growth of *Cynodon dactylon* cv. Tif Dwarf. However in fourth month, differences can be found in 30% treatment at 3.61 cm, compared to the other two treatments of 3.85 cm and 3.95 cm.

4.6.3 *Zoysia matrella*

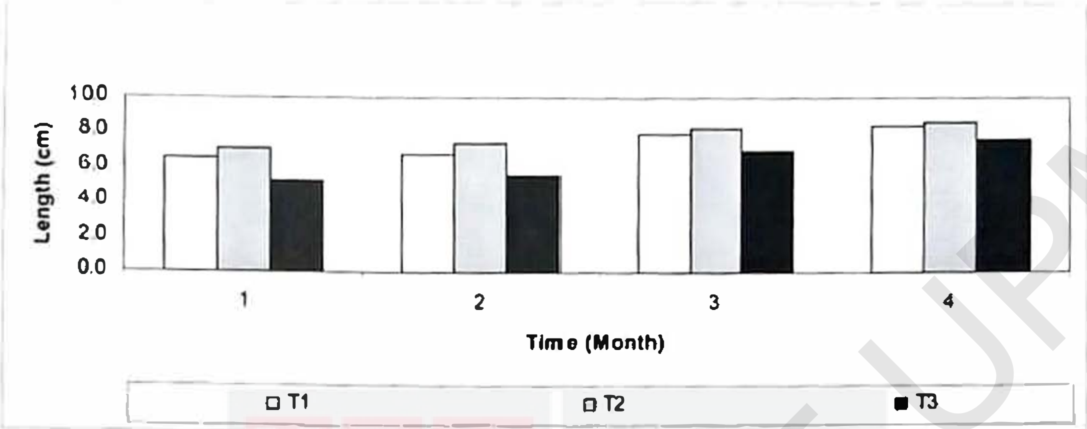

Figure 4.3.3 Root growth of *Zoysia matrella* under T_1; 30% light, T_2; 50% light, T_3; control treatment for four months.

Table 4.6.3 Mean for root growth of *Zoysia matrella* after four months, (cm).

Treatment	1st Month	2nd Month	3rd Month	4th Month
30%	6.51 ^{a}	6.77 ^{a}	7.89 ^{ab}	8.32 ^{a}
50%	7.04 ^{a}	7.42 ^{a}	8.22 ^{a}	8.58 ^{a}
Control	5.25 ^{b}	5.54 ^{b}	7.00 ^{b}	7.65 ^{a}

Means within the respective with the same letter are not significantly different at $p \leq 0.05$

Figure 4.3.3 and **Table 4.6.3** show root growth of *Zoysia matrella*. There was significant difference for growth of control treatment as compared to the other two treatments for two months.

However, the difference was reduced in the third month and in the end, the root lengths of all treatments were not significantly different. The highest means for every month were recorded in 50% light treatment with the value of 7.04 cm in the first month to 8.58 cm in the final month. The lowest means were control treatment, initially started with 5.25 cm and finished with 7.65 cm.

4.7 Weight Growth

4.7.1 *Axonopus compressus* cv. Pearl

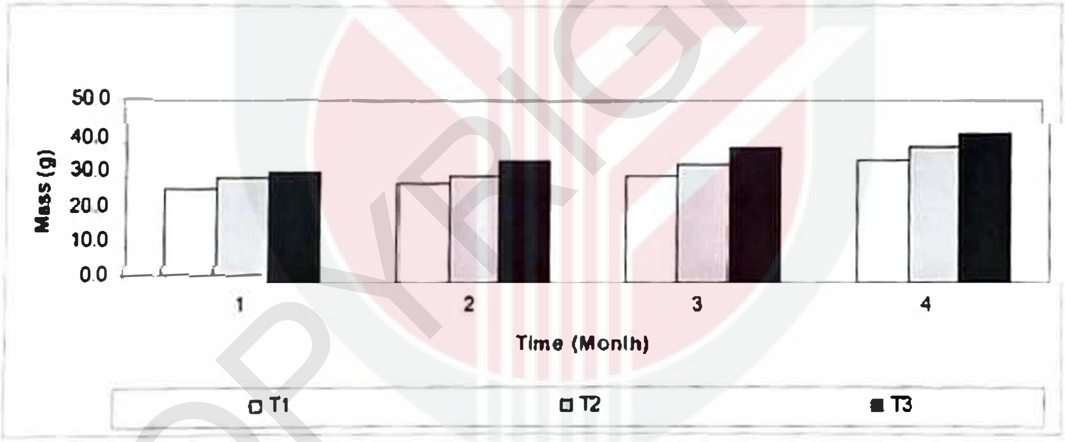

Figure 4.4.1 Weight growth of *Axonopus compressus* cv. Pearl under T_1; 30% light, T_2; 50% light, T_3; control treatment, for four months.

Table 4.7.1 Mean for weight growth of *Axonopus compressus* cv. Pearl after four months, (g).

Treatment	1st Month	2nd Month	3rd Month	4th Month
30%	26.86^{b}	28.37^{b}	28.37^{b}	34.76^{b}
50%	29.98^{ab}	30.74^{b}	30.74^{b}	38.45^{ab}
Control	31.82^{a}	35.15^{a}	35.15^{a}	42.68^{a}

Means within the respective with the same letter are not significantly different at $p \leq 0.05$

In **Figure 4.4.1** and **Table 4.7.1**, weight growth of *Axonopus compressus* cv. Pearl shows significant difference between control treatment and both 30% sunlight and 50% sunlight.

Mean for full sunlight was 31.82 g as compared to 30% light (26.86 g) and 50% light (29.98 g). Differences remained for the following two months but in the fourth month, there was a slight different between control treatment (42.68 g) and 50% light (38.45 g).

4.7.2 *Cynodon dactylon* cv. Tif Dwarf

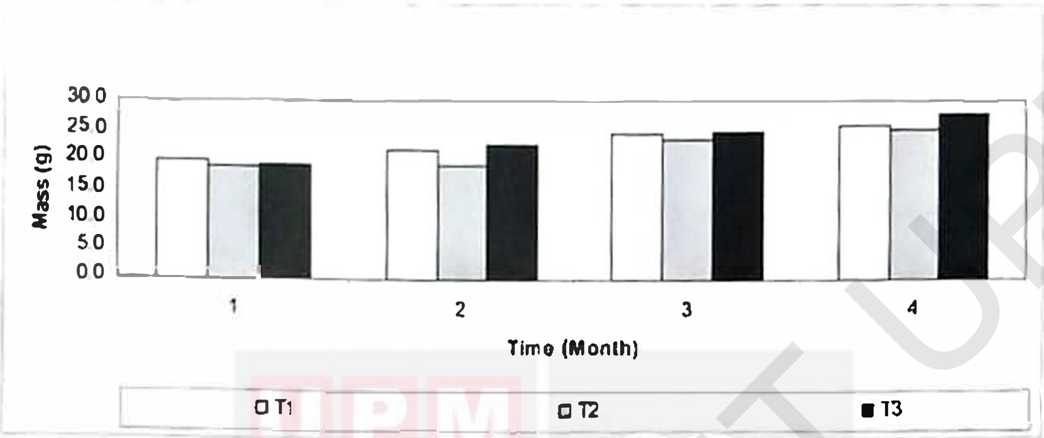

Figure 4.4.2 Weight growth of *Cynodon dactylon* cv. Tif Dwarf under T_1; 30% light, T_2; 50% light, T_3; control treatment for four months.

Table 4.7.2 Mean for weight growth of *Cynodon dactylon* cv. Tif Dwarf after four months, (g).

Treatment	1st Month	2nd Month	3rd Month	4th Month
30%	19.85 ^{a}	21.61 ^{a}	24.54 ^{a}	25.84 ^{a}
50%	18.89 ^{a}	19.11 ^{a}	23.58 ^{a}	25.31 ^{a}
Control	19.22 ^{a}	22.67 ^{a}	24.89 ^{a}	27.60 ^{a}

Means within the respective with the same letter are not significantly different at $p \leq 0.05$

Weight of *Cynodon dactylon* cv. Tif Dwarf increased slightly every month for every treatment, and the highest mean was 30% light treatment (19.85 g) while the lowest value was 50% light treatment (18.89 g). There was no significant difference in weight of every treatment for the whole four months.

4.7.3 *Zoysia matrella*

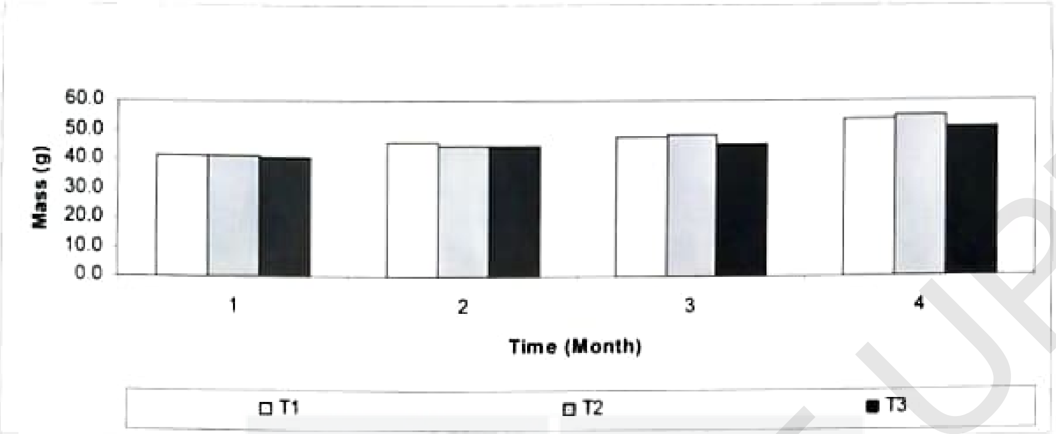

Figure 4.4.3 Weight growth of *Zoysia matrella* under T_1; 30% light, T_2; 50% light, T_3; control treatment for four months.

Table 4.7.3 Mean for weight growth of *Zoysia matrella* after four months, (g).

Treatment	1st Month	2nd Month	3rd Month	4th Month
30%	41.28 ^{a}	45.83 ^{a}	47.71 ^{a}	53.33 ^{a}
50%	41.12 ^{a}	44.59 ^{a}	48.31 ^{a}	54.61 ^{a}
Control	40.60 ^{a}	44.58 ^{a}	44.90 ^{a}	51.21 ^{a}

Means within the respective with the same letter are not significantly different at $p \leq 0.05$

Figure 4.4.3 and **Table 4.7.3** show weight growth of *Zoysia matrella*. Differences between each treatment was very slight, in the end the highest mean was 50% sunlight was 54.61 g, followed by 30% sunlight (53.33 g) and control (51.21 g).

CHAPTER 5

DISCUSSION

5.1 Growth Performances of *Axonopus compressus* cv. Pearl

From the four vegetative parameters, it was noted that there was no significant difference in blades growth, inflorescences formation and root growth among all treatments. However, weights of *A. compressus* under full sunlight differ significantly as compared to 30% light (at $p \leq 0.05$). *Axonopus compressus* cv. Pearl grown under 50% light treatment showed no significant difference as compared to the other treatments. This was agreed by Emmons (2000) who states that this turf suites well under shade stress.

Number of new blades increased almost evenly every month. According to Allard, Nelson and Pallardy (1991), growth may not necessarily effect by treatment, but also depends on species. As a warm-season grass, *A. compressus* adapt very well to both extreme heat and high humidity (Givnish, 1998).

Flowers grew well in both 50% treatment and control treatment (at $p \leq 0.05$). The numbers of flowers were not promising, but emergence of flowers proved that enough metabolic recirculation is taking place inside the plant and is a very important indicator of how success a plant is growing. This suggests why *Axonopus compressus* cv. Pearl grown under 30% sunlight produced fewer flowers (at $p \leq 0.05$), in addition to poor root development and lower value for weight.

Root growth are very good in all treatments, because the grasses were planted in medium that have balanced amount of mineral, air pores, organic matter and water passage. Length increased very rapid after three months, because initially the sods received were planted in very compact soil.

Root development is closely related to good plant growth, and also stress level in plants. Bews (1973) believed that when soil temperature is relatively low, roots that have already developed tend to perform much better than higher soil temperature. Under 30% light condition, the grass still able to produce food by photosynthesis while roots get better hospitality in order to growth and take up more water (at $p \leq 0.05$).

Weight also increased very well in *A. compressus* under 30% light condition (at $p \leq 0.05$); a result of cumulatively increased of new blades, inflorences and root. However, vegetative growth is actually a poor parameter to determine weight. Hence, there are still some useful indicator can be extracted by the growth, for example relationship of the growth of other components like stems, blades and flowers as done through this study.

5.2 Growth Performances of *Cynodon dactylon* cv. Tif Dwarf

The most notable data for *Cynodon dactylon* cv. Tif Dwarf (at $p \leq 0.05$) come from number of inflorescences, which are zero throughout the study; and significant number of blades between 30% treatment and control. It means that the grass cannot stand under heavy shades that have limited light. This is why Turgeon (2005) stated his concern about *C. dactylons*' poor tolerance to shaded areas.

Fry and Huang (2004) related poor performance under shaded areas may bring to shortened roots, reduced shoot density, erect and elongated growth of stems and leaves, thin leaves and decreased plant vigor as symptoms of light deficiency for grass that cannot tolerate shade. This may suggest why in the experiment, both number of new blades and root length in 30% light treatment showed the least values as compared to the other two treatments (at $p \leq 0.05$).

Differences in new blades' number may happen because plants are in stress conditions; less light promote favorable micro climate for pathogens, fungi and diseases (Turgeon, 2005) that reflect why most of *Cynodon dactylon* planted in this experiment were infected. Molds were also spotted around the grasses, favored by warm humid weather and high soil moisture in areas where light is limited (Smith and Woolhouse, 1989).

To overcome such stresses, the grasses either give the blades up or stop producing more internodes and leaves. This reduced photosynthesis rate and therefore limiting growth of other parts; stems, root and flowers.

There are no flower emerging from the grass because of certain factors; stress factor which force the grass not to flower, unfavorable soil condition, limited food and water and also because of the season (Dorrance, 1930). This results *Cynodon dactylon* cv. Tif Dwarf did not flower, even after four months of experiment. The flowers may have been created, but limited amount of food due to insufficient light, pest and disease may overtake flower to bloom, resulting poor number of new blades (at $p \leq 0.05$) especially in T_1 (30% light) and T_2 (50%) light.

For root length, only slight difference was noted and can be ignored except after four months where there was significant difference between treatment under 30% light and control (at $p \leq 0.05$). Roots tend to curl aside to maximize water uptake in limited areas, resulting good blades elongation rather than the roots themselves.

Blades elongation can be related to vegetative weight where after four months no significant difference can be spotted through weight gain. Van Huylenbroeck and Bockstaele (2001) stated significant difference of photosynthetic capacity and growth can only be determined under heavy shading, which are more than 65%.

However, after four months of cultivation, weight; indicator for photosynthesis success, are almost at the same level in every treatment, even in heavier shade of 70%. This may be due to high humidity and less competition among the grass that helps each individual to have better photosynthetic rate in smaller areas with more provided food and water, compared to *Cynodon dactylon* found in nature.

5.3 Growth Performances of *Zoysia matrella*

Among all planted grasses in this experiment, the growth of *Zoysia matrella* can be concluded as the most successful. *Zoysia matrella* become successful because they utilize existence blades to produce more food, and at the same time restore most of the food for other purposes such as root elongation, systemic treatment and flowers. In the first month, new blades emerged from newly cut stolons.

Zoysia matrella tends to grow vertically; as compared to the two other grasses, forcing each single blade to grow taller, thus increasing functional areas of blades. In contrast to citation by Fry and Huang (2004), density of shaded *Zoysia matrella* by decreased tiller of leaf grass is irresponsible by light factor.

Amount of flowers produced by *Z. matrella* was the highest compared to other grasses used. This reflects to their properties; moderately tolerate shade condition (Vasey, 1999). In the third month, remaining flowers continue to bloom but this number was not as much as the previous.

Root length also showed slight different between each other, but each treatment shows increase in the length. Raw data suggest that each root increased at almost the same rate. In the first through the third month, there were different between control treatment and 30% light treatment (at $p \leq 0.05$).

It was observed that besides having shorter roots, *Z. matrella* planted under 30% sunlight also lack in number of roots. This may be caused by their small adventitious roots that were not suitable in compacted mineral soil that have fewer pores. Engelke and Anderson (2003) had earlier suggested that this grass is more likely adapt sandy soil, in addition to Emmons (2000) who agreed that this grass is very good to shade.

CHAPTER 6

CONCLUSION

This study was conducted to see the growth performances of turfgrass under different light conditions. The results showed that under 30% and 50% light condition, *Axonopus compressus* cv. Pearl and *Zoysia matrella* adapt well to stress of low light while *Cynodon dactylon* cv. Tif Dwarf is intolerant to heavy shades.

After four months of experiment, only root growth increased in all species, but no significant difference was observed between them. No flower emerged from *Cynodon dactylon* cv. Tif Dwarf during the study and no new blade came out from *Z. matrella*; instead they elongate better than the other two species. They also gained weight the most. Based on the results obtained, all species tend to limit their growth when surrounding environment is unfavorable.

It was concluded that both *Axonopus compressus* cv. Pearl and *Zoysia matrella* grow well under shaded condition, but *Cynodon dactylon* cv. Tif Dwarf did not grow well under shade, thus is intolerant to heavy shade.

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APPENDICES

Figure 7.1 *Axonopus compressus* cv. Pearl.

Figure 7.2 *Cynodon dactylon* cv. Tif Dwarf.

Figure 7.3 *Zoysia matrella*

This is to certify that I have no objection to publish the project entitled **"Growth Performances of Selected Turf Grasses under Different Light Conditions"** by the supervisor in a joint authorship. However, it has to be evaluated by the Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Campus and published in the form approved by the Faculty.

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