INVESTIGATION OF NITROGEN FERTILIZER REQUIREMENT OF PEARL GRASS (*Axonopus compressus* (SW.) P. Beauv.)

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ABSTRACT

In this study, three concentrations of N (0 ppm, 25 ppm and 50 ppm) were applied on *A. compressus* (Pearl grass) to investigate which one is suitable to support the grass to grow well. The experiment was arranged following a randomized complete design of five replicates per treatment. The N was applied every two weeks after grass planting. Pearl grass under 25 ppm and 50 ppm N application were found to be closely similar in term of dry matter (16.92 g vs. 22.57 g), leaf surface area (5.14 sg. cm vs. 5.05 sg.cm), root length (34.62 cm vs. 35.92 cm), stolon length (11.72 cm vs. 12.23 cm), shoot density (37 shoots/sg. cm vs. 37.4 shoots/sg. cm), coverage (75.67% vs. 89.10%) and colour canopy (108.98 hue vs. 105.50 hue). Hence, 25 ppm was suggested as the suitable N application to support the grass to grow well at least when planted in trays. This suggestion was proposed partly because of the lower cost to use lower concentration of N.

Kajian Keperluan Baja Nitrogen Rumput Mutiara (*Axonopus compressus* (Sw.) P. Beauv)

ABSTRAK

Kajian ini mempunyai tiga peringkat yang digunakan untuk kepekatan N (0 ppm, 25 ppm dan 50 ppm) yang telah diaplikasikan pada rumput *A. compressus* dengan tujuan untuk mengkaji kepekatan raw atan yang sesuai untuk pertumbuhan rumput yang baik. Eksperimen ini telah disusun dalam Reka Bentuk Rawak Lengkap, dengan lime replikasi bagi setiap rawatan. Rawatan baja N telah diberi setelah dua minggu penanaman rumput. Rumput yang menerima rawatan 25 ppm dan 50 ppm telah didapati mempunyai persamaan dari segi berat kering (16.92 g vs. 22.57 g), luas permukaan daun (5.14 sg. cm vs. 5.05 sg.cm), panjang akar (34.62 cm vs. 35.92 cm), panjang pucuk (11.72 cm vs. 12.23 cm), kemampatan pucuk (37 shoots/sg. cm vs. 37.4 shoots/sg. cm), kemampatan pertumbuhan daun (75.67% vs. 89.10%) dan kanopi warna daun (108.98 hue vs. 105.50 hue). Oleh itu, rawatan yang sesuai yang telah dicadangkan adalah 25 ppm untuk menyokong pertumbuhan yang baik untuk rumput meskipun bertumbuh di dalam pasu. Ini adalah kerana ia dapat mengurangkan kos dan penggunaan kepekatan N yang minima kepada rumput.

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%	Per cent
ANOVA	Analysis of variance
°C	Degree Celsius
cm	Centimetre
CRD	Completely Randomized Design
DMRT	Duncan's Multiple Range Test
g	Gram
ha	Hectare
kg	Kilogram
ml	Millilitre
USDA	United State Department of Agriculture

CHAPTER 1

INTRODUCTION

1.0 Background

Turfgrasses are produced and planted to improve the visual and functional qualities of landscape. It improves the visual appearance of originally bare land and indirectly enhances the aesthetic value of the area. In terms of function, it provides a cushion for sport field and improves the quality of the game. In fact, the importance of turfgrass in sport has already been reported even during Persian time specifically in a game called chogan, or game similar to polo (Turgeon, 2012). Turfgrass also improves soil stability and reduce soil erosion as well as acts as a filter of dust and unwanted gaseous from fosil-fuelled machines and vehicles (Aldous, 1999).

Axonopus compressus (Sw.) P. Beauv., is one of the common warm season turfgrasses. It naturalises in humid tropical and subtropical regions including in Malaysia but could also be found at warm region of the temperate belt. There are many slightly different version of this species being planted as turfgrass. One of them is Pearl grass. Pearl grass is similar to common carpetgrass in appearance and environmental adaptation; however, it is less cold hardy and its use should be restricted to humid subtropical and tropical climates (Turgeon, 2012). Although all of these different versions of *A. compressus* are equally important (compared with other turfgrasses) in improving the functional quality of landscape, the management of this grass is rarely reported quantitatively especially its fertilizer requirement. There is no publish data up until today of the amount of nutritional requirements on common carpetgrass in lawn (Bush, 2000).

N has been one of the most important nutrients for carpet or pearl grass and turfgrasses. The N requirement of carpet grass, for example, has been reported range from 39 to 78 kg N/ha per year could contain 3% to 5% nitrogen on a dry-weight basis except where severe nitrogen deficiencies are encountered (Turgeon, 2012). Adequate nitrogen fertilizer application will improve turfgrass overall health, and increase turfgrass cover and density. However, N application at a rate above optimum is detrimental to turfgrass health and can result in increased traffic damage, pest susceptibility, decreased root growth and even death of the grass (Bell, 2011). Excessive N fertilizer application could also lead to nitrate pollution in environment and higher management cost of turf. There are times when N fertilizer application should be reduced even lower than the normal amounts applied (Bell, 2011).

The N requirement of turfgrass, has been reported to be 39 to 78 kg N/ha per year, and it could contain 3% to 5% nitrogen on a dry-weight basis except where severe nitrogen deficiencies are encountered (Turgeon, 2012). However, in many cases, there is no published data of the amount of nutritional requirements of common carpetgrass in lawn (Bush, 2000). This trend is also the case for pearl grass in Malaysia.
Therefore, in the present study, the effects of 0, 25 and 50 ppm N application on the growth performance and development of pearl grass were investigated. Based on the results of the experiment, the minimum N requirement of pearl grass will be estimated. The data are expected to be useful to provide an insight on N fertilizer application in pearl grass management in Malaysia in the future where the species is commonly used but little studied.

1.1 Objective

The objective of this study was investigated through the growth performance and development of pearl grass (*Axonopus compressus* (Sw.) P. Beauv.) under without, low and medium N application.

1.2 Justification

Pearl grass is one of the popular turfgrasses in Malaysia. However, little is known on the N requirement of this grass under the ecological condition in this country especially the lowest N requirement. Bush *et. al* (2000) reported that, deficiency of nitrogen in tropical turfgrass can reduce the inflorescence development, root growth, and dry-matter production. On the other hand, an excessive supply of N fertilizer will lead to nitrate pollution in environment. Hence, the results of this study could provide a guide on the lower N fertilizer application when pearl grass is used for landscaping; it could provide an insight on the fertilizer management of this grass in Malaysia to beautify the landscape as well as to reduce nitrate-pollution of waterways.

The goal for a fertilization program should be to apply the least amount of fertilizer needed to produce healthy turf, while meeting the aesthetic and functional standards for the area. N is the element most needed by turfgrass for growth and is at the centres of most fertilization programs. While P and K are essential nutrients, lawns require much less sustaining adequate plant health and growth (Akdeniz, 2016).

1.3 Hypothesis

H_0: There is no significant difference in growth performance of pearl grass (*Axonopus compressus* (sw.) P. Beauv.) lower than 50 PPM of N fertilizer application.

H_A: There is a significant difference in growth performance of pearl grass (*Axonopus compressus* (Sw.) P. Beauv.) lower than 50 PPM of N fertilizer application.

CHAPTER 2:

LITERATURE REVIEW

2.1 Popular turfgrasses in Malaysia

Pearl grass is gaining popularity in Malaysia particularly in a golf courses and specialized lawn but less is known on the management of this grass. At the moment, the types of turf grass that are common for gardens in Malaysia are *Axonopus compressus* (pearl grass), *Axonopus affinis* (cow grass), *Zoysia japonica* (Japenese lawngrass) and *Zoysia matrella* (Manilagrass). The factors of selection of turfgrass before establishing it in the lawn should be taken as consideration such as the weather of the country, amount of sunlight receive, water requirement, average of rainfall in the particular area and amount of fertilizer to be applied. Yilmaz *et al.* (2012) determined that turf culture gained significance in the country during recent years. Also, there are many landscapes in turf establishment and management activities in this sector.

The characteristic of turfgrass has been stated by Emmons in 2008 that the turf can knit the soil together and hold it in place. This is because grass plants have extensive root systems on the ground that can make an outstanding ground cover for athletic fields and recreational facilities. In Australia, *A. affinis* invades hilly as well as flat country; A. compressus favours low-lying areas where soil moisture is plentiful throughout the year. Meanwhile, Aldous, 1999 stated that in Malaysia, *A. compressus* can be found in golf course and parkland in subtropical area as fairway turf. It grows best on moist sandy or loamy soils, especially those rich in organic matter, and can withstand temporary flooding.

2.2 Environmental issue in turfgrass management

Turfgrasses release significant amounts of oxygen into the air. A turf area 50 feet by 50 feet (15 m by 15 m) produces enough oxygen to meet the needs of a family of four(Emmons, 2008). However, environmental issues could rise up if fertilizers and pesticides used to maintain specifically a lawn with turfgrass that can pollute drinking water supplies, which could include both surface and groundwater resources (Aldous, 1999). Especially at golf courses area where almost all places being covered with different types of turfgrass species. Golf has gained its popularity during the past 20 years, with more than 25 million golfers in United States of America (Aldous, 1999). Since the proper techniques are not imposed during turf studies, turf areas are lost in a very short period deteriorated. The main problems are lack of experienced stuff and infrastructure, effect from different ecologies, failures in genus and species preferences, overuse of seed supplies, lack of high-quality seed sources and lack of maintenance measures (Akdeniz, 2016).

2.2.1 Nitrate pollution from turf area

Nitrogen represents a fundamental nutrient in turfgrass to maintain the green color, adequate density and to allow recovery from stresses such as drought, diseases and wear. Different levels of nitrogen are required for sports field turfgrass according to the use of the playgrounds (Agati G. *et al.*, 2012). It can be a problem if turfgrass is given the amount of nitrogen more than they needed. On the other hand, nitrogen leaching was significant when nitrogen was applied at heavy rates and under less-than-ideal circumstances. Leaching was significantly less when peat was added to the sand, occurring at a level of about 3% (Aldous, 1999).

2.2.2 Mitigation measure of nitrate pollution

Improper or excessive use of fertilizer can lead to nitrate pollution of ground or surface water (EPA, 2001). Nitrogen fertilizer, whether organic or inorganic, is biologically transformed to nitrate that is highly soluble in water. Applying amounts on a more frequent basis also can reduce leaching losses. The goals of a nutrient management program are to ensure that are all essential nutrients are in adequate supply and to the extent possible, nutrient-use efficiency is maximized by targeting the low end of the adequate zone (Turgeon, 2012). In putting green construction, mixing peat moss with sand significantly reduced nitrogen leaching compared to pure sand rootzones during the year of establishment. Light application of nitrate onto the turfgrass can provide an excellent protection from nitrate leaching (Aldous, 1999). Remote sensing of leaf nitrogen (N) content in precision agriculture is highly interesting for both economic and environmental reasons. It allows the monitoring of crop fertilization in order to optimize plant growth and limit N applications to real plant needs. In this way, the cost for fertilizer N lost due to un-optimized N use efficiency and the N-related pollution can be reduced (Samborski *et al.*, 2009).

2.3 Pearl grass

As stated earlier, pearl grass or carpet grass is gaining popularity turfgrass in Malaysia. Carpet grass belongs to the subfamily Panicoideae of the plant family Gramineae or Poaceae. The origin of this turfgrass is from indigenous to Central America and the West Indies (Aldous, 1999). *Axonopus* is a masculine noun, the specific epithet, *compressus,* also must be masculine (Turgeon, 2012). Poaceaecea consists of 25 tribes, 600 genera, and 7500 species and the turfgrass species mainly from subfamilies Pocoideae, Chloridoideae and Ponicoideae. The latter comprises 70 species but, only two, the common carpet grass, *Axonopus affinis* and the tropical carpetgrass *Axonopus compressus* are used as turfgrasses (Turgeon, 2012).

2.3.1 Importance as turf

Axonopus compressus has important role in golf and landscape industry as a vegetative ground cover. It serves a functional purpose by preventing soil erosion, but they have an aesthetic purpose as well (Emmons, 2008). Turfgrass also reduces glare from the sun and removes significant amounts of carbon dioxide, air pollutants, and dust particles from the atmosphere. Besides, living turf provides considerable aesthetic, ecological, functional, recreational and social benefits for the whole community. As stated by Aldous in 1999, turf can comes in many function of functional and ecological benefits include soil improvement on the stabilization at the surface. It is done by reducing the potential for erosion and windblown soil particles, and acting as a filter for improving quality of groundwater.

Moreover, with the green dense foliage of turf, it can substantially influence heat loss, reduce noise, glare and visual pollution as well as saving cost including the cost impact surface for many sporting and recreational surface, highways and roadsides (Robert, 1985).

2.3.2 Botanical description

Carpet grass, *Axonopus affinis* was originally identified as *Axonopous compressus* (Swartz) Beauv., a species which included a broad and narrow leaf form. The distinction between the two types was made by her who recognized *Axonopous affinis*, the narrow leaf form, and a distinct species. In West Africe, it is described as a polyploidy series of *Axonopous* spp. of which *A. Compressus* (2n=40) was a member. In 1966, he suggested that A. Affinis, an octaploid functioning as a diploid (2n=80) might be a further member of this series. It also grows well in partial shade (Aldous, 1999).

Table 2.1 Scientific classification of pearl grass.

Domain	Eukaryota
Kingdom	Plantae
Phyllum	Spermatophyta
Subphyllum	Angiospermae
Class	Monocotyledonae
Order	Cyperales
Family	Poaceae
Genus	Axonopus
Species	*Axonopus compressus*

Source: Adapted from Invasive Species Compendium, CABI.

There are two season type of turfgrasses. The one with cool season grass have an optimum growth occurs within temperature range of 60 degree F to 75 dgree F (16 degree Celsius to 24 degree Celsius) and have limitation on adapting in seasonal heat and drought tolerance stresses conditions. While, warm season grasses grow best at temperature between 80 F to 95 F (27 °C to 35 °C). *Axonopus compressus* on the other hand, is a warm season grass that is limited in its poleward adaptation by the intensity abd duration of cold temperature.

Panicoids are warm-season grass occurring in tropical and subtropical country which makes them called as C4 grass. It required short or intermediate day and warm night without vernalization at the time of floral initiation. Cool season turfgrasses are generally adapted to temperate and subarctic climates (Turgeon, 2012).

2.3.3 Growth responses of pearl grass to nitrogen, N

The response of Nitrogen in *A. compressus* is greater than P and K fertilizers. It is a mineral element used in the largest quantity by the grass plants. Nitrogen also present in soil organic matter about five percent and must break down to release it to the soil then absorb primarily from the soil by the plant's root system (Wiecko, 2006). According to Turgeon (2012), grass plants contain about three to five per cent nitrogen on a dry weight basis. He then said that, sufficient requirement of nitrogen in turfgrass can help in better plant growth. Other than that, nitrogen also is the component of chlorophyll, proteins, amino acids, enzymes, and numerous other plant substances. The effect of nitrogen fertilization can be shortly seen as soon as it being fertilized by showing darker color of leaves and vertical shoot growth increases significantly (Emmons, 2008). However, excessive applications of nitrogen in certain species or cultivars can caused excessive aerial shoot growth, poor root and lateral shoot growth, more prone to diseases, reduced carbohydrate reserves, poor tolerance to extreme environment and other environmental stresses. Nitrogen deficiency symptoms in tropical carpetgrass, *Axonopus compressus* (Swartz) Beauv., reduced inflorescence development, root growth, and dry-matter production under hydroponic condition (Bush, 2000). Thus, it is important to know the optimum requirement amount of nitrogen needed by the turfgrass to get the best growth responses from time to time. In general, higher rates of fertilization with N deliver the better quality of turf, regardless of fertilizer sources. Fertilization programs generally are built around this element. In regions where in warm-season grasses are dormant during part of the year and overseeding is not employed, the need for N fertilization will vary throughout the year (Akdeniz, 2016). Russi *et al.*, (2004) also concluded that the turfrass quality is largely dependent on the genotype and environment interaction.

In order for the root to absorb nutrient from the nitrogen element, it must first break into two most commonly form that are the ammonium ion NH_4^+ and nitrate ion NO_3^- (Wiecko, 2006) which being converted by soil microorganisms. Wai (2016) stated that the uptake of both nitrate ion and ammonium ion exerts influence on rhizosphere, the narrow band of soil environment immediate to root zone, pH. Whereas, ammonium can causes a decrease in soil pH of the rhizosphere and nitrate results in an increase of the rhizosphere pH which can lead to micronutrient deficiencies. Decrease of nitrogen in turfgrass can occur through microbial immobilization during organic matter decomposition, leaching of nitrate, clipping removal, gaseous loss due to volatilization of ammonia and denitrification to N2 and N2O (Emmons, 2008; Turgeon, 2012).

Landschoot (2017) explained that to produce a high quality turf, application of nitrogen fertilizer need to be applied every twice or more times per year using higher rates of nitrogen that is 1.0 to 1.5 pounds N/1, 000 square feet per application. The rate of application is different for different season turf but, the general rule is the same where maximum nitrogen rate per application should not exceed 1 pound N/1, 000 square feet (Emmons, 2008). N should be applied sufficiently but not abundantly. In this way, a balanced relationship between soil and crops can evolve to ensure crops are maintained in a healthy state. Many studies have considered the effects of various N fertilization rates on quality, but very few have included the practice of returning grass clippings (Akdeniz, 2016).

2.3.3.1 Height

The best turfgrass will have a specific mowing height depending on its species stated by Wiecko (2006). *Axonopus compressus* appear to have two to five one-sided spikes that is located two at the top of the main stem and others belows is stem (Aldous, 1999). The recommended mowing height for tropical grass like carpet grass is 25 to 75 mm. While other turfgrasses such as hybrid cynodon are mowed at 4 to 5 mm only. Hence, the maximum percentage of mowing height for every turfgrass is 30 to 50 percent of the shoot growth to keep the a neat appearance for the turf (Aldous, 1999).

2.3.3.2 Leaf

Axonopus compresus is normally called as broad-leaves turfgrass and its leaf is folded in the bud (Aldous, 1999). As compared to *Axonopus affinis* it has a narrow leaves, continuous, occasionally with hairs blade and only 4 to 8 mm wide (Turgeon, 2012). The leaf sheath of *Axonopus compressus* is fine and also hairy along the outer margin with only 2.5 to 16 mm wide of base broadly rounded leaves (Anonymous, 2017). Both *Axonopus compressus* and *Axonopus affinis* have similar appearance and environmental adaptation except for it is less cold hardy thus restricted to humid tropical and subtropical climates (Turgeon, 2012). The rate of leaf formation is influenced by the climatic conditions and it will continue to elongate from the basal meristem (Emmons, 2008).

2.3.3.4 Root

Axonopus compressus is a robust plant that spread by stolons. It has stouter culms and stolons, wider leaves and longer spikelets which are more acute (Rahman, 2014). It can be a shallow rooted, stoloniferous in the same time thus, forms a turf of medium density and in a form of seeds and that is adapted to tropical and warm subtropical climates (Turgeon, 2012)(Emmons, 2008). The optimum root growth temperature in the soil for cool season grass is about 13°C (55 °F) and for warm season turfgrasses is 27 °C (80 °F) (Emmons, 2008). Plant roots can be very effective in the fall season, but they need to be stimulated by the presences of nutrients, notable N and P, to branch out and explore new areas. (Akdeniz, 2016).

2.3.3.5 Shoot

Pearl grass is considered an unattractive species, partially because of the shoot that grow tall, course seedheads developed throughout the summer (Emmons, 2008). Turfgrasses are perennials and continue producing tillers, the primary lateral shoots which increase the number of shoots in a turf area. Thus, tillering is refers to the production of side shoots and gradually form a very dense clump. Specifically, grass shoot consists of leaves, stem and inflorescence where it defined into two parts that is the upper, mostly flat part called the blade and the lower called sheath (Wiecko, 2008).

Falkowski *et al.,* (1986) reported that N when applied at the beginning of vegetation affects formation and development of inflorescences. Higher doses of mineral N result in an increase in some generative tillers. Apart from generative tillers, also, vegetative shoots develop intensively at a high level of N fertilization. (Akdeniz, 2016) A study showed that a response to N related to increasing on tiller density has been reported by Wiman and Pearse (1989) for some grass species. Petrovic A. (1986)and Wilman and Pearse also showed that N fertilization is determinant for pasture productivity, as it results in increasing forage yield and is associated with the growth physiology of forage plants. The rate of tiller development, evaluated in each of the seven-day periods, was affected by N rates and time of application.

2.3.4 Other factors for successful establishment of pearl grass

2.3.4.1 Selection of planting materials

Turfgrass contributes beauty to the landscape. It has an attractive green color and a uniform appearance (Emmons, 2008). The selection of turfgrass in certain places will be much dependant on the quality, location weather, and the purpose of it is being managed (Aldous, 1999). In tropical condition in Malaysia, the selection of *Axonopus compressus* is more precise than other cool season turf to be used in a study here. *Axonopus compressus,* broad-leaved carpetgrass can be established through seed or sod (Aldous, 1999). In tropical, high seedling density during the establishment period can prevent weeds and increase competitive turfgrass plant (Wiecko, 2008). For sod, the selection of seedling should be uniform, pest free, have a strong foundation of hold together during handling and producing roots after one to two weeks of planting (Turgeon, 2012). *Axonopus compressus* grows best on moist sandy or loamy soils especially those rich in organic matter but grows well in partial shade which is not exposed to sunlight in full light day (Aldous, 1999). Thus, it can survive from flooding problem.

2.3.4.2 Media for planting

The media used for turfgrass establishment is soil that consists of mineral, air, water and humus (Wiecko, 2006). There are different types of organic materials in turf root zone, including soil organic matter, soil organic residue and soil biomass. The optimum amount of organic matter depends on whether the root zone media is sand or soil-based. Three to five percent of organic matter is adequate for sand-based and in soil-based root zone needed 10 percent of soil organic matter (Li, 2004). Li (2004) said that life of microorganisms cannot

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