EFFECT OF TEMPERATURE AND LIGHT ON GERMINATION OF BERMUDAGRASS (*Cynodon dactylon* (L.) Pers.) SEEDS

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ABSTRACT

A study was conducted at the Faculty of Sustainable Agriculture, Universiti Malaysia Sabah, to investigate the effect of temperature and light on seed germination of *Cynodon dactylon* (L.) Pers. This study was arranged in a Completely Randomized Design (CRD), with 4 replicates for each treatment. Temperatures used in this study were ambient environment (±24 °C), alternating temperature of 30/20 °C, 20 °C, 25 °C and 30 °C. Germinating seeds were exposed to different light levels comprising 24 hours light, 24 hours darkness and alternating 12 hours light and 12 hours dark. Parameters evaluated in this study included germination percentage, plumule length, radicle length, seedling length, seedling fresh and dry weight, germination index as well as seedling length vigour index. Significant interactions between temperature and light were observed in this study. Optimum germination occurred at an alternating 30/20 °C temperature regime and alternating light level with highest final germination percentage (92.75 %), radicle length (1.71 cm), germination index (13.25) and seedling length vigour index (275.86). Temperature regime of 20 °C under continuous dark condition produced the poorest germination performance with only 2.5 % of seeds germinated for 7 days since the start of germination. This treatment also resulted the lowest germination index with only 0.36 and 2.52 of seedling length vigour index. No significant interaction was observed in seedling fresh and dry weight. Increasing temperature from 24 °C (ambient) to 30 °C resulted in increase of germination percentage, plumule length, radicle length, seedling length, seedling fresh and dry weight, germination index as well as seedling length vigour index.

Keywords: Seeds germination, temperature, light, alternating temperature, alternating light, germination percentage, germination index, seedling length vigour index

KESAN SUHU DAN CAHAYA TERHADAP PERCAMBAHAN BIJI BENIH RUMPUT BERMUDA (*Cynodon dactylon* (L.) Pers.)

ABSTRAK

Satu kajian telah dijalankan di Fakulti Pertanian Lestari, Universiti Malaysia Sabah, untuk mengkaji kesan suhu dan cahaya terhadap percambahan biji benih *Cynodon dactylon* (L.) Pers. Kajian ini disusun dalam Reka Bentuk Rawak Lengkap, dengan 4 replikasi bagi setiap rawatan. Suhu yang digunakan dalam kajian ini adalah persekitaran ambien (24 °C), 30/20 °C, 20 °C, 25 °C dan 30 °C. Biji benih yang sedang bercambah didedahkan kepada tahap cahaya yang berbeza iaitu 24 jam cahaya, 24 jam gelap dan berselang-seli 12 jam cahaya dan 12 jam gelap. Parameter yang dinilai dalam kajian ini termasuk peratusan percambahan, panjang plumul, panjang radikel, panjang anak benih, berat basah anak benih, berat kering anak benih, indeks percambahan serta indeks kecergasan benih. Terdapat interaksi yang signifikan antara suhu dan cahaya dalam kajian ini. Percambahan optimum berlaku pada tahap rejim suhu 30/20 °C dengan cahaya berselang-seli dengan peratusan percambahan yang tertinggi sebanyak 92.75 %, panjang radikel sebanyak 1.71 cm, indeks percambahan sebanyak 13.25 dan indeks kebernasan benih sebanyak 275.86. Suhu 20 °C dalam keadaan gelap berterusan menunjukkan prestasi percambahan yang paling lemah dengan hanya 2.5 % benih bercambah selepas 7 hari. Rawatan ini juga menunjukkan indeks percambahan terendah dengan hanya 0.36 serta indeks kebernasan benih dengan hanya 2.52. Tiada interaksi yang ketara pada berat basah dan berat kering anak benih. Peningkatkan suhu dari 24 °C (ambien) hingga 30 °C menghasilkan peningkatan peratusan percambahan, panjang plumul, panjang radikel, panjang anak benih, berat basah dan berat kering anak benih, indeks percambahan serta indeks kebernasan anak benih.

Kata Kunci: Percambahan biji benih, suhu, cahaya, suhu berselang-seli, cahaya berselang seli, peratusan percambahan, indeks percambahan, indeks kebernasan anak benih.

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LIST OF SYMBOLS, UNITS AND ABBREVIATION

%	Per cent
°C	Degree celcius
ANOVA	Analysis of variance
AOSA	Association of Official Seed Analysts
cm	Centimetre
CRD	Completely Randomized Design
DMRT	Duncan's Multiple Range Test
FSA	Faculty of Sustainable Agriculture
g	Gram
GI	Germination index
GP	Germination percentage
ha	Hectare
IPNI	International Plant Name Index
ISTA	International Seed Testing Association
kg	Kilogram
KNO_3	Potassium nitrate
mm	Millimetre
ml	Millilitre
NTEP	National Turfgrass Evaluation Programme
PSU	Pure seed units
SAS	Statistical Analysis System
SLVI	Seedling Length Vigour Index
USA	United States of America
USDA	United State Department of Agriculture

LIST OF FORMULAE

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Grasses are one of the well lawn covering materials due to uniformity of colour and texture, soft and resilient, ease of maintenance under suitable growing conditions. Sport facilities like golf courses and football fields are surfaced with turfgrass due to their strong tolerance. Besides, grass species can function as erosion control and slope stabilization (Alshammary, 2012). The grass family comprises many species of grasses, and among these species, *Cynodon dactylon* (L.) Pers. is one of the most commonly used grass species for covering or aesthetic purpose. *Cynodon dactylon* (L.) Pers., commonly known as bermudagrass, is a widely used perennial grass species. Its' stems can grow erect until 30 cm high and has gray green short leaf blades with 2 to 15 cm long (Gisele *et al.,* 2015). This species can be considered as weed, forage or ornamental. It has strong tolerance to drought and close, continuous mowing. Most of soil types are suitable for bermudagrass to grow with sandy soils being the best option (Santos *et al.*, 2004). This grass species is also able to provide aesthetic effects in garden, parks or house compound.

Grasses can self-propagate by seeds, stolons and tillers. Vegetative propagation is more popular due to the better initial development but there are several limitations such as high risk of pest and diseases outbreak, extensive labour requirement, high demand of propagation materials as well as higher cost in establishment of the field. Therefore, propagation of the grass by seeds is encouraged whenever possible (Carmona *et al.*, 1998). However, it is still not ideal method because most available hybrid cultivars are easier established by vegetative means due to poor seed production and viability (Taliaferro *et al.*, 2004).

Both endogenous and exogenous characteristics play important role in seed germination. Therefore, it is essential to highlight the environmental factors such as water, temperature and light and understand the ideal conditions for each species. In addition, these requirements vary according to regions (Santos *et al.*, 2004).

1.2 Justification

Bermudagrass can be established using seeds at lower initial cost and not as burdensome as compared to sprigging or sodding. There is a great deal of interest in using seeds of bermudagrass as it can be established on small coverage area, steep slopes and cut-over timber land that are not economical and feasible to do sodding or sprigging.

Warm season perennial grasses, including bermudagrass, are difficult to establish from seeds. Due to the slow germination and poor seed viability, warm-season perennial grass seedlings may have to compete with annual weeds. Hence, temperature and light may play the major roles in achieving maximum germination and rapid emergence through optimum planting date planning (Gisele *et al.*, 2015).

Zuk and Fry (2005) reported that with lower light levels and lower temperatures, there was a reduction in zoysiagrass seedling germination and establishment. However, there is less information on the effect of particular factors on the optimum germination of bermudagrass seeds. Hence, this study was conducted to study the effect of temperature and light on the germination of bermudagrass (*Cynodon dactylon* (L.) Pers.) seeds.

1.3 Objectives

The objectives of this study are:

1.3.1 To investigate the effect of temperature on germination of bermudagrass (*Cynodon dactylon* (L.) Pers.) seeds.

1.3.2 To investigate the effect of light on germination of bermudagrass (*Cynodon dactylon* (L.) Pers.) seeds.

1.4 Hypotheses

H_{O1} : There is no significance difference between the temperature in affecting the germination of bermudagrass (*Cynodon dactylon* (L.) Pers.) seeds.

H_{A1} : There is significance difference between the temperature in affecting the germination of bermudagrass (*Cynodon dactylon* (L.) Pers.) seeds.

H_{O2} : There is no significance difference between the light in affecting the germination of bermudagrass (*Cynodon dactylon* (L.) Pers.) seeds.

H_{A2} : There is significance difference between the light in affecting the germination of bermudagrass (*Cynodon dactylon* (L.) Pers.) seeds.

CHAPTER 2

LITERATURE REVIEW

2.1 Poaceae

The grass family was recognized by the name of Gramineae by Adanson as early as in 1763. This was later on renamed as Poaceae by Barnhart in 1895. Tzvelev (1989) reported that the family is represented by about 10300 species belonging to 898 genera. Clayton and Renvoize (1986) and Watson and Dallwitz (1992) had made significant contributions to the taxonomy of the family and recognized about 700 genera and 10,000 species worldwide. Poaceae is the third largest family of flowering plants, extending vegetation cover to about 25 % of the Earth's land surface. The grass family plays a vital role in both mankind's economic activity and in the composition of natural plant communities (Annonymous, 2007). Vast diversities exist in the morphological characteristics of this family including compound spike inflorescence, bisexual zygomorphic flowers subtended by several distichous imbricate glumes, perianth represented by two to three minute hypogynous scaly lodicules or sometimes absent, three to six stamens, superior ovary, unilocular with single ovule and fruit caryopsis (Watson and Dallwitz, 1992). Most of the grasses are herbaceous annual or perennial plants, except bamboo, which is perennial.

The family comprises many species which act as important food sources for humans and livestock. Cereals including rice, maize, wheat and barley, are the major food sources for humans. Sugarcane is widely cultivated in the tropics, which play important role in providing major source for sugar. Besides that, it is currently well-known for the production of bioalcohol in Brazil and U.S.A, to run vehicles using the bioalcohol-petrol mixture (Annonymous, 2007). Forage and fodder are grown for animal food particularly for sheep and cattle. Bamboos make good construction materials, as well as providing raw materials for the production of papers and furnitures (Clayton and Renvoize, 1986).

Apart from providing food, grasses act as the basic elements of landscape design which link all the other landscape elements such as trees, shrubs, and flowers into a harmonies whole. Grasses are one of the well lawn covering materials due to uniformity of colour and texture, soft and resilient, ease of maintenance under suitable growing conditions. They can be walked on, sat on and used for many outdoor activities and sport activities such as football, soccer, volleyball and related practices (Candan, 2013).

Turfgrasses are divided into two groups which are cool season (C3) and warm season grasses (C4). These grasses differ in climatic requirements and the way they carry out photosynthesis (Wiecko, 2006). Warm season grasses grow most vigorously at temperatures of 27 °C to 35 °C, whereas cool season grasses do best at temperatures of 15 °C to 22 °C (Turgeon, 2011). The difference between C3 and C4 grasses is the number of initial molecule formed during photosynthesis. The first product of carbon fixation in C3 grasses involves a 3-carbon molecule, while C4 grasses initially produce a 4-carbon molecule that then enters the C3 cycle. Therefore, C4 grasses are more effective in wet and dry tropics (DPI, n.d.).

2.2 Bermudagrass (*Cynodon dactylon* (L.) Pers.)

Bermudagrass was introduced from Africa in 1751. It was primarily used as a forage grass in the Carolinas. In 1927 it was utilized for the first time for golf turf and just two years later in 1929 saw its first application as a lawn grass (USDA, n.d.). Bermudagrass is adapted to grow throughout the transition zone and further south of U.S.A. (Christians, 2011). It tolerates wear and recovers quicker from stress than cool-season grasses due to the abundant production of rhizomes and stolons (Youngner, 1961; Beard, 1973).

Table 2.1 Scientific classification of bermudagrass.

Kingdom	Plantae
Division	Magnoliophyta
Class	Liliopsida
Order	Cyperales
Family	Poaceae
Genus	Cynodon Rich.
Species	Dactylon
Scientific Name	*Cynodon dactylon* (L.) Pers.

Source: Adapted from United State Department of Agriculture (USDA), n.d.

2.2.1 Common Bermudagrass

Common bermudagrasses are often used on athletic fields, bowling greens, tennis courts, golf courses and home lawns. These grasses are also widely used along roadsides, waterways and other potential erosion areas to reduce water surface runoff and soil losses. Propagation method is usually by seed as shown in Figure 2.1. Bermudagrass possess an upright growth habit with medium to coarse leaf texture and have moderate mowing tolerance below 1 inch (Brosnan and Deputy, 2008). However, in recent years, the development of improved common bermudagrass cultivars has allowed these grasses to adapt to moderate cold environment. Besides, the quality has also improved to medium green colour, medium texture, improved density, and tolerance to mowing heights below 1 inch (Samples and Sorochan, 2007). As the common bermudagrasses variety are able to produce higher biomass yield and desirable forage qualities, they are also used as forage crops for hay production and grazing. Some of the commercial varieties are Princess-77, Riveria, Southern Star and Yukon (Anonymous, 2007).

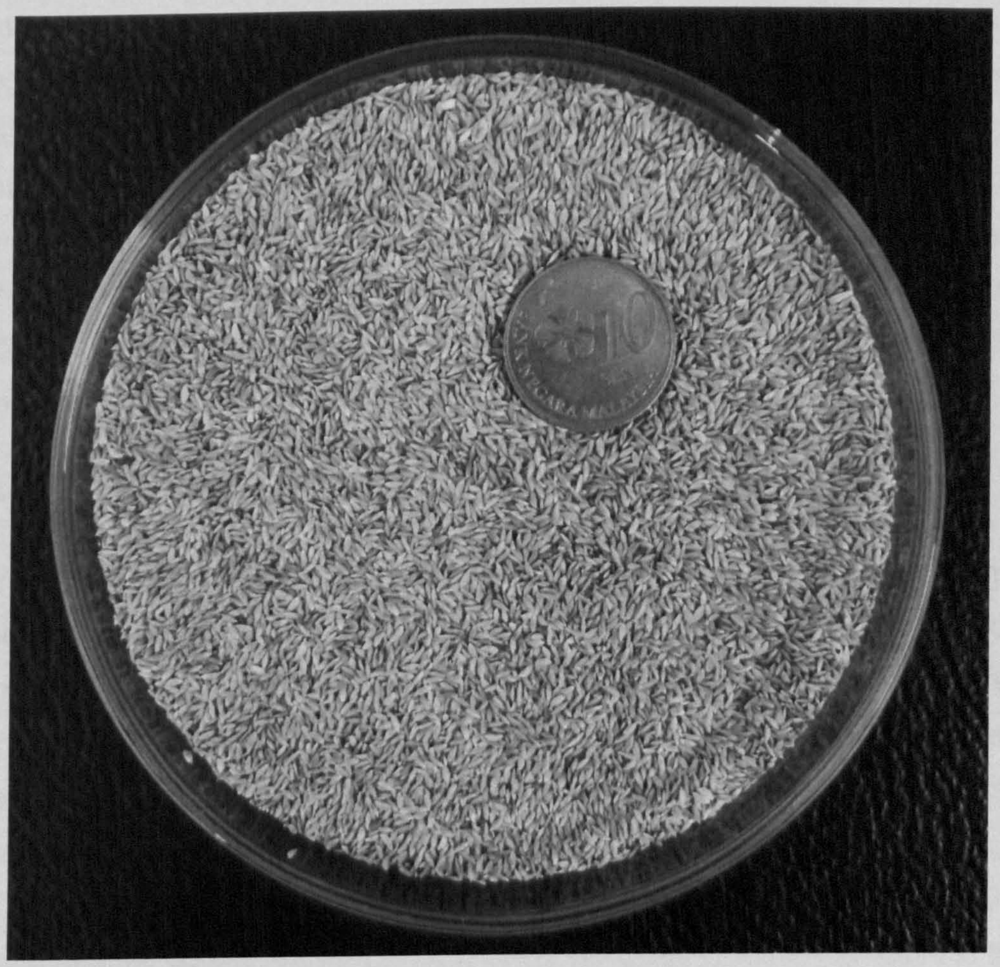

Figure 2.1 Bermudagrass (*Cynodon dactylon* (L.) Pers.) seeds.

2.2.2 Hybrid Bermudagrass

Hybrid bermudagrasses are species which resulted from the interspecific crosses between two bermudagrass species like *Cynodon dactylon* and *Cynodon transvaalensis* (Fry and Huang, 2004). These hybrid bermudagrasses must be propagated by sprigs, stolons, or sodding as they do not produce viable seeds (Christians, 2004). Hybrid bermudagrasses usually have higher levels of quality, density, colour, tolerances to the stresses of traffic, heat, and drought. Besides, they can also tolerate mowing heights less than 1 inch with very few unsightly seed heads produced (Turgeon, 2011). However, to establish lawn by using hybrid bermudagrasses, cost of establishment and maintenance requirements are relatively higher as compared to common bermudagrass. Examples of commercially available hybrid bermudagrasses include Tifway, Tifgreen, Tifdwarf, GN-1, and Celebration (Anonymous, 2007).

2.2.3 Ultradwarf Hybrid Bermudagrass

Ultradwarf bermudagrasses are superior quality bermudagrasses which were produced through the mutations of hybrid bermudagrasses. They are usually characterized by shorter internode length, higher shoot density and an improved tolerance to low mowing heights of less than 1/8 inch as compared to hybrid bermudagrasses (Brosnan and Deputy, 2008). Regular vertical mowing, grooming, and topdressing were required due to their characteristics of excessive thatch production within a short period. Examples of ultradwarf hybrid bermudagrasses including FloraDwarf, MiniVerde and TifEagle (Anonymous, 2007).

2.2.4 Seeded Bermudagrasses

In early 1980s, seeded bermudagrass were not used commercially due to its poor quality characteristics. In 1990s, new seeded cultivars were released and achieved equal or superior quality characteristics when compared to the interspecific 'hybrid' cultivars that had long been the industry standard in medium to high maintenance turf applications (Patton *et al.*, 2004a). Commercially available seeded bermudagrass cultivars are apparently easier to establish compared to vegetative propagation cultivars (Philley and Krans, 1998). However, there are exceptions. Study reported by Patton *et al.* in 2004b indicated that the cultivar Riviera can often be slow to germinate in the field due to the concurrent germination of weedy species and subsequent over-management such as over-irrigating. As compared to other means of stand establishment, seeded cultivars able to be established at a relatively lower cost. With the release of many new seeded cultivars, studies were conducted to determine optimal seeding rate, date, and fertility requirements (Shaver *et al.*, 2006; Patton *et al.*, 2004ab; Karcher *et al.*, 2004 and Munshaw *et al.*, 2002). Bermudagrass seeds are available in two forms, hulled or unhulled, with hulled seeds having faster germination rates due to the removal of the physical impediment from the seed coat (McCarty, 2001).

2.3 Establishment of Bermudagrass

Establishment of Bermudagrass can be categorized into two, seedling and vegetative propagation. Vegetative establishment include sprigging, plugging, and sodding. Common or improved bermudagrasses are typically established by seeds, whereas hybrid-bermudagrass can only be established through vegetative propagation (Christians, 2004; Fry and Huang, 2004). Under optimum germination temperature ranges between 21 °C and 35 °C (McCarty, 2001), common bermudagrass are able to produce around 3.96 million seeds per kg (Christians, 2004; McCarty, 2001). Seeding rates for bermudagrass are dependent on the site characteristics and whether hulled or unhulled seeds were used. Current recommended seeding rates ranges from 100 to 150 kg/ha (Puhalla *et al.*, 1999).

Sprigging is typically used for establishing species with dense stoloniferous growth habits and at a lower cost (Christians, 2004 and McCarty, 2001). Most of the bermudagrass species use sprigging for establishment, however, certain hybrid species can only be established by sprigs or sod due to their unviable seed characteristic resulted from intraspecific hybridization (Christians, 2004; Puhalla *et al.*, 1999).

Plugging is usually done for establishment of smaller area coverage with limited time and labour. This propagation method is less popular for high acreage sites. Bermudagrass plugs are usually spread laterally through rhizomes and stolons due to their vigorous growing habits (Turgeon, 2011).

Sodding is the most rapid establishment practice which provides an instant ground cover. Bermudagrass sod can establish within 30 days while 60 days for bermudagrass established by sprigs (Puhalla *et al.*, 1999). During establishment, adequate soil moisture should be maintained to prevent desiccation until sufficient rooting occurs (Puhalla *et al.*, 1999). Hence, establishment through sodding practice required higher maintenance cost as compared to other establishment practices (Turgeon, 2011).

2.4 Germination Environmental Factors of Seeded Bermudagrass

Growth of the embryo of mature seed is responsible for the germination of seed. Seed germination is a complex process that is affected by few environmental factors (relative humidity, light intensity, temperature and moisture availability) and controlled by several biological factors (species, seed dormancy, seed size and seed viability). Seed germination can be considered as the most sensitive stage in the life cycle. It requires favourable environmental conditions such as water, oxygen availability and temperature. (Bonnewell *et al.*, 1983; Meredith, 1985). Therefore, it is essential to determine the most optimum environment and treatments for seed germination and seedling establishment under the prevailing climatic conditions (Sakpere, 2011).

Environmental factors such as temperature, light, pH, and soil moisture are known to affect seed germination (Chachalis and Reddy, 2000; Taylorson, 1987). Characterization of the environmental factors that influence germination of seeded bermudagrass could provide useful information for the development of recommended cultural protocols for establishing a grass field. Baskin and Baskin (1998) reported that *Cynodon dactylon* have non-dormant seeds. This means that the seeds will germinate and emerge once they disseminated from their mother plants under adequate environmental conditions.

2.4.1 Temperature

Temperature is an important germination factor and had been well reported in many publications. However, few reports had been published about the role of temperature in germination of bermudagrass (Hegarty, 1973; Thompson, 1981; Simon, 1979; Roberts, 1988; Probert, 1992). Angevine and Chabot (1979) mentioned that a seed has a tendency towards favourable environmental conditions for seedling establishment when germinate under a natural environment. The mechanism of seed germination tends to avoid unconducive growth conditions to ensure optimum germination.

Angevine and Chabot (1979) recognized that physical and biotic stresses caused by the environment had resulted in several germination syndromes. These syndromes would ultimately affect the seedling establishment. Thus, temperature is unarguably the most important environmental variable for seed germination and seedling establishment because responses from seeds to temperature play a crucial role in causing several of these germination syndromes.

The effect of temperature on plant growth at different growing stages starting from germination and emergence was studied by Went in the early of 1953. Roberts (1998) had carried out studies based on three separate temperatures based on physiological processes. The first process is to determine the deterioration rate in all seeds by using various temperature and moisture content. The second and third processes are the effect of temperature in affecting the rate of dormancy loss in dry seeds and the pattern of dormancy change in moist seeds as well as the determination of germination rate in non-dormant seeds.

Higher germination rate in goose grass (*Elusine indica*), perennial ryegrass (*Lolium perenne* (L.)) and some common weed species such as waterhemp (*Amaranthus tuberculatus* (L.)) and giant foxtail (*Setaria faberi* Herrm.) can be obtained by alternating diurnal temperature (Leon *et al.*, 2004; Nishimoto and McCarty, 1997; Shen *et al.*, 2008). However, different conclusions were obtained from the studies carried out by Young and Evans (1982). They found that the maximum germination percentages could be obtained under constant temperatures for most of the perennial grasses they studied. Hylton and Bement (1961) also found optimum germination of *Festuca octoflora* Walt. under constant 20 °C rather than under various alternating temperature regimes. Terenti (2004) showed that the best germination (80 %) in *D. eriantha* occurred at 30 °C and 35 °C.

Grabe (1955) concluded that constant temperatures of 25 °C, 30 °C, or a prechill period of 5 days followed by constant 30 °C were the most favourable for cool season smooth bromegrass (*Bromus inermis*) seed germination. From his studies, he also found that germination of bromegrass didn't occur under temperature of 40 °C, 35 °C, 5 °C and 2 °C. Six different grass species were germinated under temperature of 10 °C, 20 °C and 30° °C at various osmotic pressures. From the study, it was shown that 20 °C was near the optimum temperature for germination process and that seeds were able to germinate better under high moisture stress at 20 °C than at 10 °C or 30 °C (Ginnis and William, 1960).

Harrington (1923) reported that seeds of celery, orchard grass, Kentucky bluegrass, Bermuda grass and Johnson grass showed better germination with alternations of temperature. Practically, the seeds from most other species were also able to germinate in both constant temperatures and alternating temperatures in the study. Kotowski (1926) germinated seeds of 17 vegetables in sand at six different temperatures which varied from 4 °C to 30 °C. He found that the rate of germination for all species increased as the temperature increased.

Besides grass species, a wide variety of crop seed germination studies had been carried out. Delouche (1953) used temperature of 20 °C, 25 °C, 30 °C and 35 °C as well as alternating temperature of 20/30 °C and 30/20 °C in which the first temperature was held for 16 hours and the second for 18 hours, to test the germination response of corn, soybeans and watermelon. In general, linear relationship existed as the increasing of temperature could lead to the increasing of the speed of germination. From the results obtained, the optimum temperature for maximum germination in the minimum time for corn and soybeans was 30 °C while for watermelon through use of the 20/30 °C combination.

2.4.2 Light

The quality and direction of plant are perceived by photo-sensory where light is the main component. Light has been established as one of the most important factors in plant growth and development. It is able to regulate plant development by maintaining photosynthetic efficiency (Hangarter, 1997) and regulating seed germination in most plant species (Baskin and Baskin, 1998). Every plant species will have their own requirement for light which vary with temperature for their germination (El-Keblawy and Al-Rawai, 2005). Changes in duration, direction and spectral quality of light were able to be sensed and identified by plants' photochemical systems. The activation process in plants results in qualitative modification of growth and developmental pattern in response to changes in the environment (Akinbode *et al.*, 2011). Some of the examples of activating processes that affected by light are phytochrome action, photoperiodism and breaking of dormancy.

Hartmann and Kester (1975) and Sacande and Some (1992) had reported that low light intensities could allow seeds to germinate properly. A study on the germination of *Phalaris arundinacea* L., commonly known as reed canary grass was carried out by Cisneros and Zedler in 2001. The findings reported that there was a higher germination percentage with 38 % under dark condition as compared to other light conditions. Statements concluded from this study indicated that germination of certain grass is not accelerated by light as in common grass species, or even be light inhibited in some cases. This is in conjunction with the theory which indicated that phytochrome was the main

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