Light levels influence on development and leaves reflectance index of imperial® zoysia grass

Influência de níveis de luz no desenvolvimento e índice de refletância das folhas de grama esmeralda imperial®

DOI:10.34117/bjdv7n1-107

Recebimento dos originais: 07/12/2020
Aceitação para publicação: 07/01/2021

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ABSTRACT

The lawn aesthetics is one of the most important aspect, which professionals need to observe. Shading influence on grass development may be harmful to plant physiology, which will have its photosynthetic processes reduced. A grass that receives less light may etiolate, and, in popular terms, it can fade making it less attractive, since what is expected for a lawn is its vibrant green colour. Therefore, the research aimed to study the influence of luminosity levels and changes in light spectrum in development and leaf reflectance indices of Imperial® Zoysia Grass var.. Grass was implanted in black plastic containers filled with substrate formed by, soil, sand and soil conditioner. Luminosity levels tested were: T1: full sun, T2: 50% black shading net and T3: 50% red solar spectrum manipulation net. The lawn height was assessed using the prism methodology. Digital images were obtained and red, green and blue (RGB) mean values components were reported. RGB results were converted to HSB values (Hue, Saturation and Brightness). After obtaining HSB values, Dark Green Colour Index (DGCI) was calculated. Treatments T2 and T3 interfered in the development and reflectance index of leaves of Zoysia grass Imperial®. For Hue component the cited treatments turn leaves to yellow, which means leaves chloroses caused by the reduction of chlorophyll concentration. Dark Green Colour Index, T2 and T3 influenced in leaves coloration turning them yellowish, proving hue results, which is symptom of chlorosis and etiolation.

Keywords: Zoysia japonica, vibrant green, shading influence, grass.

RESUMO

A estética dos gramados é um dos aspectos mais importantes que os profissionais precisam observar. Influência do sombreamento no desenvolvimento de gramados pode ser prejudicial para a fisiologia da planta ocasionando a redução de processos fotossintéticos. Grama que recebe menos luz pode estiolar e, em termos populares, pode desbotar tornando-se menos atrativa, já que o que se espera de um gramado é sua cor verde vibrante. Por isso, a pesquisa objetivou o estudo da influência de níveis de luminosidade e mudança no espectro de luz no desenvolvimento e índice de refletância de folhas de grama esmeralda Imperial®. Tapetes de grama foram implantados em contêineres de plástico preenchidos com substrato formado por solo, areia e condicionador de solo. Os níveis de luminosidade testados foram: T1: pleno sol, T2: tela de sombreamento preta de 50% e T3: tela de manipulação de espectro vermelha de 50%. A altura de folhas de grama foi avaliado pelo método do prisma. Imagens digitais foram obtidas e os valores médio de vermelho, verde e azul (RGB) foram avaliados. Resultados de RGB foram convertidos em valores de HSB (Matiz – H, Saturação – S e Brilho – B). Após obter HSB, Índice de cor verde escuro (DGCI) foi calculado. T2 e T3 interferiram no desenvolvimento e no índice de refletância de folhas de grama esmeralda Imperial®. Para o matiz os tratamentos supracitados tornaram as folhas amarelas, que significa clorose causada pela redução da concentração de clorofila. Índice de cor verde escuro, T2 e T3 ifluenciaram na coloração das folhas também tornando-as amareladas, comprovando os resultados de matiz, que são sintomas de clorose e estiolamento.

Palavras-chave: Zoysia japonica, verde vibrante, influência de sombreamento, grama.

1 INTRODUCTION

Zoysia grass (Zoysia japonica) is native to Japan. It is a rhizomatous and branched herbaceous grass. Its characteristics are narrow leaves, fast-growing and intense green colour; with different leaf textures and shades of green, forming a perfect rug. The Imperial® variety, selected and developed by a private research centre, is the first grass cultivation protected in Brazil by the Ministry of Agriculture, Livestock and Supply. This variety has slightly wider leaves compared to Zoysia grass. It has more vigorous root system among all grasses of this family. Excellent drought tolerance, low nutritional requirement, and slow growth when compared to other grass species (Itograss, 2020).

The presence of lawns, whether ornamental or sportive, has beneficial effects to human beings and to the environment, enabling the improvement of air quality, for example, due to the high potential for atmospheric CO2 sequestration, in addition to the efficiency in protecting the soil against erosion. However, for lawns, effectively perform these functions it is necessary to be properly deployed in environments conducive to good development (Santos et al., 2018).

For this reason, studies involving cultivated grasses have increased considerably in recent years, based on the growing demand for green grassy areas in condominiums; public areas; sports and recreational centres, as well as highways flowerbeds. This increase has been accompanied by the introduction of new species of grasses and technologies such as irrigation, fertilization, use of pesticides and growth regulators (Nascimento et al., 2019).

For lawn establishment, some abiotic factors may interfere on its development, such as water availability, soil fertility, and weeds competition. However, one of the main factors is the level of light that this lawn receives. Regardless of the goal, the lawn is part of a set weather other plants or physical structures, such as concrete, wood, iron. Therefore, it is necessary to be careful with excessive shading in grass areas.

Belonging to C4 plant group, grasses need an extra supply of energy, requiring higher luminous intensity, due to their characteristic of reducing CO2 losses, C4 plants are more productive than C3 plants, however their efficiency in converting light energy into chemical energy is lower (Amaral et al., 2016).

The shading influence on lawn may be harmful to plant physiology, which will have its photosynthetic processes reduced and as a result affecting the aesthetics of the place in which it is inserted. A grass that receives less light may etiolate, and, in popular terms, it can fade making it less attractive, since what is expected for a lawn is its vibrant green colour.

For researchers, the experimentation models may be difficult to continue the research as the only way is with destructive evaluation. For this reason, they are trying always to create new methods non-destructive.

Therefore, procedures using colour images process are increasing in agriculture field practices for maximizing profit (El-Azazy, 2018).

The author pointed that colour model is a system of colours representation and their relation to each other. One of this models is the RGB (Red, Green and Blue) whose definition is analyse an image according to intensity of red, green and blue (Kondekar and Bodhe, 2018). In this case, another index derives from RGB model such as Dark Green Colour Index (DGCI), which varies from 0 (very yellow) to 1 (dark green) (Rhezali and Lahlali, 2017).

Many studies have been used on digital images for indirectly nitrogen content determination and for other purposes in a non-destructive way in different plant species leaves as Citrus volkameriana (El-Azazy, 2018); Capsicumm annuum (Felizberto et al. 2016); Santalum album (Chen and Wang, 2019); Axonopus compressus, Zoysia matrella and Paspalum vaginatum (Malleshaiah et al. 2017).

However, in national or international literature, there are no works studying the effect of light at leaves colour characteristics of lawns, for instance. For this reason, the research aimed to study the influence of luminosity levels and changes in light spectrum on leaf reflectance indices and development of Imperial® Zoysia Grass.

2 MATERIAL AND METHODS

The experiment was conducted in a region whose clime was classified by Köppen as Aw type, characterized by tropical humid with rainy season in summer and dry in winter. In 2019, the annual precipitation was 1,044.2 mm. The relative air humidity varied from 47.9% to 96.2% (annual minimum and maximum humidity, respectively) and annual temperature means was minimum of 19.4 °C and maximum of 32.9 °C (Unesp et al., 2020).

Imperial® Zoysia grass was implanted in black plastic containers (47.5 x 17.5 cm – top; 41.5 x 11.3 cm – bottom; 15, 5 cm high, 8.46 L volume), using donated carpets from Itograss®, located in municipality of Pereira Barreto-SP. The containers were filled with substrate formed by, soil, sand and soil conditioner (1:1:1, v:v:v)

The chosen experimental design was completely randomized scheme with three treatments and seven replicates. The luminosity levels tested were: full sun, black shading net of 50% and red solar spectrum manipulation net of 50%. The nets were fixed on structures made of 1/4" iron rebar with 1 x 1 x 1 m (height x width x length) of dimension.

The containers irrigation was performed daily until substrate field capacity was reached. A covering fertilization was made on the day of experiment implementation to relieve plant stress. Fertilizer was applied by concentration of 10 g L-1 of water, according to the manufacturer recommendation, 2 L of solution per container. The product contained 13% Nitrogen, 5% Phosphorus, 13% Potassium, 1% Calcium, 1% Magnesium, 14% Sulphur, 0.06% Boron, 0.05% Copper, 0.2 % Iron, 0.1% Manganese, 0.005% Molybdenum and 0.2% Zinc.

The lawn height was assessed (7 and 14 days after grass transplant) using the prism (portable device made of steel and mirror which reflects light at 90° and contains graduated scale in cm). It was placed on the lawn surface, in three points, obtaining mean value.

The digital images were obtained once, 14 days after grass transplant, from a Sony DSC-W30 7.2 mega pixels digital camera fixed at the end of a structure in the form of a inverted "L" for images to be obtained parallel to lawn surface, in the same height (1.6 m). The images were transferred to a computer and each of these figures was analysed by Fireworks MX software.

Red, green and blue (RGB) mean values components from analysed image were reported. RGB components are the quantities of red, green and blue light transmitted by the image and are measured at values from 0 to 255. These components are combined in intensities to produce all other colours.

As only the green (G) component does not define the green colour, depending also on red (R) and blue (B) components, the RGB results were compiled for a spreadsheet in MS

Excel® and converted to HSB values (Hue, Saturation and Brightness), according to Karcher and Richardson (2003) methodology.

The hue describes colour pigment and it is measured from 0° to 360° (0° red; 60° yellow; 120° green; 180° cyan; 240° blue and 300° magenta). Saturation describes colour vividness or fading and it is measured from 0% to 100% (Higher percentage higher colour vividness). Brightness describes the amount of white that a colour contains and is also measured from 0% to 100% (higher percentage, higher the colour brightness). After obtaining HSB values, it was possible to calculate the Dark Green Colour Index (DGCI) by Karcher and Richardson (2003) proposal. DGCI value is on a scale from 0 (very yellow) to 1 (dark green) (Rhezali and Lahlali 2017). DGCI was calculated as:

$$DGCI = [((Hue) - 60) / 60 + (1 – (Saturation)) + (1 - (Brightness))] / 3$$

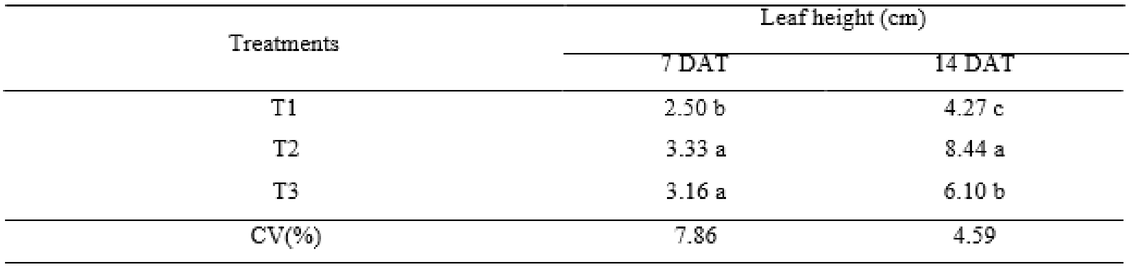
The data were analysed for analysis of variance (F test) and Tukey test at 5% of probability for means comparison in relation to levels of luminosity using SISVAR program (Ferreira, 2019) for statistical analysis.

3 RESULTS AND DISCUSSION

In Table 1, it is observed that both at 7 and 14 days after transplant (DAT) there was statistical difference for leaf height developed in different types and levels of shading. At 7 DAT, T3 (50% red solar spectrum manipulation net) and T2 (50% black shading net), presented height 3.16 and 3.33 cm, respectively and did not differ statistically from each other, but both differed in relation to T1 (full sun) which achieved only 2.50 cm.

In the other hand, at 14 DAT all treatments have differed one to the other and the order from the highest to smallest was T2 with 8.44 cm, T3 with 6.10 cm and T1 with 4.27 cm (Table 1). As we can see the amount of light received in each net type have interfered. The percentage of increment in one week also was bigger in T3 (153.45%), following to T3 (93.04%) and T1 with 70.80% of increment.

Table 1. Leaf height of Imperial® Zoysia grass under different types and levels of shading at 7 and 14 days after transplant (DAT).



Treatments	Leaf height (cm)	
	7 DAT	14 DAT
T1	2.50 b	4.27 c
T2	3.33 a	8.44 a
T3	3.16 a	6.10 b
CV(%)	7.86	4.59

T1: Full sun, T2: 50% black shading net and T3: 50% red solar spectrum manipulation net. Means followed by the same lower case letters in the columns do not differ at 5% of probability level by the Tukey test.

Díez et al. (2017), Taiz et al. (2017) and Leal et al. (2015) reported that there are many factors, which affect plant development such as abiotic ones.

The authors published, although, in this case, light availability and intensity in the cultivation environment may affect plants morphophysiological responses, acting directly in the process of photochemical and biochemical reactions of photosynthesis;

light intensity may damage photosynthetic apparatus.

For them, it may change Ribulose 1.5 bisphosphate carboxylase/oxygen as carboxylation speed and CO_2 assimilation, which may cause formation of photoassimilated substance for plant.

Jaimez et al. (2018) showed that plants create foliar functional strategies related to chlorophyll-*a* fluorescence on photosystem II (PSII), enabling efficient use of light. In this case, for present study, we may try to exemplify this theory as the reduction of luminosity increase the grass height.

Studying the influence of shading in Bermuda grass (*Cynodon dactylon*) growth, Maciel et al. (2011) and Amaral et al. (2016), found similar results in relation to data presented here, where grass had higher heights when subjected to shading.

Another interesting point of view to grass growth is the necessity to have the lawn cut to maintain aesthetic and its objective. Therefore, slower growth is advantageous for not be necessary many cuts and enhance maintenance costs (Amaral et al., 2019). However, it is important to note the colour of grass when submitted to shading. Lawns used to be green and other presented colour may be harmful for this landscape and/or sportive grasses.

Despite of the biggest growth in T2 and T3 (Table 1) for leaf height, when we analysed the radiance index it is possible to note that T1 presented the biggest values for Green component (G), Hue (H) and Dark Green Colour Index (DGCI). T1 achieved 49 value for G differing statistically of T2 (42) and T3 (43). In relation to H the difference among all treatments was bigger, T1 showed 104 °H while T2 and T3 79 °H each one. From a scale of 0 to 1, the DGCI of T1 presented value of 0.71, T2 value of 0.60 and T3 0.59 (Table 2).

Saturation (S) and Brightness (B) have not presented statistical difference among all treatments (Table 2).

Table 2. Analysis of the green component (G), Hue (H), Saturation (S), Brightness (B) and Dark Green Colour Index (LVEF) in Imperial® Zoysia grass under different types and levels of shading at 7 and 14 days after transplant (DAT).

	G^1	H	S	B	$DGCI^1$
		(°H)	(%)	(%)	
T1	49 a	104 a	21 a	38 a	0,71 a
T2	42 b	79 b	15 a	36 a	0,60 b
T3	43 b	79 b	19 a	36 a	0,59 b

CV (%)	3,19	6,55	27,87	3,19	4,47
F	21,50*	19,97**	1,06^{ns}	3,21^{ns}	18,26**

T1: Full sun, T2: 50% black shading net and T3: 50% red solar spectrum manipulation net. [1]Dimensionless. Means followed by the same lower case letters in the columns do not differ at 5% of probability level by the Tukey test.

Backes et al. (2010) and Lima et al. (2012) affirmed that lower the G value more intense the green colour is. However, both cited works also described that using only green light amount is not efficient to quantify the image green colour. For RGB system, each colour tone is defined by three channels (red, green and blue), varying from 0 to 255.

The hue (H) describes colour pigment and it is measured from 0° to 360° (0° red; 60° yellow; 120° green; 180° cyan; 240° blue and 300° magenta). For H component, T2 and T3 presented values close to yellow, which means leaves chloroses caused by the reduction of chlorophyll concentration. One alternative answer is due to higher growth rate (Table 1), which caused reduction in chlorophyll concentration by dilution effect. Oliveira et al. (2017) and Gondim et al. (2018) also published that plant to enabling greater light interception, under shading occasions tend to expand the number and size of leaf limb, corroborating to previous point of view and with results found by this research.

For Dark Green Colour Index (DGCI) we may see statistic difference among treatments (Table 2). As G and H, T1 presented the biggest mean values (0.71) followed by T2 (0.60) and T3 (0.59) being the last two treatments not significate to each other.

According to Rhezali and Lahlali (2017), DGCI value ranged from 0, which means very yellow; to 1, which means dark green. Comparing to H value, and its concept, it is possible to affirm that the shading or spectrum light change (T2 and T3) influenced in leaves coloration turning them yellowish, which is symptom of chlorosis and etiolation.

Many works have been made using DGCI for measure the correlation between dark green and fertilization, manly with nitrogen and phosphorus. Caturegli et al. (2019) found positive correlation when compared the DGCI with doses of nitrogen applied in Bermuda grass as well as EL-Azazy et al. (2018) in *Citrus volkameriana*. Ivasko Júnior et al. (2020) also found greater DGCI when fertilized *Lagerstroemia indica* with greater amount of phosphorus and Nutini et al. (2018) in *Oryza sativa*. However, all replicates of this work were used the same substrate, fertilization, amount of water; the only thing different was levels of luminosity, therefore, we may deduce that light provoked the reduction of DGCI values in T2 and T3, making leaves longer and with diluted chlorophyll content.

For Simões et al. (2019), is extremely important to quantify incident radiation during plant development, in order to evaluate their effects in various physiological functioning processes, in addition, it is possible to establish management practices that enable better use of this resource by species of grass, which contributes to a specific aesthetic expectation.

4 CONCLUSIONS

Shading and changing the light spectrum interfered in the development and reflectance index of Imperial® Zoysia grass leaves.

For Hue component, 50% black shading net and 50% red solar spectrum manipulation net presented values close to yellow, which means leaves chloroses caused by the reduction of chlorophyll concentration.

Dark Green Colour Index value ranged from 0, which means very yellow; to 1, which means dark green. Comparing to Hue value, it is possible to affirm that the shading or spectrum light change influenced in leaves coloration turning them yellowish, which is symptom of chlorosis and etiolation.

ACKNOWLEDGMENTS

Authors acknowledge Izabela Militão Garcia e Mayara Maggi for experiment setup help and Itograss® for grass donation.

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