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Full Length Research Paper

Application of silica to suppress the disease infestation of *Phytium ultimum* and increase growth of Bermudagrass cv Satiri

Hamidah bte Ab Rahim[1]*, Abdul Shukor Juraimi[1], Md. Kamal Uddin[2], Umme Aminun Naher[2] and Md. Amirul Alam[1]

[1]Faculty of Agriculture, University Putra Malaysia, Serdang, Selangor, Malaysia.
[2]Institute of Tropical Agriculture, University Putra Malaysia, Serdang, Selangor, Malaysia.

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An experiment was conducted at glasshouse of Unit Latihan Turf, Taman Pertanian, Universiti Putra Malaysia, to find out the effect of different doses of silica (Si) on growth of Bermuda cv Satiri and to suppress the *Pythium ultimum* disease infestation. Two sources of silica were used in this study: Turf speed® (T. speed), content 15% of potassium silicate (K_2SiO_3) and Tune up®, content 10% Sodium Silicate (SiO_2). Percent disease severity, shoot density, total dry weight, root and shoot dry weight and root-shoot ratio were determined. Application of Turf speed 10 ml L^{-1} produced the highest shoot density (125/25 cm²), shoot dry weight (2.49 g) and total dry weight (4.76 g). Tune up (1.0 ml L^{-1}) and without application of any Si produced the highest disease severity (73.69%) and (69.75%) respectively, while, Tune up (1.0 ml L^{-1}) produced the lowest disease severity (44%). The study proved that application of T. Speed (10 ml L^{-1}) and Tune up 2.0 ml L^{-1} produced good growth, quality and reduced *P. ultimum* infection of Bermuda cv Satiri.

Key words: Bermuda cv Satiri, *Pythium ultimum*, shoot density, relative value, turf quality.

INTRODUCTION

The tropical turf grass variety Satiri is a super dwarf with shorter internodes, fine leaves and darker green color turf. Satiri have ability to survive in heat condition and shade tolerance and also medium salt tolerant (Uddin et al., 2011; Saad and Juraimi, 2007). However, like any other Bermuda grass, cultivar Satiri also prone to disease attack such as Phytium blight, Phytium root rot, brown patch, Fairy ring, Fusarium blight and Curvularia blight (Juraimi, Personal communication).

Pythium ultimum is a fungal pathogen which causes phythium root rot and phythium blight and seriously damage golf courses and lawn ball green. *P. ultimum* complete their life cycle in living and died plant host under high temperature and soil moisture (Turgeon, 2005). Fungicides spray is the most popular and effective method to control fungal disease; however, the use of fungicide will lead to pollution problem and dangerous to golfer and environment. Silica is beneficial element and can be used to increase growth, quality, and suppressing fungal disease of warm and cold season turfgrass. Although it is a typical beneficial element but have positive effects only in some plant species or under specific growth condition (Marschner, 1995). It has been proved that Si has ability to enhance leaves and stem strength, wear tolerance and promoting greater photosynthetic activity in some turfgrass species (Hull, 2004; Saigusa et al., 2000; Schmidt et al., 1999).

Datnoff and Rodrigues (2005) reported that silica has a natural characteristic in thickened the cellulose membrane which form double cuticle layer. The deposition of silicon in the cell walls creates a physical barrier that reduces the ability of fungal hyphae to penetrate into the leaf tissue. The application of Silica is used to reduce fungal disease has been reported on turfgrass (Datnoff

*Corresponding author. E-mail: ashukor@agri.upm.edu.my.

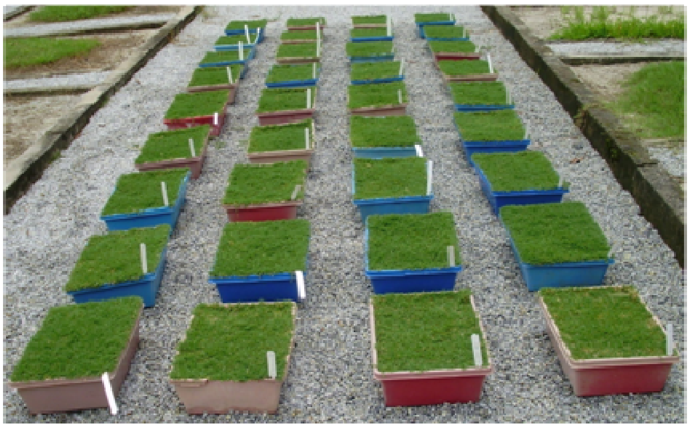

Figure 1. Lay out of the experiment.

and Rodrigues, 2005) such as Bermuda grass (Datnoff and Rutherford, 2004), and St. Augustine grass (Brechtand et al., 2004).

Fungicides spray is the most popular and effective method to control fungal diseases on turfgrass. However, the continuous use of fungicide may lead to environmental pollution and cause health hazard to golf players. The use of silica (Si) can reduce dependency on fungicide for controlling fungal disease of Bermuda Satiri. However, information on the influence of silica in reducing fungal disease of Satiri is unknown. Hence, present study had been conducted to determine the effect of silica (Si) on Bermuda cv Satiri growth, quality and suppressing fungal disease caused by *P. ultimum.*

MATERIALS AND METHODS

Location, planting and inoculation

The experiment was carried out in Unit Latihan Turf, Taman Pertanian, Universiti Putra Malaysia. Satiri stolons were planted in tray (size 37 cm length x 26.5 cm width x 10 cm depths) content soil media with ratio 8 sand: 2 peat (v/v). There were 8 treatments (T) that is, T_1 - Satiri (untreated check), T_2 (Satiri + *P. ultimum),* T_3 (Satiri + Tune up 1ml + *P. ultimum*), T_4 (Satiri + Tune up 1.5 ml Recom.) + *P. ultimum),* T_5 (Satiri + Tune up 2.0 ml + *P. ultimum),* T_6 (Satiri + Turf speed 5.0 ml + *P. ultimum),* T_7 (Satiri + Turf speed 7.5 ml Recom. + *P. ultimum*), T_8 (Satiri + Turf speed 10.0 ml + *P. ultimum*). All of the 24 trays with eight treatments were arranged in Complete Randomize Design (CRD) with four replications (Figure 1).

Three months old Bermuda grass cv Satiri were sprayed with silica solution for 8 weeks using 1 Liter hand sprayer. After that 25 g Corn Meal Agar (CMA) contain *P. ultimum* spore was injected in the root zone of Bermuda grass cv Satiri at the evening. Watering was done 3 times per day during establishment and 2 times per day at mature stage using automated sprinkler system. Exact, 4.0 g of NPK Green fertilizer was applied in each tray for every 2 weeks with broadcasting technique. Grass cutter (Isio ®) was used to cut the grass once a day with the cutting high of 3 mm to follow the standard cutting high for golf green. Clipping were removed from the site to prevent the accumulation of thatch.

Shoot density

Turf grass density was measured according to the number of shoots in 25 cm^2 quadrate. The quadrate was placed randomly at three locations in each tray. The average of the density collected in each tray was recorded.

Total dry weight and shoot and root dry weight

Total dry weight, shoot and root dry weight of the turf was measured by harvesting them using 25 cm^2 quadrate. Shoot and root were separated by cutting them at the soil surface. Each portion was washed carefully and the sample then dried in forced air oven at 60℃ for 72 h. The dry weight was recorded.

Root to shoot ratio

Root to shoot ratio is the ratio of root dry weight to shoot dry weight. Root is the portion under soil surface while shoot comprising of the leaves on soil surface.

$$Root\ shoot\ ratio = \frac{Root\ dry\ weight}{Shoot\ dry\ weight} X\ 100$$

Percentage of disease incident

Disease rating scale developed by Horsfall and Barratt (1945) was used in this study but with a slight modification. There are four level of fungal infection were observed in this experiment by visual observation. The reaction level was rated on a scale of 0 to 4, where 0 = no infection, 1 = infected at bottom part of grass, 2 = half part of grass infected, 3 = three quarter of grass infected, 4= grass is died. A type "0" infection was considered as an immune host reaction, types 1 and 2 as resistant reactions, and types 3 and 4 as susceptible reactions. The percentage of disease severity was measured base on the number of grass and shoot affected according to the total number of grass shoot in 25 cm^2 quadrate. The quadrate was placed randomly at three locations in each tray. The average of disease severity collected in each tray was record. The equation to calculated percentage is:

$$Disease severity(\%) = \frac{\sum (0\,x\,a)+(1\,x\,b)+(2\,x\,c)+(3\,x\,d)+(4\,x\,e)}{a+b+c+d+e}\ X\ \frac{100}{higher\ scale}$$

Where 0, 1, 2, 3, 4 are the level of scale while a, b, c, d, e are the number of grass shoot that was infected.

Statistical analyses

Data obtained were analyzed using Analysis of Variance (ANOVA) and Least Significant Difference (LSD). SAS program (SAS, 2004) was used in this analysis.

RESULT AND DISCUSSION

Shoot density

Significant differences were found in shoot density among the treatments (Table 1). T_8, which applied with Turf speed 10.0 ml L^{-1} produced the highest shoot density (125 / 25 cm²), while, Si untreated treatment produced

Table 1. Effect of various treatments on shoot density in Bermuda cv Satiri (25 cm²).

Treatment	Shoot density	Relative value compare to T_1 (%)	Relative value compare to T_2 (%)
T_1, Satiri (control check)	101 c	100	147
T_2, Satiri + *P. ultimum*	69 e	68	100
T_3, Satiri + *P. ultimum* + Tune up (1.0 ml L^{-1})	96 c	95	139.6
T_4, Satiri + *P. ultimum* + Tune up (1.5 ml L^{-1})	110 b	108.5	159.6
T_5, Satiri + *P. ultimum* + Tune up (2.0 ml L^{-1})	114 b	112.8	165.9
T_6, Satiri + *P. ultimum* + T. speed (5.0 ml L^{-1})	84 d	83.4	122.8
T_7, Satiri + *P. ultimum* + T. speed (7.5 ml L^{-1})	111 b	110.1	161.9
T_8, Satiri + *P. ultimum* + T. speed (10 ml L^{-1})	125 a	123.8	182.2

Means with the different letter are significantly different ($p < 0.05$) in Least. Significant Difference (LSD) Test.

Table 2. Effect of various treatments on shoot dry weight in Bermuda cv Satiri (g / 25 cm²).

Treatment	Shoot dry weight (g)	Relative value compare to T_1 (%)	Relative value compare to T_2 (%)
T_1, Satiri (control check)	2.55 a	100.00	139.44
T_2, Satiri + *P. ultimum*	1.83 d	71.71	100.00
T_3, Satiri + *P. ultimum* + Tune up (1.0 ml L^{-1})	1.94 d	76.11	106.13
T_4, Satiri + *P. ultimum* + Tune up (1.5 ml L^{-1})	2.33 bc	91.29	127.30
T_5, Satiri + *P. ultimum* + Tune up (2.0 ml L^{-1})	2.28 c	89.33	124.56
T_6, Satiri + *P. ultimum* + T. speed (5.0 ml L^{-1})	1.93 d	75.79	105.69
T_7, Satiri + *P. ultimum* + T. speed (7.5 ml L^{-1})	2.18 c	85.64	119.42
T_8, Satiri + *P. ultimum* + T. speed (10 ml L^{-1})	2.49 ab	97.69	136.22

Means with the different letter are significantly different ($p < 0.05$) in Least. Significant Difference (LSD) Test.

Table 3. Effect of various treatments on root dry weight in Bermuda cv Satiri (g / 25 cm²).

Treatment	Root dry weight (g)	Relative value compare to T_1 (%)	Relative value compare to T_2 (%)
T_1, Satiri (control check)	2.30abc	100.00	146.52
T_2, Satiri + *P. ultimum*	1.57 e	68.25	100.00
T_3, Satiri + *P. ultimum* + Tune up (1.0 ml L^{-1})	1.78 d	77.20	113.12
T_4, Satiri + *P. ultimum* + Tune up (1.5 ml L^{-1})	2.39 ab	103.58	151.77
T_5, Satiri + *P. ultimum* + Tune up (2.0 ml L^{-1})	2.43 a	105.39	154.40
T_6, Satiri + *P. ultimum* + T. speed (5.0 ml L^{-1})	2.16 c	93.76	137.37
T_7, Satiri + *P. ultimum* + T. speed (7.5 ml L^{-1})	2.23 bc	96.65	141.60
T_8, Satiri + *P. ultimum* + T. speed (10 ml L^{-1})	2.27 abc	98.73	144.66

Means with the different letter are significantly different ($p < 0.05$) in Least Significant Difference (LSD) Test.

the lowest shoot density (69 / 25 cm²). However, regardless the source of all treatments produced more shoot density (in percentage) compare to Si untreated treatment. Higher shoots density proved that Si enhanced turfgrass growth very well and high in quality especially for golf green purposes. There were several mechanisms involved in turfgrass growth enhancement by application of Si including, improve quality, color, density, disease and growth resistant under stress condition. Datnoff (2005) found Si fertilization improved turfgrass quality, color and density by 19, 13.6, and 8.5 %, respectively compared to control treatment. Silica increased shoot density by promoting photosynthetic activity and increase chlorophyll content in plants (Schmidt et al., 1999). Application of 10 ml L^{-1} of Turf speed (K_2SiO_3) significantly increased Satiri shoot density.

Shoot and root dry weight

Significant differences in shoot and root dry weights among the treatments were observed (Tables 2 and 3). T_1

Table 4. Effect of various treatments on total dry weight in Bermuda cv Satiri (g / 25 cm²).

Treatment	Total dry weight (g)	Relative value compare to T_1 (%)	Relative value compare to T_2 (%)
T_1, Satiri (control check)	4.85 a	100.00	142.70
T_2, Satiri + *P. ultimum*	3.40 e	70.08	100.00
T_3, Satiri + *P. ultimum* + Tune up (1.0 ml L^{-1})	3.72 d	76.63	109.35
T_4, Satiri + *P. ultimum* + Tune up (1.5 ml L^{-1})	4.71 a	97.12	138.59
T_5, Satiri + *P. ultimum* + Tune up (2.0 ml L^{-1})	4.70 a	96.96	138.36
T_6, Satiri + *P. ultimum* + T. speed (5.0 ml L^{-1})	4.09 c	84.33	120.34
T_7, Satiri + *P. ultimum* + T. speed (7.5 ml L^{-1})	4.41 b	90.86	129.66
T_8, Satiri + *P. ultimum* + T. speed (10 ml L^{-1})	4.76 a	98.18	140.10

Means with the different letter are significantly different ($p < 0.05$) in Least. Significant Difference (LSD) Test.

Table 5. Effect of various treatments root - shoot ratio in Bermuda cv Satiri (g / 25 cm^2).

Treatment	Root – shoot ratio	Relative value compare to T_1 (%)	Relative value compare to T_2 (%)
T_1, Satiri (control check)	90.45 c	100.00	104.82
T_2, Satiri + *P. ultimum*	86.29 c	95.40	100.00
T_3, Satiri + *P. ultimum* + Tune up (1.0 ml L^{-1})	91.62 bc	101.29	106.17
T_4, Satiri + *P. ultimum* + Tune up (1.5 ml L^{-1})	103.32 ab	114.23	119.73
T_5, Satiri + *P. ultimum* + Tune up (2.0 ml L^{-1})	106.52 a	117.77	123.44
T_6, Satiri + *P. ultimum* + T. speed (5.0 ml L^{-1})	111.73 a	123.52	129.47
T_7, Satiri + *P. ultimum* + T. speed (7.5 ml L^{-1})	102.68 ab	135.16	118.98
T_8, Satiri + *P. ultimum* + T. speed (10 ml L^{-1})	91.42b c	101.07	105.94

Means with the different letter are significantly different ($p < 0.05$) in Least Significant Difference (LSD) Test.

(control check) produced the highest shoot dry weight (2.55 g / 25 cm²) but there was no significant different found between T_1 (control check) and T_8 (Tune speed 10 ml L^{-1}) while, T_2 (Satiri + *P. ultimum*) produced the lowest shoot dry weight (1.83 g / 25 cm²). However, contrast, all treatments produce more shoot dry weight (in percentage) compare to T_2 (Satiri + *P. ultimum*) treatments.

Application of Tune up either 2.0 or 1.5 ml L^{-1} produced the highest root dry weight followed by Tune speed 10 and 7.5 ml L^{-1}. Whereas, T_2 (Satiri + *P. ultimum*) produced the lowest root dry weight (1.57 g / 25 cm²) and all treatments produced more root dry weight (in percentage) compare to this treatments which indicated beneficial effect of Si. Application of Si increased newly-generated roots and root length. Datnoff (2005) reported an increase in 0.8 to 1 cm of root length in comparison to non-fertilized control.

Total dry weight

Total dry weight differs among the treatments (Table 4). Significant higher amount of total dry weight obtained in control check (T_1), inoculated Tune speed 10 ml L^{-1} (T_8), Tune up 1.5 (T_4) and 2.0 ml L^{-1} (T_5) treatments. While, without application of Si, *Pythium* inoculated treatment (T_2) produced the lowest total dry weight (3.40 g / 25 cm²). Dry weight of Bermudagrass cv Satiri comprises of shoot and root dry weight. Ma and Takahashi, (2002) reported that Si accumulate in the tops to levels up to 10% of shoot dry weight. This experiment showed that T_8, T_4, T_5 were the best silica treatments that increased total dry weight and T_5 was the best silica treatment that increase root dry weight while, T_8 was increased shoot dry weight.

Root - shoot ratio

There were significant differences in root shoot ratio among the treatments (Table 5). T_6 produced the highest root shoot ratio (111.73/25 cm²) but there were no significant different found among T_6, T_5, T_4 and T_7 while T_2 (Satiri + *P. ultimum*) produced the lowest root-shoot ratio. Except T_2 (Satiri + *P. ultimum*), all treatments produced more root shoot ratio over control check. All of the treatments produced more root shoot ratio (in percentage) compare to T_2 (Satiri + *P. ultimum*). In terms of the silica source, it proved that Tune up (20 ml L^{-1}) was the best treatment that increased Satiri root - shoot ratio.

Disease severity (%)

Application of Si increased disease resistant of the turfgrass species Satiri (Figure 2). The increased root-

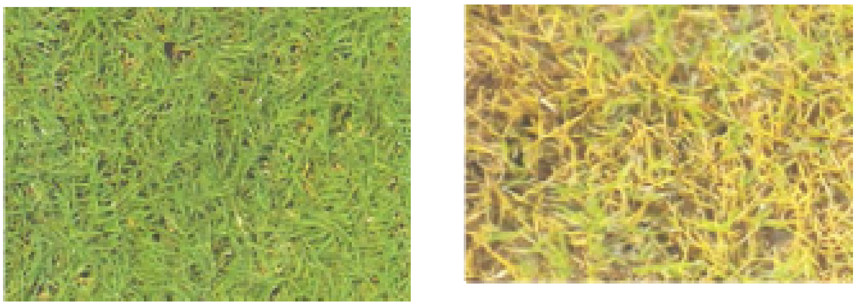

Figure 2. Bermudagrass cv Satiri was infected by *Phytium ultimum.*

Table 6. Effect of various treatments on disease severity in Bermuda cv Satiri (%) in 25 cm².

Treatment	Diseases severity (%)	Relative value compare to T_1 (%)	Relative value compare to T_2 (%)
T_1, Satiri (control check)	0 d	0	0
T_2, Satiri + *P. ultimum*	69.75 a	-	100.00
T_3, Satiri + *P. ultimum* + Tune up (1.0 ml L^{-1})	73.69 a	-	105.65
T_4, Satiri + *P.ultimum* + Tune up (1.5 ml L^{-1})	51.33 bc	-	73.58
T_5, Satiri + *P. ultimum* + Tune up (2.0 ml L^{-1})	43.08 c	-	61.77
T_6, Satiri + *P. ultimum* + T. speed (5.0 ml L^{-1})	54.75 b	-	78.50
T_7, Satiri + *P. ultimum* + T. speed (7.5 ml L^{-1})	50.50 bc	-	72.40
T_8, Satiri + *P. ultimum* + T. speed (10 ml L^{-1})	44.00 c	-	63.08

Means with the different letter are significantly different ($p < 0.05$) in Least Significant Difference (LSD).

shoot dry weight, ration and plant biomass of *Pythium* inoculated treatments proved silica resisted Pythium infestation (Table 6). T_3 and T_2 (Satiri + *P. ultimum*) produced the highest disease severity (73.69%) and (69.75%) while T_8 and T_5 produced the lowest disease severity (44%) and (43.08%). Except T_3, all treatments produced less disease severity (in percentage) compare to T_2 (Satiri + *Pultimum*). According Datnoff (2005), silica increased plant resistance from fungi infection by increasing the thickened of cell membrane (Hodson et al., 1998) and cell wall of plant epidermal cells (Datnoff and Rodregues, 2005). This experiment proved that T_5 and T_8 were the best silica treatments that reduced disease severity.

CONCLUSION

Application of silica at different rates and sources influenced the growth and quality of Satiri and reduced Pythim disease infestation. The growth and quality in term of shoot density, root dry weight, shoot dry weight, total dry weight, root shoot ratio, and disease severity showed a significant different when treated with various silica treatments. Based on this parameter, T_8 (Satiri + *P. ultimum* + T. speed 10 ml L^{-1}) and T_5 (Satiri + *P. ultimum* + Tune up 2.0 ml L^{-1}) produced good growth and quality (shoot density, total dry weight, root and shoot dry weight, root-shoot ratio) and in reducing *P. ultimum* infection on Bermuda cv Satiri.

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