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Improving quality of Bermuda Grass (*Cynodondactylon* var. *Evergreen*) by adding of bentonite to growing media and proper irrigation frequency

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Abstract: Generally sand is used as root zone of turf grass in golf course. High permeability of sand caused irrigation inefficient. This research was conducted to find the effect of addition of bentonite and frequency of irrigation to improve qualities of Bermuda grass (*Cynodondactylon* var *evergreen*). Experiments using factorial completely randomized design with two treatment factors with 3 replications. The first factor was the addition of bentonite 25 mesh which consisted of three levels i.e. 100% sand, 87.5% sand + 12.5% bentonite, and 75% sand + 25% bentonite. The second factor was the frequency of irrigation which consisted of three levels i.e. every day, every two days, every three days. Results of research showed interaction of media mix and the irrigation frequency was significantly affected all variable of grass qualities. Mix of sand 87.5% + bentonite 12.5% with watering of once every two days produced the best visual quality, and functional quality at the height of grass, clipping dry weight, shoot dry weight, as well as on the efficiency of irrigation water use (EIWU). It is recommended to use mix of sand 87.5% + bentonite 12.5 % with every two days watering that generally produced the best qualities and spends water consumption.

Keywords: bentonite, Bermuda Grass, functional quality, irrigation, visual quality,

1. Introduction

The game of golf will be interesting and fun if it is backed by a good quality of turf grass. The quality of grass is divided into two aspects, namely visual quality and functional quality [1]. Visual quality consists of density, texture, color uniformity, presence of particles on the surface, and grass type purity. While the functional quality consists of grass height, shoot dry weight, root dry weight, root length, and grass elasticity.

One important factor in the growth of grass is the availability of water and nutrients that must be available in sufficient quantities. This is because the golf course root zone is based on sand, so it has a low water and nutritional retention capacity. One thing that can be done to maintain the availability of water and nutrient is to modify the root zone. The advantage of modification of sand media has reported. Pre plant incorporation of granular subtances aided root development [2], while addition of

biochar improved water retention and increased overall plant growth [3].Bentonite is a rock with very fine grains and contains a lot of silicate clay minerals. The silicate clay mineral in bentonite is dominated by montmorillonite, a clay mineral formed from the basic components of silicon-oxygen tetrahedron and aluminum octahedron [4]. High clay mineral content in bentonite is expected to reduce the level of sand media permeability so that the water content and nutrients needed by the grass will be fulfil.

Irrigation arrangement is one of the important management of grass. Turf typically requires 1 to 1.5 inches of water per week for normal treatment conditions [5]. To maintain the quality of crops managed in large areas such as golf courses, irrigation can be a factor that can increase production costs. Improper irrigation arrangements may affect the visual and functional quality of turf grass. In addition, by determining the exact frequency of irrigation, it can reduce the cost of management without reducing the growth and quality of turf grass. Besides proper quantity of watering will ensure good water conservation which important for sustainable golf management. This study aims to find out the best combination of bentonite and sand mixture media and frequency of irrigation to the visual and functional quality of the Bermuda grass (*Cynodondactylon* var evergreen).

2. Research Method

Experiment was conducted in green house of experimental farm of Bogor Agricultural University Darmaga Campus from April to July 2015. Experiments using factorial completely randomized design with two treatment factors with 3 replications. The first factor was the addition of bentonite to sand which consisted of three levels i.e. B0 (100% sand), B1 (87.5% sand + 12.5% bentonite), and B2 (75% sand + 25% bentonite). Size of bentonite particle used in this experiment was 25 mesh). The second factor was the frequency of irrigation which consisted of three levels i.e. A1 (once every day), A2 (once every two days), and A3 (once every three days) with a volume of 400 ml/basin. Hence there were 27 experiment units such as B0A1 (treatment of 100% sand + once every day irrigation) and B1A3 (treatment of mix 87.5% sand and 12.5 % bentonite) + once every 3 days irrigation). Data were analyzed by Anovatest, if the results is significant than analyzed by *Duncan Multiple Range Test* (DMRT).

Bermuda grass (*Cynodondactylon* var evergreen) was propagated by stolon and cultivated in the basin with size 40 cm diameter, and 25 cm height. Growing media consisted of 5 cm gravel in the base of basin, and treatment media above the gravel. After planting the stolon, irrigation was done every day with 400 ml/basin until 2 weeks after planting (WAP), after that irrigation was done according to treatments of irrigation frequency.

Initial fertilizer 10 gram Nitrogen/m^2 or 3.73 gram/basin of NPK (15-15-15) was added in 3 WAP based on previous experiment .After that, fertilizer 3.73 gram NPK/basin were added every two weeks until 11 WAP. That fertilizer was dissolved in water than pour to growing media. Insect (*Spodopteraexigua*) and weeds (*Cyperusrotundus*) which appeared were manually removed.

Respond of turf to treatment was evaluated by observation of visual and functional qualities of turf. Besides, physical character of growing media were also analyzed including bulk density, porosity and permeability. Visual qualities were observed including grass coverage, height, shoots density and color. Color was measured using Munsell Color Chart for Plant Tissue. Functional qualities were observed including clipping dry weight in 7-12 WAP, than canopy dry weight, root length, root dry weight in the end of experiment. Shoot density, clipping dry weight were observed based on 10cm x 10cm square sampling area. Root, shoot and leaves dry weight were measured after 48 hours draying in 80^oC oven.

3. Research Results and Discussion

3.1. Physical Characteristic of Media

Result of experiment showed treatment was significantly influenced bulk density, porosity and permeability of media. The highest (1.45 gram/cm^3) bulk density was found in B2A1 treatment and the

lowest one (1.22 gram/m^3) was in B0A3 treatment. Generally media of 100% sand has lower bulk density. Than the higher bentonite portion, the higher value of bulk density. Based on USGA [6], good bulk density for root zone is 1.4 cm/m^3, but 1.20-1.6 cm/m^3 is suitable range for root zone.

The highest value of media porosity (53.9%) was found in treatment of B0A3 and the lowest value (46.6%) is obtained in B1A1 treatment. Generally whatever of mixture media with irrigation frequency once every day showed the lowest porosity, and frequency once every 3 days showed the highest porosity.

As the same as porosity trend, the fastest value of permeability was obtained in treatment of B0A3, and the slowest value was obtained in B2A1. Generally value of permeability tend to decrease when portion of sand decrease and frequency of watering decreased. Based on US Soil Conservation Services, treatments in this research indicate permeability values were 9.05-12.18 cm/jam which categorized as moderately fast permeability.

Table 1. Interaction of media mixture and irrigation frequency treatment to physical Characteristic of Media

Treatment	Bulk density gram/cm^3	Porosity (%)	Permeability (cm/jam)
B0A1	1.42de	46.7b	9.12ab
B0A2	1.33bc	49.7f	10.72e
B0A3	1.22a	53.9i	12.18g
B1A1	1.4de	46.5a	9.17b
B1A2	1.37cd	49.0e	10.12c
B1A3	1.29b	52.1g	12.07g
B2A1	1.45e	47.3c	9.05a
B2A2	1.39de	48.7d	10.33d
B2A3	1.3b	52.4h	11.85f

3.2. Visual qualities of grass

3.2.1. Grass coverage

The result of the research shows that there is a significant interaction between planting media and irrigation frequency at grass coverage from 3-10 weeks after planting (WAP). Treatment of 75% sand and 25% bentonite with frequency once every 3 days showed the best results from 9-10 WAP compared to other irrigation frequencies. However on 7-10 WAP, treatment of 100% sand with watering frequency once every day was not significantly different from the treatment of sand 75% + 25% bentonite. In other words watering more efficiently done every two days with a mixture of media 75% sand + 25% bentonite.

Table 2. Interaction of media mixture and irrigation frequency treatment to grass coverage

Treatment		Week rd							
Media	Watering Frequency	3	4	5	6	7	8	9	10
B0	A1	58.87bc	76.13h	78.94f	80.88e	82.98e	87.17e	94.43e	100d
	A2	57.80ab	67.77d	75.84e	78.62d	80.90d	86.02d	92.30d	97.63c
	A3	60.93d	66.17c	68.41b	70.88a	73.87a	77.07a	81.13a	89.53a
B1	A1	59.10c	72.16e	81.75g	84.85g	87.36g	91.20g	96.90f	100d
	A2	62.77e	72.17e	82.75h	83.84f	86.07f	89.07f	93.50de	99.33d
	A3	59.10c	64.97b	70.15c	75.80c	78.17c	81.00c	84.83b	92.80b
B2	A1	64.83f	75.00g	85.68i	86.75h	88.53h	93.90h	98.53g	100d
	A2	63.53e	73.77f	72.71d	78.41d	82.47e	87.47e	94.53e	99.47d
	A3	58.17a	62.43a	67.14a	72.66b	76.03b	79.03b	86.13c	93.40b

Notes: Values which followed by the same character in the same column indicate no significant difference by Duncan Multiple Range Test in alfa 5%.

3.2.2. Grass Height

At the end of study, the lowest grass height was obtained on 100% sand media treatment (B0). At 7 - 12 WAP, daily irrigation frequency treatment (W1) indicated the best results on grass height. At 11-12 WAP, treatments W1 and W2 was not significantly different. This shows that daily irrigation becomes inefficient because it produces the same grass height as on W2. The significant interaction occurred between plant media and irrigation frequency treatment at 7-12 WAP. At 8 - 12 WAP, the highest grass height was obtained on the mixture of sand 87.5% + bentonite 12.5% with irrigation frequency every two days (B1A2). At 12 WAP, the lowest result was obtained at B0A3 treatment. This indicates that the grass height is not maximal if done under less water conditions with sand medium.

Table 3. Effect of media and irrigation frequency treatment to grass height

Treatment	Week after planting					
	7	8	9	10	11	12
Media						
B0	4.14a	3.83a	3.06a	2.88a	2.73a	2.27a
B1	3.92a	3.91a	3.50b	3.27b	3.00a	2.66b
B2	3.80a	3.99a	3.39b	3.14b	2.91b	2.59b
Irrigation frequency						
A1	4.24b	4.10a	3.81b	3.61c	3.33b	2.92b
A2	4.12b	3.86a	3.64b	3.36b	3.24b	2.84b
A3	3.50a	3.78a	2.50a	2.32a	2.07a	1.74a

Table 4. Effct of interaction of media mixture and irrigation frequency treatment to grass height

Treatment		Week after planting							
Media	Irrigation frequency	3	4	5	6	7	8	9	10
B0	A1	58.87bc	76.13h	78.94f	80.88e	82.98e	87.17e	94.43e	100d
	A2	57.80ab	67.77d	75.84e	78.62d	80.90d	86.02d	92.30d	97.63c
	A3	60.93d	66.17c	68.41b	70.88a	73.87a	77.07a	81.13a	89.53a
B1	A1	59.10c	72.16e	81.75g	84.85g	87.36g	91.20g	96.90f	100d
	A2	62.77e	72.17e	82.75h	83.84f	86.07f	89.07f	93.50d e	99.33d
	A3	59.10c	64.97b	70.15c	75.80c	78.17c	81.00c	84.83b	92.80b
B2	A1	64.83f	75.00g	85.68i	86.75h	88.53h	93.90h	98.53g	100d
A2		63.53e	73.77f	72.71d	78.41d	82.47e	87.47e	94.53e	99.47d
A3		58.17a	62.43a	67.14a	72.66b	76.03b	79.03b	86.13c	93.40b

3.2.3. Shoot density

The significant interaction occurred between the combination media and the frequency of irrigation at 7 - 12 WAP on shoot density (table 5). All treatment combinations increased shoot density up to 12 WAP. At 7 WAP, the lowest shoot density was obtained by B0A3 treatment, while the highest result was obtained by B2A1 treatment at 7 - 12 WAP. However on 11-12 WAP, treatment of B2A1 was not significantly different from B2A2. This shows that irrigation every two days is more efficient to produce high shoot density.

Based on shoot grade density criteria [6], at 10 WAP the treatment of sand 87.5% + bentonite 12.5% 25 mesh and treatment of sand 75% + bentonite 25% with daily and every two days irrigation frequency produced the shoots which including in the medium density class. While at 12 MST, 100% sand with three-day irrigation frequency (B0A3) and mixed sand media treatment 87.5% + 25% mesh

bentonite with three-day irrigation frequency (B1A3) produced shoos which including in low density class.

Table 5. Effect of interaction of media mixture and irrigation frequency treatment to shoot density

Treatment		Week-					
Media	Irrigation	7	8	9	10	11	12
B0	A1	74.00cd	80.00b	87.67c	92.33c	114.00cd	121.67c
	A2	71.67bc	79.67b	85.00bc	94.33c	110.67c	120.33c
	A3		70.67a	79.33a	81.00a	85.00a	91.33a
B1	A1	78.00de	85.33c	92.67d	100.67d	120.00e	125.33cd
	A2	77.67d	84.67c	87.67c	101.67d	117.00de	124.67cd
	A3	70.03bc	77.67b	82.67ab	85.00ab	88.00ab	94.67a
B2	A1	82.33e	91.33d	98.00e	112.67e	120.67e	129.33d
	A2	74.33d	77.67b	86.33bc	104.67d	122.00e	128.33d
	A3	67.67ab	73.33a	79.33a	86.33b	90.33b	103.67b

3.2.4. Color

At 7-12 WAP, in general the lowest color score was obtained at the treatment of planting medium with daily irrigation frequency (B0A1, B1A1, B2A1 (table 6) .The highest color score was obtained at the treatment of planting media with irrigation frequency every two days (B0A2, B1A2, B2A2), whereas treatment with three-day irrigation frequencies produced a higher color score than the frequency of each day. This indicates that irrigation frequency greatly affects the quality of the grass color. The more frequent the frequency of irrigation, the decreasing the quality of the grass color. In this study, intermediate frequency of irrigation (every two days), could improve the quality of grass color.

Table 6. Interaction of plant media and irrigation frequency to leaf color (Munsell Color Chart)

Treatment		**Week rd-**					
Media	Irrigation Frequency	7	8	9	10	11	12
	A1	3.33a	3.33a	3.67a	4.00a	4.00a	3.33a
B0	A2	4.00bc	4.00ab	4.33ab	4.67ab	4.33ab	5.00cd
	A3	4.00bc	4.00ab	4.00ab	4.00a	4.00a	5.00cd
	A1	3.67ab	3.33a	3.67a	4.33ab	4.00a	4.00ab
B1	A2	4.00bc	4.67b	4.67b	5.00b	5.00bc	5.33cde
	A3	4.00bc	4.33b	4.33ab	4.33ab	4.33ab	5.33cde
	A1	4.33b	4.00ab	4.00ab	4.33ab	4.67abc	4.67bc
B2	A2	4.67c	4.67b	4.67b	5.00b	5.33c	6.00e
	A3	4.00bc	4.33b	4.33ab	4.67ab	4.67abc	5.67de

Notes: The numbers followed by the same letter in the same column show results that are not significantly different according to the DMRT test at the 5% level.
B0: sand 100%
B1: mixture of sand 87,5% + bentonite 12,5% 25 mesh
B2: mixture of sand 75% + bentonite 25% 25 mesh
A1: Irrigation frequency everyday
A2: Irrigation frequency every two days
A3: Irrigation frequency every three days

At 7-12 WAP, the highest color score was obtained at combination of sand 75% + bentonite 25% 25 mesh with every 2 days of irrigation frequency (B2A2), while the lowest score was obtain at

medium of sand 100%. This suggests that a mixture of sand with bentonite can improve grass color quality. The higher the bentonite mix, the higher the quality of the grass color.

3.3. Functional Qualities

3.3.1. Clipping dry weight

The best combination of mixed plant media treatment with irrigation frequency to dry weight of clipping occurred at 9 WAP, i.e. combination of B1A2 (mixture of sand 75% + 25% 25 mesh bentonite with irrigation frequency every other day). At the end of the study, the lowest weight was obtained by B0A3 (100% sand with every three-day irrigation frequency), while the highest weight was obtained by B1A2 (mixture of sand 87.5% + bentonite 12.5% 25 mesh with irrigation frequency every 3 days).

Combination of treatment of bentonite media with irrigation frequency greatly influence dry weight of clipping. The weight results show that watering is not necessary every day, because watering every two days is more efficient and effective in producing the best dry clipping weights.

3.3.2.. Crown dry weight

The real interaction takes place between the combination of mixed media treatment and the irrigation frequency to the crown dry weight. The lowest weight was obtained by a combination of 100% sand with irrigation frequency every three days (B0A3). While the highest result was obtained in combination of mixed of sand 87,5% + bentonite 12,5% 25 mesh with irrigation frequency every two days (B1A2).

In general, the combination treatment of irrigation frequency with 100% sand media produced the lowest crown dry weight. This suggests that the bentonite mixture is preferable in producing canopy dry weights. In addition, the combination of mixed plant media with irrigation frequency every three days, produced the lowest weight. The density of shoots and grass height is thought to affect the dry weight of the crown. It shows that water shortages can inhibit metabolism, so that less nutrients can be absorbed and transported in grass canopy.

3.3.3. Root Dry Weight

At the end of the study, there was a significant interaction between the combinations of mixed plant media with irrigation frequency to root dry weight.

Combination of mixed plant media treatment with daily irrigation frequency resulted in lowest root dry weight. However, the same result is obtained by a combination of irrigation frequencies once every 3 days with 100% sand and a mixture of sand of 87.5% + bentonite 12.5% (B0A2 and B1A2).

The highest root dry weight result was obtained by B2A3 treatment (mixture of sand 75% + 25% bentonite). In general, the combination of mixed plant media treatment with irrigation frequency every three days resulted in the highest root dry weight. This shows that in the condition of water shortage, the grassroots grew longer to find the water needs in the planting medium.

The canopy dry weight ratio with roots shows the proportion of transported nutrient distribution. The weight ratio will be greater if the root dry weight is smaller, and vice versa. In this study, more nutrients are transported to canopy than root. The highest weighted ratio was produced by combination of B0A1 treatment (100% sand with daily irrigation frequency), while the lowest weight ratio was produced by B2A3 (75% sand + 25% bentonite). In general, the combination of media treatment with irrigation frequency each day produced the highest weight ratio, while the combination of media with every three days irrigation frequency resulted in the lowest weight ratio.

3.3.4. Root Length

The significant interaction occurs between the combination treatment of planting medium and the irrigation frequency to the root length. The shortest root was obtained at B0A1 treatment (100% sand medium with irrigation frequency every day). In general, the combination of irrigation frequency treatment with 75% sand + 25% bentonite mixture resulted in longer roots than 100% sand treatment and 87.5% sand + 12.5% bentonite. This suggests that more bentonite blends can increase the length of the roots.

The longest root is produced at B2A3 treatment (75% sand + 25% bentonite mixture). It is not advisable to administer too frequent water, as this may cause grass to form roots just near the surface of the soil [7]. If the soil is made slightly dry, it forces the grass to grow deeper roots. The deeper roots are stronger in grasping the growing media, so the grass is not easily uprooted when a golf ball be beat.

3.3.5. Efficiency of Irrigation Water Use (EIWU)

Significant interaction occurs between mixture of planting media and irrigation frequency on efficiency of irrigation water use (Table 2). Observation of efficiency of irrigation water usage based on dry weight of plant can be seen in EIWU column. EIWU based on plant dry weight is also called the total dry weight ratio (DW) / irrigation volume. Total DW Ratio / Irrigation Vol, shows the amount of irrigation water used to produce the dry weight of the plant. A good ratio is the ratio the greater it is. A large ratio shows more efficient use of water in the formation of dry weights.

Table 7. Interaction beetween mixture planting media with irrigation frequency to Total Dry Weight

Treatment		Total dry weight (gram/sample)	Total irrigation volume (ml/sample)	**EIWU** (gram/ml)
Media	Irrigation frequency			
B0	A1	1.99	552.72	0.0036a
	A2	2.03	276.36	0.0073d
	A3	1.35	184.24	0.0073d
B1	A1	2.13	552.72	0.0038b
	A2	2.29	276.36	0.0083g
	A3	1.38	184.24	0.0075e
B2	A1	2.28	552.72	0.0041c
	A2	2.17	276.36	0.0078f

Description: Notes: The numbers followed by the same letter in the same column show results that are not significantly different according to the DMRT test at the 5% level.
B0: sand medium 100%
B1: mixed sand media 87.5% + bentonite 12.5%
B2: mixed sand media 75% + 25% bentonite
A1: irrigation frequency every day
A2: irrigation frequency every two days
A3: irrigation frequency every three days

The lowest water efficiency was obtained in B0A1 treatment (100% sand with daily irrigation), while the highest value was obtained in B1A2 treatment (87.5% sand + 12.5% bentonite with irrigation frequency once every two day). In general, the combination of media with irrigation every two days can produce the highest dry weight ratio every 1 ml of water. This shows that water usage for irrigation every two days is more efficient and effective than every day or every three days.

4. Conclusion

Based on the result, the treatment of planting medium with irrigation frequency gives significant effect to all observation variables. In general, mixed of sand with bentonite media produce better visual and functional quality of grass than without bentonite media. Every two days of irrigation frequency treatment, resulting in better grass quality compared to every days irrigation frequencies and three day irrigation frequencies. In general, the frequency of irrigation every two days applied to the mixture of sand media of 87.5% + 12.5% bentonite give the best visual and functional quality of grass.

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