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Research Article

Growth of Two Native Zoysiagrasses Collected from Sea Side and Mountain Area in Indonesia on Growing Media Composed of Sand and Clay

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Abstract

Zoysiagrass (*Zoysia* spp.) exists spotly in Indonesia and it has potential to be used in parks, golf courses, and football fields. Many football fields and golf course fairways use sand as top soil over native soil. This study aims to analyze growth and quality of two native zoysiagrasses Zis and Zim. Zis is a native zoysiagrass collected in sea-side and Zim is a native zoysiagrass collected in mountain area. Both types of zoysiagrasses were planted at field with altitude of 300 m with various growing media mixes of sand and reservoir's sediment. Thickness of the growing medium was 10 cm over an alfisol clay soil. Experimental plots were constructed using factorial completely randomized design with two native zoysiagrasses and 5 types of growing media. Two ecotypes of native zoysiagrasses showed different in growth habits combined with mixtures of growth media. Zim showed higher growing speed including more vigor with uniformity and texture than Zis. There were not significanthly differences on leaf color and root length between two ecotypes of native zoysiagrasses collected in Indonesia.

Keywords: Ecotype, Indonesia, Native zoysiagrass, Soil medium, Turfgrass quality

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INTRODUCTION

Zoysiagrasses (*Zoysia* spp.) breeding effort for industrial purposes has been minimal in Indonesia. Demand of proper turfgrass for recreational places and sports facilities such as golf and football courts has been increased. There need to be an effort to initiate the use of Indonesian native grasses, with improved quality, low water use and adaptibility to wide environmental stress. Turfgrass with suitable characteristics for such an environment includes zoysiagrass, which is already widely used in recreational places in many countries with similar climatic conditions as Indonesia. Zoysiagrass grows slowly and takes longer to recover from damage than Kentucky bluegrass and bermudagrass (Christians, 1998). Since zoysiagrass has resistance to drought by minimizing transpiration and dense root system, water necessity for irrigation can be minimized. Zoysiagrass also has good resistance to wear, drought and shade stress (Beard, 1973). Zoysiagrasses (*Zoysia* spp.) breeding effort for industrial purposes has been minimal in Indonesia. Demand of proper turfgrass for recreational places and sports facilities such as golf and football courts has been increased. There need to be an effort to initiate the use of Indonesian native grasses, with improved quality, low water use and adaptibility to wide environmental stress. Turfgrass with suitable characteristics for such an environment includes zoysiagrass, which is already widely used in recreational places in many countries with similar climatic conditions as Indonesia. Zoysiagrass grows slowly and takes longer to recover from damage than Kentucky bluegrass and bermudagrass (Christians, 1998). Since zoysiagrass has resistance to drought by minimizing transpiration and dense root system, water necessity for irrigation can be minimized. Zoysiagrass also has good resistance to wear, drought and shade stress (Beard, 1973).

Zoysiagrass is also resistant to soil compaction and can adapt to various types of soils including salt-affected but grows better on fine-textured and fertile soil with good irrigation (Carrow and Petrovic, 1992). However, it has a relatively low resistance against poor drainage and inundation (Beard, 1973). Zoysiagrass is known to be tolerant to salinity, but there are significant differences between species. *Zoysia matrella* is more tolerant to salinity than *Zoysia japonica* (Patton, 2010). Patton (2010) also reported that *Zoysia japonica* has broader leaves (>2 mm) than *Zoysia matrella* (<2 mm). Zoysiagrass has needle-shaped leaves with flat surface, 2-4 mm in width and 3-11 cm in length, delicate hairs are 0.2 mm long which located in ligule (Beard, 1973). Zoysiagrass produces many stolons and rhizomes to reproduce vegetatively. Maximum depth of zoysiagrass root is about 25.6-29.5 cm.

In turfgrass industry, sand is a preferable choice as the turfgrass growing media due to its characteristics in good permeability, resistance to compaction and pest, and playability of turf. Since sand capping on all the golf course area is expensive (Waltz et al., 2003), some golf course use existing soil as growing media, or adding sand as ameliorant and topping of the surface soil. The good inorganic amendments can be chosen to increase moisture retention, improve capillary water movement with still acceptable root zone texture, drainage or air exchange (Huang and Petrovic, 1994).

According to Beard (1982), sand prevents compaction and has aeration, infiltration and percolation, so it can be used as a medium for root zone in green construction of modern golf field. Sandy soil has good drainage and aeration making easier for root penetration, and facilitates water and air circulation, although having issue of low water holding capacity (Turgeon, 2002). Sand growing media should also be fertilized more often than other soil textures because sand is a weak medium in handling and storing nutrients (Emmons, 2000).

Sand used in this study was from eruption of Mount Merapi. Average once in five years this mount erupts to produce a large amount of sand. According to Idjudin et al. (2010) Merapi volcanic material has sand-texture with very low index of aggregate stability with loose or firm consistency. Aeration pore of Merapi vocanic materil is very high (about 40% by volume), very porous, and water holding capacity is very low with approximately 1-3% by volume. Volcanic material contains considerable potential mineral nutrients to improve soil fertility, because material weathering producing volcanic ash will produce Ca, Mg, Na, K and micro-nutrients (Cu) that plants need, but poor in N, P, and K. Sandy soil is a favorite as a turfgrass growing medium because its characteristics is suitable for play ground.

Sediment used in this research was from Gajah Mungkur reservoir. Gajah Mungkur reservoir has 8,800 ha area for irrigating rice field of 23,600 ha. This reservoir was designed for 100 years usage with maximum capacity of sediment storage about 120 million m^3 with assumption of sediment rate was 2 mm per year (Sudaryo, 2010). Accumulated sediment in reservoir was a result of surface erosion with quite high organic matter compared to subsoil (Kartasapoetra, 2005). Soil sediment is alluvial, formed from deposition of materials on flat or slightly flat area through erosion process and deposited by water power or gravity (Prasetyo and Subardja, 1998). Landform alluvial soil fertility is usually better than soil at the top, because it is the result of precipitation (Hanna et al., 1982). It is estimated annually that thousands of cubic meters deposited at the base of reservoir as accumulated sediment erosion. Every years in dry season, reservior is dredged in an attempt to extend reservoir life. Sediment utilization as growing media in atlethic field and recreational place can be a part of solution of sediment utilization.This study was to compare growth and quality of two native zoysiagrasses, and also to compare the growth of turfgrass in sand media and montain sediments from reservoir.

MATERIALS AND METHODS

This research was conducted at the Laboratory of Dryland Jumantono Faculty of Agriculture, Sebelas Maret University, Surakarta, Indonesia. Experimental design was completely randomized design factorial with two factors. The plot was 1 ㎡ width for each treatment unit and was replicated 4 times. Growing media was mixed with sand and soil sediment and topped on native clayey soil with 10 cm thickness. Sand was taken from Mount Merapi, while sediments was taken from Gajah Mungkur reservoir, Wonogiri. Growing media were S100 = sediment soil 100%; SP25 = sediment soil 75+sand 25%; SP50 = sediment soil 50+sand 50%; SP75 = sediment soil 25+sand 75%; P100 = sand 100%, respectively. Small plugs of 3 cm^2 were planted with 15 cm interval. Fertilizer was applied every month, using N, P, K with dosages of urea 14 g m^{-2} $month^{-1}$; P_2O_5 of 7.0 g m^{-2} $month^{-1}$; KCl 7.0 g m^{-2} $month^{-1}$. Irrigation was practiced every morning or afternoon on each plot. Weeding was done once a week. Mount Merapi sand was composed of sand 66%, silt 25% and clay 9%, while sediment contains sand 25%, silt 64% and clay 11%. Soil chemeical characteristics were shown in Table 1. Soils were analysed by the Analysis of Laboratorium of Chemical Soil, Faculty of Agriculture Sebelas Maret University, Surakarta.

Table 1. Characteristics of sand and sediment used as a growing media in this study.

Variable	Mount Merapi sand	Category	Gajah Mungkur reservoir sediment	Category[z]
Permeability (cm h^{-1})	7.2	Fast	0.12	Very slow
Organic matter (%)	2.0	Low	1.7	Low
pH H_2O (1:5)	6.3	Slightly acid	7.3	Neutral
pH KCl	3.4	Acid	6.2	Slightly acid
ECp (dS m^{-1})	0.011	Low	0.130	Low

[z]Category based on the Soil Research Institute of Indonesia 2005.

Two zoysiagrass ecotypes were used in this study. Zis is a native zoysiagrass collected in sea-side and Zim is a native zoysiagrass collected in mountain area. Zis was collected from Jepara district of Central Jawa region with elevation 1-2 m sea level at 6°33'14.35" South, latitude 110°38'50.12", which was natively grown as large colony in sandy soil. Plant height of Zis was 15.7 cm, seed color was black with 31-34 seeds per spike, leaf width was 3.4-3.6

mm, leaf length was 17.7cm, leaf angle was 40-50°, length of stolon inter-node was 3-4 cm with green color, and trichome was 2.3 mm long at the upper side of leaf blade only. Zim was collected from Merapi Mount Sleman district of Yogyakarta region with elevation 843 m sea level at 7°39'53.86" South, latitude 110°27'25.17", and were natively grown in sandy loam soil with limited availability. The characteristic of this zoysiagrass showed plant height of 20.5 cm, seed color was yellow with 33-36 seeds per spike, leaf width was 3.5-3.8 mm, leaf length was 13.2 cm, leaf angle was 45-50°, length of stolon inter node was 3.5- 4 cm with purple color, and trichome was 2.4 mm long at the upper side of leaf blade only.

Observation was done once a week for 9 months. Leaf color, leaf texture and turfgrass density were observed from every plot. Leaf color was analysed by Munshel color chart, and scoring as 1 = 2.5 GY P 9/6, 2 = 2.5 GY B.1 8/9, 3 = 2.5 GY L.3 7.5/6, 4 = 2.5 GY L.4 6/6.5, 5 = 2.5 GY DI.3 5/6.5, 6 = 2.5 GY DI.4 4/6, respectively. Quality measurements include soil surface covering percentage, shoot dry weight, root length, root dry weight and recovery ability. Samples of grass and soil were taken from the plot by cutter with the size of 10 × 10cm then dug and pull up the soil. From this sample, no. of tillers was counted as shoot density. Shoot dry weight was measured after drying in the 105°C oven for 24 hours. Root length from bottom of thatch was measured and the root dry weight measured as the same method for shoot dry weight. Leaf width was measured with ruler. Turfgrass recovering day was measured by scalping to 0.5 cm height then counted days to grow back similar to before scalping. Turfgrass uniformity of leaf size and color uniformity were measured visually on the plot. Organic matter content, pH, electric conductivity and soil texture were evaluated in laboratory. Data of parameters was analyzed statistically using by SPSS.

RESULTS AND DISCUSSION

There were highly significant difference (p<0.01) between growing media for zoysiagrass growth. S100 had the highest levels of OM 1.87 %, while media P100 had the lowest OM of 1.12 % (Table 2). According to Prasetyo and Subardja (1998), alluvial soil was formed from the deposition of materials on a flat area or a slightly flat, and an accumulation of other places that contain organic matter. Zoysiagrass was able to grow on a wide soil conditions. But, to have better grow, zoysiagrass needs to be planted on soil pH 5.8-7.5 with intensive sunlight. However, it is more resistant to shade than other warm season turfgrasses (Brosnan and Deputy, 2008). Media S100 had a higher EC than P100, meaning higher acids, bases, and salts were contained in soil colloids.

Table 2. Characteristics of growing media used in this study at the end of experiment.

Media[z]	Perme-ability (cm)	O.M. (%)	pH H_2O (1:5)	pH KCl	ECp (dS m^{-1})	Sand (%)	Silt (%)	Clay (%)	Texture
S100	0.15	1.87	7.3	5.4	1.00	45.2	37.1	17.6	Loam
SP25	0.14	1.54	7.3	5.3	0.08	52.1	24.7	23.0	Sandy clay loam
SP50	0.22	1.48	7.3	5.5	0.07	64.6	14.1	21.2	Sandy clay loam
SP75	0.15	1.24	7.4	5.4	0.09	65.5	12.3	22.1	Sandy clay loam
P100	0.25	1.12	7.4	5.2	0.04	60.3	38.7	0.91	Sandy loam

[z]S100 = sediment soil 100%, SP25 = sediment soil 75%+ sand 25%, SP50 = sediment soil 50+sand 50%, SP75 = sediment soil 25+sand 75%, P100 = sand 100%. Zis = collected zoysiagrass native in sea side, Zim = collected zoysiagrass native in mountain area.

Turfgrass quality was significantly different between ecotypes from mountain and sea side (Table 3). The average uniformity of Zim was 7.6, while Zis was 6.1. Turfgrass quality was also determined by tiller density per area unit. Beard (1973) grouped that density was based on the number of shoots per 100 cm^2. Density category based on the number of shoots was high: >200, moderate: 100-200, low: <100. The highest density was from P100 and the lowest was from SP75. Result showed that growing media with more sand composition resulted in higher shoot density. McCarty et al., (2001) stated that sand led to better turfgrass quality. In this study, total quality was high when Zim was cultivated on 100% sediment, and higher shoot density was found from Zis when cultivated on 100% sand.

Table 3. Charactersistics of two native zoysiagrasses grown on sand or various sediment growing media.

Treatments[z]	Turf quality (1:Low-9:High)	Shoot density (Tiller/100 cm^2)	Leaf width (mm)	Leaf color (Scale 1-6)[y]
Zis S100	6.3 bc[x]	149.0 bc	2.5 b	3.0 a
Zis SP25	6.0 bc	198.7 b	2.4 b	3.5 a
Zis SP50	5.5 c	159.5 bc	2.4 b	3.0 a
Zis SP75	6.3 bc	132.7 bc	2.4 b	3.3 a
Zis P100	6.5 bc	263.0 a	2.4 b	3.0 a
Zim S100	8.9 a	144.2 bc	2.7 ab	3.5 a
Zim SP25	7.0 abc	138.0 bc	2.8 ab	3.0 a
Zim SP50	7.6 a	102.2 c	2.6 b	3.0 a
Zim SP75	7.5 abc	113.7 c	3.2 a	3.3 a
Zim P100	6.8 bc	132.7 bc	2.6 b	3.0 a
Zis	6.1*	180.6*	2.4 *	3.2 ns
Zim	7.6*	126.2*	2.8 *	3.2 ns

[z]S100 = sediment soil 100%, SP25 = sediment soil 75+sand 25%, SP50 = sediment soil 50+sand 50%, SP75 = sediment soil 25+sand 75%, P100 = sand 100%. Zis = collected zoysiagrass native in sea side, Zim = collected zoysiagrass native in mountain area.
[y]Munshel color chart, and scoring as 1 = 2.5 GY P 9/6, 2 = 2.5 GY B.1 8/9, 3 = 2.5 GY L.3 7.5/6, 4 = 2.5 GY L.4 6/6.5, 5 = 2.5 GY DI.3 5/6.5, 6 = 2.5 GY DI.4 4/6.
[x]Mean separation within colums by Duncan's multiple range test at $P = 0.05$.

Native zoysiagrass scollected in sea side (Zis) had finer texture than native zoysiagrass collected in mountain (Zim). Leaf of Zis was narrower, and was longer than Zim. Zis had smaller leaf that may have benefit of reducing transpiration because sea side climate condition had higher temperature than mountain. Leaf color of Zis was darker green than Zim, which was light green or yellow. According to Kellogg (2013), photosynthesis of C-4 plant is more effective on higher light intensity. Harjadi (1989) stated that temperature affects stability of enzyme system. Under optimum temperature condition, enzymes work optimally, but enzymes became inactive under low temperature and denaturated under high temperature. Photosysthesis ran more slowly under lower temperature that led to lower growth rate. Zim had longer and finer leaves than Zis.

Leaf color was not significantly different among 4 variables of zoysiagrass. Color determination was measured by scoring method, the lowest score was 1 and the highest was 5. F-test on shoot color showed that there was no significant difference in color of all media and these two types of turfgrasses. Leaf texture represented by leaf width was categorized by very fine (<1 mm), smooth (1-2 mm), fine (2-3 mm), coarse (3-4 mm) and very coarse (>4 mm) (Beard, 1973). Leaf texture of both zoysiagrasses had moderate texture, however Zis had finer texture of 2.4 mm than Zim of 2.8 mm. Thus Zis had better quality because of its finer texture. According to Emmons (2000) finer leaf texture with higher uniformity of turfgrass resulted in more attractive quality than coarse texture with broad leaf.

The fastest soil surface coverage was from Zim on S100, and overall, Zim had faster coverage than Zis (Table 4). Growing medium of sand had the best recovery ability for Zis. It proved that sand was the best growing medium for turfgrass covering ability. Zim had more extent surface coverage of 86.8% than Zis of 74.6% during 36 weeks after planting. The slow growth of both zoysiagrasses could be attributed by planting method using small plugs (3 cm^2) and narrow plugs interval of 15 cm. The faster soil surface coverage of zoysiagrass from mountain was observed from early evaluation at 10 WAP, and continued to 36 WAP (Table 5). Rate of turfgrass surface coverage was influenced by lateral shoot growth, frequency of stolons formation and new rhizomes. Rhizomes growth was affected by photoperiodism, light intensity and nitrogen status (Beard, 1973). Since the zoysiagrasses were grown on the same growing medium, different growth rate may indicate that genotype of grasses affect the turfgrass growth.

Table 4. Growth characteristics of zoysiagrass in various sand and sediment growing media.

Treatment[z]	Soil surface coverage (%)	Shoot dry weight ($g/100\ cm^2$)	Root dry weight ($g/100\ cm^2$)	Root length (cm)	Recovery (Day after scalping)	Plant height (cm)
Zis S100	70.2 bc[y]	1.8 bc	0.51 a	12.7 a	17.5 ab	5.2 ef
Zis SP25	66.7 c	2.0 ab	0.64 a	10.6 a	17.7 ab	5.2 ef
Zis SP50	73.5 abc	1.8 bcd	0.47 a	10.0 a	18.0 a	4.8 f
Zis SP75	82.5 abc	1.6 cd	0.53 a	12.4 a	17.7 ab	6.7 cd
Zis P100	80.0 abc	2.7 a	0.67 a	11.4 a	16.5 bc	6.3 de
Zim S100	91.2 a	1.9 bc	0.90 a	8.9 a	17.5ab	9.1 a
Zim SP25	85.0 ab	1.6 bcd	0.65 a	11.0 a	17.7 ab	7.1 bcd
Zim SP50	88.7 a	0.9 de	0.62 a	11.1 a	17.7 ab	8.3 ab
Zim SP75	88.7 a	1.0 cde	0.65 a	11.0 a	17.5 ab	7.8 bc
Zim P100	80.0 abc	0.7 e	0.74 a	11.7 a	15.5 c	7.8 bc
Zis	74.6*	1.95*	0.54 ns	11.5 ns	17.5 ns	5.65*
Zim	86.8*	1.21*	0.91 ns	10.9 ns	17.2 ns	8.05*

[z]S100 = sediment soil 100%, SP25 = sediment soil 75+sand 25%, SP50 = sediment soil 50+sand 50%, SP75 = sediment soil 25+sand 75%, P100 = sand 100%. Zis = collected zoysiagrass native in sea side, Zim = collected zoysiagrass native in mountain area.
[y]Mean separation within colums by Duncan's multiple range test at $P = 0.05$.

Table 5. Soil surface coverage of zoysiagrass at sediment 100% growing media.

Ecotype[z]	Soil surface coverage (%)			
	10 WAP[y]	20 WAP	30 WAP	36 WAP
Zis (Zoysiagrass native to sea-side)	11.3 a[x]	28.1 b	50.9 b	74.6 b
Zim (Zoysiagrass native to mountain)	19.3 b	47.6 a	79.3 a	86.7 a

[z]Zis = collected zoysiagrass native in sea side, Zim = collected zoysiagrass native in mountain area.
[y]WAP: Weeks After Planting.
[x]Mean separation within colums by Duncan's multiple range test at $P = 0.05$.

Shoot dry weigth was made with shoot clipping dried at 105°C (Turgeon, 2002). Shoot dry weight on Zis with 100% sand was the highest than other treatments. Zim on 100% sand resulted in the lowest shoot dry weight. According to Rahayu et al. (2014) different medium between clay soil and volcanic sand did not show different shoot density of zoysiagrass. Basically better management will result in better shoot density of turfgrass and unsuitable management is the most contributing factor for low shoot density (Emmon, 2000). Shoot dry weight was correlated positively with shoot density (0.765**), thus higher shoot density can be the reason for higher shoot dry weight. Results did not show difference in root length in spite of being planted on different media. This was caused by the material used as growing media was only 10 cm for topping over the clayey soil, thus during observation, root length passed topping depth and reached to clay soil. In most of turfgrasses, 60-80% of the total root length generally occurs in the top 30 cm of soil (Carrow, 1996).

Recovery ability was an ability of turfgrass to re-grow from damage caused by pest, pathogen and/or excessive use. There were many issues influencing recovery ability, such as genetic factor, cultivation technology and environment condition (Turgeon, 2002). Measurement of recovery ability was measured by the number of days after scalping to full recovery (DAS). Medium composition promoted recovering ability of zoysiagrass. Turfgrass with medium composition of 100% sand had faster recovery ability compared to medium containing soil. The fastest recovery in sand was 16.5 DAS in Zis and 15.5 DAS in Zim. Generally, recovery rate of zoysiagrass from sea side and mountain were similar (Table 4). However, zoysiagrasses from mountain have lower ability to recover when planted in mountain sand, and the recovery rate of zoysiagrasses from seaside was faster in the mixture of sediment and mountain sand. The ability of turfgrasses to recover from damage and stress depends on growing condition and culture technique (Turgeon, 2002). Zoysiagrass recovery rate was increased by application of fertilizer, even the inorganic fertilizer showed faster recovery than organic fertilizer (Rahayu et al., 2014). According to Johns (2004), aeration or air existance on medium may improve plant ability in uptaking nutrients, water and oxygen to survive and grow.

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