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Evaluation of native *Zoysia japonica* and *Zoysia matrella* accessions on river sediment and Alfisol media for turfgrass quality in Indonesia

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Abstract. *Rahayu, Abidin ZI, Herdiansyah G, Supriyadi, Saputri AA. 2026. Evaluation of native* Zoysia japonica *and* Zoysia matrella *accessions on river sediment and Alfisol media for turfgrass quality in Indonesia. Biodiversitas 27 (6): d270601. https://doi.org/10.13057/biodiv/d270601.* Native turfgrass species in Indonesia have considerable potential for landscape and sports field applications; however, comparative evaluations of different accessions under contrasting soil media remain limited. This study evaluated the turf quality performance of several native accessions of *Zoysia japonica* and *Zoysia matrella* grown in two soil types, river sediment and Alfisol. The experiment was conducted using a randomized complete block design with three replications. Turf performance was assessed using visual and functional quality parameters based on the National Turfgrass Evaluation Program (NTEP) scoring system. Data were analyzed using Analysis of Variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT) to determine significant differences among treatments. The results showed that soil media significantly influenced several turf quality traits. ANOVA revealed significant interactions between accession and growing media ($p<0.05$), indicating genotype-specific responses to soil conditions. In general, river sediment provided more favorable conditions for turf growth than Alfisol. Among the evaluated accessions, the Kopeng accession of *Z. matrella* showed the highest visual quality, with scores approximately 1.92% higher than Zeon on sediment and 48.78% higher on Alfisol. Compared with Zmeet, Kopeng also showed higher visual quality, reaching 44.71% on sediment and 46.47% on Alfisol. Overall, *Z. matrella* accessions showed higher visual quality, whereas *Z. japonica* tended to exhibit better functional traits under sediment conditions. These findings demonstrate that selected Indonesian *Zoysia* accessions possess high adaptability and competitive turf quality, supporting their potential as locally adapted alternatives to imported cultivars for sports fields and landscape applications. The study provides important baseline information for turfgrass management and breeding programs aimed at improving turf performance in Indonesian environments. *Z. japonica* accession in higher elevation showed better quality, while *Z. matrella* showed better quality in relatively lower elevation.

Keywords: Alfisols, landscape, native turfgrass, turfgrass quality, *Zoysia*

INTRODUCTION

Indonesia is a tropical archipelago along the equator, providing favorable conditions for turfgrass used in landscapes, sports fields, and soil and water conservation. Several turfgrass species are native or well adapted to Indonesia, including *Zoysia japonica* Steud., *Zoysia matrella* (L.) Merr., *Bermuda* grass, *Kikuyu* grass, and Seashore paspalum (Rahayu 2022). This diversity reflects the potential of local turfgrass germplasm that remains underexplored. Therefore, developing turfgrass germplasm suited to local conditions is important to support sustainable turf management and reduce dependence on imported planting materials.

Among these species, *Z. japonica* and *Z. matrella* are widely used in Indonesia for sports fields, lawns, and urban green spaces. Both species have been applied in professional stadiums, including Manahan Stadium, Maguwoharjo Stadium, and Si Jalak Harupat Stadium (Muakhor et al. 2013). Zoysiagrasses are warm-season grasses that grow well in tropical environments and adapt to light conditions from full sunlight to partial shade (Rahayu et al. 2020; Wang et al. 2024). These characteristics make them suitable for turfgrass development in Indonesia. *Z. japonica* is an Indonesian native grass distributed from mountains to coastal regions and from Java to Bali, with turf quality ranging from 6.19 to 7.88 on the 1-9 NTEP scale (Rahayu et al. 2016). *Z. matrella* also grows naturally in Indonesian habitats, including beaches, roadsides, and mountains (Rahayu et al. 2014). Its occurrence in eight provinces opens opportunities for developing high-quality native cultivars (Rahayu et al. 2024).

Selecting appropriate growing media is essential for turfgrass development and quality. In professional turf management, sandy-textured media such as river sediment are preferred because of good drainage, aeration, and resistance to compaction (Rahayu et al. 2018; Moechtar 2021). These properties promote root growth and surface water runoff, which are important for safe playing surfaces. However, sandy soils usually have low nutrient-holding capacity. In contrast, clay-rich soils such as Alfisols often have lower permeability and denser structure, limiting root growth and air circulation. Therefore, careful management is required to support turf performance (Minardi et al. 2023; Rahayu et al. 2023). Despite these limitations, Alfisols and clay-textured soils are widely used in semi-professional and community sports fields in Indonesia. Thus, evaluating turfgrass under contrasting media is important for identifying accessions adapted to common field conditions.

Turfgrass performance is generally assessed using visual and functional quality parameters that reflect aesthetic value and field usability (Liu et al. 2019). Visual quality is related to leaf width, shoot density, and leaf color, whereas functional quality includes turf coverage, plant dry weight, and root development (Rahayu et al. 2023). Standardized systems such as the National Turfgrass Evaluation Program (NTEP) allow objective comparison among genotypes across environments. In this study, two imported cultivars, Zeon and Zmeet, were included as reference materials commonly used on professional sports fields in Indonesia.

Although native *Zoysia* has considerable potential, studies evaluating Indonesian native accessions under contrasting growing media remain limited. Previous studies examined turfgrass growth and quality in other species, such as *Paspalum vaginatum* Sw. under different soil types (Rahayu et al. 2023), and evaluated limited accessions in sediment soil (Rahayu et al. 2024). However, comparative evaluations involving multiple native accessions of *Z. japonica* and *Z. matrella* under contrasting media are still scarce. Limited information is available on how native accessions respond to river sediment and Alfisol media when assessed using standardized turf-quality methods alongside imported cultivars.

This gap limits the use of native turfgrass resources and contributes to reliance on imported cultivars for professional sports fields in Indonesia. Comprehensive evaluation of native accessions is needed to identify locally adapted turfgrass with strong visual and functional performance. Given differences in soil characteristics and genetic diversity among native *Zoysia* accessions, turf quality is expected to vary depending on accession and growing medium. Some accessions may show superior performance under specific soil conditions.

Therefore, this study aimed to evaluate the visual and functional quality of Indonesian native accessions of *Z. japonica* and *Z. matrella* grown on river sediment and Alfisol media, and compare their performance with imported cultivars Zeon and Zmeet. We hypothesized that specific native *Z. matrella* accessions would exhibit higher visual turf quality than imported cultivars, while native *Z. japonica* accessions would demonstrate equal or superior functional performance, particularly on river sediment media used in professional turf systems.

MATERIALS AND METHODS

Study site and experimental conditions

This study was conducted at the Jumantono Laboratory, part of the Faculty of Agriculture at Universitas Sebelas Maret. It is located in the charming Sukosari Village, within the Jumantono Sub-district of Karanganyar District, Central Java Province, Indonesia (7°37'53" S; 110°56'54" E, at an elevation of 170 m above sea level). The research was carried out from July to October 2023, during the dry season, providing a clear picture of the conditions during that time. Based on data from the Automatic Weather Station (AWS) at the experimental site, the average air temperature was 29.7°C, with a relative humidity of 76% and a typical monthly rainfall of 0.2 mm. These conditions reflect the typical warm-season environment for turfgrass establishment in the Indonesian lowlands, where high temperatures and limited rainfall often shape early turf growth and root development. The recorded temperature falls within the ideal range (25-35°C) for warm-season Zoysiagrasses, such as *Z. japonica* and *Z. matrella* (Beard 1973).

Experimental design

This study was an experiment using a Randomized Complete Block Design (RCBD) with two main factors: growing media and turfgrass. The growing media factor had two levels: Alfisol soil obtained from the Jumantono laboratory and river sediment collected from the Bengawan Solo River. The turfgrass factor consisted of 12 accessions (five *Z. japonica*, five *Z. matrella*, and two imported *Z. matrella* cultivars (Zeon and Zmeet) (Table 1). The term accession refers to individual genetic materials collected from different locations or cultivars used as experimental units.

The experiment was thoughtfully organized into three blocks, each representing different spatial rows of pots to capture any environmental variations. Every treatment combination was randomly assigned once within each block to ensure fairness and variability. Each pot served as a unique experimental unit, making our study quite comprehensive. In total, we used 72 pots, with three replicates—meaning three pots for each treatment combination—adding robustness to our results. When analyzing the data, we treated the blocks as random effects to account for potential variability, helping us draw more reliable conclusions.

Procedures

Planting and maintenance

Planting was conducted using the sprigging method, with small stem or stolon segments containing viable roots and shoots. Each pot was prepared with a single planting hole to cultivate three tillers. Each tiller bore a stolon with three nodes. Experimental units comprised pots measuring 50 cm × 25 cm × 5 cm, each filled with 4 kg of growth medium. The pots were arranged at random in an open area without any specific shelter. Turfgrass production commonly involves sod; producing sand-based sod on a 25-mm topdress over native soil performed better during the sod establishment period prior to sod harvest, and in terms of pre-harvest sod quality, 25 mm of sand performed better than 50 mm of sand (Stewart et al. 2017). In this study, using a pot with a width of 5 cm is suitable for getting turf quality information, especially for sod production.

At planting, NPK fertilizer (16-16-16) was applied at 2.5 g per pot, supplying 400 mg of N, P_2O_5, and K_2O per pot per application. The same rate was reapplied biweekly for 12 weeks post-planting. Consequently, the total nutrient input over the experimental period was 2.8 g of N, P_2O_5, and K_2O per pot, equivalent to 224 kg ha^{-1} for each nutrient on an area basis. Additionally, organic fertilizer was applied at 25 g per pot at planting.

Crop maintenance involved fertilization, irrigation, and weed control, but no mowing was done during the experiment. Irrigation was evenly applied to all treatments, twice a day, to keep the soil moist and prevent water stress in the growing media. This means that any differences in plant growth and performance were mainly due to the natural qualities of the growing media, not water issues. Weeds were carefully removed by hand at regular times.

Observation of visual and functional quality parameters

Observations of visual and functional quality involved measuring several plant parameters. The percentage of ground cover was evaluated biweekly for 12 weeks, starting 2 weeks after planting. This assessment used digital image analysis with ArcGIS ISO Cluster software to distinguish green and non-green pixels. Photographs were captured under consistent lighting conditions. The ground cover percentage was computed as the ratio of green pixels to the total number of pixels. At 16 weeks, measurements of leaf width, leaf color, shoot density, shoot dry weight, root dry weight, and root length were performed. Leaf color was assessed using the Munsell Plant Tissue Color Book, while leaf width and root length were measured with vernier calipers. Leaf width measurements were taken from three fully developed leaves per pot, chosen randomly from the upper canopy to ensure they are good representative samples. Root length was averaged across three different plants in each pot. We also looked at some important quality parameters like shoot dry weight (biomass), root dry weight, root length (rooting), and the percentage of ground cover (Rahayu 2022). Turfgrass quality was evaluated based on both functional and visual attributes such as density, uniformity, texture, fineness, ground cover, and color (Głąb et al. 2020).

Turfgrass quality score and visual-functional quality assessment

The final assessment of turfgrass visual and functional quality was conducted using a 1 to 9 rating scale, where 1 indicates poor quality and 9 indicates excellent quality, following the National Turfgrass Evaluation Program (NTEP) rating method (Morris and Shearman 1998). The objective of NTEP was to provide information by evaluating turfgrass quality, density, drought tolerance, diseases, and other abiotic and biotic stresses at different locations. NTEP score is a scale of 1-9, where 9 is outstanding or ideal turf, 6 is considered acceptable for turfgrass, and 1 is the poorest or dead. NTEP is one of the most widely known turfgrass research programs in the world and has coordinated multi-location turfgrass cultivar evaluation trials since 1981 (Xie et al. 2021). Thus, NTEP is used in Indonesia because Indonesia has no own turfgrass quality evaluation.

Raw observation values for each parameter were first converted into intermediate initial scores using predefined threshold ranges (Table 2). These threshold values were adopted from established turfgrass evaluation references, including Beard (1973), Kazemi et al. (2020), and Rahayu et al. (2023). Leaf texture was evaluated based on leaf width, with narrower leaves receiving higher scores, indicating finer texture (Agnihotri et al. 2017). Leaf color was assessed according to the degree of greenness, with a score of 1 indicating yellowish-brown coloration and higher scores representing progressively darker green (Kazemi et al. 2024). Shoot density was determined by counting the number of shoots within a 25 cm² area. Based on the classification proposed by Beard (1973) and Da Silva et al. (2015), shoot density per 100 cm² was categorized as high (>200), medium (100-200), and low (<100). Because observations in this study were conducted within a 25 cm² area, these thresholds were proportionally adjusted to >50 (high), 25-50 (medium), and <25 (low).

For all parameters except leaf color, the initial score was calculated using the following equation:

$$\text{Initial} - \text{score} = \frac{s_{\min} + ((n - n_{\min}) \times (s_{\max} - s_{\min}))}{n_{\max} - n_{\min}} \quad (1)$$

Where :

n : Raw value (observed results of each parameter)
nmin : The lower threshold values
nmax : The upper threshold values
smax : Maximum initial score
smin : Minimum initial score

To ensure comparability among parameters with different initial-score ranges, the initial scores were linearly transformed to the standardized NTEP 1-9 scale using the following equation:

$$y = \frac{(9-1)\times(x-x_{\min})}{x_{\max}-x_{\min}} + 1 \quad (2)$$

Where :

y : Final NTEP score (1-9)
x : Initial score obtained from Equation (1)
xmax : Maximum initial score defined in Table 2
xmin : Minimum initial score defined in Table 2

Visual and functional quality indices were calculated using the standardized NTEP scores. Visual quality was determined as the mean of the scores for leaf width, leaf color, and shoot density, whereas functional quality was calculated as the mean of the scores for ground cover percentage, root dry weight, root length, and shoot dry weight (Agnihotri et al. 2017; Rahayu et al. 2023).

Statistical analysis

We analyzed the data using Analysis of Variance (ANOVA) with SPSS software, ensuring a 95% confidence level for our results. Before performing ANOVA, we checked for normality and homogeneity of variance with the Shapiro-Wilk and Levene's tests. We used a nested design, where accession was nested within species. Our model considered growing media, species, accession within species, and their interactions, providing a comprehensive understanding of the data. Species-level comparisons were derived by grouping accessions within each species to evaluate the interaction between species and growing media.

Table 1. Origin and geographic characteristics of the turfgrass accessions used in the study

Accession	Turfgrass	Latitude	Longitude	Altitude
Zoysia japonica				
Ngemplak	Sleman (DIY)	-7.70108	110.4472	187 masl
Tanjung Pasir	Tangerang (Banten)	-6.21592	106.8048	2 masl
Siwil Beach	Pacitan (East Java)	-8.26521	111.2798	2 masl
Padang	Padang (West Sumatra)	1.19577	99.1073	15 masl
Parangtritis	Parangtritis Beach, Bantul (Special Region of Yogyakarta)	-8.02415	110.3315	3 masl
Zoysia matrella				
West Aceh	Meulaboh District, West Aceh District	4.15823	96.1303	80 masl
Sleman	Sleman (Special Region of Yogyakarta)	-7.62147	110.4465	215 masl
Kopeng	Semarang District (Central Java)	-7.39662	110.4159	176 masl
Buleleng	Genungan Waterfall, Buleleng (Bali)	-8.57626	115.2895	250 masl
Malang	Malang (East Java)	-7.99514	112.6317	343 masl
Zmeet	Thailand	-	-	-
Zeon	Gelora Bung Karno Main Stadium	-	-	-

Table 2. Criteria for evaluating turfgrass visual and functional quality based on the scoring system

Parameters	Unit	Range of raw value	Initial-score	Reference
Shoot density	Shoots per 25 cm^2	≤25	1	Beard (1973)
		≥50	9	
Leaf color		2.5 GY 6/6	1	Rahayu et al. (2023)
		2.5 GY 6/4	2	
		2.5 GY 5/6	3	
		2.5 GY 5/4	4	
		2.5 GY 5/2	5	
Leaf width	cm	≥0.4	1	Beard (1973)
		≤0.1	9	
Percentage ground cover	%	0%	1	Kazemi et al. (2020)
		100%	9	
Shoot dry weight	g	≤0.625	1	Rahayu et al. (2023)
		≥0.875	3	
Root length	cm	≤10	1	Rahayu et al. (2023)
		≥23	4	
Root dry weight	g	≤0.75	1	Rahayu et al. (2023)
		≥1.75	3	

Note: Range of raw value: Threshold values and corresponding intermediate initial-score ranges used for turf quality assessment prior to normalization. The initial score represents intermediate values derived from raw measurements using Equation (1)

ANOVA was performed on both the raw observational data and the NTEP scores for each parameter. The standardized NTEP scores derived from Equation (2) were also used to calculate visual and functional quality indices and to facilitate comparative evaluation among accessions. When significant differences were detected ($p<0.05$), mean separation was performed using Duncan's Multiple Range Test (DMRT), which was commonly applied for screening multiple turfgrass accessions and identifying potentially superior materials in agronomic evaluation studies.

RESULTS AND DISCUSSION

Soil physical and chemical characteristics of growing media

Based on Table 3, the river sediment had higher pH, electrical conductivity, permeability, and bulk density than the Alfisol. The river sediment soil was classified as sandy-textured, whereas the Alfisol was clayey in texture. In addition, the Alfisol showed higher values of soil organic carbon, Cation Exchange Capacity (CEC), total N, and available P and K than the river sediment soil. Alfisols are characterized by clay accumulation in the subsurface horizon due to eluviation-illuviation processes, forming an argillic horizon dominated by clay minerals such as illite, kaolinite, and vermiculite (Ndzana et al. 2018; Bekele and Birhan 2021). Despite being generally considered relatively fertile soils, Alfisols in tropical regions often contain low levels of soil organic matter and essential nutrients (Buol et al. 2011; Adekiya et al. 2021). In this study, Alfisols exhibited low levels of organic carbon and nutrient availability, consistent with the findings of Rahayu et al. (2021), that about approximately 0.89%. Table 3 shows that there are differences in physical and chemical properties between river sediment soil and Alfisol as potential growing media for turfgrass.

Soil texture affects water retention and permeability. Coarse soils, such as sandy sediments, have macropores that facilitate rapid water infiltration and drainage, leading to lower water retention and increased risk of nutrient leaching (Meli et al. 2018; Sharma and Warren 2024). Clay soils, such as Alfisols, have more micropores, which reduce permeability and enhance water retention within the soil structure, thereby limiting the movement of water and air through the soil (de Lima et al. 2022; Shi et al. 2024). These characteristics affect turfgrass growth. Sandy soils promote deep roots due to drainage and aeration, but are drought-prone, especially for fibrous-rooted turfgrass (Jiang et al. 2022). Clay soils provide more stable moisture in the upper layer, supporting turfgrass establishment.

Zoysiagrasses are known for their adaptability to a wide range of soil conditions, including relatively low-fertility soils and varying textures, within a pH range of 5-8 (Loch and Zhou 2013). However, optimal growth generally occurs under slightly acidic conditions (pH 6.0-6.5) (Fresenburg 2022). In addition, *Z. matrella* has been reported to exhibit greater salinity tolerance than other species, such as *Z. japonica* and *Zoysia pacifica* (Goudsw.) M.Hotta & Kuroki (Ming et al. 2022). Differences in soil texture, permeability, and nutrient status between the two media may contribute to variations in turfgrass performance observed in this study.

Therefore, a thorough understanding of the characteristics of each soil type is essential for determining optimal growing media for Zoysiagrasses, particularly *Z. japonica* and *Z. matrella.*

Turfgrass visual quality

The visual quality of turfgrass was evaluated utilizing the National Turfgrass Evaluation Program (NTEP) methodology, which delineates specific evaluation parameters and assigns average scores on a scale from 1 to 9, where 1 denotes poor quality and 9 signifies excellent quality (Morris and Shearman 1998). As noted by Rahayu (2022), the assessment of visual quality is essential due to its close correlation with the physical appearance of turfgrass.

Analysis of variance revealed a significant visual quality among species with different growing media. The differences were indicated significantly in leaf width, leaf color, and shoot density ($p<0.01$; Table 4). Leaf color values represent the intensity of green coloration, where higher leaf color values indicate a darker and more intense green shade. In *Z. japonica,* the highest leaf color values were recorded in the Ngemplak and Siwil Beach accessions grown in both sediment and Alfisol media. Similarly, within *Z. matrella*, the Kopeng accession produced the highest leaf color values under both media. However, these combinations did not differ significantly from several other accession-media treatments, including the Malang accession grown in both media.

Within Z. *japonica*, Parangtritis and Siwil Beach accessions consistently produced the widest leaves across both sediment and Alfisol media, whereas the Ngemplak accession exhibited the narrowest leaves (Table 4). Although the interaction between growing media and accession was statistically significant, the relatively consistent ranking of accessions across both media suggests that genetic differences among accessions strongly influenced leaf width expression, whereas the magnitude of this trait varied depending on the growing medium. As finer leaf texture is generally associated with superior turfgrass quality, the narrower leaves of Ngemplak likely contributed to its higher visual quality score (Table 5). Similar patterns have been reported by Taher et al. (2023), that morphological characteristics such as leaf width and color in turfgrasses are often more strongly influenced by cultivar or genetic background than by soil type or growing media. This observation is also consistent with the findings of Shakywal et al. (2024) that variations in leaf width and leaf color among turfgrass genotypes are primarily attributed to genetic differences, although environmental conditions may still modify their phenotypic expression. The Ngemplak accession grows naturally at a relatively higher elevation of 187 m above sea level, compared to other *Z. japonica* accessions found on the coast at low elevations (Table 1). *Zoysia* from the mountains showed higher growing speed and more vigor with uniformity and texture than *Zoysia* seaside (Rahayu et al. 2018).

A similar pattern was observed in *Z. matrella*, where Zmeet produced the widest leaves under both media, and Zeon consistently had the narrowest leaves, even in sediment and Alfisols media. However, the type of growing medium can still influence how these genetic traits are expressed (Pirnajmedin et al. 2025). Differences in soil properties can impact pigment makeup, including chlorophyll, carotenoids, and flavonoids, which in turn affect how green the leaves appear. These responses highlight the interesting ways genotype and environment interact, with genetic traits expressing themselves differently depending on environmental conditions. Evidence of such interactions and local genetic adaptation to soil conditions has been found in several turfgrass species (Qiu et al. 2017; Wang et al. 2025).

The observed patterns indicate that genetic differences among accessions strongly influence morphological traits such as leaf width and leaf color, while the growing medium modulates the magnitude of their expression. This suggests the presence of genotype-environment interactions, where trait expression varies depending on environmental conditions. These findings are consistent with previous studies showing that turfgrass morphological characteristics are primarily controlled by genetic background rather than soil type under uniform management conditions, although environmental conditions may still influence their phenotypic expression (Taher et al. 2023; Shakywal et al. 2024). Environmental factors such as soil properties can influence pigment composition, including chlorophyll, carotenoids, and flavonoids, thereby affecting leaf green intensity (Wang et al. 2025). Similar genotype-environment interactions have been reported in various plant species, where environmental conditions modify the expression of genetic traits (Qiu et al. 2017; Pirnajmedin et al. 2025).

The highest shoot density among *Z. japonica* was observed in the Ngemplak accession grown on sediment. Among *Z. matrella,* the higher shoot density was observed in Malang, Zeon, and Kopeng accessions when grown in sediment. The Malang accession under sediment exhibited a shoot density 287.5% greater than the Padang accession of *Z. japonica* under Alfisol, which recorded the lowest value. These results indicate that growing media influenced shoot density among *Zoysia* species. High shoot density contributes to dense turf canopy, while dense and uniform turf tillers resulted high-quality sports fields (Straw et al. 2020).

Table 3. Physical and chemical characteristics of river sediment and Alfisol growing media used in the turfgrass experiment

Parameters	Sediment	Alfisol
pH (1:2.5)	7.02	6.51
EC (dS m^{-1})	0.24	0.09
Bulk density (g cm^{-3})	1.17	1.11
SOC (%)	0.24	1.71
Texture		
Sand	88.30	13.19
Loam	7.02	23.52
Clay	4.68	63.29
Permeability (cm hr^{-1})	11.75	3.41
CEC (me $100g^{-1}$)	6.99	13.99
Total N (%)	0.11	0.14
Available P (ppm)	2.23	3.23
Available K (me $100g^{-1}$)	0.18	0.28

Note: EC: Electrical Conductivity, SOC: Soil Organic Carbon, CEC: Cation Exchange Capacity

Among *Z. matrella* accessions, the Kopeng and Aceh accessions have relatively lower elevations, resulting in a warmer environment than the other accessions (Table 1). The good performance of the Kopeng accession is influenced by elevation and media. This condition is the opposite for *Z. japonica* accessions, where the Ngemplak accession, with a higher elevation than the other *Z. japonica* accessions, performed better. This difference indicates the different behaviors between *Z. japonica* and *Z. matrella*. *Zoysia matrella* has excellent tolerance to drought and high-temperature stresses, but is sensitive to low temperatures (Long et al. 2020).

The visual quality assessment showed that under sediment media, the Ngemplak accession of *Z. japonica* exhibited the highest visual quality. In Alfisols, Ngemplak also recorded the highest value among *Z. japonica* accessions. Within *Z. matrella,* the Kopeng accession achieved the highest visual quality under sediment. In Alfisols, Kopeng showed significantly higher visual quality than the imported cultivars Zeon and Zmeet. Overall, the Kopeng accession grown in Alfisol recorded the highest visual quality among all treatment combinations, exceeding *Z. japonica* Parangtritis by 4.72 points on the NTEP scale, which had the lowest score.

Most accessions tended to exhibit higher visual quality in sediment media than in Alfisols, although some showed contrasting responses, indicating genotype-specific adaptability to soil conditions. This trend was observed in accessions such as Buleleng, Malang, Ngemplak, Siwil Beach, Parangtritis, and Zeon, whereas Sleman and Tanjung Pasir showed comparable or better performance in Alfisol (Figure 1). The highest visual quality was consistently recorded in the Kopeng and West Aceh accessions across both media, indicating stable performance, whereas Padang and Tanjung Pasir showed the lowest values, particularly in Alfisol, suggesting greater sensitivity to soil conditions. Overall, this pattern reflects a genotype-environment interaction.

Soil physical properties, such as aeration and porosity, can significantly affect root and shoot development, thereby influencing tiller density and visual turf quality (Wei et al. 2022). For instance, sand-amended media have been shown to enhance root growth, soil biological activity, and nutrient availability, which indirectly support improved shoot development and turf performance (Yousfi et al. 2021; Rahayu et al. 2023).

The high performance of the Ngemplak and Kopeng accessions suggests that certain local accessions are more adaptable to local varying soil conditions. Based on the analysis results, the Kopeng accession grown in sediment medium exhibited a higher visual quality of 1.92% than Zeon and 44.71% than Zmeet, and in Alfisols, it was 48.78% higher than Zeon and 46.47% higher than Zmeet. The ability to exploit larger soil volumes for water extraction and rapidly regulate transpiration has been identified as an effective combination of drought-avoidance traits, often absent in commercial cultivars (Jespersen and Schwartz 2018). Turfgrass has fibrous roots. Root growth requires sufficient soil macropores. Clay Alfisols have much lower macropores than sand. Fibrous root growth significantly supports canopy growth and density. A relatively large volume of macropore space promotes rapid water infiltration, thus making it a desirable and advantageous medium for turfgrass growth and athletic fields (Kowalewski et al. 2010; Jiang et al. 2022). These findings were consistent with Rahayu et al. (2024), who reported that several native Indonesian *Z. matrella* accessions, such as Sampit, exhibited better visual and functional quality than commercial *Zoysia* cultivars.

Table 4. Raw measurement values of turfgrass visual quality parameters under different growing media

Growing media	Accession	Visual quality parameters		
		Leaf width (cm)	Leaf color	Shoot density (25 cm^2)
Sediment	*Zoysia japonica* Ngemplak	0.22 c	4.67 ab	52.67 bcd
	Zoysia japonica Tanjung Pasir	0.27 ab	3.33 c	27.67 i
	Zoysia japonica Siwil Beach	0.28 a	4.33 abc	43.00 efg
	Zoysia japonica Padang	0.26 b	3.33 c	30.67 hi
	Zoysia japonica Parangtritis	0.29 a	3.33 c	46.33 defg
Alfisols	*Zoysia japonica* Ngemplak	0.23 c	4.67 ab	44.67 defg
	Zoysia japonica Tanjung Pasir	0.27 b	3.33 c	38.67 gh
	Zoysia japonica Siwil Beach	0.28 a	4.33 abc	27.00 i
	Zoysia japonica Padang	0.26 b	3.67 bc	16.00 k
	Zoysia japonica Parangtritis	0.29 a	3.67 bc	17.33 jk
Sediment	*Zoysia matrella* Zeon	0.13 h	4.33 abc	59.67 ab
	Zoysia matrella Zmeet	0.20 d	4.33 abc	33.33 hi
	Zoysia matrella West Aceh	0.16 f	4.67 ab	51.33 bcde
	Zoysia matrella Sleman	0.17 ef	4.67 ab	42.00 fg
	Zoysia matrella Kopeng	0.15 g	5.00 a	55.67 abc
	Zoysia matrella Buleleng	0.18 e	4.33 abc	46.33 defg
	Zoysia matrella Malang	0.14 g	4.00 abc	62.00 a
Alfisols	*Zoysia matrella* Zeon	0.12 h	4.33 abc	24.33 ij
	Zoysia matrella Zmeet	0.20 d	4.33 abc	32.33 hi
	Zoysia matrella West Aceh	0.17 ef	4.67 ab	51.67 bcde
	Zoysia matrella Sleman	0.17 ef	4.67 ab	48.33 cdef
	Zoysia matrella Kopeng	0.15 g	5.00 a	52.67 bcd
	Zoysia matrella Buleleng	0.18 e	4.67 ab	26.00 i
	Zoysia matrella Malang	0.14 g	4.00 abc	26.67 i

Note: Means within the same column followed by the same letter are not significantly different according to DMRT at $\alpha = 0.05$

Table 5. NTEP-based parameter scoring and visual quality assessment

Growing media	Accession	Visual quality parameters			Visual quality
		Leaf width score	Leaf color score	Shoot density score	
Sediment	*Zoysia japonica* Ngemplak	5.71 f	8.33 ab	9.00 a	7.68 abcd
	Zoysia japonica Tanjung Pasir	4.38 gh	5.67 c	1.85 fg	3.97 h
	Zoysia japonica Siwil Beach	4.11 h	7.67 abc	6.76 bcd	6.18 e
	Zoysia japonica Padang	4.64 g	5.67 c	2.81 efg	4.37 h
	Zoysia japonica Parangtritis	4.02 h	5.67 c	7.83 abc	5.84 ef
Alfisols	*Zoysia japonica* Ngemplak	5.53 f	8.33 ab	7.29 abc	7.05 d
	Zoysia japonica Tanjung Pasir	4.56 g	5.67 c	5.37 d	5.20 fg
	Zoysia japonica Siwil Beach	4.11 h	7.67 abc	1.64 fg	4.47 gh
	Zoysia japonica Padang	4.64 g	6.33 bc	1.00 g	3.99 h
	Zoysia japonica Parangtritis	4.02 h	6.33 bc	1.00 g	3.79 h
Sediment	*Zoysia matrella* Zeon	8.29 a	7.67 abc	9.00 a	8.32 ab
	Zoysia matrella Zmeet	6.24 e	7.67 abc	3.67 e	5.86 ef
	Zoysia matrella West Aceh	7.31 c	8.33 ab	8.79 a	8.14 abc
	Zoysia matrella Sleman	7.13 cd	8.33 ab	6.44 cd	7.30 cd
	Zoysia matrella Kopeng	7.67 b	9.00 a	8.79 a	8.48 a
	Zoysia matrella Buleleng	6.87 d	7.67 abc	7.83 abc	7.45 bcd
	Zoysia matrella Malang	7.84 b	7.00 abc	8.79 a	7.88 abcd
Alfisols	*Zoysia matrella* Zeon	8.38 a	7.67 abc	1.11 g	5.72 ef
	Zoysia matrella Zmeet	6.42 e	7.67 abc	3.35 ef	5.81 ef
	Zoysia matrella West Aceh	7.22 cd	8.33 ab	8.89 a	8.15 abc
	Zoysia matrella Sleman	7.04 cd	8.33 ab	8.36 ab	7.91 abcd
	Zoysia matrella Kopeng	7.76 b	9.00 a	8.79 a	8.51 a
	Zoysia matrella Buleleng	6.87 d	8.33 ab	1.43 g	5.54 ef
	Zoysia matrella Malang	7.84 b	7.00 abc	1.75 fg	5.53 ef

Note: Means within the same column followed by the same letter were not significantly different according to Duncan's Multiple Range Test (DMRT) at α = 0.05

Table 6. Comparison of visual quality between *Zoysia japonica* and *Zoysia matrella* in different growing media

Species	Growing media	Leaf width (cm)	Leaf color	Shoot density	Visual quality
Zoysia japonica	Sediment	0.27 a	3.80 b	40.07 b	5.61 c
	Alfisols	0.27 a	3.93 b	28.73 c	4.90 c
Zoysia matrella	Sediment	0.16 b	4.48 a	50.05 a	7.63 a
	Alfisols	0.16 b	4.52 a	37.43 b	6.74 b
p-value		0.000**	0.000**	0.000*	0.000**

Note: Values represent means of accessions within each species. Means within the same column followed by the same letter are not significantly different according to DMRT at α = 0.05

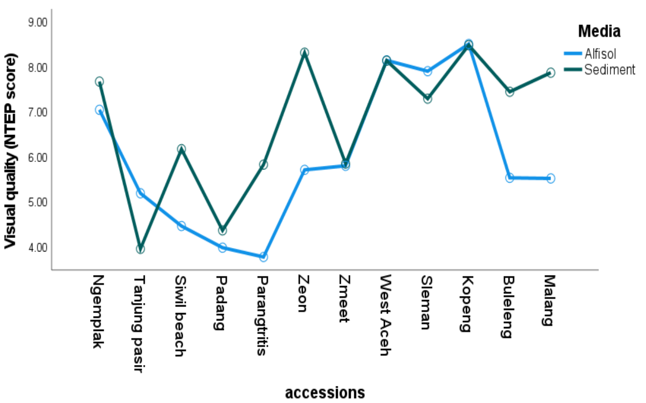

Figure 1. Interaction effect of growing media and accessions on turfgrass visual quality (NTEP scores)

Based on averaged accession values, differences between species and growing media were observed for all visual quality parameters. *Z. matrella* grown in both media generally exhibited higher leaf color scores, narrower leaves, and slightly higher shoot density than *Z. japonica*, resulting in higher overall visual quality values. Across both growing media, the leaf width of *Z. japonica* was 68.75% wider than that of *Z. matrella* (Table 6). The wider leaves observed in *Z. japonica* were consistent with Patton et al. (2017), that *Z. japonica* exhibits two leaf width categories: wide leaves (>3.5 mm) and intermediate leaves (2.5-3.5 mm), whereas *Z. matrella* generally has narrower leaves, ranging from 1.5 to 2.5 mm. Finer leaf texture contributes to a more visually aesthetically pleasing appearance, which is an important factor in visual quality assessment (Patton 2010). Similarly, De (2017) reported that *Z. matrella* has finer leaves than both *Z. japonica* and Seashore paspalum, which tend to exhibit coarser leaf textures. De Barreda et al. (2025) reported that the green color intensity of *Z. matrella* was 11.99% higher than that of *Z. japonica*, a difference primarily attributable to genotypic factors. In this study, the highest leaf color values were observed in *Z. matrella* grown on Alfisol, although these values were not significantly different from those obtained on sediment media. Takahashi et al. (2025) reported that *Z. matrella* generally exhibits dark green leaves, with visual scores ranging from 4.5 to 6, indicating greater greenness. Dark green coloration is commonly associated with better physiological conditions and greater plant vigor. The shoot density of *Z. matrella* was also higher on average than that of *Z. Japonica,* representing 24.91% under sediment media and 30.28% under Alfisol. This characteristic is associated with its faster stolon growth rate and narrower leaf width. These characteristics result in greater tiller production compared to *Z. japonica*.

The shoot density of *Z. matrella* was also higher on average than that of *Z. Japonica,* representing 24.91% under sediment media and 30.28% under Alfisol. This characteristic is associated with its faster stolon growth rate and narrower leaf width. These characteristics result in greater tiller production compared to *Z. japonica*. This finding aligns with Patton (2010), who reports that *Z. matrella* generally exhibits higher shoot density than *Z. japonica*. Higher shoot density produces denser, more uniform turf that enhances turfgrass visual quality. This denser and more uniform canopy structure is further illustrated in Figures 2.C-2.D, where *Z. matrella* exhibits a more compact and visually uniform turf surface compared to *Z. japonica*.

Overall, *Z. matrella* tended to exhibit higher visual quality scores than *Z. Japonica*. This tendency was associated with finer leaf texture, darker green leaf color, and higher shoot density. However, variability among accessions within each species was also observed, indicating that accession-level differences contribute to the overall visual performance. These traits make *Z. matrella* particularly suitable for applications requiring high visual turf quality, such as sports turf systems where dense canopy coverage, fine leaf texture, and stable surface conditions are required to maintain high-quality playing surfaces.

Turfgrass functional quality

The functional quality of turfgrasses was evaluated using general functional traits, including final coverage, shoot biomass, and root characteristics. Because turfgrass performance varies depending on its intended use, this study focused on general functional indicators rather than application-specific criteria. Analysis of variance showed that growing media significantly affected final coverage percentage, root dry weight, and root length ($p<0.01$) among accession, while shoot dry weight was affected at $p<0.05$.

Figure 2. Visual comparison of *Zoysia japonica* and *Zoysia matrella*. A. Morfology of *Z. japonica* (left) and *Z. matrella* (right), B. *Z. japonica* in Gelora Bung Karno (2018), C. *Z. matrella* in Gelora Bung Karno (2025)

The highest final coverage (100%) was observed in *Z. japonica* from Siwil Beach, Ngemplak, and Parangtritis, all of which were grown in sediment media and reached the maximum score of 9. Within *Z. matrella*, complete coverage (100%) was observed only in the Kopeng accession grown in sediment. Turfgrass coverage is widely recognized as a primary indicator of field quality, with values approaching or exceeding 90% reflecting optimal establishment (Burbrink and Straw 2023). The superior coverage observed in these treatments was likely associated with rapid stolon growth and lateral spread, which enhance surface uniformity and accelerate canopy closure (Gaetani et al. 2017). Table 7 confirms that the highest shoot dry weight was observed in *Z. japonica* Siwil Beach grown in sediment, which was approximately 98.15% higher than the lowest value recorded for *Z. matrella* Buleleng grown in Alfisol media.

Root traits also varied among accessions and growing media. In *Z. japonica,* the highest root dry weight was observed in the Ngemplak, Siwil Beach, and Parangtritis grown in sediment, as well as in Ngemplak grown in Alfisols, although these differences were not statistically significant. In all treatment combinations, the *Z. matrella* Malang accession produced the highest root dry weight under sediment, which was 475.47% higher than that of the same accession grown in Alfisol media. A similar pattern was observed for root length. The highest values within *Z. japonica* were recorded in sediment-grown Ngemplak, Siwil Beach, and Parangtritis, as well as Ngemplak under Alfisols. In *Z. matrella*, the highest value was observed in the Malang accession under sediment. Overall, the greatest root length was produced by the *Z. japonica* Parangtritis accession grown in sediment, exceeding the lowest value (Siwil Beach in Alfisols) by 38.55%.

Root systems play a crucial role in turfgrass functional quality by supporting water and nutrient uptake and plant stability. In the present study, accessions with greater root biomass and longer root systems tended to exhibit higher turf coverage and shoot development, indicating that strong root growth contributed to improved functional turf performance. Well-developed roots can also improve soil physical properties and water retention (Głąb et al. 2020) and enhance plant tolerance to environmental stress (Juliantika and Wicaksono 2017). In addition, extensive root growth promotes stolon and rhizome development, which can increase shoot density and accelerate turf coverage.

Overall, as shown in Table 8, the highest functional quality within *Z. japonica* was observed in the Siwil Beach accession grown in sediment, with high final coverage percentage, shoot dry weight, and root length. The second-highest functional quality was recorded in the Ngemplak accession grown in both sediment and Alfisol media, which combined high coverage percentage with relatively long root systems. However, the lowest functional quality was observed in the Parangtritis accession grown in Alfisols. Among *Z. matrella* accessions, the Malang accession grown in sediment exhibited the highest functional quality, driven primarily by high coverage and exceptionally high root dry weight. This value was not significantly different from the West Aceh and Kopeng accessions in the sediment. Both accessions showed comparable root biomass; however, the Kopeng accession achieved slightly higher functional performance because it reached complete turf coverage (100%), whereas West Aceh reached 96.51% coverage. These three accessions showed significantly higher functional quality than Zeon and Zmeet.

Figure 3 clearly demonstrates a strong accession and media interaction, indicating that the effect of growing media is genotype-dependent rather than uniform. Accessions such as Siwil Beach, Padang, Parangtritis, Zeon, Buleleng, and Malang showed substantial increases in functional quality under sediment, whereas others, including Ngemplak, Zmeet, West Aceh, and Kopeng, exhibited relatively stable responses across both media. This pattern suggests that the effect of growing media on functional quality is accession-dependent, with some accessions being specifically adapted to sediment conditions while others maintain broader adaptability.

In general, sediment media promoted better functional performance than Alfisols. This advantage is related to improved soil aeration, which enhances root proliferation and water uptake efficiency (Abuarab et al. 2019). Although Alfisols had higher nutrient levels than river sediments (Table 3), their clay-rich soils often have denser structures that can restrict root penetration and reduce soil aeration, affecting plant performance and soil quality (Bhatt et al. 2025). In contrast, the sandy texture of sediment facilitates better aeration and deeper root penetration, supporting more extensive root development. Enhanced root growth can optimize root contact, thereby increasing carbon inputs to the soil and stimulating microbial activity and soil structure (Vetterlein et al. 2022). These conditions ultimately contributed to improved turf establishment and functional quality in sediment media.

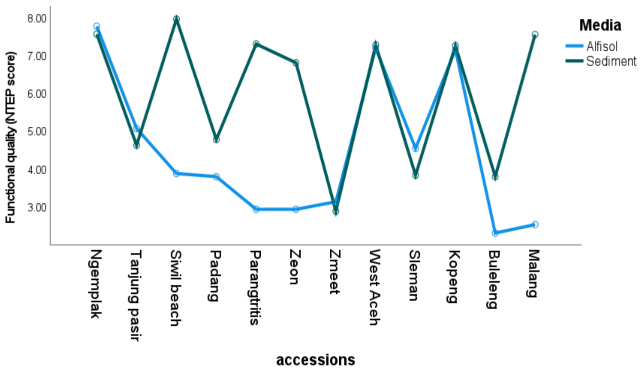

Figure 3. Interaction effect of growing media and accessions on turfgrass functional quality (NTEP scores)

Table 7. Raw measurement values of turfgrass functional quality parameters under different growing media

Growing media	Accession	Functional quality parameters			
		Final coverage percentage (%)	Shoot dry weight (g)	Root dry weight (g)	Root length (cm)
Sediment	*Zoysia japonica* Ngemplak	100.00 a	1.01 b	1.42 b	18.06 a
	Zoysia japonica Tanjung Pasir	58.50 def	0.88 b	0.91 cd	11.28 f
	Zoysia japonica Siwil Beach	100.00 a	1.07 a	1.62 b	18.02 a
	Zoysia japonica Padang	76.43 bc	0.87 b	0.54 d	12.45 d
	Zoysia japonica Parangtritis	100.00 a	0.84 b	1.40 b	18.26 a
Alfisols	*Zoysia japonica* Ngemplak	98.41 a	0.93 b	1.57 b	18.22 a
	Zoysia japonica Tanjung Pasir	97.92 a	0.84 b	0.82 d	11.26 f
	Zoysia japonica Siwil Beach	72.59 cd	0.77 b	0.63 d	11.22 f
	Zoysia japonica Padang	47.80 f	0.69 b	1.10 bc	13.86 c
	Zoysia japonica Parangtritis	31.45 g	0.73 b	0.77 d	12.52 d
Sediment	*Zoysia matrella* Zeon	99.82 a	0.83 b	1.68 b	13.16 c
	Zoysia matrella Zmeet	57.91 def	0.66 b	0.82 cd	11.80 f
	Zoysia matrella West Aceh	96.51 a	0.92 b	1.68 b	12.85 d
	Zoysia matrella Sleman	89.42 ab	0.71 b	0.79 d	12.00 ef
	Zoysia matrella Kopeng	100.00 a	0.94 b	1.68 b	13.00 c
	Zoysia matrella Buleleng	69.83 cd	0.74 b	0.83 d	11.97 ef
	Zoysia matrella Malang	97.20 a	0.91 b	3.05 a	14.10 b
Alfisols	*Zoysia matrella* Zeon	58.87 def	0.69 b	0.58 d	11.74 f
	Zoysia matrella Zmeet	64.85 cde	0.68 b	0.78 d	12.05 de
	Zoysia matrella West Aceh	90.66 ab	0.87 b	1.90 b	13.14 c
	Zoysia matrella Sleman	73.35 cd	0.76 b	1.02 cd	12.85 d
	Zoysia matrella Kopeng	89.79 ab	0.91 b	1.75 b	13.03 c
	Zoysia matrella Buleleng	52.10 ef	0.54 b	0.59 d	11.77 f
	Zoysia matrella Malang	52.53 ef	0.65 b	0.53 d	11.73 f

Note: Means within the same column followed by the same letter were not significantly different according to Duncan's Multiple Range Test (DMRT) at α = 0.05

Table 8. NTEP-based parameter scoring and functional quality assessment

Growing media	Accession	Function quality parameters				Functional quality
		Final coverage percentage score	Shoot dry weight score	Root dry weight score	Root length score	
Sediment	*Zoysia japonica* Ngemplak	9.00 a	9.00 a	6.33 b	5.96 b	7.57 ab
	Zoysia japonica Tanjung Pasir	5.68 def	8.72 a	2.36 cde	1.79 k	4.64 d
	Zoysia japonica Siwil Beach	9.00 a	9.00 a	7.96 a	5.94 b	7.97 a
	Zoysia japonica Padang	7.11 bc	8.53 a	1.00 e	2.51 h	4.79 d
	Zoysia japonica Parangtritis	9.00 a	8.01 a	6.17 b	6.08 a	7.32 abc
Alfisols	*Zoysia japonica* Ngemplak	8.87 a	8.64 a	7.56 ab	6.06 a	7.78 ab
	Zoysia japonica Tanjung Pasir	8.83 a	7.79 a	1.91 de	1.78 k	5.08 d
	Zoysia japonica Siwil Beach	6.81 cd	5.66 b	1.35 e	1.75 k	3.89 e
	Zoysia japonica Padang	4.82 f	3.21 def	3.83 c	3.38 d	3.81 e
	Zoysia japonica Parangtritis	3.52 g	4.20 bcd	1.51 e	2.55 h	2.94 fg
Sediment	*Zoysia matrella* Zeon	8.99 a	7.47 a	7.85 a	2.95 e	6.82 c
	Zoysia matrella Zmeet	5.63 def	2.15 efg	1.69 de	2.11 j	2.89 fg
	Zoysia matrella West Aceh	8.97 a	9.00 a	8.44 a	2.75 g	7.29 abc
	Zoysia matrella Sleman	8.18 ab	3.63 cde	1.32 e	2.23 i	3.84 e
	Zoysia matrella Kopeng	9.00 a	9.00 a	8.23 a	2.85 f	7.27 abc
	Zoysia matrella Buleleng	6.59 cd	4.81 bc	1.61 de	2.21 i	3.80 e
	Zoysia matrella Malang	8.78 a	8.95 a	9.00 a	3.53 c	7.56 ab
Alfisols	*Zoysia matrella* Zeon	5.71 def	2.99 def	1.00 e	2.07 j	2.94 fg
	Zoysia matrella Zmeet	6.19 cde	2.72 def	1.40 e	2.26 i	3.14 f
	Zoysia matrella West Aceh	8.25 ab	8.64 a	9.00 a	2.93 ef	7.21 bc
	Zoysia matrella Sleman	6.87 cd	5.46 b	3.13 cd	2.76 g	4.55 d
	Zoysia matrella Kopeng	8.18 ab	8.95 a	8.65 a	2.86 ef	7.16 bc
	Zoysia matrella Buleleng	5.17 ef	1.00 g	1.00 e	2.09 j	2.31 g
	Zoysia matrella Malang	5.20 ef	1.90 fg	1.00 e	2.06 j	2.54 fg

Note: Means within the same column followed by the same letter were not significantly different according to Duncan's Multiple Range Test (DMRT) at α = 0.05

Table 9. Comparison of functional quality between *Zoysia japonica* and *Zoysia matrella* in different growing media

Species	Growing media	Final coverage percentage score	Shoot dry weight	Root dry weight	Root length	Functional quality
Zoysia	Sediment	86.99 a	0.94 a	1.18 ab	15.61 a	6.46 a
japonica	Alfisols	69.63 b	0.79 bc	0.98 b	13.42 b	4.70 bc
Zoysia	Sediment	87.73 a	0.82 b	1.50 a	12.70 b	5.64 ab
matrella	Alfisols	68.88 b	0.73 c	1.02 b	12.33 b	4.27 c
p-value		0.004**	0.000**	0.024*	0.000**	0.004*

Note: Values represent means of accessions within each species. Means within the same column followed by the same letter are not significantly different according to DMRT at $\alpha = 0.05$

Values across accessions of *Z. japonica* were generally higher than those of *Z. matrella* for several functional parameters, including shoot dry weight, root length, and functional quality (Table 9). The final coverage of *Z. japonica* grown in sediment was approximately 26.29% higher than that observed for *Z. matrella* grown in Alfisol. For shoot dry weight and root length, *Z. japonica* grown in sediment recorded the highest values. Root length in this treatment was approximately 22.91% longer than that of *Z. matrella* grown in sediment and about 26.60% longer than that of *Z. matrella* grown in Alfisol, which exhibited the lowest root length. These findings are consistent with Fuentealba et al. (2015), who reported that *Z. japonica* often exhibits faster root development, greater coverage, and longer root growth than *Z. matrella*. The difference has been associated with greater capacity for early root establishment and more vigorous root system development. This inherent rooting advantage enhances the acquisition of soil resources, contributing to the superior biomass accumulation observed under sediment conditions (Kyum et al. 2025).

Overall, under the conditions tested, accessions of *Z. japonica* tended to produce higher shoot biomass and longer roots, particularly in sediment media. However, several *Z. matrella* accessions exhibited comparable functional performance, indicating that variation among accessions within species also plays an important role in determining turfgrass functional quality.

Limitations of this study

Although this study provides useful insights into the visual and functional performance of several *Zoysia* accessions under different growing media, several limitations should be acknowledged. The experiment was conducted in pots with a relatively shallow soil depth (5 cm) and a relatively short observation period, which may not fully represent long-term field conditions or root development dynamics. In addition, the study focused on the establishment phase over a relatively short period (16 weeks) and, therefore, does not fully represent long-term turf performance. Important management factors typical of sports fields, such as mowing, wear or traffic stress, and variable irrigation regimes, were not included in this experiment. These conditions may influence turfgrass growth, canopy density, and functional traits in real-world field conditions. Therefore, additional long-term field trials under real-world sports-field management conditions are needed to validate the performance of these accessions for stadium turf applications. Future research should therefore evaluate these accessions under field conditions, incorporate longer observation periods, and assess responses to management practices and environmental stresses. Such studies would provide more comprehensive insights into the performance and adaptability of native *Zoysia* germplasm for sustainable turfgrass development.

In conclusion, this study demonstrates that both genetic variation and soil growing media influence the turf quality of native *Zoysia* accessions. River sediment generally supported better turf performance than Alfisol, particularly for visual quality traits such as canopy density, color, and overall turf appearance. Among the evaluated accessions, the Kopeng accession of *Z. matrella* showed the highest visual quality with an NTEP score of approximately 8.51, while the Siwil Beach accession of *Z. japonica* achieved the highest functional turf quality with a score of approximately 7.97. Statistical analysis indicated significant interactions between accession and growing media ($p<0.05$), confirming that turfgrass performance depends on genotype-specific responses to soil conditions. These findings highlight the importance of evaluating local genetic resources to identify turfgrass accessions that are well adapted to specific soil environments. The results provide a useful foundation for selecting native *Zoysia* accessions for turfgrass development, landscape applications, and sports field management in Indonesia.

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