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1	EJBO-2209-2150	Original Article	THE SIMILARITY MATRIX AND DENDROGRAM OF BARNYARDGRASS WEED ON LOWLAND RICE FIELD	2022-09-25	Submitted by Author	2022-09-25			

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1	EJBO-2209-2150	Original Article	THE SIMILARITY MATRIX AND DENDROGRAM OF BARNYARDGRASS WEED ON LOWLAND RICE FIELD	2022-09-25	Under Review	2022-10-06			

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Reviewers Recommendation

Reviewer 1	EJBO-2209-2150	Major Revision

Reviewer Comment For Author:

Dear Authors,

It is an interesting paper that investigate the seed morphological variation in Echinochloa crus-galli in 9 sub-districts Serdang Bedagai and one accession as a comparison from Medan City in Indonesia. I have some concerns to be considered before publication:

1- However, it is well known that Echinochloa is a weed species that may grow in rice fields but the authors didn't refer to the intensity and distribution of the weed in Indonesia or in these 9 sub districts or the actual economical cost of the presence of this weed

2- Authors did not provide any relation between the information about seed morphology of Echinochloa and farmers management of barnyardgrass weeds in their lowland rice fields as mentioned in the manuscript

3- I believe that the title should be changed to suit the content about the species seed morphology variation and the aim of the paper should be clear to relate the morphological variation

4- The word accession was mentioned many times in the manuscript but it is not clear how many individuals are included in the accession (it needs to be clarified)

5- No information included in the manuscript about the rice cultivation pattern in Indonesia

6- DMRT post hoc analysis should be replaced with Tukey as it is not clear how many plants included in each accession (12 seeds but leaves from how many individuals?). In general Tukey is much robust analysis.

7- SPSS is not the best software for cluster analysis and average grouping is not the best method (I suggest the use of Euclidean distance and wards method for cluster analysis)

8- numbers mentioned in the text should be as mean +- SE as it is in the tables not as a single numbers

9- the variation among various accessions and individuals is very high specially for the upper lemma measurements and there is no explanation provided

10- What are the environmental conditions for different accessions and why have the authors chose the MDN sample to be a baseline or control for the rest of the accessions

Good luck

Reviewer 2	EJBO-2209-2150	Minor Revision

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Original Manuscript Status: Manuscript Needs Revision (Major Revision)

Revision Due Date: 2022-12-06

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1	EJBO-2209-2150 (R1)	Original Article	The Seed Characteristics and Similarity of Barnyardgrass Weed on Lowland Rice Field	2022-09-25	2022-11-11	Manuscript Revised by Author	2022-11-11			

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#	Manuscript ID	Manuscript Type	Manuscript Title	Submit Date	Current Status	Modify Date	Revision Due Date	Email	Withdraw
1	EJBO-2209-2150 (R2)	Original Article	The Seed Characteristics and Similarity of Barnyardgrass Weed on Lowland Rice Field	2022-09-25	Manuscript Needs Revision (Acceptance With Minor Revision)	2022-11-29	2022-12-29		

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Authors

Alridiwirsah Alridiwirsah [1]; Mohammad Basyuni [2]; Koko Tampubolon [3]; Novilda E. Mustamu [4]

[1]Program Study of Agrotechnology, Faculty of Agriculture, Universitas Muhammadiyah Sumatera Utara, Medan 20238, Indonesia

[2]Program Study of Forestry, Faculty of Forestry, Universitas Sumatera Utara, Medan 20155, Indonesia

[3]Program Study of Agrotechnology, Faculty of Agriculture, Universitas Sumatera Utara, Medan 20155, Indonesia

[4]Program Study of Agrotechnology, Faculty of Science and Technology, Universitas Labuhanbatu, Rantauprapat 21415, Sumatera Utara, Indonesia

Abstract

In lowland rice areas, the presence of barnyardgrassweed (*Echinochloa crus-galli*) is disadvantageous to Indonesian farmers and requires an initial assessment and identification of characteristics for management. Therefore, this study aimed to obtain the characteristics and similaritiesof barnyardgrassaccessions from lowland rice fields based on the morphological characteristics of the seed. A descriptive-analytical method was used to determine the barnyardgrasscharacteristics of 45 accessions from nine sub-districts in Serdang Bedagai and one accession from Medan City (MDN), Indonesia, as a comparison. This studywas conducted from May to August 2022 and the datawere analyzed using one-way ANOVA, followed by Tukey's test at $P<0.05$. The hierarchical cluster and constellation plot were generated using Ward's method. The results showed that 45 accessions of barnyardgrassfrom lowland rice fields had sizes of upper glume, lower glume, upper lemma, flag leaf length, and flag leaf width ranging from 2.93 to 4.33 mm, 1.45 to 1.96 mm, 0.03 to 17.10 mm, 22.77 to 45.40 cm, and 0.53 to 1.13 cm, respectively. Among all accessions, only PG4 accession was nearest (1.825) to MDN. Furthermore, there were five clusters with 13 accessions including SB4; PC1; PC5; PG3; PG4; BK1; BK3; BK5; PB1; PB2; TB2; TB1; and TT2, classified in the same cluster as MDN. This information is very important as an initial reference for farmers in the management of barnyardgrassweeds in their lowland rice fields.

Keywords

Accession; Characteristics; Identification; Lowland rice; Similarity

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THE SIMILARITY MATRIX AND DENDROGRAM OF BARNYARDGRASS WEED ON LOWLAND RICE FIELD

Alridiwirsah[1], Mohammad Basyuni[2]*, Koko Tampubolon[3], & Novilda Elizabeth Mustamu[4]

[1]Program Study of Agrotechnology, Faculty of Agriculture, Universitas Muhammadiyah Sumatera Utara, Medan 20238, Indonesia.

[2]Program Study of Forestry, Faculty of Forestry, Universitas Sumatera Utara, Medan 20155, Indonesia.

[3]Program Study of Agrotechnology, Faculty of Agriculture, Universitas Sumatera Utara, Medan 20155, Indonesia.

[4]Program Study of Agrotechnology, Faculty of Science and Technology, Universitas Labuhanbatu, Rantauprapat 21415, Sumatera Utara, Indonesia.

*Corresponding author: m.basyuni@usu.ac.id

ABSTRACT

The presence of barnyardgrass weed (*Echinochloa crus-galli*) in lowland rice areas will be disadvantageous to farmers in Indonesia. Initial information assessment (characteristics identification) is needed for the weed management. This study was to obtain the characteristics and similarit**ies** of barnyardgrass accessions from lowland rice fields based on morphological characters. This study used a descriptive-analytic method by determining the barnyardgrass characteristics of 45 accessions from nine sub-districts in Serdang Bedagai and one accession as a comparison from Medan City (MDN), Indonesia. The characteristics determined of

barnyardgrass were conducted from May-August 2022. Data were analyzed using one-way ANOVA and followed by DMRT at $P<0.05$. The similarity matrix and dendrogram were constructed by the hierarchical cluster analysis. The results showed that 45 accessions of barnyardgrass from lowland rice fields had sizes of upper glume (2.93-4.33 mm), lower glume (1.45-1.96 mm), an upper lemma (0.03-17.10 mm), flag leaf length (22.77-45.40 cm), and flag leaf width (0.53-1.13 cm). Among all accessions, only PG4 accessions had the nearest neighbors (1.825) with MDN accessions. There were four clusters of barnyardgrass accession and PG3-4; PC1-2; PB4; and TT1 accessions were classified into one cluster with MDN accessions. This information is very important as an initial reference for farmers in the management of barnyardgrass weeds in their lowland rice fields.

Keywords: accession; characteristics; identification; lowland rice; similarity

INTRODUCTION

Barnyardgrass (*Echinochloa crus-galli*) is an annual weed that reproduces through seeds and grows to a height of up to 150 cm (Bagavathiannan *et al.,* 2012). Barnyardgrass can grow in tropical and subtropical climates and can produce up to 39,000 seeds (Bagavathiannan *et al.,* 2012; Miller *et al.,* 2018). In addition, barnyardgrass had high adaptability, quickly germination, abundant seed production, and strongly competitiveness which can cause economic losses to the main crop (Mennan *et al.,* 2012; Bajwa *et al.,* 2015), and can cause a loss of rice yield ranging from 21-79% (Wilson *et al.,* 2014).

The presence of a barnyardgrass population at a distance of 40 cm from lowland rice plants can decrease yield by 27% and it can absorb nitrogen

availability ranging from 60-80%, inhibiting rice growth (Wilson *et al.,* 2014), and it can decrease rice yield by 30-100% throughout the growing season (Bhullar *et al.*, 2016; Marchesi & Saldain, 2019). *E. crus galli* var. mitis can decrease rice grain production by 12.7-42.6% and inhibit the photosynthesis rate, root weight, root oxidation activity, and biomass accumulation (Zhang *et al.*, 2017). Alridiwirsah *et al.*, (2022) added barnyardgrass with five populations in lowland rice which had root length and volume, dry weight of roots, and shoots of 39.4 cm; 246.1 ml; 92.7 g; and 65.6 g, respectively.

The presence of barnyardgrass in lowland rice fields is fearfulness to be disadvantageous to farmers in the central areas of lowland rice such as Serdang Bedagai District. It has been reported that Serdang Bedagai District had the second highest rice harvest area (48,121.62 ha) after Deli Serdang District from North Sumatra Province, Indonesia in 2021 (Statistics of Sumatera Utara, 2022). Barnyardgrass weeds need to be managed appropriately based on several approaches, one of which is the initial effort by identifying the characteristics and similarit**ies** of barnyardgrass to obtain the relationship between accessions from several regions. Tahir, (2016) reported the barnyardgrass characteristics had the leaf length 16.2-30.0 cm, leaf width 1.2-1.5 cm, upper glume 2.94-3.80 mm, lower glume 1.21-1.68 mm, upper lemma 2.71-3.55 mm, and the number of seeds/plants 7186-71494 from several locations in Arkansas. The researchers found eight of 95 accessions from *Echinochloa sp.* which are classified as barnyardgrass based on morphological characters. Alridiwirsah *et al.*, (2022) also added the histological characteristics of barnyardgrass leaves (upper epidermis, mesophyll, lower

epidermis, and stomata density) in lowland rice plants of 44.3 μm; 155.6 μm; 40.8 μm; and 69.0 n/μm.

Characteristics identification and similarity of barnyardgrass from lowland rice fields in Indonesia have never been reported, therefore an initial effort is needed by determining several characters (flag leaf length and width, upper and lower glume, and upper lemma) from several sub-districts in Serdang Bedagai. This study was to obtain the characteristics and similarit**ies** of barnyardgrass weed accessions from lowland rice fields based on morphological characters. This information is expected to be a basic strategy for the management of barnyardgrass weeds.

MATERIAL AND METHODS

Seed Collection Area of Barnyardgrass Accession

The barnyardgrass seeds accessions were taken from nine sub-districts (Sei Bamban, Sei Rampah, Tebing Tinggi, Perbaungan, Teluk Mengkudu, Pegajahan, Pantai Cermin, Tanjung Beringin, and Bandar Kalifah) in Serdang Bedagai District, and one accession for comparison was taken from Medan City, Indonesia. The barnyardgrass accession from 9 sub-districts had been controlled with herbicide based on farmer interviews, while accession for comparison was controlled manually. Each sub-district consisted of five accessions from different villages, resulting in 45 accessions. Barnyardgrass seeds are taken from lowland rice fields with physiological maturity criteria marked by the loss of seeds when held. The flag leaf length and width of each accession were measured. It was recorded that the environmental conditions of the barnyardgrass growth (Table 1). The barnyardgrass seeds were taken from May-August 2022. The seeds were dried for two days.

Methodology and Data Analysis

This study used a descriptive-analytic method that describes the similarity of barnyardgrass based on the seeds morphological observations (upper and lower glume, upper lemma) and flag leaves (length, width) and then constructed a dendrogram between accessions. Twelve seeds were taken at random from each accession of barnyardgrass and then the glume and lemma were measured using an electronic digital caliper. The characteristics of the seeds and leaves were analyzed using one-way ANOVA and continued with the DMRT at $P<0.05$. The similarity matrix and dendrogram between accessions of barnyardgrass weeds were measured using a hierarchical cluster analysis using IBM SPSS Statistics v.20 software.

Table 1. Locations and accession codes of barnyardgrass form Serdang Bedagai District and Medan City.

Sub-districts	Accessions	Villages	Longitude	Latitude	Altitude (m asl)	Temperature (°C)	Humidity (%)	Air pressure (hPa)
Sei Bamban	SB1	Bakaran Batu	99º08.089'	3º25.259'	5	26.7	88	1012
	SB2	Hapoltahan Nauli	99º08.383'	3º26.552'	4	25.1	92	1011
	SB3	Gempolan	99º07.415'	3º25.078'	9	25.0	93	1011
	SB4	Sei Buluh	99º10.605'	3º26.848'	2	25.3	91	1010
	SB5	Sukadamai	99º09.636'	3º24.762'	6	24.6	92	1010
Sei Rampah	SR1	Firdaus	99º08.210'	3º30.776'	9	29.1	68	1005
	SR2	Pematang Ganjang	99º08.235'	3º27.905'	13	28.0	76	1006
	SR3	Sei Parit	99º07.958'	3º28.603'	11	32.2	56	1006
	SR4	Sei Rejo	99º09.885'	3º30.434'	10	30.7	65	1004
	SR5	Sei Rampah	99º10.168'	3º29.590'	10	30.4	67	1004
Tebing Tinggi	TT1	Paya Lombang	99º11.737'	3º22.216'	16	29.0	75	1009

	TT2	Paya Mabar	99º12.323'	3º23.715'	15	28.9	75	1009
	TT3	Sei Priok	99º13.738'	3º24.511'	12	29.9	67	1008
	TT4	Kuta Baru	99º12.491'	3º21.887'	16	31.2	63	1006
	TT5	Meriah Padang	99º05.111'	3º18.138'	30	29.3	81	1005
	PB1	Melati I	98º58.034'	3º33.567'	10	24.1	79	1009
	PB2	Melati II	98º58.032'	3º33.177'	22	25.1	79	1009
Perbaungan	PB3	Jambur Pulau	98º57.755'	3º34.322'	1	25.1	78	1008
	PB4	Cinta Air	98º59.606'	3º34.488'	16	26.1	77	1007
	PB5	Citaman Jernih	98º57.526'	3º33.731'	10	27.1	63	1007
	TM1	Pasar Baru	99º06.396'	3º33.056'	9	30.2	63	1006
	TM2	Pematang Gantung	99º07.967'	3º33.068'	10	29.9	64	1006
Teluk Mengkudu	TM3	Sialang Buah	99º07.082'	3º33.862'	14	30.2	65	1005
	TM4	Bongak Besar	99º09.038'	3º33.060'	17	29.5	65	1005
	TM5	Sentang	99º08.333'	3º33.287'	12	29.5	65	1005

Pegajahan	PG1	Bingkat IX-B	98º57.552'	3º28.899'	30	29.0	93	1008
	PG2	Bingkat XI	98º57.512'	3º28.546'	13	28.0	93	1008
	PG3	Bingkat X-A	98º57.107'	3º28.800'	13	28.0	93	1008
	PG4	Pegajahan	98º56.800'	3º28.821'	19	28.0	93	1008
	PG5	Bingkat X-B	98º58.427'	3º28.729'	26	28.0	94	1009
Pantai Cermin	PC1	Kota Pari	98º57.625'	3º38.446'	14	30.1	65	1009
	PC2	Pematang Kasih	99º01.282'	3º37.617'	2	31.2	67	1006
	PC3	Kuala Lama	99º01.512'	3º37.137'	11	30.2	67	1006
	PC4	Naga Kaisar	99º03.656'	3º36.252'	19	30.2	70	1007
	PC5	Pantai Cermin Kanan	98º58.150'	3º38.430'	21	30.1	71	1007
Tanjung Beringin	TB1	Nagur	99º11.259'	3º30.712'	8	28.0	79	1005
	TB2	Mangga Dua	99º11.018'	3º30.637'	7	27.1	80	1006
	TB3	Tebing Tinggi	99º13.680'	3º29.070'	22	25.6	90	1009
	TB4	Pematang Cermai	99º12.650'	3º28.709'	6	25.9	89	1009

	TB5	Pematang Terang	99º14.571'	3º26.858'	9	25.8	90	1009
Bandar Kalifah	BK1	Galam Sei Serimah	99º15.197'	3º26.468'	5	29.0	67	1006
	BK2	Pekan Bandar Kalifah	99º16.767'	3º26.633'	4	28.9	68	1006
	BK3	Kayu Besar	99º17.133'	3º25.996'	1	29.0	68	1005
	BK4	Jahar	99º16.897'	3º24.302'	10	28.8	72	1005
	BK5	Bandar Tengah	99º15.907'	3º23.973'	17	27.4	81	1006
Medan Selayang	MDN	Padang Bulan	98º39.009'	3º33.170'	14	25.0	34	1002

RESULTS AND DISCUSSION

Morphological Characters of the Seeds and Flag Leaf in Barnyardgrass

The results showed that the sizes of the seeds glume and lemma between barnyardgrass accessions were significantly different from the comparison accessions (Table 2). The highest size of upper and lower glume was found in TB3 and TM1 accessions (Tanjung Beringin 3 and Teluk Mengkudu 1) at 4.33 mm and 1.96 mm, respectively. Among all accessions, PB1 (Perbaungan 1) had the longest upper lemma size by 17.10 mm. The highest size of flag leaf length and width of barnyardgrass accession were found in PB4 and PC2 by 45.40 and 1.13 cm, respectively.

The difference in the size of the barnyardgrass seeds for each accession (Serdang Bedagai) with the comparison accession (MDN) can be seen visually in Figure 1. Among the observations of the size of the barnyardgrass seed, the upper lemma is visible. The longest lemma size from each sub-district was found in SB5; SR2; TT5; PB1; TM1; PC4; TB3; and BK2 accessions, but the upper lemma of PG1-5 was not significantly different from the accession comparison (MDN).

Correlation Coefficient

The flag leaf length and width were positively correlated with the size of the upper glume of barnyardgrass accessions (Table 3). Likewise, both characters were significant and positively correlated (0.505^{**} and 0.344^{*}) to the size of the lower glume of barnyardgrass seeds.

Similarity Matrix and Dendrogram of Barnyardgrass Accessions

The similarity matrix between barnyardgrass accessions from Serdang Bedagai and the comparison accession can be presented in Table 4. Only PG4

accession had the nearest neighbors (1.825). It was indicated the accession is nearest to the characteristics of barnyardgrass seeds from the comparison accessions. Based on the results of the dendrogram, barnyardgrass accessions can be grouped into 4 groups (Figure 2). Group 1 had seven accessions (MDN; PG3-4; PC1-2; PB4; TT1) and group 2 consisted of TB3 and SB5 accessions, while group 3 had only the SR5 accession. Group 4 consisted of 36 accessions (SB1-4; SR1-4; TT2-5; PB1-3; PB5; TM1-5; PG1-2; PG5; PC3-5; TB1-2; TB4-5; BK1-5).

Table 2. Upper dan lower glume, upper lemma, flag leaf length, and width of barnyardgrass accessions from lowland rice fields in Serdang Bedagai District.

Accessions	UG (mm)	LG (mm)	UL (mm)	FLL (cm)	FLW (cm)
MDN	3.90±0.30 a-e	1.85±0.07 a-d	0.04±0.01 l	35.57±2.56 a-g	0.87±0.03 a-e
SB1	3.80±0.06 a-f	1.71±0.04 a-i	8.80±0.22 f-i	31.40±1.32 c-j	0.80±0.03 b-f
SB2	3.54±0.05 b-i	1.74±0.02 a-h	12.94±0.74 cd	30.80±0.69 c-j	0.73±0.03 c-f
SB3	3.82±0.09 a-f	1.83±0.01 a-e	7.20±0.24 h-k	31.90±1.24 c-j	0.83±0.03 a-f
SB4	3.84±0.08 a-f	1.76±0.03 a-g	9.63±0.25 e-h	33.87±0.01 b-h	0.87±0.03 a-e
SB5	4.06±0.09 ab	1.65±0.02 c-i	13.12±0.41 bcd	28.23±2.89 f-j	0.73±0.07 c-f
SR1	4.01±0.07 abc	1.75±0.04 a-g	11.26±0.21 d-g	33.53±2.49 b-i	0.83±0.04 a-f
SR2	3.64±0.08 b-h	1.71±0.03 a-i	11.86±0.77 cde	37.27±2.05 a-f	0.83±0.04 a-f
SR3	3.55±0.06 a-f	1.69±0.03 b-i	9.26±0.42 e-i	30.80±0.41 c-j	0.67±0.01 ef
SR4	3.43±0.03 b-i	1.82±0.05 a-f	6.12±0.07 jk	31.00±2.98 c-j	1.00±0.04 a-d
SR5	3.52±0.01 b-i	1.83±0.04 a-f	0.03±0.00 l	29.57±0.46 d-j	0.53±0.01 f
TT1	3.55±0.07 b-i	1.89±0.02 abc	0.05±0.01 l	44.53±0.66 a	1.07±0.01 ab
TT2	3.37±0.04 c-i	1.48±0.02 hi	5.12±0.25 k	39.03±0.70 a-e	1.03±0.01 abc
TT3	3.52±0.07 b-i	1.46±0.02 i	12.97±0.27 cd	29.83±0.08 c-j	0.67±0.01 ef
TT4	2.95±0.09 i	1.57±0.02 f-i	11.28±0.52 d-g	30.27±2.33 c-j	0.83±0.10 a-f
TT5	3.40±0.09 b-i	1.55±0.02 ghi	14.21±0.82 bc	24.80±0.77 hij	0.53±0.01 f
PB1	3.33±0.01 d-i	1.48±0.01 hi	17.10±0.18 a	32.87±0.12 b-j	0.97±0.01 a-e
PB2	3.47±0.06 b-i	1.62±0.03 d-i	13.43±0.77 bcd	26.63±0.95 g-j	1.03±0.04 abc
PB3	2.93±0.08 i	1.57±0.04 e-i	9.99±0.32 efg	27.30±2.86 f-j	0.77±0.08 b-f
PB4	3.78±0.13 a-f	1.94±0.05 ab	0.04±0.00 l	45.40±0.66 a	1.07±0.01 ab
PB5	3.62±0.10 b-h	1.90±0.04 abc	11.50±0.95 c-f	39.17±0.66 a-d	1.00±0.03 a-d

TM1	3.09±0.13 ghi	1.96±0.02 a	15.67±0.11 ab	31.70±0.70 c-j	0.80±0.03 b-f
TM2	3.18±0.06 f-i	1.71±0.01 a-i	11.54±0.37 c-f	27.30±1.37 f-j	0.77±0.06 b-f
TM3	3.37±0.07 c-i	1.60±0.05 d-i	6.85±0.69 ijk	33.60±0.57 b-i	1.00±0.07 a-d
TM4	3.56±0.10 b-i	1.82±0.00 a-g	11.87±0.99 cde	27.70±0.68 f-j	0.80±0.03 b-f
TM5	2.99±0.08 hi	1.64±0.04 c-i	5.81±0.36 k	28.47±1.86 f-j	0.70±0.05 def
PG1	3.68±0.05 b-g	1.67±0.02 c-i	0.07±0.01 l	28.83±0.77 d-j	0.90±0.03 a-e
PG2	3.25±0.06 e-i	1.57±0.04 e-i	0.05±0.01 l	31.37±0.50 c-j	1.07±0.01 ab
PG3	3.57±0.03 b-i	1.80±0.03 a-g	0.08±0.01 l	42.53±0.97 ab	0.93±0.01 a-e
PG4	3.51±0.07 b-i	1.78±0.03 a-g	0.06±0.01 l	35.70±1.57 a-g	0.90±0.03 a-e
PG5	3.50±0.03 b-i	1.71±0.03 a-i	0.04±0.01 l	26.73±2.83 g-j	0.77±0.08 b-f
PC1	3.31±0.02 e-i	1.83±0.04 a-f	0.06±0.01 l	39.13±0.85 a-d	0.97±0.01 a-e
PC2	3.68±0.09 b-g	1.94±0.04 ab	0.07±0.01 l	40.13±0.38 abc	1.13±0.03 a
PC3	3.17±0.09 f-i	1.55±0.04 ghi	0.05±0.01 l	23.13±1.57 ij	0.80±0.03 b-f
PC4	2.99±0.05 hi	1.47±0.02 i	8.61±0.49 g-j	27.43±0.36 f-j	0.73±0.01 c-f
PC5	3.54±0.08 b-i	1.80±0.04 a-g	0.06±0.01 l	24.63±1.67 hij	0.87±0.03 a-e
TB1	3.29±0.07 e-i	1.58±0.04 d-i	0.08±0.01 l	28.70±0.08 e-j	0.97±0.01 a-e
TB2	3.58±0.12 b-i	1.65±0.03 c-i	0.04±0.01 l	26.10±0.49 g-j	0.97±0.04 a-e
TB3	4.33±0.20 a	1.48±0.00 i	12.02±0.33 cde	26.13±1.10 g-j	0.67±0.04 ef
TB4	4.02±0.10 abc	1.67±0.05 c-i	0.07±0.00 l	28.67±0.51 e-j	0.90±0.03 a-e
TB5	3.10±0.10 ghi	1.68±0.05 b-i	0.05±0.01 l	31.17±1.27 c-j	0.80±0.03 b-f
BK1	3.68±0.11 b-g	1.77±0.04 a-g	0.06±0.01 l	25.40±0.52 g-j	0.93±0.04 a-e
BK2	3.25±0.07 e-i	1.45±0.04 i	11.74±0.37 cde	22.77±0.49 j	0.53±0.01 f
BK3	4.00±0.10 a-d	1.69±0.04 b-i	0.09±0.01 l	28.40±1.14 f-j	1.03±0.05 abc
BK4	3.53±0.11 b-i	1.49±0.02 hi	10.59±0.42 d-g	32.27±0.61 c-j	0.80±0.03 b-f

BK5	3.49±0.06 b-i	1.75±0.05 a-g	0.08±0.01 l	28.00±1.09 f-j	1.03±0.03 abc

Note: the mean followed by a different letter is significant in the DMRT at $P<0.005$ ± standard error. UG= upper glume; LG= lower glume; UL= upper lemma; FLL= flag leaf length, FLW= flag leaf width.

Table 3. The correlation coefficient between the barnyardgrass accessions from Serdang Bedagai District and the comparison accession.

Traits	FLL	FLW	UG	LG	UL
FLL	1	0.528**	0.156	0.505**	-0.185
FLW		1	0.110	0.344*	-0.436**
UG			1	0.254	-0.080
LG				1	-0.323*
UL					1

Note: *and** Correlation is significant at the 0.05 and 0.01 level. FLL= flag leaf length, FLW= flag leaf width, UG= upper glume, LG= lower glume, UL= upper lemma.

Table 4. The similarity matrix value between the barnyardgrass accessions from Serdang Bedagai District and the comparison accession (MDN).

No	Accessions	Matrix value	No	Accessions	Matrix value
1	SB1	4.151	26	PG1	3.681
2	SB2	8.473	27	PG2	10.584
3	SB3	2.123	28	PG3	3.021
4	SB4	3.253	29	PG4	1.825
5	SB5	10.001	30	PG5	5.680
6	SR1	4.549	31	PC1	4.419

7	SR2	5.956	32	PC2	4.627
8	SR3	7.589	33	PC3	15.327
9	SR4	4.833	34	PC4	20.879
10	SR5	7.879	35	PC5	5.469
11	TT1	5.818	36	TB1	9.449
12	TT2	12.000	37	TB2	6.506
13	TT3	16.903	38	TB3	17.747
14	TT4	17.800	39	TB4	3.410
15	TT5	22.047	40	TB5	8.795
16	PB1	19.415	41	BK1	4.456
17	PB2	13.647	42	BK2	27.019
18	PB3	19.117	43	BK3	4.261
19	PB4	5.600	44	BK4	11.736
20	PB5	5.988	45	BK5	5.280
21	TM1	15.179			
22	TM2	12.882			
23	TM3	8.225			
24	TM4	7.651			
25	TM5	14.563			

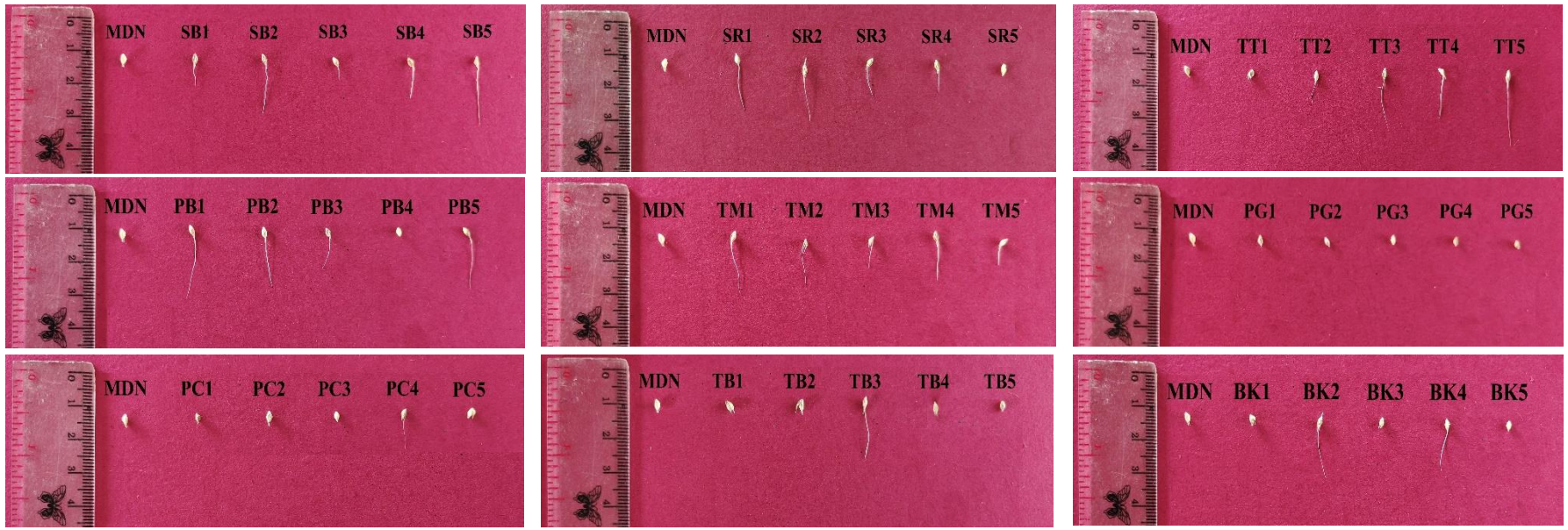

Figure 1. The difference in the size of the seed glume and lemma in barnyardgrass accessions from Serdang Bedagai District and the comparison accession (MDN) visually.

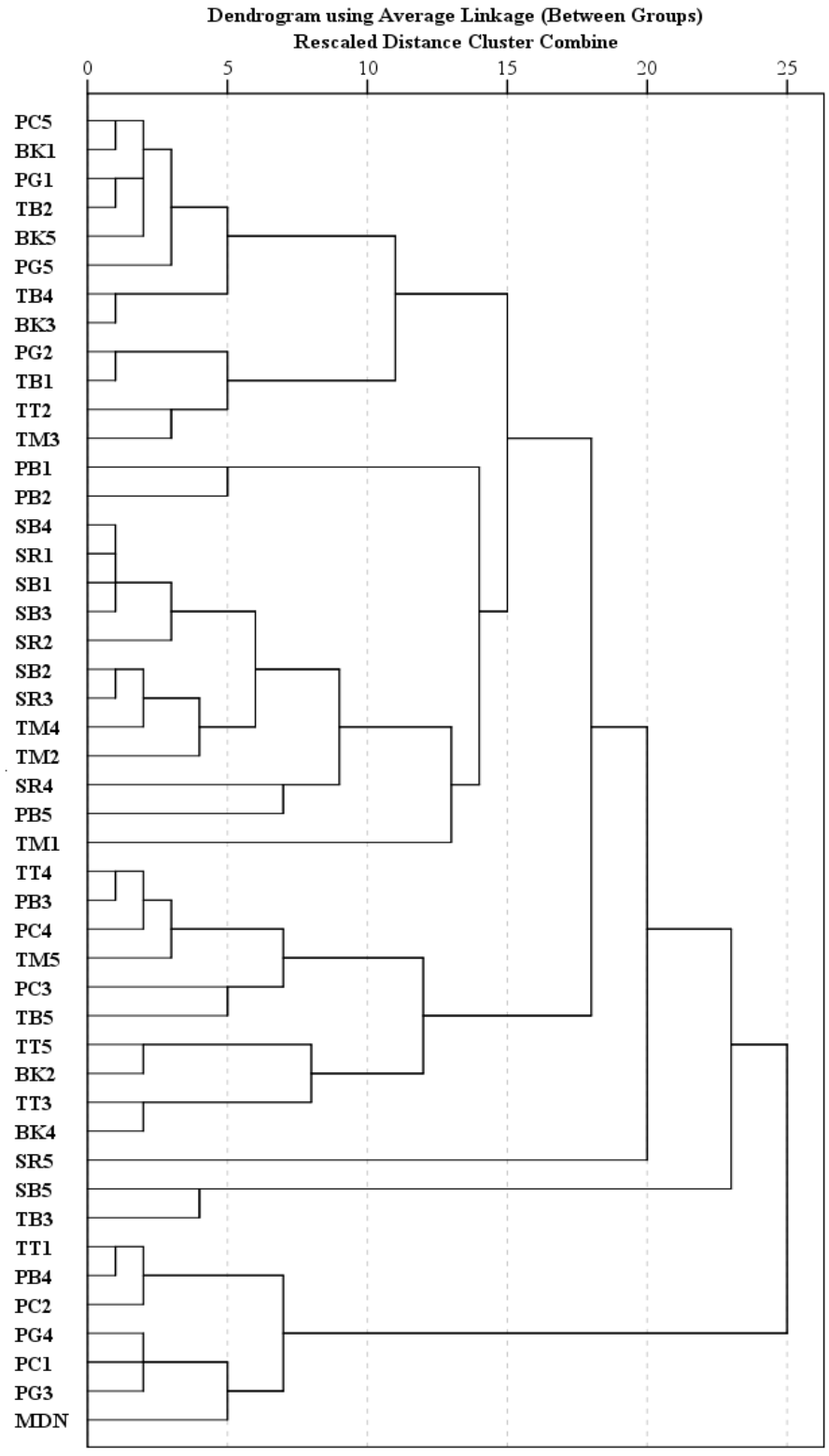

Figure 2. Dendrogram of barnyardgrass accessions from Serdang Bedagai District and Medan City (comparison) using hierarchical cluster analysis. n= 46 samples.

Discussion

The results showed that the sizes of upper glume, lower glume, upper lemma, flag leaf length, and width of the barnyardgrass accession from Serdang Bedagai District ranged from 2.93-4.33 mm; 1.45-1.96 mm; 0.03-17.10 mm; 22.77-45.40 cm; and 0.53-1.13 cm, respectively (Table 2). The size of the upper and lower glume in TB3 and TM1 accessions were higher than in other accessions, as well as the upper lemma found in PB1 accession. The results also showed that PB4 and PC2 accessions had the highest flag leaf length and width compared to other accessions. This indicates that the size of seed glume from these locations could be due to the total assimilating produced from the flag leaf area (length and width) of the barnyardgrass. This finding was supported by the flag leaf length and width were positively correlated (0.156 and 0.110) with the size of the upper glume of barnyardgrass seeds, and both positively correlated character and significantly (0.505^{**} and 0.344^{*}) with the size of the lower glume of the seeds (Table 3). In contrast, the size of the upper lemma of seeds was negatively correlated with the flag leaf length and width. This finding was supported by Asana, (1968) that flag leaf had an important role in providing photosynthesis to seeds. Ashrafuzzaman *et al.*, (2009); Rahman et al., (2013) added that flag leaf area was positively correlated with panicle length and seed production. Tahir, (2016) also reported that the characteristics of barnyardgrass from Arkansas had flag leaf length 16.2-30 cm, flag leaf width 1.2-1.5 cm, panicle length 13.8-20.8 cm, upper glume 3.1-3.8 mm, lower glume 1.2-1.7 mm, and upper lemma 2.7-3.6 mm.

It can be seen that only the PG4 accession had the nearest neighbors with comparison accessions (MDN) with a similarity value of 1.825. These findings

were corroborated by the resulting dendrogram, the PG3-4; PC1-2; PB4; and TT1 accessions were clustered in one group with the comparison accessions (MDN). This indicates that the characters of upper and lower glume, upper lemma, flag leaf length, and width of the PG3-4; PC1-2; PB4; and TT1 accessions were not more different from the MDN accession (Table 2). This result was supported by Tahir, (2016) that eight of 95 accessions *Echinochloa sp* were clustered to the barnyardgrass cluster based on vegetative and generative characters from several locations in Arkansas. Altop & Mennan, (2011) grouped the barnyardgrass weeds from lowland rice fields in Turkey into three clusters based on morphological characters, 28 of 34 barnyardgrass populations had nearest neighbors. The researcher's findings also showed that the morphological character approach is almost similar when a molecular approach (RAPD), 33 of 34 barnyardgrass populations were clustered into one group.

These findings indicate that six of 45 accessions (PG3-4; PC1-2; PB4; and TT1) from lowland rice fields in Serdang Bedagai District were similar to comparison accession. This result showed the management of barnyardgrass weeds carried out by farmers from these accessions were not more different with the farmers from the comparison accession. These findings are the first report in Indonesia. However, the assessment of similarity through the morphological character approach must be re-examined molecularly.

CONCLUSIONS

Based on morphological characters, 45 accessions of barnyardgrass weeds from Serdang Bedagai District had the sizes of upper and lower glume (2.93-4.33

mm and 1.45-1.96 mm), an upper lemma (0.03-17.10 mm), the flag leaf length and width (22.77-45.40 cm and 0.53-1.13 cm). Accessions of TB3; TM1; PB1; PB4; and PC2 had the highest characteristic size compared to other accessions. The PG4 accession had the nearest neighbors (1.825) with the comparison accession (MDN). It was also found that the PG3-4; PC1-2; PB4; TT1 accessions were classified into one cluster with the MDN accession.

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#	Manuscript ID	Manuscript Type	Manuscript Title	Submit Date	Current Status	Modify Date	Manuscript Main File	Email	Withdraw
1	EJBO-2209-2150	Original Article	THE SIMILARITY MATRIX AND DENDROGRAM OF BARNYARDGRASS WEED ON LOWLAND RICE FIELD	2022-09-25	Submitted by Author	2022-09-25			

- Editor-in-Chief Comments
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- Finish Submission

Editor-in-Chief Comment for Author

Reviewers Recommendation

Reviewer 1	EJBO-2209-2150	Major Revision

Reviewer Comment For Author:

Dear Authors,

It is an interesting paper that investigate the seed morphological variation in Echinochloa crus-galli in 9 sub-districts Serdang Bedagai and one accession as a comparison from Medan City in Indonesia. I have some concerns to be considered before publication:

1- However, it is well known that Echinochloa is a weed species that may grow in rice fields but the authors didn't refer to the intensity and distribution of the weed in Indonesia or in these 9 sub districts or the actual economical cost of the presence of this weed

2- Authors did not provide any relation between the information about seed morphology of Echinochloa and farmers management of barnyardgrass weeds in their lowland rice fields as mentioned in the manuscript

3- I believe that the title should be changed to suit the content about the species seed morphology variation and the aim of the paper should be clear to relate the morphological variation

4- The word accession was mentioned many times in the manuscript but it is not clear how many individuals are included in the accession (it needs to be clarified)

5- No information included in the manuscript about the rice cultivation pattern in Indonesia

6- DMRT post hoc analysis should be replaced with Tukey as it is not clear how many plants included in each accession (12 seeds but leaves from how many individuals?). In general Tukey is much robust analysis.

7- SPSS is not the best software for cluster analysis and average grouping is not the best method (I suggest the use of Euclidean distance and wards method for cluster analysis)

8- numbers mentioned in the text should be as mean +- SE as it is in the tables not as a single numbers

9- the variation among various accessions and individuals is very high specially for the upper lemma measurements and there is no explanation provided

10- What are the environmental conditions for different accessions and why have the authors chose the MDN sample to be a baseline or control for the rest of the accessions

Good luck

Reviewer 2	EJBO-2209-2150	Minor Revision

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Original Manuscript Status: Manuscript Needs Revision (Major Revision)

Revision Due Date: 2022-12-06

Editor-in-Chief Comment

Next

THE SIMILARITY MATRIX AND DENDROGRAM OF BARNYARDGRASS WEED ON LOWLAND RICE FIELD

ABSTRACT

The presence of barnyardgrass weed (*Echinochloa crus-galli*) in lowland rice areas will be disadvantageous to farmers in Indonesia. Initial information assessment (characteristics identification) is needed for the weed management. This study was to obtain the characteristics and similarit**ies** of barnyardgrass accessions from lowland rice fields based on morphological characters. This study used a descriptive-analytic method by determining the barnyardgrass characteristics of 45 accessions from nine sub-districts in Serdang Bedagai and one accession as a comparison from Medan City (MDN), Indonesia. The characteristics determined of barnyardgrass were conducted from May-August 2022. Data were analyzed using one-way ANOVA and followed by DMRT at $P<0.05$. The similarity matrix and dendrogram were constructed by the hierarchical cluster analysis. The results showed that 45 accessions of barnyardgrass from lowland rice fields had sizes of upper glume (2.93-4.33 mm), lower glume (1.45-1.96 mm), an upper lemma (0.03-17.10 mm), flag leaf length (22.77-45.40 cm), and flag leaf width (0.53-1.13 cm). Among all accessions, only PG4 accessions had the nearest neighbors (1.825) with MDN accessions. There were four clusters of barnyardgrass accession and PG3-4; PC1-2; PB4; and TT1 accessions were classified into one cluster with MDN accessions. This information is very important as an initial reference for farmers in the management of barnyardgrass weeds in their lowland rice fields.

Keywords: accession, characteristics, identification, lowland rice, similarity

INTRODUCTION

Barnyardgrass (*Echinochloa crus-galli*) is an annual weed that reproduces through seeds and grows to a height of up to 150 cm (Bagavathiannan *et al.*, 2012). Barnyardgrass can grow in tropical and subtropical climates and can produce up to 39,000 seeds (Bagavathiannan *et al.*, 2012; Miller *et al.*, 2018). In addition, barnyardgrass had high adaptability, quick~~ly~~ germination, abundant seed production, and strong~~ly~~ competitiveness which can cause economic losses to the main crop (Mennan *et al.*, 2012; Bajwa *et al.*, 2015), and can cause a loss of rice yield ranging from 21-79% (Wilson *et al.*, 2014).

The presence of a barnyardgrass population at a distance of 40 cm from lowland rice plants can decrease yield by 27% and it can ~~absorb~~ reduce nitrogen availability ~~ranging~~ from 60-80%, inhibiting rice growth (Wilson *et al.*, 2014), and it can decrease rice yield by 30-100% throughout the growing season (Bhullar *et al.*, 2016; Marchesi & Saldain, 2019). *E. crus galli* var. mitis can decrease rice grain production by 12.7-42.6% and inhibit the photosynthesis rate, root weight, root oxidation activity, and biomass accumulation (Zhang *et al.*, 2017). Alridiwirsah *et al.*, (2022) added that barnyardgrass with five populations in lowland rice which had root length and volume, dry weight of roots, and shoots of 39.4 cm; 246.1 ml; 92.7 g; and 65.6 g, respectively.

The presence of barnyardgrass in lowland rice fields is fearfulness to be disadvantageous to farmers in the central areas of lowland rice such as Serdang Bedagai District. It has been reported that Serdang Bedagai District had the second highest rice harvest area (48,121.62 ha) after Deli Serdang District from North Sumatra Province, Indonesia in 2021 (Statistics of Sumatera Utara, 2022).

Barnyardgrass weeds need to be managed appropriately based on several approaches, one of which is the initial effort by identifying the characteristics and similarit**ies** of barnyardgrass to obtain the relationship between accessions from several regions. Tahir (2016) reported that the characteristics of barnyardgrass from several locations in Arkansas ~~had the~~ are: leaf length 16.2-30.0 cm, leaf width 1.2-1.5 cm, upper glume 2.94-3.80 mm, lower glume 1.21-1.68 mm, upper lemma 2.71-3.55 mm, and the number of seeds/plants 7186-71494. ~~The researchers found eight of 95 accessions from *Echinochloa sp.* which are classified as barnyardgrass based on morphological characters.~~ Alridiwirsah *et al.,* (2022) also added the histological characteristics of barnyardgrass leaves in lowland rice plants: upper epidermis, mesophyll thickness, lower epidermis, and stomata density as 44.3 µm; 155.6 µm; 40.8 µm; and 69.0 n/µm, respectively.

Characteristics identification and similarity of barnyardgrass from lowland rice fields in Indonesia have not been reported. An initial effort is needed to determine several characters (flag leaf length and width, upper and lower glume, and upper lemma) from several sub-districts in Serdang Bedagai. This study was carried out to obtain the characteristics and similarit**ies** of barnyardgrass weed accessions from lowland rice fields based on morphological characters. This information is expected to be a basis for establishing a management strategy for the control of barnyardgrass weeds.

MATERIAL AND METHODS

Seed Collection Area of Barnyardgrass Accession

The barnyardgrass seeds accessions were taken from nine sub-districts (Sei Bamban, Sei Rampah, Tebing Tinggi, Perbaungan, Teluk Mengkudu, Pegajahan, Pantai Cermin, Tanjung Beringin, and Bandar Kalifah) in Serdang Bedagai District, and one accession for comparison was taken from Medan City, Indonesia. The barnyardgrass accession from 9 sub-districts had been controlled with herbicide based on farmer interviews, while accession for comparison was controlled manually. Five accessions were collected from different villages in each sub-district, resulting in 45 accessions. Barnyardgrass seeds are taken from lowland rice fields with physiological maturity criteria marked by the loss of seeds when held. The flag leaf length and width of each accession were measured. Environmental conditions of barnyardgrass growth were recorded (Table 1). Barnyardgrass seeds were taken from May-August 2022. The seeds were dried for two days.

Methodology and Data Analysis

This study used a descriptive-analytic method that describes the similarity of barnyardgrass based on the seeds morphological observations (upper and lower glume, upper lemma) and flag leaves (length, width) and then constructed a dendrogram between accessions. Twelve seeds were taken at random from each accession and then the glume and lemma were measured using an electronic digital caliper. The characteristics of the seeds and leaves were analyzed using one-way ANOVA and continued with the DMRT at $P<0.05$. The similarity matrix and dendrogram between accessions of barnyardgrass weeds were measured using a hierarchical cluster analysis using IBM SPSS Statistics v.20 software.

Table 1. Locations and accession codes of barnyardgrass form Serdang Bedagai District and Medan City, Indonesia.

Sub-districts	Accessions	Villages	Longitude	Latitude	Altitude (m asl)	Temperature (°C)	Humidity (%)	Air pressure (hPa)
Sei Bamban	SB1	Bakaran Batu	99º08.089'	3º25.259'	5	26.7	88	1012
	SB2	Hapoltahan Nauli	99º08.383'	3º26.552'	4	25.1	92	1011
	SB3	Gempolan	99º07.415'	3º25.078'	9	25.0	93	1011
	SB4	Sei Buluh	99º10.605'	3º26.848'	2	25.3	91	1010
	SB5	Sukadamai	99º09.636'	3º24.762'	6	24.6	92	1010
Sei Rampah	SR1	Firdaus	99º08.210'	3º30.776'	9	29.1	68	1005
	SR2	Pematang Ganjang	99º08.235'	3º27.905'	13	28.0	76	1006
	SR3	Sei Parit	99º07.958'	3º28.603'	11	32.2	56	1006
	SR4	Sei Rejo	99º09.885'	3º30.434'	10	30.7	65	1004
	SR5	Sei Rampah	99º10.168'	3º29.590'	10	30.4	67	1004
Tebing Tinggi	TT1	Paya Lombang	99º11.737'	3º22.216'	16	29.0	75	1009

	TT2	Paya Mabar	99º12.323'	3º23.715'	15	28.9	75	1009
	TT3	Sei Priok	99º13.738'	3º24.511'	12	29.9	67	1008
	TT4	Kuta Baru	99º12.491'	3º21.887'	16	31.2	63	1006
	TT5	Meriah Padang	99º05.111'	3º18.138'	30	29.3	81	1005
Perbaungan	PB1	Melati I	98º58.034'	3º33.567'	10	24.1	79	1009
	PB2	Melati II	98º58.032'	3º33.177'	22	25.1	79	1009
	PB3	Jambur Pulau	98º57.755'	3º34.322'	1	25.1	78	1008
	PB4	Cinta Air	98º59.606'	3º34.488'	16	26.1	77	1007
	PB5	Citaman Jernih	98º57.526'	3º33.731'	10	27.1	63	1007
Teluk Mengkudu	TM1	Pasar Baru	99º06.396'	3º33.056'	9	30.2	63	1006
	TM2	Pematang Gantung	99º07.967'	3º33.068'	10	29.9	64	1006
	TM3	Sialang Buah	99º07.082'	3º33.862'	14	30.2	65	1005
	TM4	Bongak Besar	99º09.038'	3º33.060'	17	29.5	65	1005
	TM5	Sentang	99º08.333'	3º33.287'	12	29.5	65	1005

Pegajahan	PG1	Bingkat IX-B	98º57.552'	3º28.899'	30	29.0	93	1008
	PG2	Bingkat XI	98º57.512'	3º28.546'	13	28.0	93	1008
	PG3	Bingkat X-A	98º57.107'	3º28.800'	13	28.0	93	1008
	PG4	Pegajahan	98º56.800'	3º28.821'	19	28.0	93	1008
	PG5	Bingkat X-B	98º58.427'	3º28.729'	26	28.0	94	1009
Pantai Cermin	PC1	Kota Pari	98º57.625'	3º38.446'	14	30.1	65	1009
	PC2	Pematang Kasih	99º01.282'	3º37.617'	2	31.2	67	1006
	PC3	Kuala Lama	99º01.512'	3º37.137'	11	30.2	67	1006
	PC4	Naga Kaisar	99º03.656'	3º36.252'	19	30.2	70	1007
	PC5	Pantai Cermin Kanan	98º58.150'	3º38.430'	21	30.1	71	1007
Tanjung Beringin	TB1	Nagur	99º11.259'	3º30.712'	8	28.0	79	1005
	TB2	Mangga Dua	99º11.018'	3º30.637'	7	27.1	80	1006
	TB3	Tebing Tinggi	99º13.680'	3º29.070'	22	25.6	90	1009

	TB4	Pematang Cermai	99º12.650'	3º28.709'	6	25.9	89	1009
	TB5	Pematang Terang	99º14.571'	3º26.858'	9	25.8	90	1009
	BK1	Galam Sei Serimah	99º15.197'	3º26.468'	5	29.0	67	1006
	BK2	Pekan Bandar	99º16.767'	3º26.633'	4	28.9	68	1006
Bandar		Kalifah						
Kalifah	BK3	Kayu Besar	99º17.133'	3º25.996'	1	29.0	68	1005
	BK4	Jahar	99º16.897'	3º24.302'	10	28.8	72	1005
	BK5	Bandar Tengah	99º15.907'	3º23.973'	17	27.4	81	1006
Medan		Padang Bulan	98º39.009'	3º33.170'	14	25.0	34	1002
Selayang	MDN							

RESULTS AND DISCUSSION

Morphological Characters of the Seeds and Flag Leaf in Barnyardgrass

The results showed that the sizes of the seeds, glume and lemma between barnyardgrass accessions were significantly different from the comparison accessions (Table 2). The ~~highest~~ largest size of upper and lower glumes was found in TB3 and TM1 accessions (Tanjung Beringin 3 and Teluk Mengkudu 1) at 4.33 mm and 1.96 mm, respectively. Among all accessions, PB1 (Perbaungan 1) had the longest upper lemma (17.10 mm). The ~~highest size~~ largest values of flag leaf length and width of barnyardgrass accession were found in PB4 and PC2 by 45.40 and 1.13 cm, respectively.

The difference in the size of the barnyardgrass seeds for each accession (Serdang Bedagai) with the comparison accession (MDN) can be seen visually in Figure 1. Among the observations of the size of the barnyardgrass seed, the upper lemma is visible. The longest lemma ~~size~~ from each sub-district was found in accessions SB5, SR2, TT5, PB1, TM1, PC4, TB3 and BK2, but the upper lemma of PG1-5 was not significantly different from the comparison accession MDN.

Correlation Coefficient

The flag leaf length and width were positively correlated with the size of the upper glume of barnyardgrass accessions (Table 3). Likewise, both characters were significant and positively correlated (0.505^{**} and 0.344^{*}) to the size of the lower glume of barnyardgrass seeds.

Similarity Matrix and Dendrogram of Barnyardgrass Accessions

The similarity matrix between barnyardgrass accessions from Serdang Bedagai and the comparison accession ~~can be~~ is presented in Table 4. Only PG4

accession had the nearest neighbors (1.825). It was indicated the accession is nearest to the characteristics of barnyardgrass seeds from the comparison accessions. Based on the results of the dendrogram, barnyardgrass accessions can be grouped into 4 groups (Figure 2). Group 1 had seven accessions (MDN; PG3-4; PC1-2; PB4; TT1) and group 2 consisted of TB3 and SB5 accessions, while group 3 had only the SR5 accession. Group 4 consisted of 36 accessions (SB1-4; SR1-4; TT2-5; PB1-3; PB5; TM1-5; PG1-2; PG5; PC3-5; TB1-2; TB4-5; BK1-5).

Table 2. Upper dan lower glume, upper lemma, flag leaf length, and width of barnyardgrass accessions from lowland rice fields in Serdang Bedagai District.

Accessions	UG (mm)	LG (mm)	UL (mm)	FLL (cm)	FLW (cm)
MDN	3.90±0.30 a-e	1.85±0.07 a-d	0.04±0.01 l	35.57±2.56 a-g	0.87±0.03 a-e
SB1	3.80±0.06 a-f	1.71±0.04 a-i	8.80±0.22 f-i	31.40±1.32 c-j	0.80±0.03 b-f
SB2	3.54±0.05 b-i	1.74±0.02 a-h	12.94±0.74 cd	30.80±0.69 c-j	0.73±0.03 c-f
SB3	3.82±0.09 a-f	1.83±0.01 a-e	7.20±0.24 h-k	31.90±1.24 c-j	0.83±0.03 a-f
SB4	3.84±0.08 a-f	1.76±0.03 a-g	9.63±0.25 e-h	33.87±0.01 b-h	0.87±0.03 a-e
SB5	4.06±0.09 ab	1.65±0.02 c-i	13.12±0.41 bcd	28.23±2.89 f-j	0.73±0.07 c-f
SR1	4.01±0.07 abc	1.75±0.04 a-g	11.26±0.21 d-g	33.53±2.49 b-i	0.83±0.04 a-f
SR2	3.64±0.08 b-h	1.71±0.03 a-i	11.86±0.77 cde	37.27±2.05 a-f	0.83±0.04 a-f
SR3	3.55±0.06 a-f	1.69±0.03 b-i	9.26±0.42 e-i	30.80±0.41 c-j	0.67±0.01 ef
SR4	3.43±0.03 b-i	1.82±0.05 a-f	6.12±0.07 jk	31.00±2.98 c-j	1.00±0.04 a-d
SR5	3.52±0.01 b-i	1.83±0.04 a-f	0.03±0.00 l	29.57±0.46 d-j	0.53±0.01 f
TT1	3.55±0.07 b-i	1.89±0.02 abc	0.05±0.01 l	44.53±0.66 a	1.07±0.01 ab
TT2	3.37±0.04 c-i	1.48±0.02 hi	5.12±0.25 k	39.03±0.70 a-e	1.03±0.01 abc
TT3	3.52±0.07 b-i	1.46±0.02 i	12.97±0.27 cd	29.83±0.08 c-j	0.67±0.01 ef
TT4	2.95±0.09 i	1.57±0.02 f-i	11.28±0.52 d-g	30.27±2.33 c-j	0.83±0.10 a-f
TT5	3.40±0.09 b-i	1.55±0.02 ghi	14.21±0.82 bc	24.80±0.77 hij	0.53±0.01 f
PB1	3.33±0.01 d-i	1.48±0.01 hi	17.10±0.18 a	32.87±0.12 b-j	0.97±0.01 a-e
PB2	3.47±0.06 b-i	1.62±0.03 d-i	13.43±0.77 bcd	26.63±0.95 g-j	1.03±0.04 abc
PB3	2.93±0.08 i	1.57±0.04 e-i	9.99±0.32 efg	27.30±2.86 f-j	0.77±0.08 b-f
PB4	3.78±0.13 a-f	1.94±0.05 ab	0.04±0.00 l	45.40±0.66 a	1.07±0.01 ab
PB5	3.62±0.10 b-h	1.90±0.04 abc	11.50±0.95 c-f	39.17±0.66 a-d	1.00±0.03 a-d

TM1	3.09±0.13 ghi	1.96±0.02 a	15.67±0.11 ab	31.70±0.70 c-j	0.80±0.03 b-f
TM2	3.18±0.06 f-i	1.71±0.01 a-i	11.54±0.37 c-f	27.30±1.37 f-j	0.77±0.06 b-f
TM3	3.37±0.07 c-i	1.60±0.05 d-i	6.85±0.69 ijk	33.60±0.57 b-i	1.00±0.07 a-d
TM4	3.56±0.10 b-i	1.82±0.00 a-g	11.87±0.99 cde	27.70±0.68 f-j	0.80±0.03 b-f
TM5	2.99±0.08 hi	1.64±0.04 c-i	5.81±0.36 k	28.47±1.86 f-j	0.70±0.05 def
PG1	3.68±0.05 b-g	1.67±0.02 c-i	0.07±0.01 l	28.83±0.77 d-j	0.90±0.03 a-e
PG2	3.25±0.06 e-i	1.57±0.04 e-i	0.05±0.01 l	31.37±0.50 c-j	1.07±0.01 ab
PG3	3.57±0.03 b-i	1.80±0.03 a-g	0.08±0.01 l	42.53±0.97 ab	0.93±0.01 a-e
PG4	3.51±0.07 b-i	1.78±0.03 a-g	0.06±0.01 l	35.70±1.57 a-g	0.90±0.03 a-e
PG5	3.50±0.03 b-i	1.71±0.03 a-i	0.04±0.01 l	26.73±2.83 g-j	0.77±0.08 b-f
PC1	3.31±0.02 e-i	1.83±0.04 a-f	0.06±0.01 l	39.13±0.85 a-d	0.97±0.01 a-e
PC2	3.68±0.09 b-g	1.94±0.04 ab	0.07±0.01 l	40.13±0.38 abc	1.13±0.03 a
PC3	3.17±0.09 f-i	1.55±0.04 ghi	0.05±0.01 l	23.13±1.57 ij	0.80±0.03 b-f
PC4	2.99±0.05 hi	1.47±0.02 i	8.61±0.49 g-j	27.43±0.36 f-j	0.73±0.01 c-f
PC5	3.54±0.08 b-i	1.80±0.04 a-g	0.06±0.01 l	24.63±1.67 hij	0.87±0.03 a-e
TB1	3.29±0.07 e-i	1.58±0.04 d-i	0.08±0.01 l	28.70±0.08 e-j	0.97±0.01 a-e
TB2	3.58±0.12 b-i	1.65±0.03 c-i	0.04±0.01 l	26.10±0.49 g-j	0.97±0.04 a-e
TB3	4.33±0.20 a	1.48±0.00 i	12.02±0.33 cde	26.13±1.10 g-j	0.67±0.04 ef
TB4	4.02±0.10 abc	1.67±0.05 c-i	0.07±0.00 l	28.67±0.51 e-j	0.90±0.03 a-e
TB5	3.10±0.10 ghi	1.68±0.05 b-i	0.05±0.01 l	31.17±1.27 c-j	0.80±0.03 b-f
BK1	3.68±0.11 b-g	1.77±0.04 a-g	0.06±0.01 l	25.40±0.52 g-j	0.93±0.04 a-e
BK2	3.25±0.07 e-i	1.45±0.04 i	11.74±0.37 cde	22.77±0.49 j	0.53±0.01 f
BK3	4.00±0.10 a-d	1.69±0.04 b-i	0.09±0.01 l	28.40±1.14 f-j	1.03±0.05 abc
BK4	3.53±0.11 b-i	1.49±0.02 hi	10.59±0.42 d-g	32.27±0.61 c-j	0.80±0.03 b-f

BK5	3.49±0.06 b-i	1.75±0.05 a-g	0.08±0.01 l	28.00±1.09 f-j	1.03±0.03 abc

Note: the mean followed by a different letter is significant in the DMRT at $P<0.005$ ± standard error. UG= upper glume; LG= lower glume; UL= upper lemma; FLL= flag leaf length, FLW= flag leaf width.

Table 3. The correlation coefficient between the barnyardgrass accessions from Serdang Bedagai District and the comparison accession.

Traits	FLL	FLW	UG	LG	UL
FLL	1	0.528**	0.156	0.505**	-0.185
FLW		1	0.110	0.344*	-0.436**
UG			1	0.254	-0.080
LG				1	-0.323*
UL					1

Note: *and** Correlation is significant at the 0.05 and 0.01 level. FLL= flag leaf length, FLW= flag leaf width, UG= upper glume, LG= lower glume, UL= upper lemma.

Table 4. The similarity matrix value between the barnyardgrass accessions from Serdang Bedagai District and the comparison accession (MDN).

No	Accessions	Matrix value	No	Accessions	Matrix value
1	SB1	4.151	26	PG1	3.681
2	SB2	8.473	27	PG2	10.584
3	SB3	2.123	28	PG3	3.021
4	SB4	3.253	29	PG4	1.825
5	SB5	10.001	30	PG5	5.680
6	SR1	4.549	31	PC1	4.419

7	SR2	5.956	32	PC2	4.627
8	SR3	7.589	33	PC3	15.327
9	SR4	4.833	34	PC4	20.879
10	SR5	7.879	35	PC5	5.469
11	TT1	5.818	36	TB1	9.449
12	TT2	12.000	37	TB2	6.506
13	TT3	16.903	38	TB3	17.747
14	TT4	17.800	39	TB4	3.410
15	TT5	22.047	40	TB5	8.795
16	PB1	19.415	41	BK1	4.456
17	PB2	13.647	42	BK2	27.019
18	PB3	19.117	43	BK3	4.261
19	PB4	5.600	44	BK4	11.736
20	PB5	5.988	45	BK5	5.280
21	TM1	15.179			
22	TM2	12.882			
23	TM3	8.225			
24	TM4	7.651			
25	TM5	14.563			

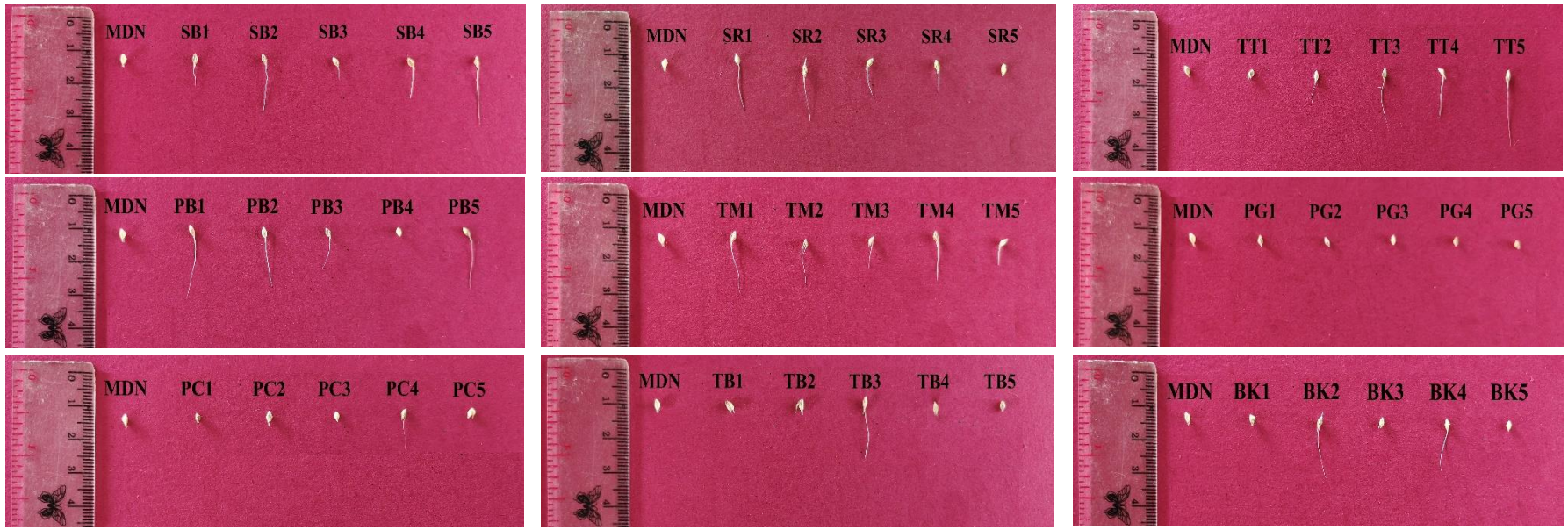

Figure 1. The differences in the size of the seed, glume and lemma in barnyardgrass accessions from Serdang Bedagai District and the comparison accession (MDN) visually.

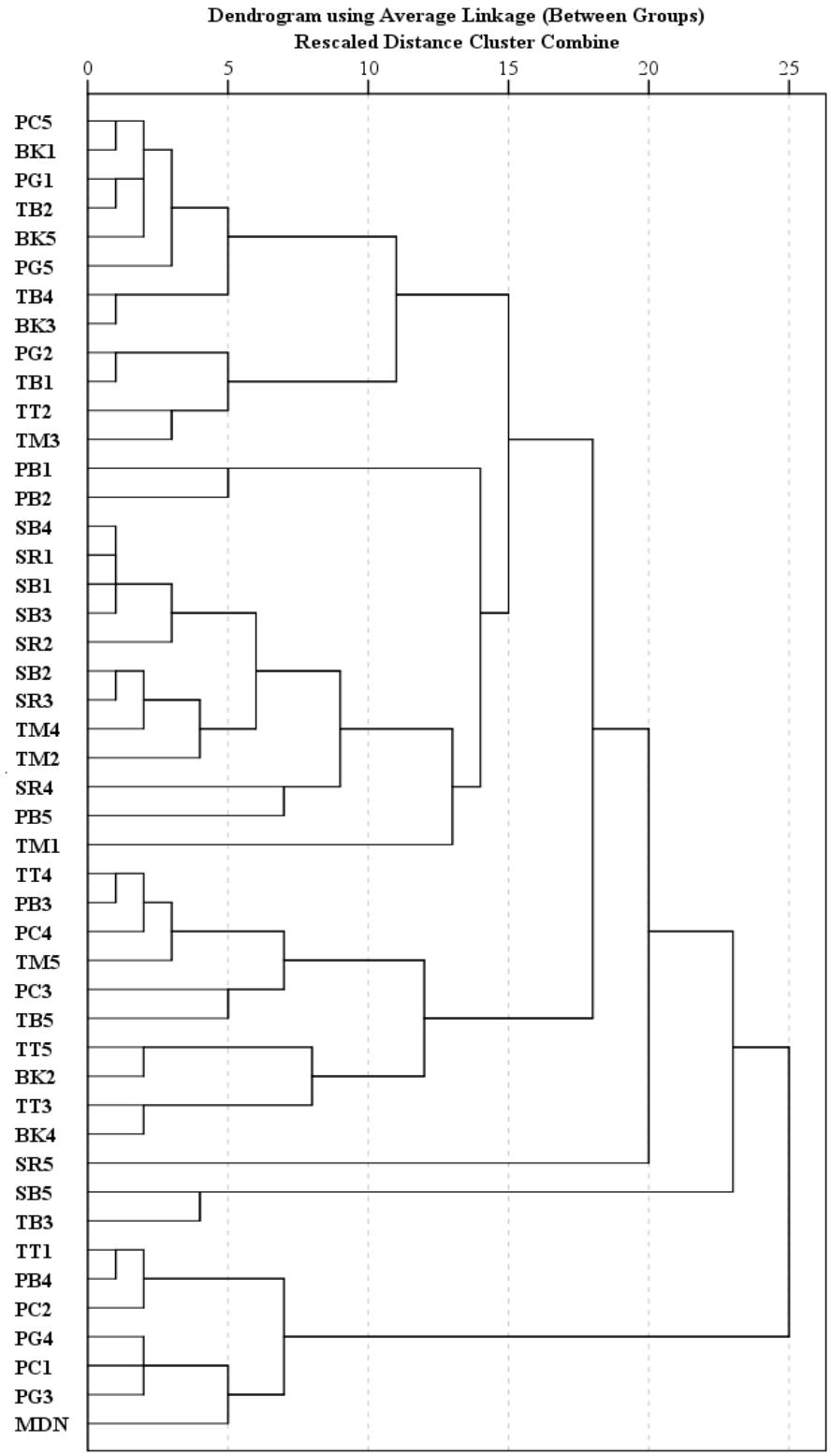

Figure 2. Dendrogram of 45 barnyardgrass accessions from Serdang Bedagai District and Medan City (comparison), Indonesia constructed using

hierarchical cluster analysis. n= 46 samples. Codes of barnyardgrass accessions and their localities are listed in Table 1.

Discussion

The results showed that the sizes of upper glume, lower glume, upper lemma, flag leaf length, and width of the barnyardgrass accession from Serdang Bedagai District ranged from 2.93-4.33 mm; 1.45-1.96 mm; 0.03-17.10 mm; 22.77-45.40 cm; and 0.53-1.13 cm, respectively (Table 2). The size of the upper and lower glume in TB3 and TM1 accessions were higher than in other accessions, as well as the upper lemma found in PB1 accession. The results also showed that PB4 and PC2 accessions had the ~~highest~~ largest values of flag leaf length and width compared to other accessions. This indicates that the size of seed glume from these locations could be due to the total assimilation productivity of the large flag leaf area (length and width). This finding was supported by the flag leaf length and width ~~were~~ which are positively correlated (0.156 and 0.110) with the size of the upper glume of barnyardgrass seeds, and both positively correlated character and significantly (0.505^{**} and 0.344^{*}) with the size of the lower glume of the seeds (Table 3). In contrast, the size of the upper lemma of seeds was negatively correlated with the flag leaf length and width. This finding was supported by Asana, (1968) that flag leaf had an important role in providing photosynthesis products to seeds. Ashrafuzzaman *et al.* (2009), Rahman *et al.* (2013) added that flag leaf area was positively correlated with panicle length and seed production.

~~Tahir, (2016) also reported that the characteristics of barnyardgrass from Arkansas had flag leaf length 16.2-30 cm, flag leaf width 1.2-1.5 cm, panicle length 13.8-20.8 cm, upper glume 3.1-3.8 mm, lower glume 1.2-1.7 mm, and upper lemma 2.7-3.6 mm.~~ This is repeated in the Introduction.

It can be seen that only the PG4 accession had the nearest neighbors with comparison accessions (MDN) with a similarity value of 1.825. These findings were corroborated by the resulting dendrogram, the PG3-4; PC1-2; PB4; and TT1 accessions were clustered in one group with the comparison accessions (MDN). This indicates that the characters of upper and lower glume, upper lemma, flag leaf length, and width of the PG3-4; PC1-2; PB4; and TT1 accessions were not more different from the MDN accession (Table 2). This result was supported by Tahir, (2016) that eight of 95 accessions *Echinochloa sp* were clustered to the barnyardgrass cluster based on vegetative and generative characters from several locations in Arkansas. Altop & Mennan, (2011) grouped the barnyardgrass weeds from lowland rice fields in Turkey into three clusters based on morphological characters, 28 of 34 barnyardgrass populations had nearest neighbors. The researcher's findings also showed that the morphological character approach is almost similar when a molecular approach (RAPD), 33 of 34 barnyardgrass populations were clustered into one group.

These findings indicate that six of 45 accessions (PG3-4; PC1-2; PB4; and TT1) from lowland rice fields in Serdang Bedagai District were similar to comparison accession. This result showed the management of barnyardgrass weeds carried out by farmers from these accessions were not more different with the farmers from the comparison accession. These ~~findings~~ results are reported for the first report in Indonesia. However, the assessment of similarity through the morphological characters approach ~~must~~ should be re-examined by molecular means.

CONCLUSIONS

Based on morphological characters, 45 accessions of barnyardgrass weeds from Serdang Bedagai District had the sizes of upper and lower glume (2.93-4.33 mm and 1.45-1.96 mm), an upper lemma (0.03-17.10 mm), the flag leaf length and width (22.77-45.40 cm and 0.53-1.13 cm). Accessions of TB3; TM1; PB1; PB4; and PC2 had the highest characteristic size compared to other accessions. The PG4 accession ~~had~~ is the nearest neighbor (1.825) ~~with~~ to the comparison accession (MDN). It was also found that the PG3-4, PC1-2, PB4 and TT1 accessions were classified into one cluster with the MDN accession.

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THE SEED CHARACTERISTICS AND SIMILARITY OF BARNYARDGRASS WEED ON LOWLAND RICE FIELD

ABSTRACT

The presence of barnyardgrass weed (*Echinochloa crus-galli*) in lowland rice areas will be disadvantageous to farmers in Indonesia. Initial information assessment (characteristics identification) is needed for the weed management. This study was to obtain the characteristics and similarities of barnyardgrass accessions from lowland rice fields based on seed morphological characters. This study used a descriptive-analytic method by determining the barnyardgrass characteristics of 45 accessions from nine sub-districts in Serdang Bedagai and one accession as a comparison from Medan City (MDN), Indonesia. The characteristics determined of barnyardgrass were conducted from May-August 2022. Data were analyzed using one-way ANOVA and followed by Tukey at $P<0.05$. The hierarchical cluster and constellation plot with the Wards method was constructed. The results showed that 45 accessions of barnyardgrass from lowland rice fields had sizes of upper glume (2.93-4.33 mm), lower glume (1.45-1.96 mm), an upper lemma (0.03-17.10 mm), flag leaf length (22.77-45.40 cm), and flag leaf width (0.53-1.13 cm). Among all accessions, only PG4 accessions had the nearest neighbors (1.825) with MDN accessions. There were five clusters of barnyardgrass accession and thirteen accessions (SB4; PC1; PC5; PG3; PG4; BK1; BK3; BK5; PB1; PB2; TB2; TB1; and TT2) were classified into one cluster with MDN accessions. This information is very important as an initial reference for farmers in the management of barnyardgrass weeds in their lowland rice fields.

Keywords: accession; characteristics; identification; lowland rice; similarity

INTRODUCTION

Barnyardgrass (*Echinochloa crus-galli*) is an annual weed that reproduces through seeds and grows to a height of up to 150 cm (Bagavathiannan et al., 2012). Barnyardgrass can grow in tropical and subtropical climates and can produce up to 39,000 seeds (Bagavathiannan et al., 2012; Miller et al., 2018). In addition, barnyardgrass had high adaptability, quick germination, abundant seed production, and strong competitiveness which can cause economic losses to the main crop (Mennan et al., 2012; Bajwa et al., 2015), and can cause a loss of rice yield ranging from 21-79% (Wilson et al., 2014).

The presence of a barnyardgrass population at a distance of 40 cm from lowland rice plants can decrease yield by 27% and it can reduce nitrogen availability from 60-80%, inhibiting rice growth (Wilson et al., 2014), and it can decrease rice yield by 30-100% throughout the growing season (Bhullar et al., 2016; Marchesi & Saldain, 2019). *E. crus galli* var. mitis can decrease rice grain production by 12.7-42.6% and inhibit the photosynthesis rate, root weight, root oxidation activity, and biomass accumulation (Zhang et al., 2017). Alridiwirsah et al. (2022) added that barnyardgrass with five populations in lowland rice which had root length and volume, dry weight of roots, and shoots of 39.4 cm; 246.1 ml; 92.7 g; and 65.6 g, respectively.

The presence of barnyardgrass in lowland rice fields is fearfulness to be disadvantageous to farmers in the central areas of lowland rice such as Serdang Bedagai District. It has been reported that Serdang Bedagai District had the second highest rice harvest area (48,121.62 ha) after Deli Serdang District from North Sumatra Province, Indonesia in 2021 (Statistics of Sumatera Utara, 2022). As

additional information, based on the Indonesian Center for Rice Research, (2020) land preparation for lowland rice cultivation in Indonesia includes: (1) land was flooded condition at 2-5 cm above the surface for 2-3 days before the soil is plowed, (2) the first plowing of the soil as deep as 15-20 cm using a tractor to kill weeds, then the soil is incubated for 3-4 days, (3) the second plowing was carried out one week after the first tilling for mudding the soil, (4) finally, flattening the ground, left in a moist condition, and unflooded for 1-2 days. Rice seeds are sown, then transplanted and plant management were conducted, one of which is weed control using manual, mechanical, and chemical.

In Serdang Bedagai District, farmers generally use herbicides to control weeds in their planting areas. Barnyardgrass weed is often found and difficult to control. Barnyardgrass weeds need to be managed appropriately based on several approaches, one of which is the initial effort by identifying the characteristics and similarities of barnyardgrass to obtain the relationship between accessions from several regions. Tahir, (2016) reported that the barnyardgrass of characteristics from several locations in Arkansas are the leaf length 16.2-30.0 cm, leaf width 1.2-1.5 cm, upper glume 2.94-3.80 mm, lower glume 1.21-1.68 mm, upper lemma 2.71-3.55 mm, and the number of seeds/plants 7186-71494. Alridiwirsah et al. (2022) also added the histological characteristics of barnyardgrass leaves (upper epidermis, mesophyll, lower epidermis, and stomata density) in lowland rice plants of 44.3 µm; 155.6 µm; 40.8 µm; and 69.0 n/µm.

A characteristics similarity approach is needed for decisions regarding weed control and it has been reported by several researchers (Tampubolon et al., 2019; Bastiani et al., 2016; Juraimi et al., 2005). However, the characteristics

identification and similarity of barnyardgrass from lowland rice fields in Indonesia have never been reported. Therefore an initial effort is needed by determining several characters (flag leaf length and width, upper and lower glume, and upper lemma) from several sub-districts in Serdang Bedagai. This study was to obtain the characteristics and similarities of barnyardgrass weed accessions from lowland rice fields based on seed morphological characters. This information is expected to be a basic strategy for the management of barnyardgrass weeds.

MATERIAL AND METHODS

Seed Collection Area of Barnyardgrass Accession

The barnyardgrass seeds accessions were taken from nine sub-districts (Sei Bamban, Sei Rampah, Tebing Tinggi, Perbaungan, Teluk Mengkudu, Pegajahan, Pantai Cermin, Tanjung Beringin, and Bandar Kalifah) in Serdang Bedagai District, and one accession for comparison was taken from Medan City, Indonesia. The barnyardgrass accession from nine sub-districts had been controlled with herbicide based on farmer interviews, while comparison accession was controlled manually. Each sub-district consisted of five accessions from different villages, resulting in 45 accessions. Each accession was collected by ten populations of barnyardgrass and then composited. Barnyardgrass seeds are taken from lowland rice fields with physiological maturity criteria marked by the loss of seeds when held. The flag leaf length and width of each accession were measured. It was recorded that the environmental conditions of the barnyardgrass growth (Table 1). The barnyardgrass seeds were taken from May-August 2022. The seeds were dried for two days.

Table 1. Locations and accession codes of barnyardgrass form Serdang Bedagai District and Medan City, Indonesia.

Sub-districts	Accessions	Villages	Longitude	Latitude	Altitude (m asl)	Temperature (°C)	Humidity (%)	Air pressure (hPa)
Sei Bamban	SB1	Bakaran Batu	99º08.089'	3º25.259'	5	26.7	88	1012
	SB2	Hapoltahan Nauli	99º08.383'	3º26.552'	4	25.1	92	1011
	SB3	Gempolan	99º07.415'	3º25.078'	9	25.0	93	1011
	SB4	Sei Buluh	99º10.605'	3º26.848'	2	25.3	91	1010
	SB5	Sukadamai	99º09.636'	3º24.762'	6	24.6	92	1010
Sei Rampah	SR1	Firdaus	99º08.210'	3º30.776'	9	29.1	68	1005
	SR2	Pematang Ganjang	99º08.235'	3º27.905'	13	28.0	76	1006
	SR3	Sei Parit	99º07.958'	3º28.603'	11	32.2	56	1006
	SR4	Sei Rejo	99º09.885'	3º30.434'	10	30.7	65	1004
	SR5	Sei Rampah	99º10.168'	3º29.590'	10	30.4	67	1004
Tebing Tinggi	TT1	Paya Lombang	99º11.737'	3º22.216'	16	29.0	75	1009

	TT2	Paya Mabar	99º12.323'	3º23.715'	15	28.9	75	1009
	TT3	Sei Priok	99º13.738'	3º24.511'	12	29.9	67	1008
	TT4	Kuta Baru	99º12.491'	3º21.887'	16	31.2	63	1006
	TT5	Meriah Padang	99º05.111'	3º18.138'	30	29.3	81	1005
	PB1	Melati I	98º58.034'	3º33.567'	10	24.1	79	1009
	PB2	Melati II	98º58.032'	3º33.177'	22	25.1	79	1009
Perbaungan	PB3	Jambur Pulau	98º57.755'	3º34.322'	1	25.1	78	1008
	PB4	Cinta Air	98º59.606'	3º34.488'	16	26.1	77	1007
	PB5	Citaman Jernih	98º57.526'	3º33.731'	10	27.1	63	1007
	TM1	Pasar Baru	99º06.396'	3º33.056'	9	30.2	63	1006
	TM2	Pematang Gantung	99º07.967'	3º33.068'	10	29.9	64	1006
Teluk Mengkudu	TM3	Sialang Buah	99º07.082'	3º33.862'	14	30.2	65	1005
	TM4	Bongak Besar	99º09.038'	3º33.060'	17	29.5	65	1005
	TM5	Sentang	99º08.333'	3º33.287'	12	29.5	65	1005

Pegajahan	PG1	Bingkat IX-B	98º57.552'	3º28.899'	30	29.0	93	1008
	PG2	Bingkat XI	98º57.512'	3º28.546'	13	28.0	93	1008
	PG3	Bingkat X-A	98º57.107'	3º28.800'	13	28.0	93	1008
	PG4	Pegajahan	98º56.800'	3º28.821'	19	28.0	93	1008
	PG5	Bingkat X-B	98º58.427'	3º28.729'	26	28.0	94	1009
Pantai Cermin	PC1	Kota Pari	98º57.625'	3º38.446'	14	30.1	65	1009
	PC2	Pematang Kasih	99º01.282'	3º37.617'	2	31.2	67	1006
	PC3	Kuala Lama	99º01.512'	3º37.137'	11	30.2	67	1006
	PC4	Naga Kaisar	99º03.656'	3º36.252'	19	30.2	70	1007
	PC5	Pantai Cermin Kanan	98º58.150'	3º38.430'	21	30.1	71	1007
Tanjung Beringin	TB1	Nagur	99º11.259'	3º30.712'	8	28.0	79	1005
	TB2	Mangga Dua	99º11.018'	3º30.637'	7	27.1	80	1006
	TB3	Tebing Tinggi	99º13.680'	3º29.070'	22	25.6	90	1009
	TB4	Pematang Cermai	99º12.650'	3º28.709'	6	25.9	89	1009

	TB5	Pematang Terang	99º14.571'	3º26.858'	9	25.8	90	1009
Bandar Kalifah	BK1	Galam Sei Serimah	99º15.197'	3º26.468'	5	29.0	67	1006
	BK2	Pekan Bandar Kalifah	99º16.767'	3º26.633'	4	28.9	68	1006
	BK3	Kayu Besar	99º17.133'	3º25.996'	1	29.0	68	1005
	BK4	Jahar	99º16.897'	3º24.302'	10	28.8	72	1005
	BK5	Bandar Tengah	99º15.907'	3º23.973'	17	27.4	81	1006
Medan Selayang	MDN	Padang Bulan	98º39.009'	3º33.170'	14	25.0	34	1002

Methodology and Data Analysis

This study used a descriptive-analytic method that describes the similarity of barnyardgrass based on the seeds morphological observations (upper and lower glume, upper lemma) and flag leaves (length, width). Twelve seeds were taken at random from each accession of barnyardgrass and then the glume and lemma were measured using an electronic digital caliper. The characteristics of the seeds and leaves were analyzed using one-way ANOVA and continued with the Tukey at $P<0.05$. The similarity between accessions of barnyardgrass weeds were measured using a hierarchical cluster analysis and constellation plot with the Wards method applying the JMP 17 software.

RESULTS AND DISCUSSION

Seeds Morphological Characters and Flag Leaf in Barnyardgrass

The results showed that the sizes of the glume and lemma, as well as flag leaf length and width of barnyardgrass accessions were significantly different (Table 2). The largest size of upper and lower glume was found in TB3 and TM1 accessions (Tanjung Beringin 3 and Teluk Mengkudu 1) at 4.33±0.20 mm and 1.96±0.02 mm, respectively. Among all accessions, PB1 (Perbaungan 1) had the longest upper lemma size by 17.10±0.18 mm. The largest values of flag leaf length and width of barnyardgrass accession were found in PB4 and PC2 by 45.40±0.66 and 1.13±0.03 cm, respectively.

The difference in the size of the barnyardgrass seeds for each accession (Serdang Bedagai) with the comparison accession (MDN) can be seen visually in Figure 1. Among the observations of the size of the barnyardgrass seed, the upper

lemma is visible. The longest lemma from each sub-district was found in SB5; SR2; TT5; PB1; TM1; PC4; TB3; and BK2 accessions, but the upper lemma of PG1-5 were not different from the accession comparison (MDN).

Correlation Coefficient

The flag leaf length and width were positively correlated with the size of the upper glume of barnyardgrass accessions (Table 3). Likewise, both characters were significant and positively correlated (0.505^{**} and 0.344^{*}) to the size of the lower glume of barnyardgrass seeds.

Hierarchical Cluster and Similarity Matrix of Barnyardgrass Accessions

The similarity matrix between barnyardgrass accessions from Serdang Bedagai and the comparison accession is presented in Table 4. Only PG4 accession had the nearest neighbors (1.825). It was indicated the accession is nearest to the characteristics of barnyardgrass seeds from the comparison accessions. Based on the hierarchical cluster analysis and constellation plot, barnyardgrass accessions could be grouped into five clusters (Figure 2). Cluster 1 had eight accessions (SB1; SB3; SR1; SR2; TT4; PB3; TM2; PG5) and cluster 2 consisted of five accessions (TM1; TM4; BK4; PC3; TB5), meanwhile cluster 3 had six accessions (TT1; PG1; PG2; PB4; PC2; TB4). Cluster 4 consisted of thirteen accessions (TM3; TM5; SR3; SR4; SR5; TT3; TT5; SB2; SB5; PB5; BK2; TB3; PC4) and cluster 5 also had fourteen accessions (MDN; SB4; PC1; PC5; PG3; PG4; BK1; BK3; BK5; PB1; PB2; TB2; TB1; TT2).

Table 2. Upper dan lower glume, upper lemma, flag leaf length, and width of barnyardgrass accessions from lowland rice fields in Serdang Bedagai District and the comparison accession (MDN), Indonesia.

Accessions	UG (mm)	LG (mm)	UL (mm)	FLL (cm)	FLW (cm)
MDN	3.90±0.30 abc	1.85±0.07 a-d	0.04±0.01 i	35.57±2.56 a-e	0.87±0.03 ab
SB1	3.80±0.06 abc	1.71±0.04 a-d	8.80±0.22 d-h	31.40±1.32 a-e	0.80±0.03 ab
SB2	3.54±0.05 abc	1.74±0.02 a-d	12.94±0.74 a-d	30.80±0.69 a-e	0.73±0.03 ab
SB3	3.82±0.09 abc	1.83±0.01 a-d	7.20±0.24 e-h	31.90±1.24 a-e	0.83±0.03 ab
SB4	3.84±0.08 abc	1.76±0.03 a-d	9.63±0.25 c-h	33.87±0.01 a-e	0.87±0.03 ab
SB5	4.06±0.09 ab	1.65±0.02 a-d	13.12±0.41 a-d	28.23±2.89 a-e	0.73±0.07 ab
SR1	4.01±0.07 abc	1.75±0.04 a-d	11.26±0.21 b-f	33.53±2.49 a-e	0.83±0.04 ab
SR2	3.64±0.08 abc	1.71±0.03 a-d	11.86±0.77 b-e	37.27±2.05 a-e	0.83±0.04 ab
SR3	3.55±0.06 abc	1.69±0.03 a-d	9.26±0.42 d-h	30.80±0.41 a-e	0.67±0.01 ab
SR4	3.43±0.03 abc	1.82±0.05 a-d	6.12±0.07 gh	31.00±2.98 a-e	1.00±0.04 ab
SR5	3.52±0.01 abc	1.83±0.04 a-d	0.03±0.00 i	29.57±0.46 a-e	0.53±0.01 b
TT1	3.55±0.07 abc	1.89±0.02 abc	0.05±0.01 i	44.53±0.66 ab	1.07±0.01 a
TT2	3.37±0.04 abc	1.48±0.02 bcd	5.12±0.25 h	39.03±0.70 a-e	1.03±0.01 ab
TT3	3.52±0.07 abc	1.46±0.02 cd	12.97±0.27 a-d	29.83±0.08 a-e	0.67±0.01 ab
TT4	2.95±0.09 c	1.57±0.02 a-d	11.28±0.52 b-f	30.27±2.33 a-e	0.83±0.10 ab
TT5	3.40±0.09 abc	1.55±0.02 a-d	14.21±0.82 abc	24.80±0.77 de	0.53±0.01 b
PB1	3.33±0.01 abc	1.48±0.01 bcd	17.10±0.18 a	32.87±0.12 a-e	0.97±0.01 ab
PB2	3.47±0.06 abc	1.62±0.03 a-d	13.43±0.77 a-d	26.63±0.95 cde	1.03±0.04 ab
PB3	2.93±0.08 c	1.57±0.04 a-d	9.99±0.32 c-h	27.30±2.86 b-e	0.77±0.08 ab
PB4	3.78±0.13 abc	1.94±0.05 a	0.04±0.00 i	45.40±0.66 a	1.07±0.01 a

PB5	3.62±0.10 abc	1.90±0.04 ab	11.50±0.95 b-f	39.17±0.66 a-e	1.00±0.03 ab
TM1	3.09±0.13 bc	1.96±0.02 a	15.67±0.11 ab	31.70±0.70 a-e	0.80±0.03 ab
TM2	3.18±0.06 bc	1.71±0.01 a-d	11.54±0.37 b-f	27.30±1.37 b-e	0.77±0.06 ab
TM3	3.37±0.07 abc	1.60±0.05 a-d	6.85±0.69 fgh	33.60±0.57 a-e	1.00±0.07 ab
TM4	3.56±0.10 abc	1.82±0.00 a-d	11.87±0.99 b-e	27.70±0.68 b-e	0.80±0.03 ab
TM5	2.99±0.08 bc	1.64±0.04 a-d	5.81±0.36 gh	28.47±1.86 a-e	0.70±0.05 ab
PG1	3.68±0.05 abc	1.67±0.02 a-d	0.07±0.01 i	28.83±0.77 a-e	0.90±0.03 ab
PG2	3.25±0.06 abc	1.57±0.04 a-d	0.05±0.01 i	31.37±0.50 a-e	1.07±0.01 a
PG3	3.57±0.03 abc	1.80±0.03 a-d	0.08±0.01 i	42.53±0.97 abc	0.93±0.01 ab
PG4	3.51±0.07 abc	1.78±0.03 a-d	0.06±0.01 i	35.70±1.57 a-e	0.90±0.03 ab
PG5	3.50±0.03 abc	1.71±0.03 a-d	0.04±0.01 i	26.73±2.83 cde	0.77±0.08 ab
PC1	3.31±0.02 abc	1.83±0.04 a-d	0.06±0.01 i	39.13±0.85 a-e	0.97±0.01 ab
PC2	3.68±0.09 abc	1.94±0.04 a	0.07±0.01 i	40.13±0.38 a-d	1.13±0.03 a
PC3	3.17±0.09 bc	1.55±0.04 a-d	0.05±0.01 i	23.13±1.57 de	0.80±0.03 ab
PC4	2.99±0.05 bc	1.47±0.02 bcd	8.61±0.49 d-h	27.43±0.36 b-e	0.73±0.01 ab
PC5	3.54±0.08 abc	1.80±0.04 a-d	0.06±0.01 i	24.63±1.67 de	0.87±0.03 ab
TB1	3.29±0.07 abc	1.58±0.04 a-d	0.08±0.01 i	28.70±0.08 a-e	0.97±0.01 ab
TB2	3.58±0.12 abc	1.65±0.03 a-d	0.04±0.01 i	26.10±0.49 cde	0.97±0.04 ab
TB3	4.33±0.20 a	1.48±0.00 bcd	12.02±0.33 b-e	26.13±1.10 cde	0.67±0.04 ab
TB4	4.02±0.10 abc	1.67±0.05 a-d	0.07±0.00 i	28.67±0.51 a-e	0.90±0.03 ab
TB5	3.10±0.10 bc	1.68±0.05 a-d	0.05±0.01 i	31.17±1.27 a-e	0.80±0.03 ab
BK1	3.68±0.11 abc	1.77±0.04 a-d	0.06±0.01 i	25.40±0.52 cde	0.93±0.04 ab
BK2	3.25±0.07 abc	1.45±0.04 d	11.74±0.37 b-f	22.77±0.49 e	0.53±0.01 b
BK3	4.00±0.10 abc	1.69±0.04 a-d	0.09±0.01 i	28.40±1.14 a-e	1.03±0.05 ab

BK4	3.53±0.11 abc	1.49±0.02 bcd	10.59±0.42 c-g	32.27±0.61 a-e	0.80±0.03 ab
BK5	3.49±0.06 abc	1.75±0.05 a-d	0.08±0.01 i	28.00±1.09 b-e	1.03±0.03 ab

Note: the mean followed by a different letter is significant in the Tukey at $P<0.005$ ± standard error. UG= upper glume; LG= lower glume; UL= upper lemma; FLL= flag leaf length, FLW= flag leaf width.

Table 3. The correlation coefficient between the barnyardgrass accessions from Serdang Bedagai District, Indonesia and the comparison accession.

Traits	FLL	FLW	UG	LG	UL
FLL	1	0.528**	0.156	0.505**	-0.185
FLW		1	0.110	0.344*	-0.436**
UG			1	0.254	-0.080
LG				1	-0.323*
UL					1

Note: *and** Correlation is significant at the 0.05 and 0.01 level. FLL= flag leaf length, FLW= flag leaf width, UG= upper glume, LG= lower glume, UL= upper lemma.

Table 4. The similarity matrix value between the barnyardgrass accessions from Serdang Bedagai District compared to the comparison accession (MDN), Indonesia.

No	Accessions	Matrix value	No	Accessions	Matrix value
1	SB1	4.151	26	PG1	3.681
2	SB2	8.473	27	PG2	10.584
3	SB3	2.123	28	PG3	3.021
4	SB4	3.253	29	PG4	1.825
5	SB5	10.001	30	PG5	5.680

6	SR1	4.549	31	PC1	4.419
7	SR2	5.956	32	PC2	4.627
8	SR3	7.589	33	PC3	15.327
9	SR4	4.833	34	PC4	20.879
10	SR5	7.879	35	PC5	5.469
11	TT1	5.818	36	TB1	9.449
12	TT2	12.000	37	TB2	6.506
13	TT3	16.903	38	TB3	17.747
14	TT4	17.800	39	TB4	3.410
15	TT5	22.047	40	TB5	8.795
16	PB1	19.415	41	BK1	4.456
17	PB2	13.647	42	BK2	27.019
18	PB3	19.117	43	BK3	4.261
19	PB4	5.600	44	BK4	11.736
20	PB5	5.988	45	BK5	5.280
21	TM1	15.179			
22	TM2	12.882			
23	TM3	8.225			
24	TM4	7.651			
25	TM5	14.563			

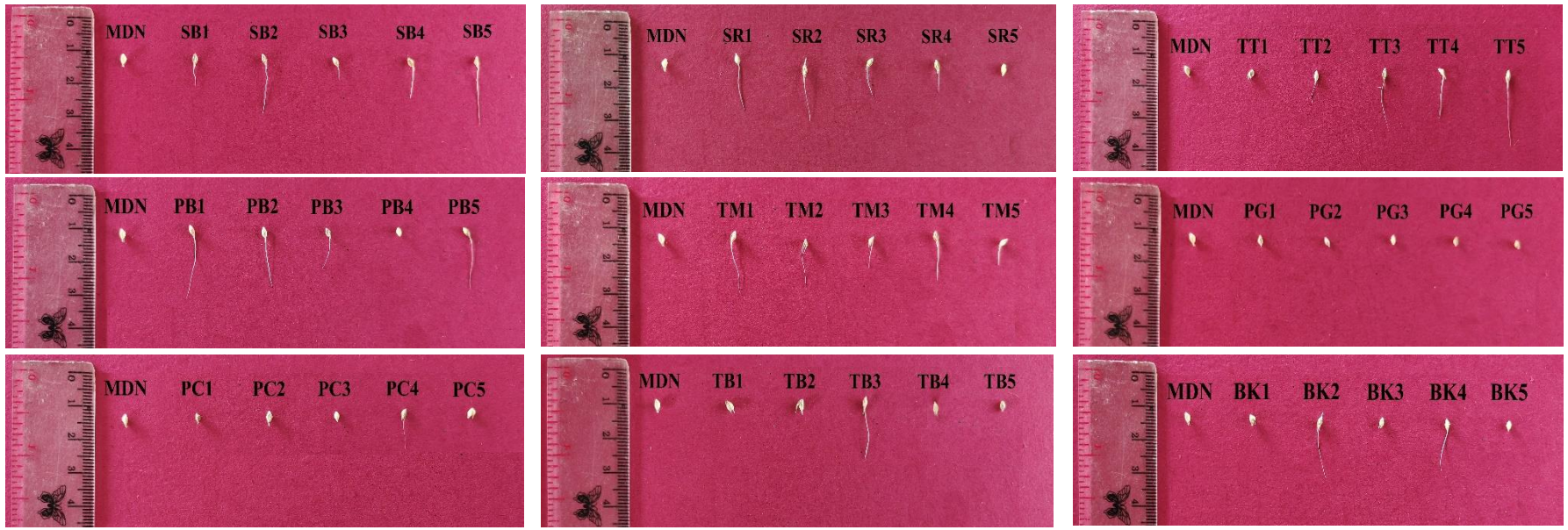

Figure 1. The difference in the size of the seed glume and lemma in barnyardgrass accessions from Serdang Bedagai District, Indonesia and the comparison accession (MDN) visually.

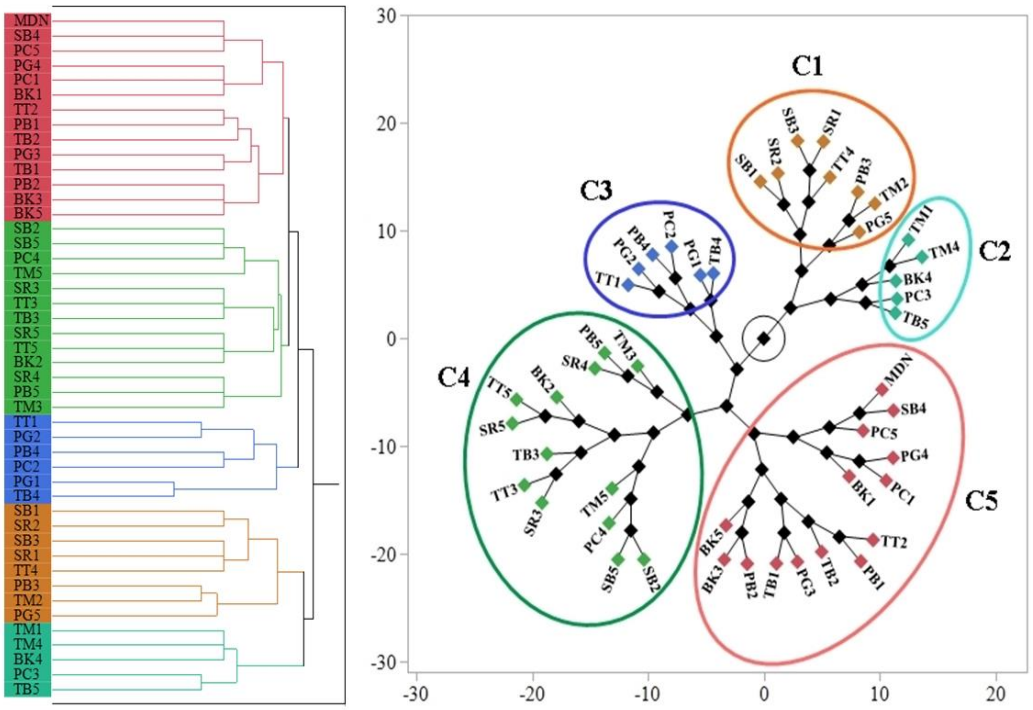

Figure 2. Hierarchical clustering and constellation plot of 46 barnyardgrass accessions from Serdang Bedagai District and Medan City (comparison), Indonesia. Codes of barnyardgrass accessions and their localities are listed in Table 1.

The results showed that the sizes of upper glume, lower glume, upper lemma, flag leaf length, and width of the barnyardgrass accession from Serdang Bedagai District ranged from 2.93-4.33 mm; 1.45-1.96 mm; 0.03-17.10 mm; 22.77-45.40 cm; and 0.53-1.13 cm, respectively (Table 2). The size of the upper and lower glume in TB3 and TM1 accessions were higher than in other accessions, as well as the upper lemma found in PB1 accession. The results also showed that PB4 and PC2 accessions had the largest values flag leaf length and width compared to other accessions. This indicates that the size of seed glume from these locations could be due to the total assimilating productivity of the large flag leaf area (length and

width) of the barnyardgrass. This finding was supported by the flag leaf length and width which are positively correlated (0.156 and 0.110) with the size of the upper glume, and both characters positively correlated and significantly (0.505** and 0.344*) with the size of the lower glume (Table 3). This finding was supported by Asana, (1968) that flag leaf had an important role in providing photosynthesis products to seeds. Ashrafuzzaman et al. (2009); Rahman et al., (2013) added that flag leaf area was positively correlated with panicle length and seed production. In contrast, the size of the upper lemma was negatively correlated with the flag leaf length and width (Table 3). It was assumed that photosynthate product from flag leaf tend to glume formation and panicle length. Liu et al., (2021) also reported that flag leaf length and width were positively correlated with panicle length of *Echinochloa* ecotypes.

It can be seen that only the PG4 accession had the nearest neighbors with comparison accessions (MDN) with a similarity value of 1.825. These findings were corroborated by the hierarchical cluster, the SB4; PC1; PC5; PG3; PG4; BK1; BK3; BK5; PB1; PB2; TB2; TB1; and TT2 accessions were clustered in one group with the comparison accessions (MDN). This indicates that the characters of upper and lower glume, upper lemma, flag leaf length, and width of the thirteen accessions were not more different from the MDN accession (Table 2). This result was supported by Tahir, (2016) that eight of 95 accessions *Echinochloa sp* were clustered to the barnyardgrass cluster based on vegetative and generative characters from several locations in Arkansas. Altop & Mennan, (2011) grouped the barnyardgrass weeds from lowland rice fields in Turkey into three clusters based on morphological characters, 28 of 34 barnyardgrass populations had nearest

neighbors. The researcher's findings also showed that the morphological character approach is almost similar when a molecular approach (RAPD), 33 of 34 barnyardgrass populations were clustered into one group. Liu et al., (2021) also characterized the morphophysiology of *E. cruss-galli*; *E. colona*; and *E. muricata* from rice-growing in Texas producing five clusters and it was found that *E. cruss-galli* (ECH22) ecotype is related to *E. muricata* (ECH33). Claerhout et al., (2016) found three clusters of 14 barnyardgrass accessions based on morphological charactersfrom maize fields in Belgium.

These findings indicate that 13 of 45 accessions from lowland rice fields in Serdang Bedagai District were similar to comparison accession. This result showed the management of barnyardgrass weeds carried out by farmers from these accessions were not more different with the farmers from the comparison accession. These results are reported for the first report in Indonesia. However, the assessment of similarity through the morphological character approach should be re-examined by molecular means.

CONCLUSIONS

Based on morphological characters, 45 accessions of barnyardgrass weeds from Serdang Bedagai District had the sizes of upper and lower glume (2.93-4.33 mm and 1.45-1.96 mm), an upper lemma (0.03-17.10 mm), the flag leaf length and width (22.77-45.40 cm and 0.53-1.13 cm). Accessions of TB3; TM1; PB1; PB4; and PC2 had the highest characteristic size compared to other accessions. The PG4 accession is the nearest neighbors (1.825) to the comparison accession (MDN). It was also found that the SB4; PC1; PC5; PG3; PG4; BK1; BK3; BK5; PB1; PB2;

TB2; TB1; and TT2 accessions were classified into one cluster with the MDN accession.

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The Similarity of Barnyardgrass Weed in Lowland Rice Fields Based on Seed Characteristics

Alridiwirsah[1], Mohammad Basyuni[2]*, Koko Tampubolon[3], & Novilda Elizabeth Mustamu[4]

[1]Program Study of Agrotechnology, Faculty of Agriculture, Universitas Muhammadiyah Sumatera Utara, Medan 20238, Indonesia.

[2]Program Study of Forestry, Faculty of Forestry, Universitas Sumatera Utara, Medan 20155, Indonesia.

[3]Program Study of Agrotechnology, Faculty of Agriculture, Universitas Sumatera Utara, Medan 20155, Indonesia.

[4]Program Study of Agrotechnology, Faculty of Science and Technology, Universitas Labuhanbatu, Rantauprapat 21415, Sumatera Utara, Indonesia.

*Corresponding author: m.basyuni@usu.ac.id

ABSTRACT

In lowland rice areas, the presence of barnyardgrass weed (*Echinochloa crus-galli*) is disadvantageous to Indonesian farmers and requires an initial assessment and identification of characteristics for management. Therefore, this study aimed to obtain the characteristics and similarities of barnyardgrass accessions from lowland rice fields based on the morphological characteristics of the seed. A descriptive-analytical method was used to determine the barnyardgrass characteristics of 45 accessions from nine sub-districts in Serdang Bedagai and one accession from Medan City (MDN), Indonesia, as a comparison. This study was

conducted from May to August 2022 and the data were analyzed using one-way ANOVA, followed by Tukey's test at $P<0.05$. The hierarchical cluster and constellation plot were generated using Ward's method. The results showed that 45 accessions of barnyardgrass from lowland rice fields had sizes of upper glume, lower glume, upper lemma, flag leaf length, and flag leaf width ranging from 2.93 to 4.33 mm, 1.45 to 1.96 mm, 0.03 to 17.10 mm, 22.77 to 45.40 cm, and 0.53 to 1.13 cm, respectively. Among all accessions, only PG4 accession was nearest (1.825) to MDN. Furthermore, there were five clusters with 13 accessions including SB4; PC1; PC5; PG3; PG4; BK1; BK3; BK5; PB1; PB2; TB2; TB1; and TT2, classified in the same cluster as MDN. This information is very important as an initial reference for farmers in the management of barnyardgrass weeds in their lowland rice fields.

Keywords: accession; characteristics; identification; lowland rice; similarity

INTRODUCTION

Barnyardgrass **(***Echinochloa crus-galli*) is an annual weed that grows to a height of 150 cm and reproduces through seeds (Bagavathiannan et al. 2012). It can grow in tropical and subtropical climates and produce up to 39,000 seeds (Bagavathiannan et al. 2012; Miller et al. 2018). Additionally, it exhibits high adaptability, rapid germination, abundant seed production, and strong competitiveness, which can result in economic losses to the main crop (Mennan et al. 2012; Bajwa et al. 2015) and a loss of rice yield ranging from 21 to 79% (Wilson et al. 2014).

The presence of a barnyardgrass population at a distance of 40 cm from lowland rice plants can decrease yield by 27%, nitrogen availability by 60 to 80%, inhibits rice growth (Wilson et al. 2014) and decrease rice yield by 30 to 100% throughout the growing season (Bhullar et al. 2016; Marchesi & Saldain, 2019). *E. crus galli* var. mitis can lower rice grain production by 12.7 to 42.6% by inhibiting photosynthesis rate, root weight, root oxidation activity, and biomass accumulation (Zhang et al. 2017). Alridiwirsah et al. (2022) added that barnyardgrass had five populations in lowland rice, with root length and volume of 39.4 cm and 246.1 ml and dry weight of roots and shoots of 92.7 g and 65.6 g, respectively.

The presence of barnyardgrass in lowland rice fields is feared to be unfavorable to farmers in the central areas, such as Serdang Bedagai District. In 2021, Serdang Bedagai District had the second-largest rice harvest area (48,121.62 ha) after Deli Serdang District from North Sumatra Province, Indonesia (Statistics of Sumatera Utara 2022). Based on the Indonesian Center for Rice Research (2020), land preparation for lowland rice cultivation in Indonesia includes flooding the land to 2-5 cm above the surface for 2-3 days before plowing the soil to a depth of 15-20 cm with a tractor to kill weeds. The soil is then incubated for 3-4 days before conducting a second plowing one week after the first tilling for mudding the soil. Additionally, the ground is flattened and left moist and unflooded for 1-2 days. Rice seeds are then sown and transplanted before plant management is conducted by weed control using manual, mechanical, and chemical methods.

Herbicides are commonly used by farmers in Serdang Bedagai District to control weeds in their planting areas. Barnyardgrass is a common weed that is difficult to control. The weed must be managed appropriately using several

approaches, which begin by identifying its characteristics and similarities to determine the relationship between accessions from various regions. According to Tahir (2016), the barnyardgrass from several locations in Arkansas has a leaf length of 16.2 to 30.0 cm, a leaf width of 1.2-1.5 cm, upper glume of 2.94 to 3.80 mm, lower glume of 1.21 to 1.68 mm, an upper lemma of 2.71 to 3.55 mm, and 7,186-71,494 seeds per plants. Alridiwirsah et al. (2022) also added that the upper epidermis, mesophyll, lower epidermis, and stomata density of barnyardgrass leaves from lowland rice plants were 44.3 μm, 155.6 μm, 40.8 μm, and 69.0 n/μm, respectively.

A characteristics similarity approach is required for decisions regarding weed control (Tampubolon et al. 2019). However, the characteristics identification and similarity of barnyardgrass from lowland rice fields in Indonesia have never been reported. Therefore, an initial effort is required to determine several characters, such as flag leaf length and width, upper and lower glume, and upper lemma from various sub-districts in Serdang Bedagai. This study aimed to obtain the characteristics and similarities of barnyardgrass accessions from lowland rice fields based on the morphological characteristics of the seed. This information is expected to be a basic strategy for the management of barnyardgrass weed.

MATERIAL AND METHODS

Seed Collection Area of Barnyardgrass Accession

The barnyardgrass accessions were obtained from nine sub-districts in Serdang Bedagai District, including Sei Bamban, Sei Rampah, Tebing Tinggi, Perbaungan, Teluk Mengkudu, Pegajahan, Pantai Cermin, Tanjung Beringin, and

Bandar Khalipah, and one accession from Medan City, Indonesia, for comparison. Based on farmer interviews, the sub-district accessions were controlled with herbicide, while the comparison was controlled manually. Each sub-district consisted of five accessions from different villages, resulting in 45 accessions. Each was collected from ten populations of barnyardgrass and composited. Barnyardgrass seeds with physiological maturity criteria marked by seeds loss when held were obtained from lowland rice fields. The flag leaf length and width of each accession were measured and environmental conditions influencing the barnyardgrass growth were recorded (Table 1). Furthermore, the barnyardgrass seeds were collected between May and August 2022 and dried for two days.

Methodology and Data Analysis

A descriptive-analytical method was used to describe the similarity of barnyardgrass based on the morphological observations of the seeds, which include the upper and lower glume, upper lemma, and flag leaf length and width. Twelve seeds were randomly taken from each barnyardgrass accession, and the glume and lemma were measured using an electronic digital caliper. The characteristics of the seeds and leaves were analyzed using one-way ANOVA (analysis of variance) followed by Tukey's test at $P<0.05$. Using the JMP 17 software, the similarity of barnyardgrass weed accessions was determined using a hierarchical cluster analysis and a constellation plot with Ward's method.

Table 1. Locations and accession codes of barnyardgrass form Serdang Bedagai District and Medan City, Indonesia.

Sub-districts	Accessions code	Villages	Longitude	Latitude	Altitude (m asl)	Temperature (°C)	Humidity (%)	Air pressure (hPa)
Sei Bamban	SB1	Bakaran Batu	99º08.089'	3º25.259'	5	26.7	88	1012
	SB2	Hapoltahan Nauli	99º08.383'	3º26.552'	4	25.1	92	1011
	SB3	Gempolan	99º07.415'	3º25.078'	9	25.0	93	1011
	SB4	Sei Buluh	99º10.605'	3º26.848'	2	25.3	91	1010
	SB5	Sukadamai	99º09.636'	3º24.762'	6	24.6	92	1010
Sei Rampah	SR1	Firdaus	99º08.210'	3º30.776'	9	29.1	68	1005
	SR2	Pematang Ganjang	99º08.235'	3º27.905'	13	28.0	76	1006
	SR3	Sei Parit	99º07.958'	3º28.603'	11	32.2	56	1006
	SR4	Sei Rejo	99º09.885'	3º30.434'	10	30.7	65	1004
	SR5	Sei Rampah	99º10.168'	3º29.590'	10	30.4	67	1004
Tebing Tinggi	TT1	Paya Lombang	99º11.737'	3º22.216'	16	29.0	75	1009

	TT2	Paya Mabar	99º12.323'	3º23.715'	15	28.9	75	1009
	TT3	Sei Priok	99º13.738'	3º24.511'	12	29.9	67	1008
	TT4	Kuta Baru	99º12.491'	3º21.887'	16	31.2	63	1006
	TT5	Meriah Padang	99º05.111'	3º18.138'	30	29.3	81	1005
	PB1	Melati I	98º58.034'	3º33.567'	10	24.1	79	1009
	PB2	Melati II	98º58.032'	3º33.177'	22	25.1	79	1009
Perbaungan	PB3	Jambur Pulau	98º57.755'	3º34.322'	1	25.1	78	1008
	PB4	Cinta Air	98º59.606'	3º34.488'	16	26.1	77	1007
	PB5	Citaman Jernih	98º57.526'	3º33.731'	10	27.1	63	1007
	TM1	Pasar Baru	99º06.396'	3º33.056'	9	30.2	63	1006
	TM2	Pematang Gantung	99º07.967'	3º33.068'	10	29.9	64	1006
Teluk Mengkudu	TM3	Sialang Buah	99º07.082'	3º33.862'	14	30.2	65	1005
	TM4	Bongak Besar	99º09.038'	3º33.060'	17	29.5	65	1005
	TM5	Sentang	99º08.333'	3º33.287'	12	29.5	65	1005

Pegajahan	PG1	Bingkat IX-B	98º57.552'	3º28.899'	30	29.0	93	1008
	PG2	Bingkat XI	98º57.512'	3º28.546'	13	28.0	93	1008
	PG3	Bingkat X-A	98º57.107'	3º28.800'	13	28.0	93	1008
	PG4	Pegajahan	98º56.800'	3º28.821'	19	28.0	93	1008
	PG5	Bingkat X-B	98º58.427'	3º28.729'	26	28.0	94	1009
Pantai Cermin	PC1	Kota Pari	98º57.625'	3º38.446'	14	30.1	65	1009
	PC2	Pematang Kasih	99º01.282'	3º37.617'	2	31.2	67	1006
	PC3	Kuala Lama	99º01.512'	3º37.137'	11	30.2	67	1006
	PC4	Naga Kaisar	99º03.656'	3º36.252'	19	30.2	70	1007
	PC5	Pantai Cermin Kanan	98º58.150'	3º38.430'	21	30.1	71	1007
Tanjung Beringin	TB1	Nagur	99º11.259'	3º30.712'	8	28.0	79	1005
	TB2	Mangga Dua	99º11.018'	3º30.637'	7	27.1	80	1006
	TB3	Tebing Tinggi	99º13.680'	3º29.070'	22	25.6	90	1009
	TB4	Pematang Cermai	99º12.650'	3º28.709'	6	25.9	89	1009

	TB5	Pematang Terang	99º14.571'	3º26.858'	9	25.8	90	1009
	BK1	Galam Sei Serimah	99º15.197'	3º26.468'	5	29.0	67	1006
	BK2	Pekan Bandar Kalifah	99º16.767'	3º26.633'	4	28.9	68	1006
Bandar Khalipah	BK3	Kayu Besar	99º17.133'	3º25.996'	1	29.0	68	1005
	BK4	Jahar	99º16.897'	3º24.302'	10	28.8	72	1005
	BK5	Bandar Tengah	99º15.907'	3º23.973'	17	27.4	81	1006
Medan Selayang	MDN	Padang Bulan	98º39.009'	3º33.170'	14	25.0	34	1002

RESULTS AND DISCUSSION

Seeds Morphological Characters and Flag Leaf in Barnyardgrass

The results showed that the sizes of the glume and lemma, as well as flag leaf length and width, differed significantly between barnyardgrass accessions (Table 2). Upper and lower glume sizes were found to be the largest in TB3 and TM1 accessions (Tanjung Beringin 3 and Teluk Mengkudu 1), measuring 4.33 ± 0.20 mm and 1.96 ± 0.02 mm, respectively. PB1 (Perbaungan 1) had the longest upper lemma of all accessions, measuring 17.10 ± 0.18 mm. Furthermore, the largest values of flag leaf length and width of barnyardgrass accession were found in PB4 and PC2, measuring 45.40 ± 0.66 and 1.13 ± 0.03 cm, respectively.

The difference in the size of the barnyardgrass seeds for each accession (Serdang Bedagai) with the comparison accession (MDN) can be seen visually in Figure 1. Based on the observations of the barnyardgrass seed, the upper lemma was visible. The longest lemma from each sub-district was found in SB5; SR2; TT5; PB1; TM1; PC4; TB3; and BK2 accessions, but the upper lemma of PG1-5 did not differ from the accession comparison.

Correlation Coefficient Value

The flag leaf length and width were positively correlated with the size of the upper glume of barnyardgrass accessions (Table 3). Similarly, both characters were significant and positively correlated (0.505^{**} and 0.344^{*}) with the size of the lower glume of barnyardgrass seeds.

Hierarchical Cluster and Similarity Matrix of Barnyardgrass Accessions

Based on the similarity matrix between barnyardgrass accessions from Serdang Bedagai and MDN (Table 4), only the PG4 accession was closely related

(1.825). This indicates that it had the most similar characteristics to the barnyardgrass seeds from MDN. Barnyardgrass accessions were grouped into five clusters based on the hierarchical cluster analysis and constellation plot (Figure 2). Cluster 1 had eight accessions, including SB1; SB3; SR1; SR2; TT4; PB3; TM2; and PG5, while cluster 2 consisted of five accessions including TM1; TM4; BK4; PC3; and TB5. Cluster 3 had six accessions consisting of TT1; PG1; PG2; PB4; PC2; and TB4, while Cluster 4 consisted of 13 accessions comprising TM3; TM5; SR3; SR4; SR5; TT3; TT5; SB2; SB5; PB5; BK2; TB3; and PC4. Meanwhile, cluster 5 had 14 accessions containing MDN; SB4; PC1; PC5; PG3; PG4; BK1; BK3; BK5; PB1; PB2; TB2; TB1; and TT2.

Table 2. Upper dan lower glume, upper lemma, flag leaf length, and width of barnyardgrass accessions from lowland rice fields in Serdang Bedagai District and the comparison accession (MDN), Indonesia.

Accessions	UG (mm)	LG (mm)	UL (mm)	FLL (cm)	FLW (cm)
MDN	3.90±0.30 abc	1.85±0.07 a-d	0.04±0.01 i	35.57±2.56 a-e	0.87±0.03 ab
SB1	3.80±0.06 abc	1.71±0.04 a-d	8.80±0.22 d-h	31.40±1.32 a-e	0.80±0.03 ab
SB2	3.54±0.05 abc	1.74±0.02 a-d	12.94±0.74 a-d	30.80±0.69 a-e	0.73±0.03 ab
SB3	3.82±0.09 abc	1.83±0.01 a-d	7.20±0.24 e-h	31.90±1.24 a-e	0.83±0.03 ab
SB4	3.84±0.08 abc	1.76±0.03 a-d	9.63±0.25 c-h	33.87±0.01 a-e	0.87±0.03 ab
SB5	4.06±0.09 ab	1.65±0.02 a-d	13.12±0.41 a-d	28.23±2.89 a-e	0.73±0.07 ab
SR1	4.01±0.07 abc	1.75±0.04 a-d	11.26±0.21 b-f	33.53±2.49 a-e	0.83±0.04 ab
SR2	3.64±0.08 abc	1.71±0.03 a-d	11.86±0.77 b-e	37.27±2.05 a-e	0.83±0.04 ab
SR3	3.55±0.06 abc	1.69±0.03 a-d	9.26±0.42 d-h	30.80±0.41 a-e	0.67±0.01 ab
SR4	3.43±0.03 abc	1.82±0.05 a-d	6.12±0.07 gh	31.00±2.98 a-e	1.00±0.04 ab
SR5	3.52±0.01 abc	1.83±0.04 a-d	0.03±0.00 i	29.57±0.46 a-e	0.53±0.01 b
TT1	3.55±0.07 abc	1.89±0.02 abc	0.05±0.01 i	44.53±0.66 ab	1.07±0.01 a
TT2	3.37±0.04 abc	1.48±0.02 bcd	5.12±0.25 h	39.03±0.70 a-e	1.03±0.01 ab
TT3	3.52±0.07 abc	1.46±0.02 cd	12.97±0.27 a-d	29.83±0.08 a-e	0.67±0.01 ab
TT4	2.95±0.09 c	1.57±0.02 a-d	11.28±0.52 b-f	30.27±2.33 a-e	0.83±0.10 ab
TT5	3.40±0.09 abc	1.55±0.02 a-d	14.21±0.82 abc	24.80±0.77 de	0.53±0.01 b
PB1	3.33±0.01 abc	1.48±0.01 bcd	17.10±0.18 a	32.87±0.12 a-e	0.97±0.01 ab
PB2	3.47±0.06 abc	1.62±0.03 a-d	13.43±0.77 a-d	26.63±0.95 cde	1.03±0.04 ab
PB3	2.93±0.08 c	1.57±0.04 a-d	9.99±0.32 c-h	27.30±2.86 b-e	0.77±0.08 ab
PB4	3.78±0.13 abc	1.94±0.05 a	0.04±0.00 i	45.40±0.66 a	1.07±0.01 a

PB5	3.62±0.10 abc	1.90±0.04 ab	11.50±0.95 b-f	39.17±0.66 a-e	1.00±0.03 ab
TM1	3.09±0.13 bc	1.96±0.02 a	15.67±0.11 ab	31.70±0.70 a-e	0.80±0.03 ab
TM2	3.18±0.06 bc	1.71±0.01 a-d	11.54±0.37 b-f	27.30±1.37 b-e	0.77±0.06 ab
TM3	3.37±0.07 abc	1.60±0.05 a-d	6.85±0.69 fgh	33.60±0.57 a-e	1.00±0.07 ab
TM4	3.56±0.10 abc	1.82±0.00 a-d	11.87±0.99 b-e	27.70±0.68 b-e	0.80±0.03 ab
TM5	2.99±0.08 bc	1.64±0.04 a-d	5.81±0.36 gh	28.47±1.86 a-e	0.70±0.05 ab
PG1	3.68±0.05 abc	1.67±0.02 a-d	0.07±0.01 i	28.83±0.77 a-e	0.90±0.03 ab
PG2	3.25±0.06 abc	1.57±0.04 a-d	0.05±0.01 i	31.37±0.50 a-e	1.07±0.01 a
PG3	3.57±0.03 abc	1.80±0.03 a-d	0.08±0.01 i	42.53±0.97 abc	0.93±0.01 ab
PG4	3.51±0.07 abc	1.78±0.03 a-d	0.06±0.01 i	35.70±1.57 a-e	0.90±0.03 ab
PG5	3.50±0.03 abc	1.71±0.03 a-d	0.04±0.01 i	26.73±2.83 cde	0.77±0.08 ab
PC1	3.31±0.02 abc	1.83±0.04 a-d	0.06±0.01 i	39.13±0.85 a-e	0.97±0.01 ab
PC2	3.68±0.09 abc	1.94±0.04 a	0.07±0.01 i	40.13±0.38 a-d	1.13±0.03 a
PC3	3.17±0.09 bc	1.55±0.04 a-d	0.05±0.01 i	23.13±1.57 de	0.80±0.03 ab
PC4	2.99±0.05 bc	1.47±0.02 bcd	8.61±0.49 d-h	27.43±0.36 b-e	0.73±0.01 ab
PC5	3.54±0.08 abc	1.80±0.04 a-d	0.06±0.01 i	24.63±1.67 de	0.87±0.03 ab
TB1	3.29±0.07 abc	1.58±0.04 a-d	0.08±0.01 i	28.70±0.08 a-e	0.97±0.01 ab
TB2	3.58±0.12 abc	1.65±0.03 a-d	0.04±0.01 i	26.10±0.49 cde	0.97±0.04 ab
TB3	4.33±0.20 a	1.48±0.00 bcd	12.02±0.33 b-e	26.13±1.10 cde	0.67±0.04 ab
TB4	4.02±0.10 abc	1.67±0.05 a-d	0.07±0.00 i	28.67±0.51 a-e	0.90±0.03 ab
TB5	3.10±0.10 bc	1.68±0.05 a-d	0.05±0.01 i	31.17±1.27 a-e	0.80±0.03 ab
BK1	3.68±0.11 abc	1.77±0.04 a-d	0.06±0.01 i	25.40±0.52 cde	0.93±0.04 ab
BK2	3.25±0.07 abc	1.45±0.04 d	11.74±0.37 b-f	22.77±0.49 e	0.53±0.01 b
BK3	4.00±0.10 abc	1.69±0.04 a-d	0.09±0.01 i	28.40±1.14 a-e	1.03±0.05 ab

BK4	3.53±0.11 abc	1.49±0.02 bcd	10.59±0.42 c-g	32.27±0.61 a-e	0.80±0.03 ab
BK5	3.49±0.06 abc	1.75±0.05 a-d	0.08±0.01 i	28.00±1.09 b-e	1.03±0.03 ab

Note: the mean followed by a different letter is significant in the Tukey's test at $P<0.005$ ± standard error. UG= upper glume; LG= lower glume; UL= upper lemma; FLL= flag leaf length, FLW= flag leaf width.

Table 3. The correlation coefficient between the barnyardgrass accessions from Serdang Bedagai District, Indonesia and the comparison accession.

Traits	FLL	FLW	UG	LG	UL
FLL	1	0.528**	0.156	0.505**	-0.185
FLW		1	0.110	0.344*	-0.436**
UG			1	0.254	-0.080
LG				1	-0.323*
UL					1

Note: *and** Correlation is significant at the 0.05 and 0.01 level. FLL= flag leaf length, FLW= flag leaf width, UG= upper glume, LG= lower glume, UL= upper lemma.

Table 4. The similarity matrix value between the barnyardgrass accessions from Serdang Bedagai District compared to the comparison accession (MDN), Indonesia.

No	Accessions	Matrix value	No	Accessions	Matrix value
1	SB1	4.151	26	PG1	3.681
2	SB2	8.473	27	PG2	10.584
3	SB3	2.123	28	PG3	3.021
4	SB4	3.253	29	PG4	1.825
5	SB5	10.001	30	PG5	5.680

6	SR1	4.549	31	PC1	4.419
7	SR2	5.956	32	PC2	4.627
8	SR3	7.589	33	PC3	15.327
9	SR4	4.833	34	PC4	20.879
10	SR5	7.879	35	PC5	5.469
11	TT1	5.818	36	TB1	9.449
12	TT2	12.000	37	TB2	6.506
13	TT3	16.903	38	TB3	17.747
14	TT4	17.800	39	TB4	3.410
15	TT5	22.047	40	TB5	8.795
16	PB1	19.415	41	BK1	4.456
17	PB2	13.647	42	BK2	27.019
18	PB3	19.117	43	BK3	4.261
19	PB4	5.600	44	BK4	11.736
20	PB5	5.988	45	BK5	5.280
21	TM1	15.179			
22	TM2	12.882			
23	TM3	8.225			
24	TM4	7.651			
25	TM5	14.563			

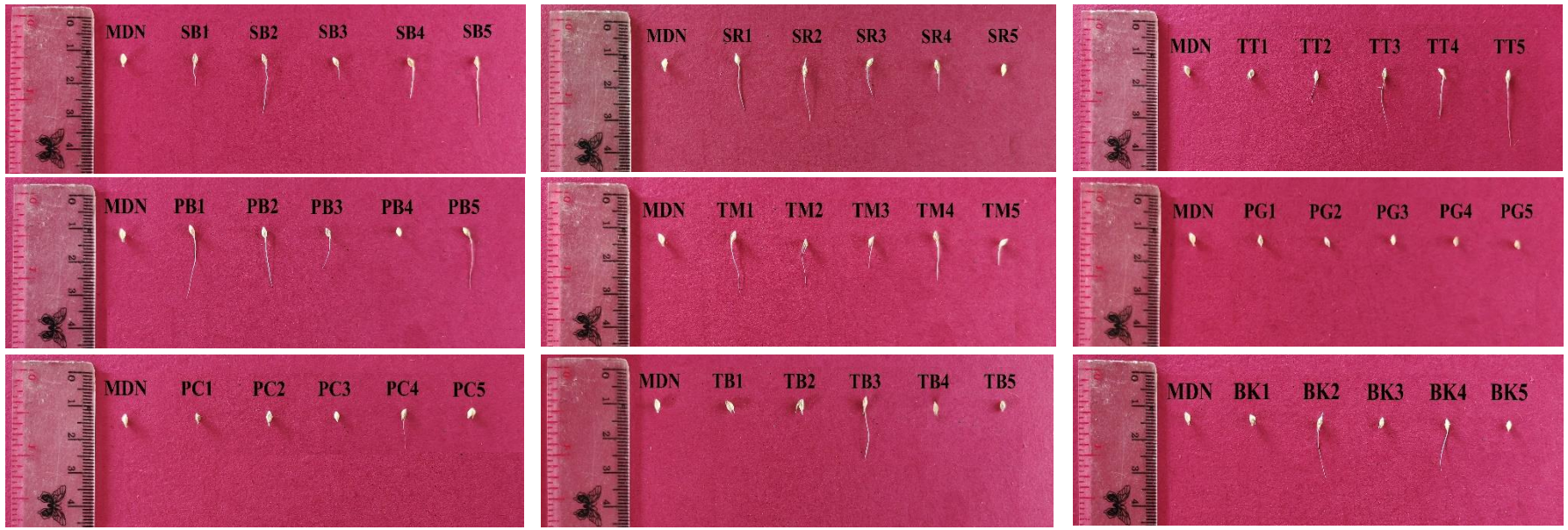

Figure 1. The difference in the size of the seed glume and lemma in barnyardgrass accessions from Serdang Bedagai District, Indonesia and the comparison accession (MDN) visually.

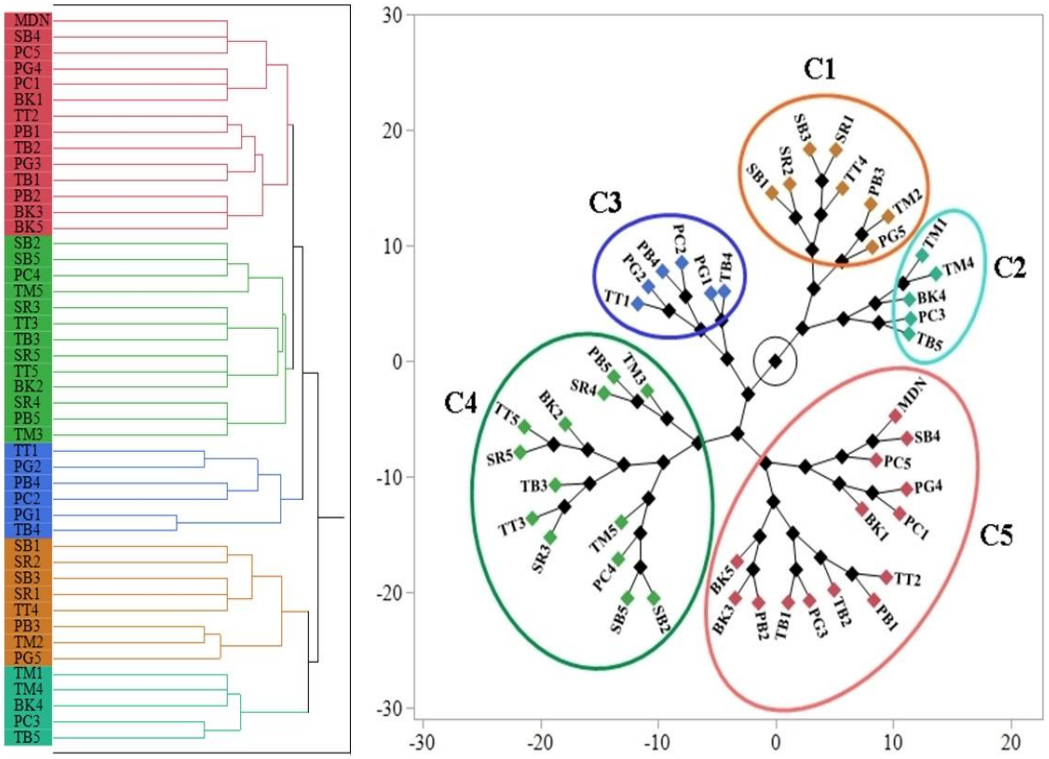

Figure 2. Hierarchical clustering and constellation plot of 46 barnyardgrass accessions from Serdang Bedagai District and Medan City (comparison), Indonesia. Codes of barnyardgrass accessions and their localities are listed in Table 1.

The results showed that the sizes of the upper and lower glume, upper lemma, and flag leaf length and width of the barnyardgrass accession from Serdang Bedagai District ranged from 2.93 to 4.33 mm, 1.45 to 1.96 mm, 0.03 to 17.10 mm, 22.77 to 45.40 cm, and 0.53 to 1.13 cm, respectively (Table 2). The upper and lower glume sizes in TB3 and TM1, as well as the upper lemma found in PB1 accessions, were larger than in other accessions. The results also revealed that PB4 and PC2 accessions had the highest flag leaf length and width values when compared to other accessions. This indicates that the size of seed glume from these locations could be due to the total assimilating productivity of the large flag leaf length and width.

This finding was supported by the flag leaf length and width, which are positively correlated (0.156 and 0.110) with the size of the upper glume, and positively correlated and significant (0.505** and 0.344*) with the size of the lower glume (Table 3). Asana (1968) supported this result by stating that flag leaves play an important role in providing photosynthesis products to seeds. According to Ashrafuzzaman et al. (2009); Rahman et al. (2013), flag leaf area was positively correlated with panicle length and seed production. In contrast, the size of the upper lemma was negatively correlated with the flag leaf length and width (Table 3). It was assumed that the photosynthate product from the flag leaf influenced glume formation and panicle length. Liu et al. (2021) also reported that flag leaf length and width were positively correlated to panicle length in *Echinochloa* ecotypes.

It was observed that only the PG4 accession was closely related to MDN, with a similarity value of 1.825. The hierarchical cluster confirmed these findings, with the SB4; PC1; PC5; PG3; PG4; BK1; BK3; BK5; PB1; PB2; TB2; TB1; and TT2 accessions clustered in one group with the MDN. This indicates that the characters of the upper and lower glume, upper lemma, flag leaf length, and width of the 13 accessions were not significantly different from MDN (Table 2). This was consistent with a study by Tahir (2016) which stated that eight of 95 *Echinochloa sp* accessions from several locations in Arkansas were clustered with the barnyardgrass based on vegetative and generative characteristics. Altop & Mennan (2011) classified barnyardgrass weeds from lowland rice fields in Turkey into three clusters based on morphological characters, with 28 of 34 barnyardgrass populations having similarities. The findings also showed that the morphological character approach is almost similar when using a molecular approach (RAPD),

with 33 of 34 barnyardgrass populations clustered into one group. Liu et al. (2021) also characterized the morphophysiology of *E. crus-galli*; *E. colona*; and *E. muricata* from rice-growing in Texas, producing five clusters and discovered that the *E. crus-galli* (ECH22) ecotype was related to *E. muricata* (ECH33). Claerhout et al. (2016) identified three clusters of 14 barnyardgrass accessions based on morphological characters from maize fields in Belgium.

Based on the result, 13 of 45 accessions from lowland rice fields in Serdang Bedagai District were similar to MDN. This result showed that farmers' management of barnyardgrass weeds from these accessions did not differ significantly to the comparison accession. These results are reported for the first time in Indonesia. However, the morphological character approach to assessing similarity should be re-examined using molecular methods.

CONCLUSIONS

Based on morphological characters, 45 accessions of barnyardgrass weeds from Serdang Bedagai District had different sizes of upper and lower glume, upper lemma, and flag leaf length and width ranged from 2.93-4.33 mm; 1.45-1.96 mm; 0.03-17.10 mm; 22.77-45.40 cm; and 0.53-1.13 cm, respectively. Accessions of TB3; TM1; PB1; PB4; and PC2 had the largest characteristic size compared to other accessions. Additionally, the PG4 accession was closely related to MDN (1.825). It was also found that the SB4; PC1; PC5; PG3; PG4; BK1; BK3; BK5; PB1; PB2; TB2; TB1; and TT2 accessions were classified into one cluster with MDN.

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The Similarity of Barnyardgrass Weed in Lowland Rice Fields Based on Seed Characteristics

Alridiwirsah[(1)], Mohammad Basyuni[(2)#], Koko Tampubolon[(3)], Novilda E. Mustamu[(4)]

[(1)]Program Study of Agrotechnology, Faculty of Agriculture, Universitas Muhammadiyah Sumatera Utara, Medan 20238, Indonesia; [(2)]Program Study of Forestry, Faculty of Forestry, Universitas Sumatera Utara, Medan 20155, Indonesia; [(3)]Program Study of Agrotechnology, Faculty of Agriculture, Universitas Sumatera Utara, Medan 20155, Indonesia; [(4)]Program Study of Agrotechnology, Faculty of Science and Technology, Universitas Labuhanbatu, Rantauprapat 21415, Sumatera Utara, Indonesia.

IN LOWLAND rice areas, the presence of barnyardgrass weed (*Echinochloa crus-galli*) is disadvantageous to Indonesian farmers and requires an initial assessment and identification of characteristics for management. Therefore, this study aimed to obtain the characteristics and similarities of barnyardgrass accessions from lowland rice fields based on the morphological characteristics of the seed. A descriptive-analytical method was used to determine the barnyardgrass characteristics of 45 accessions from nine sub-districts in Serdang Bedagai and one accession from Medan City (MDN), Indonesia, as a comparison. This study was conducted from May to August 2022 and the data were analyzed using one-way ANOVA, followed by Tukey's test at $P<0.05$. The hierarchical cluster and constellation plot were generated using Ward's method. The results showed that 45 accessions of barnyardgrass from lowland rice fields had sizes of upper glume, lower glume, upper lemma, flag leaf length, and flag leaf width ranging from 2.93 to 4.33mm, 1.45 to 1.96mm, 0.03 to 17.10mm, 22.77 to 45.40cm, and 0.53 to 1.13cm, respectively. Among all accessions, only PG4 accession was nearest (1.825) to MDN. Furthermore, there were five clusters with 13 accessions including SB4; PC1; PC5; PG3; PG4; BK1; BK3; BK5; PB1; PB2; TB2; TB1; and TT2, classified in the same cluster as MDN. This information is very important as an initial reference for farmers in the management of barnyardgrass weeds in their lowland rice fields.

Keywords: Accession, Characteristics, Identification, Lowland rice, Similarity

Introduction

Barnyardgrass (*Echinochloa crus-galli*) is an annual weed that grows to a height of 150cm and reproduces through seeds (Bagavathiannan et al., 2012). It can grow in tropical and subtropical climates and produce up to 39,000 seeds (Bagavathiannan et al., 2012; Miller et al., 2018). Additionally, it exhibits high adaptability, rapid germination, abundant seed production, and strong competitiveness, which can result in economic losses to the main crop (Mennan et al., 2012; Bajwa et al., 2015) and a loss of rice yield ranging from 21 to 79% (Wilson et al., 2014).

The presence of a barnyardgrass population at a distance of 40cm from lowland rice plants can decrease yield by 27%, nitrogen availability by 60 to 80%, inhibits rice growth (Wilson et al., 2014) and decrease rice yield by 30 to 100% throughout the growing season (Bhullar et al., 2016; Marchesi & Saldain, 2019). *E. crus galli* var. mitis can lower rice grain production by 12.7 to 42.6% by inhibiting photosynthesis rate,

#Corresponding author email: m.basyuni@usu.ac.id
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root weight, root oxidation activity, and biomass accumulation (Zhang et al., 2017). Alridiwirsah et al. (2022) added that barnyardgrass had five populations in lowland rice, with root length and volume of 39.4cm and 246.1ml and dry weight of roots and shoots of 92.7 g and 65.6g, respectively.

The presence of barnyardgrass in lowland rice fields is feared to be unfavorable to farmers in the central areas, such as Serdang Bedagai District. In 2021, Serdang Bedagai District had the second-largest rice harvest area (48,121.62ha) after Deli Serdang District from North Sumatra Province, Indonesia (Statistics of Sumatera Utara, 2022). Based on the Indonesian Center for Rice Research (2020), land preparation for lowland rice cultivation in Indonesia includes flooding the land to 2-5cm above the surface for 2-3 days before plowing the soil to a depth of 15-20cm with a tractor to kill weeds. The soil is then incubated for 3-4 days before conducting a second plowing one week after the first tilling for mudding the soil. Additionally, the ground is flattened and left moist and unflooded for 1-2 days. Rice seeds are then sown and transplanted before plant management is conducted by weed control using manual, mechanical, and chemical methods.

Herbicides are commonly used by farmers in Serdang Bedagai District to control weeds in their planting areas. Barnyardgrass is a common weed that is difficult to control. The weed must be managed appropriately using several approaches, which begin by identifying its characteristics and similarities to determine the relationship between accessions from various regions. According to Tahir (2016), the barnyardgrass from several locations in Arkansas has a leaf length of 16.2 to 30.0cm, a leaf width of 1.2-1.5 cm, upper glume of 2.94 to 3.80mm, lower glume of 1.21 to 1.68mm, an upper lemma of 2.71 to 3.55mm, and 7,186-71,494 seeds per plants. Alridiwirsah et al. (2022) also added that the upper epidermis, mesophyll, lower epidermis, and stomata density of barnyardgrass leaves from lowland rice plants were 44.3 µm, 155.6µm, 40.8µm, and 69.0n/µm, respectively.

A characteristics similarity approach is required for decisions regarding weed control (Tampubolon et al., 2019). However, the characteristics identification and similarity of barnyardgrass from lowland rice fields in Indonesia have never been reported. Therefore, an initial effort is required to determine several characters, such as flag leaf length and width, upper and lower glume, and upper lemma from various sub-districts in Serdang Bedagai. This study aimed to obtain the characteristics and similarities of barnyardgrass accessions from lowland rice fields based on the morphological characteristics of the seed. This information is expected to be a basic strategy for the management of barnyardgrass weed.

Materials and Methods

Seed collection area of barnyardgrass accession

The barnyardgrass accessions were obtained from nine sub-districts in Serdang Bedagai District, including Sei Bamban, Sei Rampah, Tebing Tinggi, Perbaungan, Teluk Mengkudu, Pegajahan, Pantai Cermin, Tanjung Beringin, and Bandar Khalipah, and one accession from Medan City, Indonesia, for comparison. Based on farmer interviews, the sub-district accessions were controlled with herbicide, while the comparison was controlled manually. Each sub-district consisted of five accessions from different villages, resulting in 45 accessions. Each was collected from ten populations of barnyardgrass and composited. Barnyardgrass seeds with physiological maturity criteria marked by seeds loss when held were obtained from lowland rice fields. The flag leaf length and width of each accession were measured and environmental conditions influencing the barnyardgrass growth were recorded (Table 1). Furthermore, the barnyardgrass seeds were collected between May and August 2022 and dried for two days.

Methodology and data analysis

A descriptive-analytical method was used to describe the similarity of barnyardgrass based on the morphological observations of the seeds, which include the upper and lower glume, upper lemma, and flag leaf length and width. Twelve seeds were randomly taken from each barnyardgrass accession, and the glume and lemma were measured using an electronic digital caliper. The characteristics of the seeds and leaves were analyzed using one-way ANOVA (analysis of variance) followed by Tukey's test at $P<0.05$. Using the JMP 17 software, the similarity of barnyardgrass weed accessions was determined using a hierarchical cluster analysis and a constellation plot with Ward's method.

TABLE 1. Locations and accession codes of barnyardgrass form Serdang Bedagai District and Medan City, Indonesia

Sub-districts	Accessions code	Villages	Longitude	Latitude	Altitude (m asl)	Temperature (°C)	Humidity (%)	Air pressure (hPa)
Sei Bamban	SB1	Bakaran Batu	99º08.089’	3º25.259’	5	26.7	88	1012
	SB2	Hapoltahan Nauli	99º08.383’	3º26.552’	4	25.1	92	1011
	SB3	Gempolan	99º07.415’	3º25.078’	9	25.0	93	1011
	SB4	Sei Buluh	99º10.605’	3º26.848’	2	25.3	91	1010
	SB5	Sukadamai	99º09.636’	3º24.762’	6	24.6	92	1010
Sei Rampah	SR1	Firdaus	99º08.210’	3º30.776’	9	29.1	68	1005
	SR2	Pematang Ganjang	99º08.235’	3º27.905’	13	28.0	76	1006
	SR3	Sei Parit	99º07.958’	3º28.603’	11	32.2	56	1006
	SR4	Sei Rejo	99º09.885’	3º30.434’	10	30.7	65	1004
	SR5	Sei Rampah	99º10.168’	3º29.590’	10	30.4	67	1004
Tebing Tinggi	TT1	Paya Lombang	99º11.737’	3º22.216’	16	29.0	75	1009
	TT2	Paya Mabar	99º12.323’	3º23.715’	15	28.9	75	1009
	TT3	Sei Priok	99º13.738’	3º24.511’	12	29.9	67	1008
	TT4	Kuta Baru	99º12.491’	3º21.887’	16	31.2	63	1006
	TT5	Meriah Padang	99º05.111’	3º18.138’	30	29.3	81	1005
Perbaungan	PB1	Melati I	98º58.034’	3º33.567’	10	24.1	79	1009
	PB2	Melati II	98º58.032’	3º33.177’	22	25.1	79	1009
	PB3	Jambur Pulau	98º57.755’	3º34.322’	1	25.1	78	1008
	PB4	Cinta Air	98º59.606’	3º34.488’	16	26.1	77	1007
	PB5	Citaman Jernih	98º57.526’	3º33.731’	10	27.1	63	1007
Teluk Mengkudu	TM1	Pasar Baru	99º06.396’	3º33.056’	9	30.2	63	1006
	TM2	Pematang Gantung	99º07.967’	3º33.068’	10	29.9	64	1006
	TM3	Sialang Buah	99º07.082’	3º33.862’	14	30.2	65	1005
	TM4	Bongak Besar	99º09.038’	3º33.060’	17	29.5	65	1005
	TM5	Sentang	99º08.333’	3º33.287’	12	29.5	65	1005
Pegajahan	PG1	Bingkat IX-B	98º57.552’	3º28.899’	30	29.0	93	1008
	PG2	Bingkat XI	98º57.512’	3º28.546’	13	28.0	93	1008
	PG3	Bingkat X-A	98º57.107’	3º28.800’	13	28.0	93	1008
	PG4	Pegajahan	98º56.800’	3º28.821’	19	28.0	93	1008
	PG5	Bingkat X-B	98º58.427’	3º28.729’	26	28.0	94	1009
Pantai Cermin	PC1	Kota Pari	98º57.625’	3º38.446’	14	30.1	65	1009
	PC2	Pematang Kasih	99º01.282’	3º37.617’	2	31.2	67	1006
	PC3	Kuala Lama	99º01.512’	3º37.137’	11	30.2	67	1006
	PC4	Naga Kaisar	99º03.656’	3º36.252’	19	30.2	70	1007
	PC5	Pantai Cermin Kanan	98º58.150’	3º38.430’	21	30.1	71	1007

TABLE 1. Cont.

Sub-districts	Accessions code	Villages	Longitude	Latitude	Altitude (m asl)	Temperature (°C)	Humidity (%)	Air pressure (hPa)
Tanjung Beringin	TB1	Nagur	99º11.259’	3º30.712’	8	28.0	79	1005
	TB2	Mangga Dua	99º11.018’	3º30.637’	7	27.1	80	1006
	TB3	Tebing Tinggi	99º13.680’	3º29.070’	22	25.6	90	1009
	TB4	Pematang Cermai	99º12.650’	3º28.709’	6	25.9	89	1009
	TB5	Pematang Terang	99º14.571’	3º26.858’	9	25.8	90	1009
Bandar Khalipah	BK1	Galam Sei Serimah	99º15.197’	3º26.468’	5	29.0	67	1006
	BK2	Pekan Bandar Kalifah	99º16.767’	3º26.633’	4	28.9	68	1006
	BK3	Kayu Besar	99º17.133’	3º25.996’	1	29.0	68	1005
	BK4	Jahar	99º16.897’	3º24.302’	10	28.8	72	1005
	BK5	Bandar Tengah	99º15.907’	3º23.973’	17	27.4	81	1006
Medan Selayang	MDN	Padang Bulan	98º39.009’	3º33.170’	14	25.0	34	1002

Results and Discussion

Seeds morphological characters and flag leaf in barnyardgrass

The results showed that the sizes of the glume and lemma, as well as flag leaf length and width, differed significantly between barnyardgrass accessions (Table 2). Upper and lower glume sizes were found to be the largest in TB3 and TM1 accessions (Tanjung Beringin 3 and Teluk Mengkudu 1), measuring 4.33 ± 0.20mm and 1.96 ± 0.02mm, respectively. PB1 (Perbaungan 1) had the longest upper lemma of all accessions, measuring 17.10 ± 0.18mm. Furthermore, the largest values of flag leaf length and width of barnyardgrass accession were found in PB4 and PC2, measuring 45.40 ± 0.66 and 1.13 ± 0.03cm, respectively.

The difference in the size of the barnyardgrass seeds for each accession (Serdang Bedagai) with the comparison accession (MDN) can be seen visually in Fig. 1. Based on the observations of the barnyardgrass seed, the upper lemma was visible. The longest lemma from each sub-district was found in SB5; SR2; TT5; PB1; TM1; PC4; TB3; and BK2 accessions, but the upper lemma of PG1-5 did not differ from the accession comparison.

Correlation coefficient value

The flag leaf length and width were positively correlated with the size of the upper glume of barnyardgrass accessions (Table 3). Similarly, both characters were significant and positively correlated (0.505^{**} and 0.344^{*}) with the size of the lower glume of barnyardgrass seeds.

Hierarchical cluster and similarity matrix of barnyardgrass accessions

Based on the similarity matrix between barnyardgrass accessions from Serdang Bedagai and MDN (Table 4), only the PG4 accession was closely related (1.825). This indicates that it had the most similar characteristics to the barnyardgrass seeds from MDN. Barnyardgrass accessions were grouped into five clusters based on the hierarchical cluster analysis and constellation plot (Fig, 2). Cluster 1 had eight accessions, including SB1; SB3; SR1; SR2; TT4; PB3; TM2; and PG5, while cluster 2 consisted of five accessions including TM1; TM4; BK4; PC3; and TB5. Cluster 3 had six accessions consisting of TT1; PG1; PG2; PB4; PC2; and TB4, while Cluster 4 consisted of 13 accessions comprising TM3; TM5; SR3; SR4; SR5; TT3; TT5; SB2; SB5; PB5; BK2; TB3; and PC4. Meanwhile, cluster 5 had 14 accessions containing MDN; SB4; PC1; PC5; PG3; PG4; BK1; BK3; BK5; PB1; PB2; TB2; TB1; and TT2.

TABLE 2. Upper dan lower glume, upper lemma, flag leaf length, and width of barnyardgrass accessions from lowland rice fields in Serdang Bedagai District and the comparison accession (MDN), Indonesia

Accessions	UG (mm)	LG (mm)	UL (mm)	FLL (cm)	FLW (cm)
MDN	3.90±0.30 abc	1.85±0.07 a-d	0.04±0.01 i	35.57±2.56 a-e	0.87±0.03 ab
SB1	3.80±0.06 abc	1.71±0.04 a-d	8.80±0.22 d-h	31.40±1.32 a-e	0.80±0.03 ab
SB2	3.54±0.05 abc	1.74±0.02 a-d	12.94±0.74 a-d	30.80±0.69 a-e	0.73±0.03 ab
SB3	3.82±0.09 abc	1.83±0.01 a-d	7.20±0.24 e-h	31.90±1.24 a-e	0.83±0.03 ab
SB4	3.84±0.08 abc	1.76±0.03 a-d	9.63±0.25 c-h	33.87±0.01 a-e	0.87±0.03 ab
SB5	4.06±0.09 ab	1.65±0.02 a-d	13.12±0.41 a-d	28.23±2.89 a-e	0.73±0.07 ab
SR1	4.01±0.07 abc	1.75±0.04 a-d	11.26±0.21 b-f	33.53±2.49 a-e	0.83±0.04 ab
SR2	3.64±0.08 abc	1.71±0.03 a-d	11.86±0.77 b-e	37.27±2.05 a-e	0.83±0.04 ab
SR3	3.55±0.06 abc	1.69±0.03 a-d	9.26±0.42 d-h	30.80±0.41 a-e	0.67±0.01 ab
SR4	3.43±0.03 abc	1.82±0.05 a-d	6.12±0.07 gh	31.00±2.98 a-e	1.00±0.04 ab
SR5	3.52±0.01 abc	1.83±0.04 a-d	0.03±0.00 i	29.57±0.46 a-e	0.53±0.01 b
TT1	3.55±0.07 abc	1.89±0.02 abc	0.05±0.01 i	44.53±0.66 ab	1.07±0.01 a
TT2	3.37±0.04 abc	1.48±0.02 bcd	5.12±0.25 h	39.03±0.70 a-e	1.03±0.01 ab
TT3	3.52±0.07 abc	1.46±0.02 cd	12.97±0.27 a-d	29.83±0.08 a-e	0.67±0.01 ab
TT4	2.95±0.09 c	1.57±0.02 a-d	11.28±0.52 b-f	30.27±2.33 a-e	0.83±0.10 ab
TT5	3.40±0.09 abc	1.55±0.02 a-d	14.21±0.82 abc	24.80±0.77 de	0.53±0.01 b
PB1	3.33±0.01 abc	1.48±0.01 bcd	17.10±0.18 a	32.87±0.12 a-e	0.97±0.01 ab
PB2	3.47±0.06 abc	1.62±0.03 a-d	13.43±0.77 a-d	26.63±0.95 cde	1.03±0.04 ab
PB3	2.93±0.08 c	1.57±0.04 a-d	9.99±0.32 c-h	27.30±2.86 b-e	0.77±0.08 ab
PB4	3.78±0.13 abc	1.94±0.05 a	0.04±0.00 i	45.40±0.66 a	1.07±0.01 a
PB5	3.62±0.10 abc	1.90±0.04 ab	11.50±0.95 b-f	39.17±0.66 a-e	1.00±0.03 ab
TM1	3.09±0.13 bc	1.96±0.02 a	15.67±0.11 ab	31.70±0.70 a-e	0.80±0.03 ab
TM2	3.18±0.06 bc	1.71±0.01 a-d	11.54±0.37 b-f	27.30±1.37 b-e	0.77±0.06 ab
TM3	3.37±0.07 abc	1.60±0.05 a-d	6.85±0.69 fgh	33.60±0.57 a-e	1.00±0.07 ab
TM4	3.56±0.10 abc	1.82±0.00 a-d	11.87±0.99 b-e	27.70±0.68 b-e	0.80±0.03 ab
TM5	2.99±0.08 bc	1.64±0.04 a-d	5.81±0.36 gh	28.47±1.86 a-e	0.70±0.05 ab
PG1	3.68±0.05 abc	1.67±0.02 a-d	0.07±0.01 i	28.83±0.77 a-e	0.90±0.03 ab
PG2	3.25±0.06 abc	1.57±0.04 a-d	0.05±0.01 i	31.37±0.50 a-e	1.07±0.01 a
PG3	3.57±0.03 abc	1.80±0.03 a-d	0.08±0.01 i	42.53±0.97 abc	0.93±0.01 ab
PG4	3.51±0.07 abc	1.78±0.03 a-d	0.06±0.01 i	35.70±1.57 a-e	0.90±0.03 ab
PG5	3.50±0.03 abc	1.71±0.03 a-d	0.04±0.01 i	26.73±2.83 cde	0.77±0.08 ab
PC1	3.31±0.02 abc	1.83±0.04 a-d	0.06±0.01 i	39.13±0.85 a-e	0.97±0.01 ab
PC2	3.68±0.09 abc	1.94±0.04 a	0.07±0.01 i	40.13±0.38 a-d	1.13±0.03 a
PC3	3.17±0.09 bc	1.55±0.04 a-d	0.05±0.01 i	23.13±1.57 de	0.80±0.03 ab
PC4	2.99±0.05 bc	1.47±0.02 bcd	8.61±0.49 d-h	27.43±0.36 b-e	0.73±0.01 ab
PC5	3.54±0.08 abc	1.80±0.04 a-d	0.06±0.01 i	24.63±1.67 de	0.87±0.03 ab
TB1	3.29±0.07 abc	1.58±0.04 a-d	0.08±0.01 i	28.70±0.08 a-e	0.97±0.01 ab
TB2	3.58±0.12 abc	1.65±0.03 a-d	0.04±0.01 i	26.10±0.49 cde	0.97±0.04 ab
TB3	4.33±0.20 a	1.48±0.00 bcd	12.02±0.33 b-e	26.13±1.10 cde	0.67±0.04 ab
TB4	4.02±0.10 abc	1.67±0.05 a-d	0.07±0.00 i	28.67±0.51 a-e	0.90±0.03 ab
TB5	3.10±0.10 bc	1.68±0.05 a-d	0.05±0.01 i	31.17±1.27 a-e	0.80±0.03 ab
BK1	3.68±0.11 abc	1.77±0.04 a-d	0.06±0.01 i	25.40±0.52 cde	0.93±0.04 ab
BK2	3.25±0.07 abc	1.45±0.04 d	11.74±0.37 b-f	22.77±0.49 e	0.53±0.01 b
BK3	4.00±0.10 abc	1.69±0.04 a-d	0.09±0.01 i	28.40±1.14 a-e	1.03±0.05 ab
BK4	3.53±0.11 abc	1.49±0.02 bcd	10.59±0.42 c-g	32.27±0.61 a-e	0.80±0.03 ab
BK5	3.49±0.06 abc	1.75±0.05 a-d	0.08±0.01 i	28.00±1.09 b-e	1.03±0.03 ab

Note: the mean followed by a different letter is significant in the Tukey's test at $P<0.005$ ± standard error. UG= upper glume; LG= lower glume; UL= upper lemma; FLL= flag leaf length, FLW= flag leaf width.

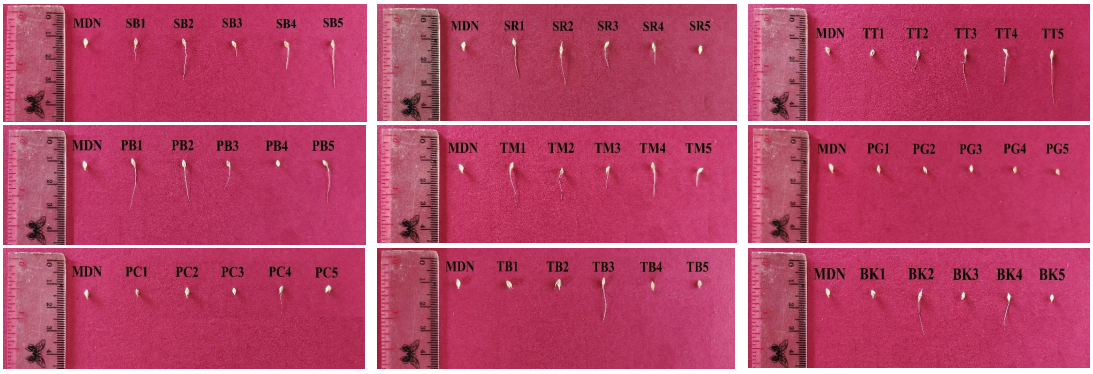

Fig. 1. The difference in the size of the seed glume and lemma in barnyardgrass accessions from Serdang Bedagai District, Indonesia and the comparison accession (MDN) visually

TABLE 3. The correlation coefficient between the barnyardgrass accessions from Serdang Bedagai District, Indonesia and the comparison accession

Traits	FLL	FLW	UG	LG	UL
FLL	1	0.528**	0.156	0.505**	-0.185
FLW		1	0.110	0.344*	-0.436**
UG			1	0.254	-0.080
LG				1	-0.323*
UL					1

Note: *and** Correlation is significant at the 0.05 and 0.01 level. FLL= flag leaf length, FLW= flag leaf width, UG= upper glume, LG= lower glume, UL= upper lemma.

TABLE 4. The similarity matrix value between the barnyardgrass accessions from Serdang Bedagai District compared to the comparison accession (MDN), Indonesia

No	Accessions	Matrix value	No	Accessions	Matrix value
1	SB1	4.151	26	PG1	3.681
2	SB2	8.473	27	PG2	10.584
3	SB3	2.123	28	PG3	3.021
4	SB4	3.253	29	PG4	1.825
5	SB5	10.001	30	PG5	5.680
6	SR1	4.549	31	PC1	4.419
7	SR2	5.956	32	PC2	4.627
8	SR3	7.589	33	PC3	15.327
9	SR4	4.833	34	PC4	20.879
10	SR5	7.879	35	PC5	5.469
11	TT1	5.818	36	TB1	9.449
12	TT2	12.000	37	TB2	6.506
13	TT3	16.903	38	TB3	17.747
14	TT4	17.800	39	TB4	3.410
15	TT5	22.047	40	TB5	8.795
16	PB1	19.415	41	BK1	4.456
17	PB2	13.647	42	BK2	27.019
18	PB3	19.117	43	BK3	4.261
19	PB4	5.600	44	BK4	11.736
20	PB5	5.988	45	BK5	5.280
21	TM1	15.179			
22	TM2	12.882			
23	TM3	8.225			
24	TM4	7.651			
25	TM5	14.563			

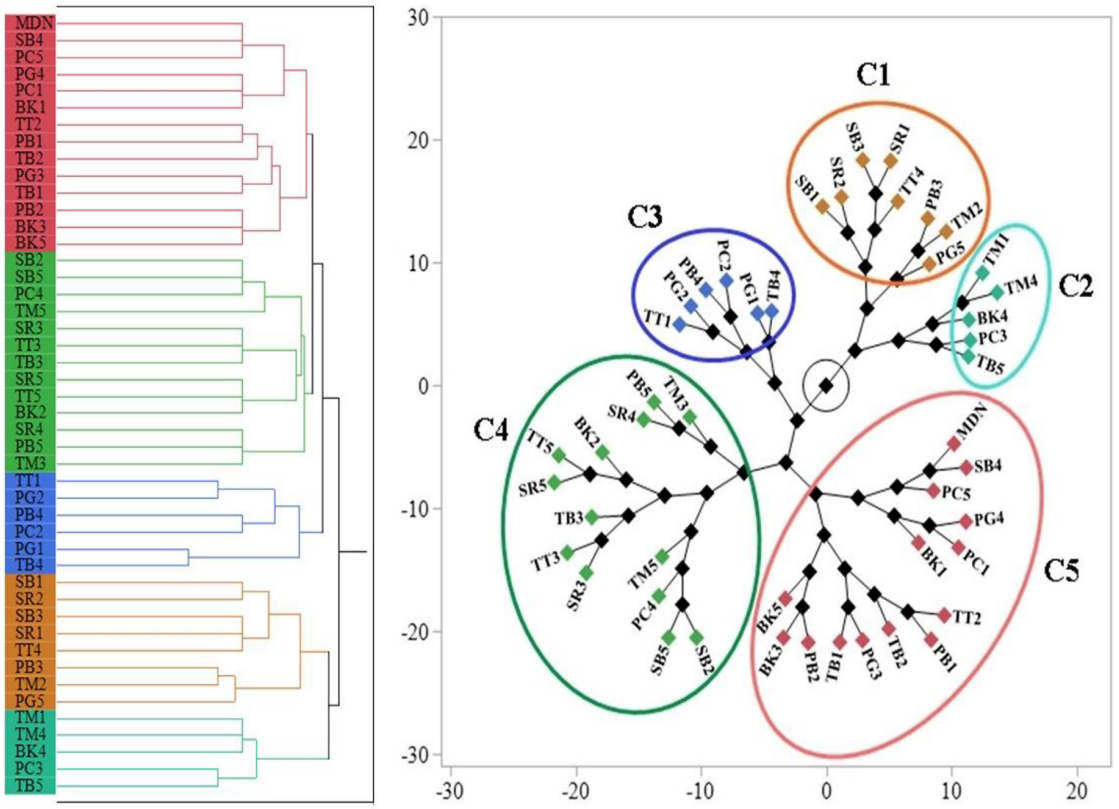

Fig. 2. Hierarchical clustering and constellation plot of 46 barnyardgrass accessions from Serdang Bedagai District and Medan City (comparison), Indonesia [Codes of barnyardgrass accessions and their localities are listed in Table 1]

The results showed that the sizes of the upper and lower glume, upper lemma, and flag leaf length and width of the barnyardgrass accession from Serdang Bedagai District ranged from 2.93 to 4.33mm, 1.45 to 1.96mm, 0.03 to 17.10mm, 22.77 to 45.40cm, and 0.53 to 1.13cm, respectively (Table 2). The upper and lower glume sizes in TB3 and TM1, as well as the upper lemma found in PB1 accessions, were larger than in other accessions. The results also revealed that PB4 and PC2 accessions had the highest flag leaf length and width values when compared to other accessions. This indicates that the size of seed glume from these locations could be due to the total assimilating productivity of the large flag leaf length and width. This finding was supported by the flag leaf length and width, which are positively correlated (0.156 and 0.110) with the size of the upper glume, and positively correlated and significant (0.505^{**} and 0.344^{*}) with the size of the lower glume (Table 3). Asana (1968) supported this result by stating that flag leaves play an important role in providing photosynthesis products to seeds. According to Ashrafuzzaman et al. (2009) and Rahman et al. (2013), flag leaf area was positively correlated with panicle length and seed production. In contrast, the size of the upper lemma was negatively correlated with the flag leaf length and width (Table 3). It was assumed that the photosynthate product from the flag leaf influenced glume formation and panicle length. Liu et al. (2021) also reported that flag leaf length and width were positively correlated to panicle length in *Echinochloa* ecotypes.

It was observed that only the PG4 accession was closely related to MDN, with a similarity value of 1.825. The hierarchical cluster confirmed these findings, with the SB4; PC1; PC5; PG3; PG4; BK1; BK3; BK5; PB1; PB2; TB2; TB1; and TT2 accessions clustered in one group with the MDN. This indicates that the characters of the upper and lower glume, upper lemma, flag leaf length, and width of the 13 accessions were not significantly different from MDN (Table 2). This was consistent with a study by Tahir (2016) which stated that eight of 95 *Echinochloa sp* accessions from several locations in Arkansas were clustered

with the barnyardgrass based on vegetative and generative characteristics. Altop & Mennan (2011) classified barnyardgrass weeds from lowland rice fields in Turkey into three clusters based on morphological characters, with 28 of 34 barnyardgrass populations having similarities. The findings also showed that the morphological character approach is almost similar when using a molecular approach (RAPD), with 33 of 34 barnyardgrass populations clustered into one group. Liu et al. (2021) also characterized the morphophysiology of *E. crus-galli*; *E. colona*; and *E. muricata* from rice-growing in Texas, producing five clusters and discovered that the *E. crus-galli* (ECH22) ecotype was related to *E. muricata* (ECH33). Claerhout et al. (2016) identified three clusters of 14 barnyardgrass accessions based on morphological characters from maize fields in Belgium.

Based on the result, 13 of 45 accessions from lowland rice fields in Serdang Bedagai District were similar to MDN. This result showed that farmers' management of barnyardgrass weeds from these accessions did not differ significantly to the comparison accession. These results are reported for the first time in Indonesia. However, the morphological character approach to assessing similarity should be re-examined using molecular methods.

Conclusions

Based on morphological characters, 45 accessions of barnyardgrass weeds from Serdang Bedagai District had different sizes of upper and lower glume, upper lemma, and flag leaf length and width ranged from 2.93-4.33mm; 1.45-1.96mm; 0.03-17.10mm; 22.77-45.40cm; and 0.53-1.13cm, respectively. Accessions of TB3; TM1; PB1; PB4; and PC2 had the largest characteristic size compared to other accessions. Additionally, the PG4 accession was closely related to MDN (1.825). It was also found that the SB4; PC1; PC5; PG3; PG4; BK1; BK3; BK5; PB1; PB2; TB2; TB1; and TT2 accessions were classified into one cluster with MDN.

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The Similarity of Barnyardgrass Weed in Lowland Rice Fields Based on Seed Characteristics

Alridiwirsah[(1)], Mohammad Basyuni[(2, 5)#], Koko Tampubolon[(3)], Novilda Elizabeth Mustamu[(4)]

[(1)]Program Study of Agrotechnology, Faculty of Agriculture, Universitas Muhammadiyah Sumatera Utara, Medan 20238, Indonesia; [(2)]Program Study of Forestry, Faculty of Forestry, Universitas Sumatera Utara, Medan 20155, Indonesia; [(3)]Program Study of Agrotechnology, Faculty of Agriculture, Universitas Sumatera Utara, Medan 20155, Indonesia; [(4)]Program Study of Agrotechnology, Faculty of Science and Technology, Universitas Labuhanbatu, Rantauprapat 21415, Sumatera Utara, Indonesia; [(5)]Center of Excellence for Mangrove, Universitas Sumatera Utara, Medan 20155, Indonesia.

IN LOWLAND rice areas, the presence of barnyardgrass weed (*Echinochloa crus-galli*) is disadvantageous to Indonesian farmers and requires an initial assessment and identification of characteristics for management. Therefore, this study aimed to obtain the characteristics and similarities of barnyardgrass accessions from lowland rice fields based on the morphological characteristics of the seed. A descriptive-analytical method was used to determine the barnyardgrass characteristics of 45 accessions from nine sub-districts in Serdang Bedagai and one accession from Medan City (MDN), Indonesia, as a comparison. This study was conducted from May to August 2022 and the data were analyzed using one-way ANOVA, followed by Tukey's test at $P<0.05$. The hierarchical cluster and constellation plot were generated using Ward's method. The results showed that 45 accessions of barnyardgrass from lowland rice fields had sizes of upper glume, lower glume, upper lemma, flag leaf length, and flag leaf width ranging from 2.93 to 4.33mm, 1.45 to 1.96mm, 0.03 to 17.10mm, 22.77 to 45.40cm, and 0.53 to 1.13cm, respectively. Among all accessions, only PG4 accession was nearest (1.825) to MDN. Furthermore, there were five clusters with 13 accessions including SB4; PC1; PC5; PG3; PG4; BK1; BK3; BK5; PB1; PB2; TB2; TB1; and TT2, classified in the same cluster as MDN. This information is very important as an initial reference for farmers in the management of barnyardgrass weeds in their lowland rice fields.

Keywords: Accession, Characteristics, Identification, Lowland rice, Similarity.

Introduction

Barnyardgrass (*Echinochloa crus-galli*) is an annual weed that grows to a height of 150cm and reproduces through seeds (Bagavathiannan et al., 2012). It can grow in tropical and subtropical climates and produce up to 39,000 seeds (Bagavathiannan et al., 2012; Miller et al., 2018). Additionally, it exhibits high adaptability, rapid germination, abundant seed production, and strong competitiveness, which can result in economic losses to the main crop (Mennan et al., 2012; Bajwa et al., 2015) and a loss of rice yield ranging from 21 to 79% (Wilson et al., 2014).

The presence of a barnyardgrass population at a distance of 40cm from lowland rice plants can decrease yield by 27%, nitrogen availability by 60 to 80%, inhibits rice growth (Wilson et al., 2014) and decrease rice yield by 30 to 100% throughout

#Corresponding author email: m.basyuni@usu.ac.id
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the growing season (Bhullar et al., 2016; Marchesi & Saldain, 2019). *E. crus galli* var. mitis can lower rice grain production by 12.7 to 42.6% by inhibiting photosynthesis rate, root weight, root oxidation activity, and biomass accumulation (Zhang et al., 2017). Alridiwirsah et al. (2022) added that barnyardgrass had five populations in lowland rice, with root length and volume of 39.4cm and 246.1ml and dry weight of roots and shoots of 92.7 g and 65.6g, respectively.

The presence of barnyardgrass in lowland rice fields is feared to be unfavorable to farmers in the central areas, such as Serdang Bedagai District. In 2021, Serdang Bedagai District had the second-largest rice harvest area (48,121.62ha) after Deli Serdang District from North Sumatra Province, Indonesia (Statistics of Sumatera Utara, 2022). Based on the Indonesian Center for Rice Research (2020), land preparation for lowland rice cultivation in Indonesia includes flooding the land to 2-5cm above the surface for 2-3 days before plowing the soil to a depth of 15-20cm with a tractor to kill weeds. The soil is then incubated for 3-4 days before conducting a second plowing one week after the first tilling for mudding the soil. Additionally, the ground is flattened and left moist and unflooded for 1-2 days. Rice seeds are then sown and transplanted before plant management is conducted by weed control using manual, mechanical, and chemical methods.

Herbicides are commonly used by farmers in Serdang Bedagai District to control weeds in their planting areas. Barnyardgrass is a common weed that is difficult to control. The weed must be managed appropriately using several approaches, which begin by identifying its characteristics and similarities to determine the relationship between accessions from various regions. According to Tahir (2016), the barnyardgrass from several locations in Arkansas has a leaf length of 16.2 to 30.0cm, a leaf width of 1.2-1.5 cm, upper glume of 2.94 to 3.80mm, lower glume of 1.21 to 1.68mm, an upper lemma of 2.71 to 3.55mm, and 7,186-71,494 seeds per plants. Alridiwirsah et al. (2022) also added that the upper epidermis, mesophyll, lower epidermis, and stomata density of barnyardgrass leaves from lowland rice plants were 44.3 ɛm, 155.6ɛm, 40.8ɛm, and 69.0n/ɛm, respectively.

A characteristics similarity approach is required for decisions regarding weed control (Juraimi et al., 2005; Bastiani et al., 2016; Tampubolon et al., 2019). However, the characteristics identification and similarity of barnyardgrass from lowland rice fields in Indonesia have never been reported. Therefore, an initial effort is required to determine several characters, such as flag leaf length and width, upper and lower glume, and upper lemma from various sub-districts in Serdang Bedagai. This study aimed to obtain the characteristics and similarities of barnyardgrass accessions from lowland rice fields based on the morphological characteristics of the seed. This information is expected to be a basic strategy for the management of barnyardgrass weed.

Materials and Methods

Seed collection area of barnyardgrass accession

The barnyardgrass accessions were obtained from nine sub-districts in Serdang Bedagai District, including Sei Bamban, Sei Rampah, Tebing Tinggi, Perbaungan, Teluk Mengkudu, Pegajahan, Pantai Cermin, Tanjung Beringin, and Bandar Khalipah, and one accession from Medan City, Indonesia, for comparison. Based on farmer interviews, the sub-district accessions were controlled with herbicide, while the comparison was controlled manually. Each sub-district consisted of five accessions from different villages, resulting in 45 accessions. Each was collected from ten populations of barnyardgrass and composited. Barnyardgrass seeds with physiological maturity criteria marked by seeds loss when held were obtained from lowland rice fields. The flag leaf length and width of each accession were measured and environmental conditions influencing the barnyardgrass growth were recorded (Table 1). Furthermore, the barnyardgrass seeds were collected between May and August 2022 and dried for two days.

Methodology and data analysis

A descriptive-analytical method was used to describe the similarity of barnyardgrass based on the morphological observations of the seeds, which include the upper and lower glume, upper lemma, and flag leaf length and width. Twelve seeds were randomly taken from each barnyardgrass accession, and the glume and lemma were measured using an electronic digital caliper. The characteristics of the seeds and leaves were analyzed using one-way ANOVA (analysis of variance) followed by Tukey's test at $P<0.05$. Using the JMP 17 software, the similarity of barnyardgrass weed accessions was determined using a hierarchical cluster analysis and a constellation plot with Ward's method.

TABLE 1. Locations and accession codes of barnyardgrass form Serdang Bedagai District and Medan City, Indonesia

Sub-districts	Accessions code	Villages	Longitude	Latitude	Altitude (m asl)	Temperature (°C)	Humidity (%)	Air pressure (hPa)
Sei Bamban	SB1	Bakaran Batu	99º08.089’	3º25.259’	5	26.7	88	1012
	SB2	Hapoltahan Nauli	99º08.383’	3º26.552’	4	25.1	92	1011
	SB3	Gempolan	99º07.415’	3º25.078’	9	25.0	93	1011
	SB4	Sei Buluh	99º10.605’	3º26.848’	2	25.3	91	1010
	SB5	Sukadamai	99º09.636’	3º24.762’	6	24.6	92	1010
Sei Rampah	SR1	Firdaus	99º08.210’	3º30.776’	9	29.1	68	1005
	SR2	Pematang Ganjang	99º08.235’	3º27.905’	13	28.0	76	1006
	SR3	Sei Parit	99º07.958’	3º28.603’	11	32.2	56	1006
	SR4	Sei Rejo	99º09.885’	3º30.434’	10	30.7	65	1004
	SR5	Sei Rampah	99º10.168’	3º29.590’	10	30.4	67	1004
Tebing Tinggi	TT1	Paya Lombang	99º11.737’	3º22.216’	16	29.0	75	1009
	TT2	Paya Mabar	99º12.323’	3º23.715’	15	28.9	75	1009
	TT3	Sei Priok	99º13.738’	3º24.511’	12	29.9	67	1008
	TT4	Kuta Baru	99º12.491’	3º21.887’	16	31.2	63	1006
	TT5	Meriah Padang	99º05.111’	3º18.138’	30	29.3	81	1005
Perbaungan	PB1	Melati I	98º58.034’	3º33.567’	10	24.1	79	1009
	PB2	Melati II	98º58.032’	3º33.177’	22	25.1	79	1009
	PB3	Jambur Pulau	98º57.755’	3º34.322’	1	25.1	78	1008
	PB4	Cinta Air	98º59.606’	3º34.488’	16	26.1	77	1007
	PB5	Citaman Jernih	98º57.526’	3º33.731’	10	27.1	63	1007
Teluk Mengkudu	TM1	Pasar Baru	99º06.396’	3º33.056’	9	30.2	63	1006
	TM2	Pematang Gantung	99º07.967’	3º33.068’	10	29.9	64	1006
	TM3	Sialang Buah	99º07.082’	3º33.862’	14	30.2	65	1005
	TM4	Bongak Besar	99º09.038’	3º33.060’	17	29.5	65	1005
	TM5	Sentang	99º08.333’	3º33.287’	12	29.5	65	1005
Pegajahan	PG1	Bingkat IX-B	98º57.552’	3º28.899’	30	29.0	93	1008
	PG2	Bingkat XI	98º57.512’	3º28.546’	13	28.0	93	1008
	PG3	Bingkat X-A	98º57.107’	3º28.800’	13	28.0	93	1008
	PG4	Pegajahan	98º56.800’	3º28.821’	19	28.0	93	1008
	PG5	Bingkat X-B	98º58.427’	3º28.729’	26	28.0	94	1009
Pantai Cermin	PC1	Kota Pari	98º57.625’	3º38.446’	14	30.1	65	1009
	PC2	Pematang Kasih	99º01.282’	3º37.617’	2	31.2	67	1006
	PC3	Kuala Lama	99º01.512’	3º37.137’	11	30.2	67	1006
	PC4	Naga Kaisar	99º03.656’	3º36.252’	19	30.2	70	1007
	PC5	Pantai Cermin Kanan	98º58.150’	3º38.430’	21	30.1	71	1007

TABLE 1. Cont.

Sub-districts	Accessions code	Villages	Longitude	Latitude	Altitude (m asl)	Temperature (°C)	Humidity (%)	Air pressure (hPa)
Tanjung Beringin	TB1	Nagur	99º11.259’	3º30.712’	8	28.0	79	1005
	TB2	Mangga Dua	99º11.018’	3º30.637’	7	27.1	80	1006
	TB3	Tebing Tinggi	99º13.680’	3º29.070’	22	25.6	90	1009
	TB4	Pematang Cermai	99º12.650’	3º28.709’	6	25.9	89	1009
	TB5	Pematang Terang	99º14.571’	3º26.858’	9	25.8	90	1009
Bandar Khalipah	BK1	Galam Sei Serimah	99º15.197’	3º26.468’	5	29.0	67	1006
	BK2	Pekan Bandar Kalifah	99º16.767’	3º26.633’	4	28.9	68	1006
	BK3	Kayu Besar	99º17.133’	3º25.996’	1	29.0	68	1005
	BK4	Jahar	99º16.897’	3º24.302’	10	28.8	72	1005
	BK5	Bandar Tengah	99º15.907’	3º23.973’	17	27.4	81	1006
Medan Selayang	MDN	Padang Bulan	98º39.009’	3º33.170’	14	25.0	34	1002

Results and Discussion

Seeds morphological characters and flag leaf in barnyardgrass

The results showed that the sizes of the glume and lemma, as well as flag leaf length and width, differed significantly between barnyardgrass accessions (Table 2). Upper and lower glume sizes were found to be the largest in TB3 and TM1 accessions (Tanjung Beringin 3 and Teluk Mengkudu 1), measuring 4.33 ± 0.20mm and 1.96 ± 0.02mm, respectively. PB1 (Perbaungan 1) had the longest upper lemma of all accessions, measuring 17.10 ± 0.18mm. Furthermore, the largest values of flag leaf length and width of barnyardgrass accession were found in PB4 and PC2, measuring 45.40 ± 0.66 and 1.13 ± 0.03cm, respectively.

The difference in the size of the barnyardgrass seeds for each accession (Serdang Bedagai) with the comparison accession (MDN) can be seen visually in Fig. 1. Based on the observations of the barnyardgrass seed, the upper lemma was visible. The longest lemma from each sub-district was found in SB5; SR2; TT5; PB1; TM1; PC4; TB3; and BK2 accessions, but the upper lemma of PG1-5 did not differ from the accession comparison.

Correlation coefficient value

The flag leaf length and width were positively correlated with the size of the upper glume of barnyardgrass accessions (Table 3). Similarly, both characters were significant and positively correlated (0.505^{**} and 0.344^{*}) with the size of the lower glume of barnyardgrass seeds.

Hierarchical cluster and similarity matrix of barnyardgrass accessions

Based on the similarity matrix between barnyardgrass accessions from Serdang Bedagai and MDN (Table 4), only the PG4 accession was closely related (1.825). This indicates that it had the most similar characteristics to the barnyardgrass seeds from MDN. Barnyardgrass accessions were grouped into five clusters based on the hierarchical cluster analysis and constellation plot (Fig, 2). Cluster 1 had eight accessions, including SB1; SB3; SR1; SR2; TT4; PB3; TM2; and PG5, while cluster 2 consisted of five accessions including TM1; TM4; BK4; PC3; and TB5. Cluster 3 had six accessions consisting of TT1; PG1; PG2; PB4; PC2; and TB4, while Cluster 4 consisted of 13 accessions comprising TM3; TM5; SR3; SR4; SR5; TT3; TT5; SB2; SB5; PB5; BK2; TB3; and PC4. Meanwhile, cluster 5 had 14 accessions containing MDN; SB4; PC1; PC5; PG3; PG4; BK1; BK3; BK5; PB1; PB2; TB2; TB1; and TT2.

TABLE 2. Upper dan lower glume, upper lemma, flag leaf length, and width of barnyardgrass accessions from lowland rice fields in Serdang Bedagai District and the comparison accession (MDN), Indonesia

Accessions	UG (mm)	LG (mm)	UL (mm)	FLL (cm)	FLW (cm)
MDN	3.90±0.30 abc	1.85±0.07 a-d	0.04±0.01 i	35.57±2.56 a-e	0.87±0.03 ab
SB1	3.80±0.06 abc	1.71±0.04 a-d	8.80±0.22 d-h	31.40±1.32 a-e	0.80±0.03 ab
SB2	3.54±0.05 abc	1.74±0.02 a-d	12.94±0.74 a-d	30.80±0.69 a-e	0.73±0.03 ab
SB3	3.82±0.09 abc	1.83±0.01 a-d	7.20±0.24 e-h	31.90±1.24 a-e	0.83±0.03 ab
SB4	3.84±0.08 abc	1.76±0.03 a-d	9.63±0.25 c-h	33.87±0.01 a-e	0.87±0.03 ab
SB5	4.06±0.09 ab	1.65±0.02 a-d	13.12±0.41 a-d	28.23±2.89 a-e	0.73±0.07 ab
SR1	4.01±0.07 abc	1.75±0.04 a-d	11.26±0.21 b-f	33.53±2.49 a-e	0.83±0.04 ab
SR2	3.64±0.08 abc	1.71±0.03 a-d	11.86±0.77 b-e	37.27±2.05 a-e	0.83±0.04 ab
SR3	3.55±0.06 abc	1.69±0.03 a-d	9.26±0.42 d-h	30.80±0.41 a-e	0.67±0.01 ab
SR4	3.43±0.03 abc	1.82±0.05 a-d	6.12±0.07 gh	31.00±2.98 a-e	1.00±0.04 ab
SR5	3.52±0.01 abc	1.83±0.04 a-d	0.03±0.00 i	29.57±0.46 a-e	0.53±0.01 b
TT1	3.55±0.07 abc	1.89±0.02 abc	0.05±0.01 i	44.53±0.66 ab	1.07±0.01 a
TT2	3.37±0.04 abc	1.48±0.02 bcd	5.12±0.25 h	39.03±0.70 a-e	1.03±0.01 ab
TT3	3.52±0.07 abc	1.46±0.02 cd	12.97±0.27 a-d	29.83±0.08 a-e	0.67±0.01 ab
TT4	2.95±0.09 c	1.57±0.02 a-d	11.28±0.52 b-f	30.27±2.33 a-e	0.83±0.10 ab
TT5	3.40±0.09 abc	1.55±0.02 a-d	14.21±0.82 abc	24.80±0.77 de	0.53±0.01 b
PB1	3.33±0.01 abc	1.48±0.01 bcd	17.10±0.18 a	32.87±0.12 a-e	0.97±0.01 ab
PB2	3.47±0.06 abc	1.62±0.03 a-d	13.43±0.77 a-d	26.63±0.95 cde	1.03±0.04 ab
PB3	2.93±0.08 c	1.57±0.04 a-d	9.99±0.32 c-h	27.30±2.86 b-e	0.77±0.08 ab
PB4	3.78±0.13 abc	1.94±0.05 a	0.04±0.00 i	45.40±0.66 a	1.07±0.01 a
PB5	3.62±0.10 abc	1.90±0.04 ab	11.50±0.95 b-f	39.17±0.66 a-e	1.00±0.03 ab
TM1	3.09±0.13 bc	1.96±0.02 a	15.67±0.11 ab	31.70±0.70 a-e	0.80±0.03 ab
TM2	3.18±0.06 bc	1.71±0.01 a-d	11.54±0.37 b-f	27.30±1.37 b-e	0.77±0.06 ab
TM3	3.37±0.07 abc	1.60±0.05 a-d	6.85±0.69 fgh	33.60±0.57 a-e	1.00±0.07 ab
TM4	3.56±0.10 abc	1.82±0.00 a-d	11.87±0.99 b-e	27.70±0.68 b-e	0.80±0.03 ab
TM5	2.99±0.08 bc	1.64±0.04 a-d	5.81±0.36 gh	28.47±1.86 a-e	0.70±0.05 ab
PG1	3.68±0.05 abc	1.67±0.02 a-d	0.07±0.01 i	28.83±0.77 a-e	0.90±0.03 ab
PG2	3.25±0.06 abc	1.57±0.04 a-d	0.05±0.01 i	31.37±0.50 a-e	1.07±0.01 a
PG3	3.57±0.03 abc	1.80±0.03 a-d	0.08±0.01 i	42.53±0.97 abc	0.93±0.01 ab
PG4	3.51±0.07 abc	1.78±0.03 a-d	0.06±0.01 i	35.70±1.57 a-e	0.90±0.03 ab
PG5	3.50±0.03 abc	1.71±0.03 a-d	0.04±0.01 i	26.73±2.83 cde	0.77±0.08 ab
PC1	3.31±0.02 abc	1.83±0.04 a-d	0.06±0.01 i	39.13±0.85 a-e	0.97±0.01 ab
PC2	3.68±0.09 abc	1.94±0.04 a	0.07±0.01 i	40.13±0.38 a-d	1.13±0.03 a
PC3	3.17±0.09 bc	1.55±0.04 a-d	0.05±0.01 i	23.13±1.57 de	0.80±0.03 ab
PC4	2.99±0.05 bc	1.47±0.02 bcd	8.61±0.49 d-h	27.43±0.36 b-e	0.73±0.01 ab
PC5	3.54±0.08 abc	1.80±0.04 a-d	0.06±0.01 i	24.63±1.67 de	0.87±0.03 ab
TB1	3.29±0.07 abc	1.58±0.04 a-d	0.08±0.01 i	28.70±0.08 a-e	0.97±0.01 ab
TB2	3.58±0.12 abc	1.65±0.03 a-d	0.04±0.01 i	26.10±0.49 cde	0.97±0.04 ab
TB3	4.33±0.20 a	1.48±0.00 bcd	12.02±0.33 b-e	26.13±1.10 cde	0.67±0.04 ab
TB4	4.02±0.10 abc	1.67±0.05 a-d	0.07±0.00 i	28.67±0.51 a-e	0.90±0.03 ab
TB5	3.10±0.10 bc	1.68±0.05 a-d	0.05±0.01 i	31.17±1.27 a-e	0.80±0.03 ab
BK1	3.68±0.11 abc	1.77±0.04 a-d	0.06±0.01 i	25.40±0.52 cde	0.93±0.04 ab
BK2	3.25±0.07 abc	1.45±0.04 d	11.74±0.37 b-f	22.77±0.49 e	0.53±0.01 b
BK3	4.00±0.10 abc	1.69±0.04 a-d	0.09±0.01 i	28.40±1.14 a-e	1.03±0.05 ab
BK4	3.53±0.11 abc	1.49±0.02 bcd	10.59±0.42 c-g	32.27±0.61 a-e	0.80±0.03 ab
BK5	3.49±0.06 abc	1.75±0.05 a-d	0.08±0.01 i	28.00±1.09 b-e	1.03±0.03 ab

Note: the mean followed by a different letter is significant in the Tukey's test at $P<0.005$ ± standard error. UG= upper glume; LG= lower glume; UL= upper lemma; FLL= flag leaf length, FLW= flag leaf width.

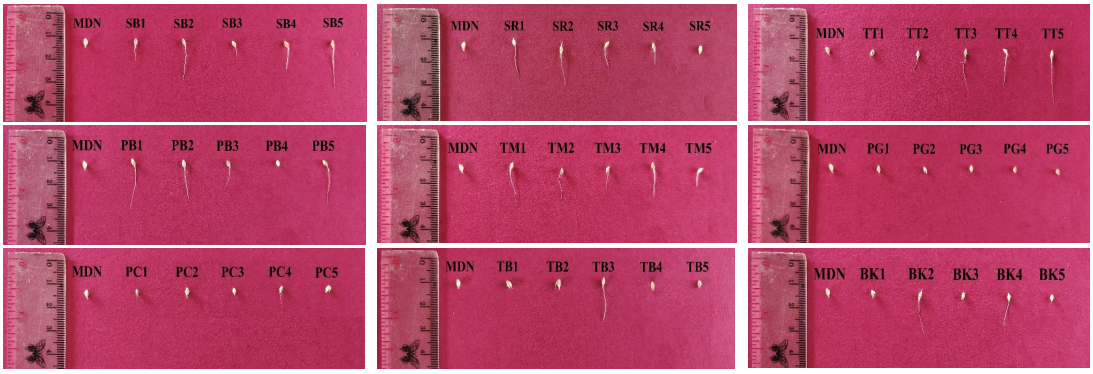

Fig. 1. The difference in the size of the seed glume and lemma in barnyardgrass accessions from Serdang Bedagai District, Indonesia and the comparison accession (MDN) visually

TABLE 3. The correlation coefficient between the barnyardgrass accessions from Serdang Bedagai District, Indonesia and the comparison accession

Traits	FLL	FLW	UG	LG	UL
FLL	1	0.528**	0.156	0.505**	-0.185
FLW		1	0.110	0.344*	-0.436**
UG			1	0.254	-0.080
LG				1	-0.323*
UL					1

Note: *and** Correlation is significant at the 0.05 and 0.01 level. FLL= flag leaf length, FLW= flag leaf width, UG= upper glume, LG= lower glume, UL= upper lemma.

TABLE 4. The similarity matrix value between the barnyardgrass accessions from Serdang Bedagai District compared to the comparison accession (MDN), Indonesia

No	Accessions	Matrix value	No	Accessions	Matrix value
1	SB1	4.151	26	PG1	3.681
2	SB2	8.473	27	PG2	10.584
3	SB3	2.123	28	PG3	3.021
4	SB4	3.253	29	PG4	1.825
5	SB5	10.001	30	PG5	5.680
6	SR1	4.549	31	PC1	4.419
7	SR2	5.956	32	PC2	4.627
8	SR3	7.589	33	PC3	15.327
9	SR4	4.833	34	PC4	20.879
10	SR5	7.879	35	PC5	5.469
11	TT1	5.818	36	TB1	9.449
12	TT2	12.000	37	TB2	6.506
13	TT3	16.903	38	TB3	17.747
14	TT4	17.800	39	TB4	3.410
15	TT5	22.047	40	TB5	8.795
16	PB1	19.415	41	BK1	4.456
17	PB2	13.647	42	BK2	27.019
18	PB3	19.117	43	BK3	4.261
19	PB4	5.600	44	BK4	11.736
20	PB5	5.988	45	BK5	5.280
21	TM1	15.179			
22	TM2	12.882			
23	TM3	8.225			
24	TM4	7.651			
25	TM5	14.563			

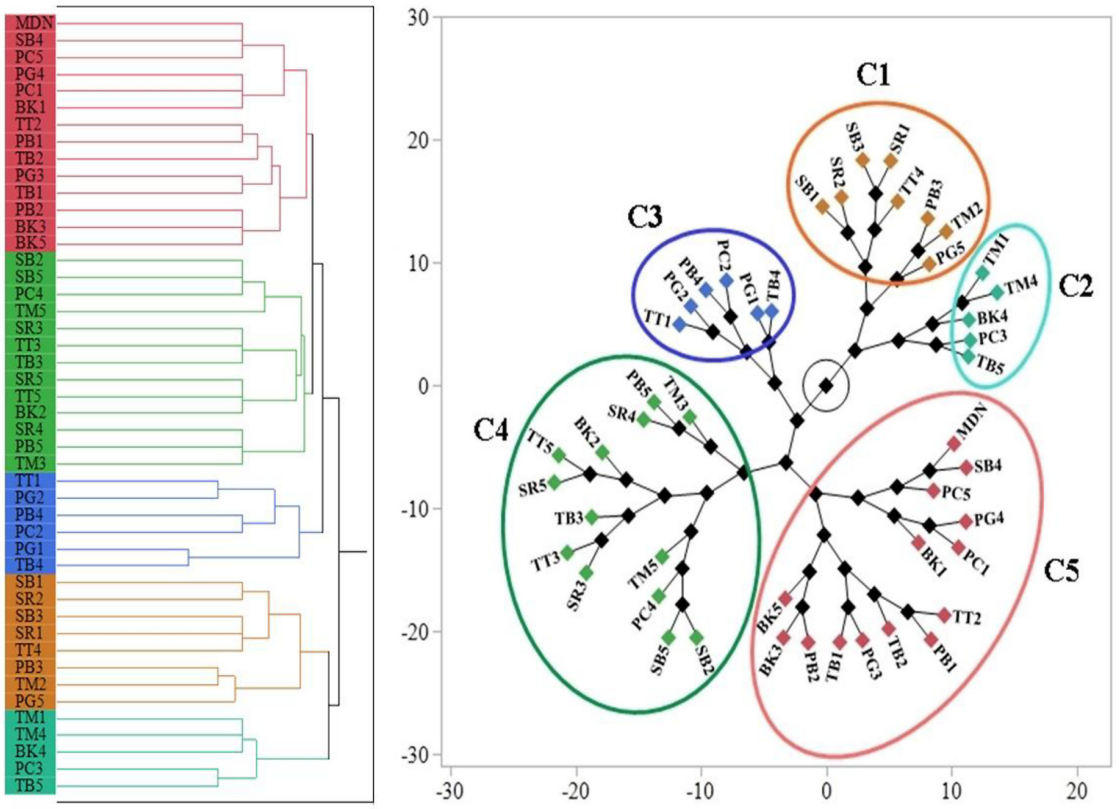

Fig. 2. Hierarchical clustering and constellation plot of 46 barnyardgrass accessions from Serdang Bedagai District and Medan City (comparison), Indonesia [Codes of barnyardgrass accessions and their localities are listed in Table 1]

The results showed that the sizes of the upper and lower glume, upper lemma, and flag leaf length and width of the barnyardgrass accession from Serdang Bedagai District ranged from 2.93 to 4.33mm, 1.45 to 1.96mm, 0.03 to 17.10mm, 22.77 to 45.40cm, and 0.53 to 1.13cm, respectively (Table 2). The upper and lower glume sizes in TB3 and TM1, as well as the upper lemma found in PB1 accessions, were larger than in other accessions. The results also revealed that PB4 and PC2 accessions had the highest flag leaf length and width values when compared to other accessions. This indicates that the size of seed glume from these locations could be due to the total assimilating productivity of the large flag leaf length and width. This finding was supported by the flag leaf length and width, which are positively correlated (0.156 and 0.110) with the size of the upper glume, and positively correlated and significant (0.505^{**} and 0.344^{*}) with the size of the lower glume (Table 3). Asana (1968) supported this result by stating that flag leaves play an important role in providing photosynthesis products to seeds. According to Ashrafuzzaman et al. (2009) and Rahman et al. (2013), flag leaf area was positively correlated with panicle length and seed production. In contrast, the size of the upper lemma was negatively correlated with the flag leaf length and width (Table 3). It was assumed that the photosynthate product from the flag leaf influenced glume formation and panicle length. Liu et al. (2021) also reported that flag leaf length and width were positively correlated to panicle length in *Echinochloa* ecotypes.

It was observed that only the PG4 accession was closely related to MDN, with a similarity value of 1.825. The hierarchical cluster confirmed these findings, with the SB4; PC1; PC5; PG3; PG4; BK1; BK3; BK5; PB1; PB2; TB2; TB1; and TT2 accessions clustered in one group with the MDN. This indicates that the characters of the upper and lower glume, upper lemma, flag leaf length, and width of the 13 accessions were not significantly different from MDN (Table 2). This was consistent with a study by Tahir (2016) which stated that eight of 95 *Echinochloa sp* accessions from several locations in Arkansas were clustered

with the barnyardgrass based on vegetative and generative characteristics. Altop & Mennan (2011) classified barnyardgrass weeds from lowland rice fields in Turkey into three clusters based on morphological characters, with 28 of 34 barnyardgrass populations having similarities. The findings also showed that the morphological character approach is almost similar when using a molecular approach (RAPD), with 33 of 34 barnyardgrass populations clustered into one group. Liu et al. (2021) also characterized the morphophysiology of *E. crus-galli*; *E. colona*; and *E. muricata* from rice-growing in Texas, producing five clusters and discovered that the *E. crus-galli* (ECH22) ecotype was related to *E. muricata* (ECH33). Claerhout et al. (2016) identified three clusters of 14 barnyardgrass accessions based on morphological characters from maize fields in Belgium.

Based on the result, 13 of 45 accessions from lowland rice fields in Serdang Bedagai District were similar to MDN. This result showed that farmers' management of barnyardgrass weeds from these accessions did not differ significantly to the comparison accession. These results are reported for the first time in Indonesia. However, the morphological character approach to assessing similarity should be re-examined using molecular methods.

Conclusions

Based on morphological characters, 45 accessions of barnyardgrass weeds from Serdang Bedagai District had different sizes of upper and lower glume, upper lemma, and flag leaf length and width ranged from 2.93-4.33mm; 1.45-1.96mm; 0.03-17.10mm; 22.77-45.40cm; and 0.53-1.13cm, respectively. Accessions of TB3; TM1; PB1; PB4; and PC2 had the largest characteristic size compared to other accessions. Additionally, the PG4 accession was closely related to MDN (1.825). It was also found that the SB4; PC1; PC5; PG3; PG4; BK1; BK3; BK5; PB1; PB2; TB2; TB1; and TT2 accessions were classified into one cluster with MDN.

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