Egypt. J. Bot. **Vol. 63**, No.2, pp. 525-533 (2023)

Egyptian Journal of Botany
http://ejbo.journals.ekb.eg/

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
Received 25/09/2022; Accepted 23/01/2023
DOI: 10.21608/ejbo.2023.165026.2150
Edited by: Dr. AlBaraa ElSaied, Faculty of Science, Al-Azhar University, Cairo, Egypt.

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 µm, 155.6µm, 40.8µm, and 69.0n/µm, 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.

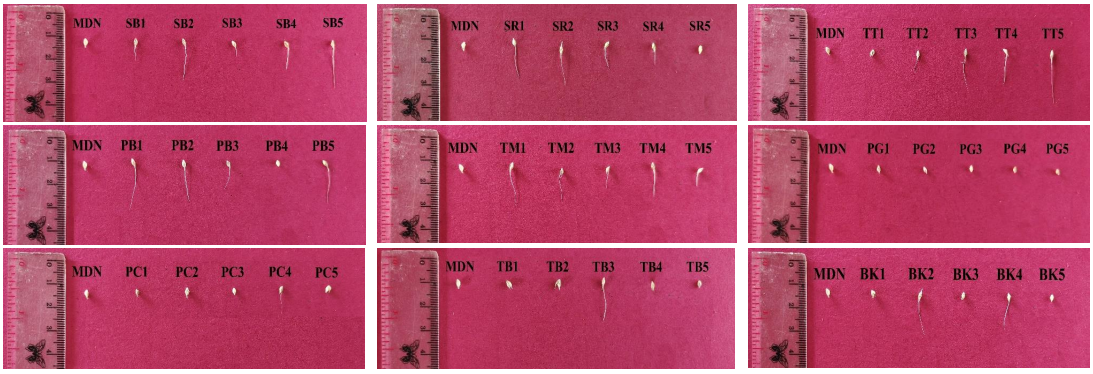

Fig. 1. The difference in the size of the seed glume and lemma in barnyardgrass accessions from Serdang Bedagai District, Indonesia and the comparison accession (MDN) visually

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			

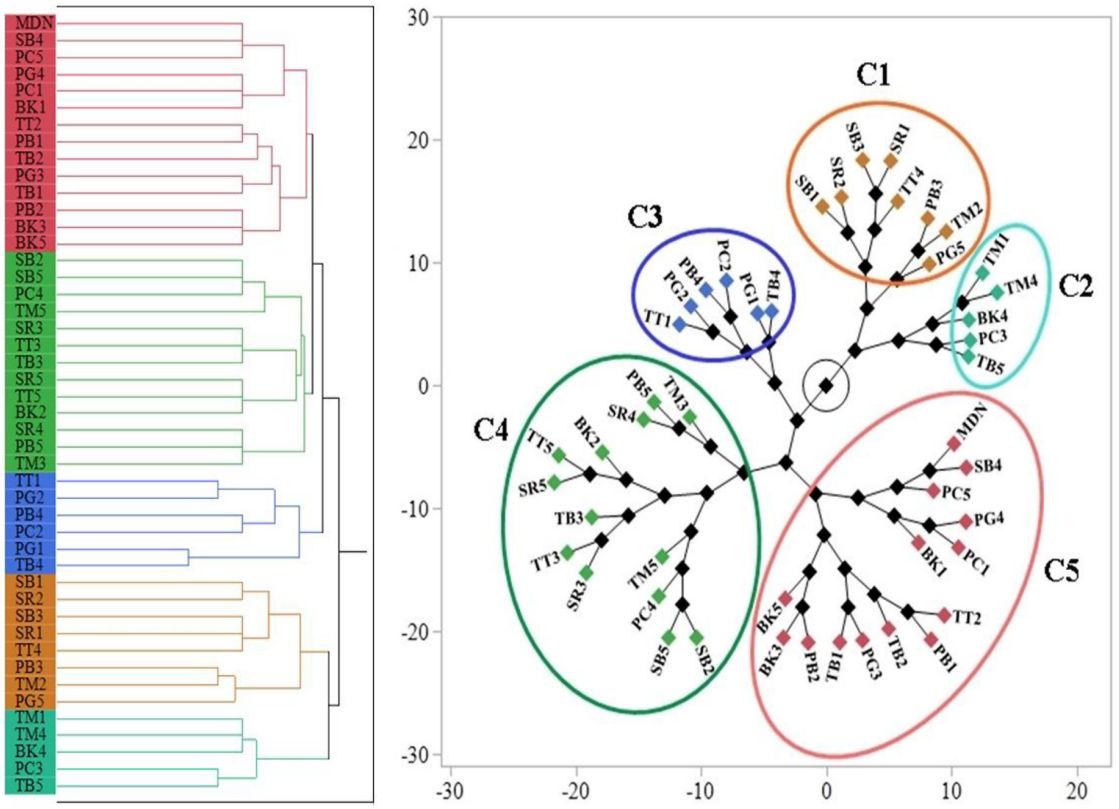

Fig. 2. Hierarchical clustering and constellation plot of 46 barnyardgrass accessions from Serdang Bedagai District and Medan City (comparison), Indonesia [Codes of barnyardgrass accessions and their localities are listed in Table 1]

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.

Acknowledgments: The authors would like to thank the Ministry of Education, Culture, Research, and Technology, (Indonesia) for funding this study with the number 153/E5/PG.02.00.PT/2022. In addition, the authors would also like to thank Fransisca Natalia Sihombing, S.Pd., M.P., Josefin Batara Raja Siagian, Emil Salim Hasibuan, S.Pt., and Febri Ardiansyah Harahap, S.Pt. who have assisted in the field.

Competing interests: The authors report no conflicts of interest regarding this work.

Authors' contributions: Conceptualization and methodology (Koko Tampubolon, Alridiwirsah, Mohammad Basyuni). Climate collecting and measuring (Novilda Elizabeth Mustamu, Alridiwirsah) Seed collecting and measuring (Mohammad Basyuni, Koko Tampubolon) Validation and data analysis (Koko Tampubolon, Novilda Elizabeth Mustamu). Writing, review, editing, and prepare manuscript for publishing (all authors).

Ethics approval: Not applicable.

References

Alridiwirsah., Tampubolon, K., Zulkifi, T.B.H., Risnawati., Yusuf, M. (2022) Allelopathic effects of *Mikania micrantha* Kunth on barnyardgrass and lowland rice. *Pesquisa Agropecuária Tropical*, **52**, e71356. https://revistas.ufg.br/pat/article/view/71356.

Altop, E.K., Mennan, H. (2011) Genetic and morphologic diversity of *Echinochloa crus-galli* populations from different origins. *Phytoparasitica*, **39**(1), 93-102.

Asana, R.D. (1968) In quest of yield. *Indian Journal of Plant Physiology*, **11**(1&2), 1-9.

Ashrafuzzaman, M., Islam, M.R., Ismail, M.R., Shahidullah, S.M., Hanafi, M.M. (2009) Evaluation of six aromatic rice varieties for yield and yield contributing characters. *International Journal of Agriculture and Biology*, **11**(5), 616-620.

Bagavathiannan, M.V., Norsworthy, J.K., Smith, K.L., Neve, P. (2012) Seed production of barnyardgrass (*Echinochloa crus-galli*) in response to time of emergence in cotton and rice. *The Journal of Agricultural Science*, **150**(6), 717-724.

Bajwa, A.A., Jabran, K., Shahid, M., Ali, H.H., Chauhan, B.S. (2015) Eco-biology and management of *Echinochloa crus-galli*. *Crop Protection*, **75**, 151-162.

Bastiani, M.O., Lamego, F.P., Agostinetto, D., Langaro,

A.C., da Silva, D.C. (2016) Relative competitiveness of soybean cultivars with barnyardgrass. *Bragantia*, **75**(4), 435-445.

Bhullar, M.S., Kumar, S., Kaur, S., Kaur, T., Singh, J., Yadav, R., Chauhan, B.S., Gill, G. (2016) Management of complex weed flora in dry-seeded rice. *Crop Protection*, **83**, 20-26.

Claerhout, S., Dewaele, K., De Riek, J., Reheul, D., De Cauwer, B. (2016) Morphological and genetic variability of local *Echinochloa* accessions and the link with herbicide sensitivity. *Weed Research*, **56**(2), 137-148.

Indonesian Center for Rice Research. (2020). Recommendations for rice cultivation in various agroecosystems. Ministry of Agriculture, Subang, West Java, Indonesia. 62p.

Juraimi, A.S., Tasrif, A., Kadir, J., Sastroutomo, S.S., Napis, S. (2005) Morphological and RAPD variability among Malaysian ecotypes of barnyardgrass (*Echinochloa crus-galli* var. crus-galli (L.) P. Beauv.). *Plant Protection Quarterly*, **20**(2), 52-57.

Liu, R., Singh, V., Abugho, S., Lin, H. S., Zhou, X. G., Bagavathiannan, M. (2021) Morphophysiological diversity and its association with herbicide resistance in *Echinochloa* ecotypes. *Weed Science*, **70**(1), 26-35.

Marchesi, C., Saldain, N.E. (2019) First report of herbicide-resistant *Echinochloa crus-galli* in Uruguayan rice fields. *Agronomy*, **9**(12), 790. https://doi.org/10.3390/agronomy9120790.

Mennan, H., Ngouajio, M., Sahin, M., Isık, D., Altop, E.K. (2012) Competitiveness of rice (*Oryza sativa* L.) cultivars against *Echinochloa crus-galli* (L.) Beauv. in water-seeded production systems. *Crop Protection*, **41**, 1-9. https://doi.org/10.1016/j.cropro.2012.04.027.

Miller, M.R., Norsworthy, J.K., Scott, R.C. (2018) Evaluation of florpyrauxifen-benzyl on herbicide-resistant and herbicide-susceptible barnyardgrass accessions. *Weed Technology*, **32**(2), 126-134.

Rahman, M.A., Haque, M.E., Sikdar, B., Islam, M.A., Matin, M.N. (2013) Correlation analysis of flag leaf with yield in several rice cultivars. *Journal of Life and Earth Science*, **8**, 49-54.

Statistics of Sumatera Utara. (2022) Sumatera Utara Province in figures 2022. Medan, Indonesia.

Tahir, H. (2016) Characterization of *Echinochloa spp.* in Arkansas. *Thesis*. University of Arkansas.

Tampubolon, K., Sihombing, F.N., Siburian, E., Sulastri, Y.S., Purba, Z., Samosir, S.T.S., Karim, S. (2019) Similarity and phylogenetic analysis of herbicide-resistant goosegrass (*Eleusine indica*) biotypes. *Caraka Tani: Journal of Sustainable Agriculture*, **34**(2), 162-169.

Wilson, M.J., Norsworthy, J.K., Scott, R.C., Gbur, E.E. (2014) Program approaches to control herbicide-resistant barnyardgrass (*Echinochloa crus-galli*) in midsouthern United States rice. *Weed Technology*, **28**(1), 39-46.

Zhang, Z., Gu, T., Zhao, B., Yang, X., Peng, Q., Li, Y., Bai, L. (2017) Effects of common *Echinochloa* varieties on grain yield and grain quality of rice. *Field Crops Research*, **203**, 163-172.