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Research article

Genetic characterization of Indonesian sorghum landraces (*Sorghum bicolor* (L.) Moench) for yield traits

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Abstract: Sorghum (*Sorghum bicolor* (L.) Moench) is the fifth most produced cereal crop in the world. The use of sorghum is very diverse and most parts of the plant, including stem, leaves, grain, panicles, stem juice, and bagasse, can be utilized as human food, animal feed, and material for industry and bioenergy production. The collection of local sorghum genetic resources should be explored to identify potential gene sources for the development of superior varieties. This study was conducted to evaluate the production potential of 40 Indonesian sorghum accessions and to further identify potentially useful accessions. Five accessions belonging to cluster 3 had high biomass productivity, including Coley, Keler, Lao, Lokal Kaltim, and Super 1. In particular, Lokal Kaltim and Lao combined high biomass yield with grain yield. Accessions with high biomass has potential for use as feedstock for biomass energy production and forage.

Keywords: characteristic; genetic sources; Indonesia; local sorghum; production

1. Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is a member of the Poaceae family. The cultivation of sorghum began in ancient Africa around 8000 BC, with the East Sudanian savanna as the center of origin, then spread and became an important food crop in China and India [1]. At present, sorghum is cultivated throughout the world from nutrient-low soils to fertile soils in tropical to temperate areas [2]. Currently, sorghum is the fifth most-produced cereal crop in the world, after corn, rice, wheat, and barley [3]. The area of sorghum cultivation reached 41.75 million ha worldwide, with the largest areas in Sudan (7.5 million ha) and Nigeria (5.7 million ha). The global sorghum production as of 2023 was 59.92 million t with an average productivity of 1.44 t ha^{-1} [4]. According to the report by the United States Department of Agriculture (USDA), the largest sorghum-producing country is the United States (8.18 million t, followed by Nigeria (6.70 million t), Sudan (5.00 million t), Mexico (4.80 million t) and India (4.40 million t) [4].

Sorghum can be utilized for various uses. Most parts of the sorghum plant, including stem, leaves, grain, panicles, stem juice, and bagasse, are utilized as human food, animal feed, and material/source for industry and bioenergy production [5–7]. Sorghum grains as food have good nutritional value [8,9]. As livestock feed, sorghum produces grains that can be a nutritionally equivalent substitute for corn, as well as dried leaves and stems as good sources of dietary fiber [10]. As industrial raw materials, a certain type of sorghum (sweet sorghum) has been developed for the manufacturing of liquid sugar and syrup [11], beer [12], and ethanol [7,13,14]. The ethanol produced from sweet sorghum can be alternative to fossil fuels [7,14,15], and the bagasse can be utilized for the production of particle boards and bio-pellets [7,16,17].

Sorghum cropping has the potential to support food and energy programs in Indonesia [9]. The area of sorghum fields in Indonesia was only 26,306 ha in 2012–2013 [18]. The major sorghum-producing areas consist of nine provinces, including East Nusa Tenggara (58.3% of cultivation area), Southeast Sulawesi (15.2%), South Sulawesi (12.9%), East Java (8.4%), and several others (< 4%). However, the productivity was not very high at that time, in the range of 1–2 t ha^{-1} [18]. There is very limited update data on sorghum production and productivity in Indonesia since sorghum is not the priority crop in Indonesia. According to the Press Release of the Coordinating Ministry for Economic Affairs of Indonesia, number HM.4.6/412/SET.M. EKON.3/08/2022, the area of sorghum field in Indonesia in 2022 was estimated at 4,335 ha and the sorghum production in six provinces was 15,243 t. The estimation of sorghum productivity in Indonesia was 3.36 t ha^{-1}. To provide enough material for the downstream industries, improving productivity is needed. In addition, sorghum production should be expanded to the marginal lands that are not suitable for the cultivation of ordinary crops in the central and eastern parts of Indonesia to avoid land-use competition between crop commodities [9]. Efficient production of sorghum in such marginal lands requires the selection of accessions with pest and disease resistance or abiotic stress tolerance.

The main repository for world sorghum germplasm is the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) which is headquartered in India. A total of 39,234 accessions from 93 countries have been recorded by the Institute [19]. In Indonesia, the Agricultural Genebank of the Ministry of Agriculture conserves 259 sorghum accessions collected from local regions in Indonesia or contributed from abroad gene banks and researchers [20]. The collected germplasms are diverse and potentially useful as the source of traits to improve grain yield for food production, biomass yield and quality for fodder production, or stem sugar content, lignin, and cellulose content for industrial application [21–26]. In this study, we characterized 40 Indonesian local sorghum accessions based on morphological and productive point of view [27], to identify suitable and promising accessions for further utilization. The characteristics analyzed include plant size, biomass production, seed/grain production, and sugar content. These parameters are critical for the performance of sorghum as food, feed, bioenergy feedstock, and other industrial materials. The results of this study will be useful for the government, researchers, farmers, and business/industry sectors in Indonesia and many other countries.

2. Material and methods

2.1. Time and location of the cultivation

Cultivation of 40 Indonesian local sorghum accessions was conducted from April to August 2017 at Cibinong Science Center and Botanic Gardens of the Indonesian Institute of Science (LIPI), which has been changed into National Research and Innovation Agency (BRIN). The area is in Bogor Regency of West Java Province of Indonesia, with the altitude of 250 m above sea level. The monthly average minimum and maximum temperature during the research were 22.96 and 31.95 °C, respectively; the monthly average of air humidity ranged between 76.61% and 85.29%, a monthly average of wind speed was from 1.43 and 5.35 km h^{-1}; and the monthly average rainfall ranged between 179.2 and 401.9 mm [28]. The soil type of the study location was alfisol with the chemical properties shown in Appendix 1.

2.2. Plant cultivation

We obtained the seeds of 37 Indonesian local sorghum accessions and the seeds of 3 (three) standard sorghum accessions from the Agricultural Genebank of the Ministry of Agriculture in Bogor-West Java, and the sub-genebank in Maros-South Sulawesi, respectively. A complete list of the 40 sorghum accessions used in this study is presented in Appendix 2. We applied a Completely Randomized Design for the study with one plot for each accession of sorghum tested. Plant cultivation was conducted in test plots sized 5 m × 5 m and placed 4 m apart. Each accession of sorghum was cultivated in one plot from a total of forty test plots. Two seeds were sown per hole, with spacing 25 cm in the rows that were 75 cm apart in the plots. The fields were plowed and applied with 10 kg of compost before planting. Urea (150 kg ha^{-1}), triple superphosphate (150 kg ha^{-1}), and potassium chloride (150 kg ha^{-1}) were applied as basal fertilizers at the time of planting, and urea (150 kg ha^{-1}) were applied as top dressing at 1 month after planting.

2.3. Measurement of parameters

Plant growth parameters and production-related parameters were measured. The plant growth parameters were analyzed during the flowering period, including plant height (PH), leaf number (LN), leaf length (LL), leaf width (LW), panicle length (PL), and panicle stalk length (PSL). The production-related parameters were analyzed at harvest, including 100 grain or seed weight (100SW), total grain weight (TSW), panicle weight (PW), fresh and dry weight of plant biomass (FWB and DWB), and sugar content in stem juice (SC). Plant growth parameters, production-related parameters, and sugar content were measured on three randomly selected individuals from each plot. Sugar contents were measured in triplicate by taking juice from the middle part of the stem using the digital refractometer (Minolta, Palette Series, ATAGO Limited Company).

2.4. Statistical analysis of the data

Obtained data were subjected to descriptive statistics, analysis of variance (ANOVA) with Posthoc Tukey, and multivariate analysis using Minitab® 19 Software (Minitab Inc., State College, Pennsylvania, USA), including correlation, principal components (PC), and cluster analysis. The PCA-biplot analysis was performed using the Biplot-Excel Program.

3. Results and discussion

3.1. Correlation analysis

Table 1. Correlation of the vegetative and production variables in 40 Indonesian local sorghum accessions.

	PH	LN	LL	LW	PL	PSL	100 SW	TSW	PW	FWB	DWB
LN	**0.397***										
LL	**0.620****	**0.357***									
LW	-0.298	**0.436****	0.004								
PL	**0.430****	0.172	0.289	-0.234							
PSL	0.167	0.146	0.068	-0.070	0.136						
100 SW	0.256	0.181	**0.339***	-0.083	-0.118	-0.086					
TSW	-0.011	0.037	0.239	0.081	-0.278	-0.219	**0.648****				
PW	0.007	0.168	0.233	0.127	-0.040	-0.189	**0.511****	**0.855****			
FWB	**0.543****	**0.703****	**0.456****	**0.347***	0.158	0.006	0.224	0.169	0.298		
DWB	**0.645****	**0.696****	**0.535****	0.294	0.152	-0.001	0.229	0.120	0.161	**0.916****	
SC	0.290	0.167	0.198	-0.276	0.046	0.230	0.174	0.131	0.120	0.111	0.209

Note: PH = Plant Height, LN = Leaf Number, LL = Leaf Length, LW = Leaf Width, PL = Panicle Length, PSL = Panicle Stalk Length, 100SW = Weight of 100 Grains, TSW = Total Grain Weight, PW = Panicle Weight, FWB = Fresh Weight of Plant Biomass, DWB = Dry Weight of Plant Biomass, SC = Sugar Content. * and ** significant at $p \leq 0.05$ and $p \leq 0.01$, respectively.

In this study, the 40 Indonesian local sorghum accessions were characterized based on multiple growth and production-related parameters. Table 1 shows the degree of association among the parameters estimated by Pearson correlation coefficients, with significant correlation shown in bold letters. In general, plant biomass (FWB and DWB) showed a significant positive correlation between the size-related parameters, including PH, LN, and LL. Positive correlations were also found among grain production- related parameters, including 100SW, TSW, and PW. No significant correlation was found between SC or PSL and other parameters (Table 1). A positive correlation between

PH and biomass production (either dried or fresh) has also been reported in previous studies [26,29–32]. These and the present results together suggest that taller sorghum has a higher capability of biomass production. The relationship may help to identify the genotype suitable for biomass utilization. On the other hand, no clear correlation was found between SC and the other parameters examined in this study, thus additional parameters need to be explored as aids in the selection of sorghum lines suitable for sugar production.

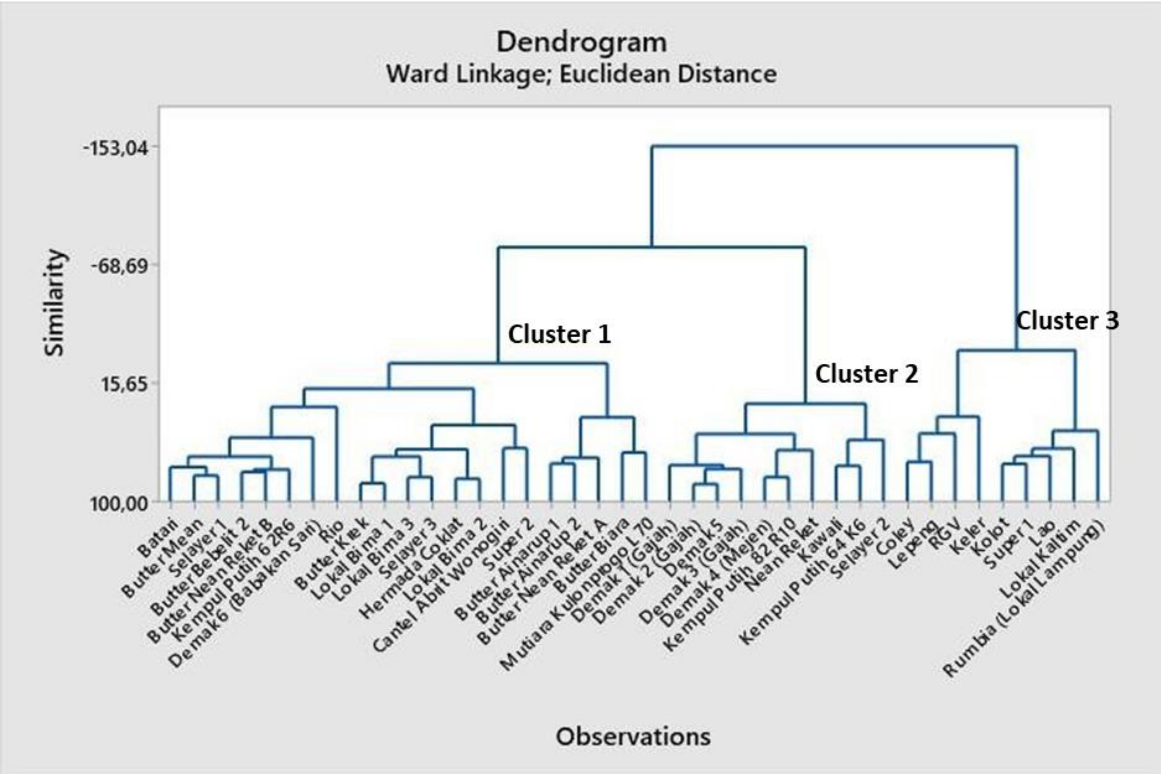

Figure 1. Hierarchical clustering analysis of 40 Indonesian local sorghum accessions.

Note: The Dendrogram was constructed by the Ward method of cluster analysis based on Euclidean distances.

3.2. Cluster analysis

A cluster analysis using all measured data separated the 40 accessions into three clusters (Figure 1). The accessions belonging to each cluster are listed in Table 2. Local sorghum accessions from the same origin tended to be placed in the same cluster. Eight accessions from Belu of Nusa Tenggara Timur Province (Butter Ainarup 1 and 2, Butter Bebelit 2, Butter Biara, Butter Krek, Butter Mean, and Butter Nean Reket A and B), and three accessions from Nusa Tenggara Barat province (Lokal Bima 1, 2, and 3) were grouped in cluster 1 (Figure 1). Two out of three accessions of Selayer (Selayer 1 and 3) also belonged to cluster 1 (Figure 1). Cluster 2 mainly consisted of the accessions from Central Java, including five out of six accessions from Demak (Demak 1, 2, 3, 4, and 5), Kempul Putih 64 K6, and Kempul Putih 82 R10 (Figure 1). Moreover, almost half of all accessions in cluster 3 were collected from West Java including Coley, Keler, Kolot, and RGV

(Figure 1). According to the mean values of the parameters within each group, the accessions in cluster 1 were characterized by lower LW, TSW, and PW compared to those of the members in clusters 2 and 3 (Table 3). The results indicated that the accessions in cluster 1 had smaller sizes of leaves and lower grain production. The accessions in cluster 2 were characterized by higher TSW and PW compared to those of the members in clusters 1 and 3 (Table 3). These results indicated that the accessions in cluster 2 had a higher capacity for grain production. The accessions in cluster 3 were characterized by higher PH, FWB, and DWB compared to those of the members in clusters 1 and 2 (Table 3). The results indicated that the accessions in cluster 3 had a higher capacity for biomass production.

The improved cultivars included in this study (Super 1, Super 2, and Kawali) were separated into different clusters. The cultivars Super 1 and Super 2 were originally developed as those having higher sugar content [33]. However, the observed variation in SC among the 40 accessions were rather small in this study, thus SC did not become the factor discriminating the cultivars in this study. Rather, they appeared to be separated according to the capacity of biomass production. The cultivars Super 1 and Super 2 produced higher amounts of biomass (FWB and DWB), whose DWB ranked 4th and 7th among the 40 cultivars, respectively.

Table 2. Member of three groups of 40 Indonesian local sorghum accessions when mapping the biplot analysis with the cluster analysis.

No	Member of Group 1	Member of Group 2	Member of Group 3
1	1: Batari	12: Demak 1 (Gajah)	11: Coley
2	2: Butter Ainarup 1	13: Demak 2 (Gajah)	20: Keler
3	3: Butter Ainarup 2	14: Demak 3 (Gajah)	24: Kolot
4	4: Butter Bebelit 2	15: Demak 4 (Mejen)	25: Lao
5	5: Butter Biara	16: Demak 5	26: Lepeng
6	6: Butter Krek	19: Kawali	30: Lokal Kaltim
7	7: Butter Mean	22: Kempul Putih 64 K6	33: RGV
8	8: Butter Nean Reket A	23: Kempul Putih 82 R10	35: Rumbia (Lokal Lampung)
9	9: Butter Nean Reket B	32: Nean Reket	39: Super 1
10	10: Cantel Abrit Wonogiri	37: Selayer 2	
11	17: Demak 6 (Babakan Sari)		
12	18: Hermada Coklat		
13	21: Kempul Putih 62R6		
14	27: Lokal Bima 1		
15	28: Lokal Bima 2		
16	29: Lokal Bima 3		
17	31: Mutiara Kulonprogo L70		
18	34: Rio		
19	36: Selayer 1		
20	38: Selayer 3		
21	40: Super 2		

Table 3. Means of sorghum vegetative and production variables in each cluster.

Variable	Pooled Mean	Means in group		
		Cluster 1	Cluster 2	Cluster 3
PH	2582	2625 ± 548 b	1793 ± 366 c	3359 ± 600 a
LN	8.83	7.94 ± 0.89 b	8.83 ± 1.38 b	10.93 ± 0.91 a
LL	88.35	86.33 ± 10.10 b	86.12 ± 9.59 b	95.56 ± 6.44 a
LW	8.338	7.711 ± 1.027 b	9.240 ± 0.650 a	8.796 ± 0.873 a
PL	424.3	425.6 ± 79.6 ab	354.9 ± 71.9 b	498.4 ± 118.9 a
PSL	93.38	93.67 ± 35.81 a	78.40 ± 21.00 a	109.3 ± 47.3 a
100 SW	2.410	2.240 ± 0.426 a	2.548 ± 0.257 a	2.653 ± 0.889 a
TSW	54.08	45.60 ± 12.07 b	70.48 ± 10.88 a	55.61 ± 22.33 ab
PW	83.14	68.21 ± 14.65 b	106.07 ± 13.46 a	92.49 ± 26.13 a
FWB	816.0	696.3 ± 159.1 b	771.1 ± 65.7 b	1145.1 ± 191.1 a
DWB	258.5	224.7 ± 55.1 b	222.6 ± 36.3 b	377.4 ± 68.5 a
SC	11.06	11.06 ± 3.38 a	9.89 ± 3.01 a	12.37 ± 2.59 a

Note: Shown are the mean ± standard deviation of values for the accessions in each cluster. The different letter indicates significant difference between the clusters ($p < 0.05$, Tukey HSD test). PH = Plant Height, LN = Leaf Number, LL = Leaf Length, LW = Leaf Width, PL = Panicle Length, PSL = Panicle Stalk Length, 100SW = Weight of 100 Grains, TSW = Total Grain Weight, PW = Panicle Weight, FWB = Fresh Weight of Plant Biomass, DWB = Dry Weight of Plant Biomass, SC = Sugar Content.

3.3. PCA-Biplot analysis

The grouping of 40 sorghum accession was further examined by PCA-biplot (Figure 2). The first and second principal component explained 32.4% and 19.6% of the variation in the traits, respectively. The accessions belonging to the same group in the clustering analysis were placed in proximity on the scatterplot. The result supports the validity of the grouping by clustering analysis. The vectors with positive value along the first axis include FWB, DWB, LL, LN, PH, and SC. The vectors with positive value along the second axis include TSW, PW, 100SW, and LW. The vectors with negative value along the second axis include PL and PSL (Figure 2). Thus, the first and the second axis are likely to indicate the capacity for biomass production and grain production, respectively. Hence the cluster 3 can be characterized as the group with high seed production, whereas the cluster 2 is characterized as the group with high seed production but not high biomass production. The members in cluster 1 can be regarded as those with neither high seed production nor high biomass production. The result is in accordance with the characteristics predicted in the clustering analysis (Table 3). Separation of the clusters 2 and 3 on the first axis suggests that most accessions with high potential for grain production are not high in biomass production, as the result of a trade-off between the two traits. The accession 34 (Rio) was placed in cluster 1 by cluster analysis, whereas it was placed closer to those in cluster 2 by PCA-Biplot (Figure 2, Table 2). This accession showed lowest biomass productivity but higher grain productivity among the 40 accessions tested, with DWB and TSW ranked 40th and 4th, respectively. These characteristics may have caused the fluctuation in classification.

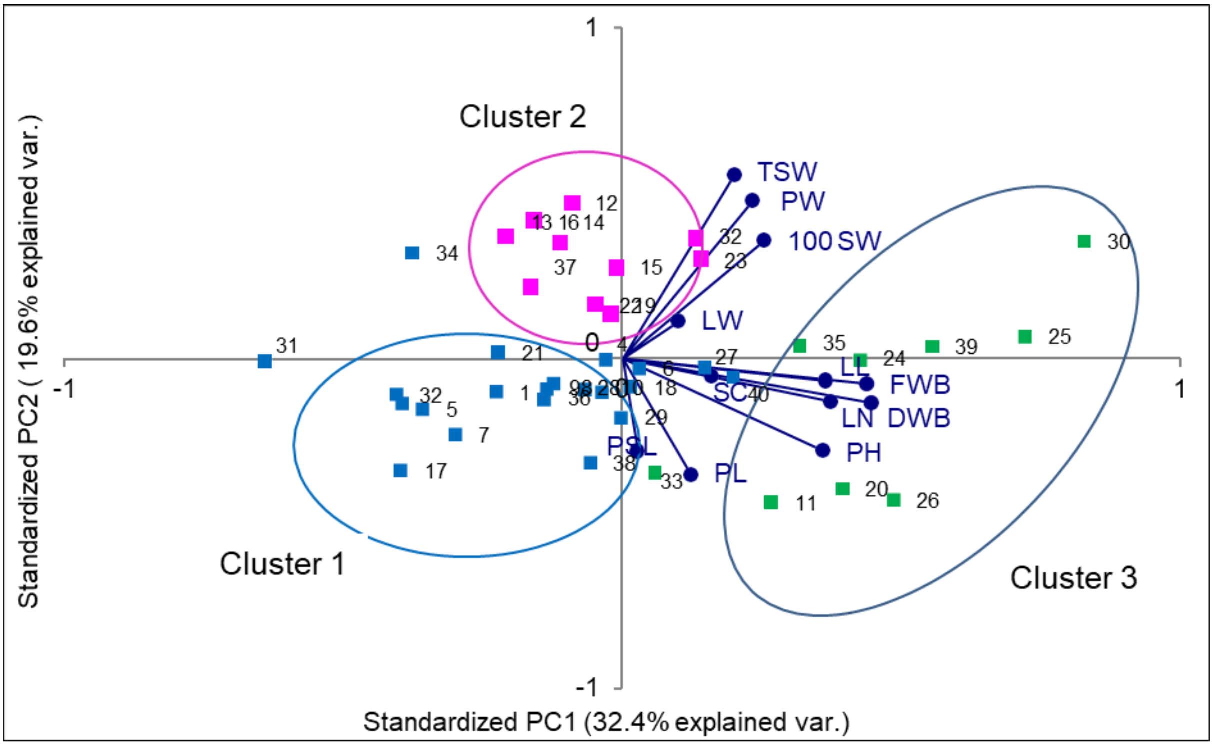

Figure 2. Biplot analysis of 40 Indonesian local sorghum accessions.

Note: Each of the dots represents an individual accession, with blue, magenta, and green representing the accession belonging to clusters 1, 2, and 3, respectively.

3.4. Analysis of variance

The results of the analysis of variances of all parameters measured among 40 sorghum accessions were significantly different (Appendixes 3 and 4). Significant higher values of the parameter related to biomass production (FWB and DWB) were found for the accessions Coley, Keler, Lao, Lokal Kaltim, and Super 1 as compared to those of the other accessions (Appendix 4). On the other hand, significantly higher values of the parameter related to grain production (100SW, TSW, PW) were found for the accessions of Demak 1, Demak 2, Demak 3, Demak 4, Demak 5, Kempul Putih 82 R10, Lao, Lokal Kaltim, Nean Reket, and Rio as compared to those of the other accessions (Appendix 4). The accession with a significantly higher value of sugar content (SC) parameters as compared to that of most of the other accessions was Rio accessions (Appendix 4).

3.5. Potential usefulness of local sorghum accessions

The results of the characterization of 40 Indonesian local sorghum accessions in this study could be utilized for many purposes, including the conservation and maintenance of genetic resources for breeding or future usage. So far, many sorghum germplasm have been collected by the Agricultural Genebank, including cultivars, landraces, and inbred lines with various phenotypes and origins [34]. Sorghum accession with high potential for biomass production is promising as livestock fodder or the material for bioenergy production [7]. The results of this study suggest that the accession with high

PH, LN, LL, FWB, and DWB could have a high potential for biomass production (Table 1, Appendix 4). The accessions having such characteristics are Coley, Keler, Lao, Lokal Kaltim, and Super 1 (Figures 1 and 2, Table 2, Appendix 4), with the value of DWB ranging 20.69 t ha^{-1}–25.28 t ha^{-1}. These accessions were placed into cluster 3 based on cluster and PCA-biplot analyses (Figures 1 and 2).

Potential for grain production is also an important trait in the development of new varieties. Sorghum grains can be utilized not only as food or feed but also as a source of starch for ethanol production [7]. The top ten accessions with high potential for seed production as judged by TSW included Demak 1, Demak 2, Demak 3, Demak 4, Demak 5, Kempul Putih 82 R10, Lao, Lokal Kaltim, Nean Reket, and Rio, with values were 3.72 t ha^{-1}–5.02 t ha^{-1}. The values are comparable with those of improved sorghum varieties released between 1960 and 2001 in Indonesia, including No 46, No 6C, UPCA-S2, UPCA-S1, KD4, Hegari Genjah, Mandau, and Numbu [18]. Most of the high grain producers identified in this study belonged to cluster 2, whereas Lokal Kaltim (ranked 2nd) and Lao (ranked 5th) belonged to cluster 3, which is characterized as high biomass producers (Figures 1 and 2, Table 2, Appendix 4). The DWB of Lokal Kaltim and Lao indeed ranked second and first among the 40 accessions, respectively (Appendix 4). As discussed above, there appears to be a trade-off between the production of biomass and grain in general (Figure 2), whereas these accessions exhibited high potential in both aspects.

4. Conclusions

The 40 local sorghum accessions could be classified into 3 groups based on their biomass and seed productivity. The clustering tends to reflect the provenance of the accessions. Five accessions belonging to cluster 3 had high biomass productivity and appeared to be promising for use as feedstock for biomass energy production and forage, or as parent lines for further improvement by breeding. The accessions include Coley, Keler, Lao, Lokal Kaltim, and Super 1. On the other hand, 10 accessions in cluster 2 could be utilized for seed production application, i.e. Demak 1, Demak 2, Demak 3, Demak 4, Demak 5, Kempul Putih 82 R10, Lao, Lokal Kaltim, Nean Reket, and Rio. Lokal Kaltim and Lao are particularly promising in that they combine high biomass yield with grain yield. The identification of genes associated with these agronomically useful traits using these lines will help in the selection of superior genotypes. Further studies on the characteristics of plant resistance to biotic and abiotic stresses of the plants are also required.

Use of AI tools declaration

The authors declare that they have not used Artificial Intelligence (AI) tools in the creation of this article.

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Conflict of interest

The authors declare no conflicts of interest in this paper.

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Appendix

Appendix 1.

Table 1. Results of Soil Analysis prior to the study.

No	Parameter	Method	Unit	Result	Catagory
1	Organic C	Walkey & Black/ Gravimetry	%	2.08–3.28	Medium-high
2	Total N	Kjeldahl	%	0.16–0.26	Low-medium
3	C/N ratio	Calculation	-	9–17	Low-high
4	Available P_2O_5	Bray/Olsen	ppm	8.83–256.8	Low-very high
5	Available K_2O	Bray/Olsen	ppm	7.68–450.54	Very low-very high
6	Cation exchange capacity	N NH4OAc	cmol/kg	8.17–10.65	Low
7	Soil water content	Gravimetry	%	9.29–18.1	-
8	pH (H_2O)	Potentiometry	-	5.31–6.18	Acid-rather acid
9	Soil texture	Pipette	%		Clay
	Sand			8.58–30.89	
	Silt			15.73–34.11	
	Clay			46.03–66.9	

Appendix 2.

Table 2. The list of Indonesian sorghum accession used in the study.

No	Accession name	Accession status	Provenance
1	Batari	Traditional cultivar	Kendari district of Southeast Sulawesi Province
2	Butter Ainarup 1	Traditional cultivar	Belu district of Nusa Tenggara Timur Province
3	Butter Ainarup 2	Traditional cultivar	Belu district of Nusa Tenggara Timur Province
4	Butter Bebelit 2	Traditional cultivar	Belu district of Nusa Tenggara Timur Province
5	Butter Biara	Traditional cultivar	Belu district of Nusa Tenggara Timur Province
6	Butter Krek	Traditional cultivar	Belu district of Nusa Tenggara Timur Province
7	Butter Mean	Traditional cultivar	Belu district of Nusa Tenggara Timur Province
8	Butter Nean Reket A	Traditional cultivar	Belu district of Nusa Tenggara Timur Province
9	Butter Nean Reket B	Traditional cultivar	Belu district of Nusa Tenggara Timur Province
10	Cantel Abrit Wonogiri	Traditional cultivar	Wonogiri district of Central Java Province

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No	Accession name	Accession status	Provenance
11	Coley	Traditional cultivar	West Java Province
12	Demak 1 (Gajah)	Traditional cultivar	Demak district, Central Java Province
13	Demak 2 (Gajah)	Traditional cultivar	Demak district, Central Java Province
14	Demak 3 (Gajah)	Traditional cultivar	Demak district, Central Java Province
15	Demak 4 (Mejen)	Traditional cultivar	Demak district, Central Java Province
16	Demak 5	Traditional cultivar	Demak district, Central Java Province
17	Demak 6 (Babakan Sari)	Traditional cultivar	Demak district, Central Java Province
18	Hermada Coklat	Traditional cultivar	Bogor district, West Java Province
19	Kawali	Improved cultivar	By Ministry of Agriculture in Maros district, SouthSulawesi Province
20	Keler	Traditional cultivar	West Java Province
21	Kempul Putih 62R6	Traditional cultivar	Central Java Province
22	Kempul Putih 64 K6	Traditional cultivar	Central Java Province
23	Kempul Putih 82 R10	Traditional cultivar	Central Java Province
24	Kolot	Traditional cultivar	Garut district of West Java Province
25	Lao	Traditional cultivar	Paser district of East Kalimantan Province
26	Lepeng	Traditional cultivar	Manggarai district of Nusa Tenggara Timur Province
27	Lokal Bima 1	Traditional cultivar	Bima district of Nusa Tenggara Barat Province
28	Lokal Bima 2	Traditional cultivar	Bima district of Nusa Tenggara Barat Province
29	Lokal Bima 3	Traditional cultivar	Bima district, Nusa Tenggara Timur Province
30	14 Lokal Kaltim	Traditional cultivar	East Kalimantan Province
31	Mutiara Kulonprogo L70	Traditional cultivar	Kulonprogo district of Yogyakarta Province
32	Nean Reket	Traditional cultivar	Belu district of Nusa Tenggara Timur Province
33	RGV	Traditional cultivar	West Java Province
34	Rio	Traditional cultivar	West Java Province
35	Rumbia (Lokal Lampung)	Traditional cultivar	Lampung Province
36	Selayer 1	Traditional cultivar	South Sulawesi Province
37	Selayer 2	Traditional cultivar	South Sulawesi Province
38	Selayer 3	Traditional cultivar	South Sulawesi Province
39	Super 1	Improved cultivar	By Ministry of Agriculture in Maros district, SouthSulawesi Province
40	Super 2	Improved cultivar	Ministry of Agriculture in Maros district, South SulawesiProvince

Appendix 3. Analysis of Variance (ANOVA) of the parameters of 40 sorghum accessions

Table 3. Plant Height (PH) Parameter.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Accession No	39	653906	16767	16.71	0.000
Error	80	80249	1003		
Total	119	734155			

Table 4. Leaf Number (LN) Parameter.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Accession No	39	287.33	7.3675	8.75	0.000
Error	80	67.33	0.8417		
Total	119	354.67			

Table 5. Leaf Length (LL) Parameter.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Accession No	39	11404	292.40	9.93	0.000
Error	80	2355	29.44		
Total	119	13759			

Table 6. Leaf Width (LW) Parameter.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Accession No	39	147.95	3.7937	5.14	0.000
Error	80	59.01	0.7376		
Total	119	206.96			

Table 7. Panicle Length (PL) Parameter.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Accession No	39	11523	295.46	13.05	0.000
Error	80	1811	22.64		
Total	119	13334			

Table 8. Panicle Stalk Length (PSL) Parameter.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Accession No	39	1560.7	40.02	3.72	0.000
Error	80	860.5	10.76		
Total	119	2421.2			

Table 9. Weight of 100 Seeds (100SW) Parameter.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Accession No	39	3563	91.37	6.04	0.000
Error	80	1210	15.12		
Total	119	4773			

Table 10. Total Seed Weight (TSW) Parameter.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Accession No	39	36567	937.6	3.67	0.000
Error	80	20436	255.5		
Total	119	57003			

Table 11. Panicle Weight (PW) Parameter.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Accession No	39	66321	1700.5	4.82	0.000
Error	80	28224	352.8		
Total	119	94545			

Table 12. Fresh Weight Biomass (FWB) Parameter.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Accession No	39	6397365	164035	5.91	0.000
Error	80	2220662	27758		
Total	119	8618027			

Table 13. Dry Weight Biomass (DWB) Parameter.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Accession No	39	822279	21084	4.73	0.000
Error	80	356944	4462		
Total	119	1179223			

Table 14. Sugar Content of Stem Juice (SC) Parameter.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Accession No	39	1178.1	30.207	5.90	0.000
Error	80	409.8	5.122		
Total	119	1587.9			

Appendix 4. Mean values of the parameters of 40 sorghum accessions

Table 15. The parameters of plant height (PH), leaf number (LN), leaf length (LL) and leaf width (LW).

Accession No	Accession name	PH (cm)	LN	LL (cm)	LW (cm)
1	Batari	216.7 ± 5.77 fghijklmn	7.33 ± 0.6 efg	89.0 ± 5.6 abcdefghi	8.2 ± 0.7 abcdefg
2	Butter Ainarup 1	185.0 ± 39.1 ijklmn	8.67 ± 0.6 bcdefg	71.7 ± 1.5 ij	9.8 ± 0.3 abc
3	Butter Ainarup 2	151.7 ± 12.6 mn	8.00 ± 1.0 defg	77.7 ± 3.8 hij	9.9 ± 0.9 abc
4	Butter Bebelit 2	308.3 ± 5.77 abcdefg	8.67 ± 0.6 bcdefg	86.3 ± 4.0 defghi	7.8 ± 0.7 abcdefg

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Accession No	Accession name	PH (cm)	LN	LL (cm)	LW (cm)
5	Butter Biara	306.7 ± 7.64 abcdefg	6.33 ± 0.6 g	87.7 ± 0.8 cdefghi	7.5 ± 0.5 bcdefg
6	Butter Krek	316.7 ± 7.64 abcdef	8.67 ± 0.6 bcdefg	92.2± 5.6 abcdefgh	7.2 ± 0.8 cdefg
7	Butter Mean	286.7 ± 32.1 bcdefghi	7.67 ± 0.6 defg	88.2 ± 1.8 bcdefghi	6.9 ± 1.1 defg
8	Butter Nean Reket A	250.0 ± 77.0 defghijklm	8.00 ± 1.0 defg	83.3 ± 4.2 efghi	9.3 ± 1.2 abcde
9	Butter Nean Reket B	290.0 ± 10.0 bcdefgh	7.67 ± 0.6 defg	84.3 ± 5.7 efghi	8.1 ± 0.7 abcdefg
10	Cantel Abrit Wonogiri	296.7 ± 5.77 abcdefgh	9.67 ± 1.2 abcdef	85.7 ± 8.4 efghi	7.7 ± 1.4 abcdefg
11	Coley	281.7 ± 128 bcdefghij	11.3 ±1.2 abc	87.7 ± 13.6 cdefghi	9.3 ± 0.3 abcde
12	Demak 1 (Gajah)	138.7 ± 9.02 n	8.33 ± 1.2 cdefg	89.0 ± 4.4 abcdefghi	10.2 ± 0.8 ab
13	Demak 2 (Gajah)	154.3 ± 2.89 mn	8.00 ± 0.0 defg	75.7 ± 1.2 hij	9.7 ± 0.3 abcd
14	Demak 3 (Gajah)	178.3 ± 4.73 jklmn	7.00 ± 1.0 fg	83.2 ± 7.1 efghi	9.0 ± 0.5 abcdef
15	Demak 4 (Mejen)	195.0 ± 5.00 hijklmn	7.67 ± 0.6 defg	97.7 ± 1.5 abcdef	9.2 ± 0.7 abcde
16	Demak 5	149.3 ± 22.5 mn	8.00 ± 0.0 defg	77.7 ± 6.8 hij	9.6 ± 1.5 abcd
17	Demak 6 (Babakan Sari)	236.7 ± 2.89 defghijklmn	7.33 ± 0.6 efg	79.7 ± 6.1 ghij	7.2 ± 0.4 cdefg
18	Hermada Coklat	275.0 ± 52.0 cdefghijk	7.67 ± 0.6 defg	105.3 ± 4.7 abc	7.4 ± 0.6 bcdefg
19	Kawali	176.3 ± 19.5 klmn	11.3 ± 1.5 abc	86.2 ± 8.4 defghi	8.0 ± 0.5 abcdefg
20	Keler	323.3 ± 67.9 abcde	9.67 ± 1.5 abcdef	90.8 ± 12 abcdefgh	8.0 ± 0.0 abcdefg
21	Kempul Putih 62R6	223.3 ± 2.89 efghijklmn	7.00 ± 1.0 fg	80.7 ± 3.1 fghi	6.9 ± 0.5 defg
22	Kempul Putih 64 K6	161.0 ± 4.00 lmn	10.3 ± 0.6 abcde	85.8 ± 1.6 efghi	9.7 ± 0.6 abcd
23	Kempul Putih 82 R10	211.7 ± 15.3 ghijklmn	8.67 ± 1.2 bcdefg	106.2 ± 5.8 a	9.0 ± 1.7 abcdef
24	Kolot	380.0 ± 20.0 ab	10.3 ± 0.6 abcde	97.7 ± 3.5 abcdef	8.6 ± 0.4 abcdefg
25	Lao	400.0 ± 34.6 a	11.7 ± 2.1 ab	96.7 ± 3.8 abcdefg	9.3 ± 1.8 abcde
26	Lepeng	376.7 ± 35.1 abc	12.7 ± 1.5 a	96.7 ± 8.0 abcdefg	9.3 ± 0.6 abcde
27	Lokal Bima 1	315.0 ± 5.00 abcdefg	8.67 ± 0.6 bcdefg	97.3 ± 6.7 abcdefg	7.4 ± 0.7 bcdefg
28	Lokal Bima 2	311.6 ± 10.4 abcdefg	8.00 ± 0.0 defg	98.7 ± 3.2 abcde	6.6 ± 0.4 efg
29	Lokal Bima 3	308.3 ± 2.89 abcdefg	8.33 ± 0.6 cdefg	96.7 ± 0.6 abcdefg	8.0 ± 0.0 abcdefg
30	14 Lokal Kaltim	396.7 ± 5.77 a	10.3 ± 0.6 abcde	104.0 ± 3.6 abcd	8.2 ± 0.3 abcdefg
31	Mutiara Kulonprogo L70	177.7 ± 14.2 jklmn	7.00 ± 1.0 fg	62.3 ± 4.9 j	6.2 ± 1.1 fg
32	Nean Reket	263.3 ± 5.77 defghijkl	8.67 ± 0.6 bcdefg	82.8 ± 3.3 efghi	8.4 ± 1.1 abcdefg
33	RGV	218.3 ± 5.77 fghijklmn	11.3 ± 1.5 abc	88.8 ± 1.3 abcdefghi	10.4 ± 0.8 a
34	Rio	168.3 ± 7.64 lmn	6.33 ± 0.6 g	72.7 ± 6.7 ij	6.0 ± 0.9 g
35	Rumbia (Lokal Lampung)	331.7 ± 14.43 abcd	10.3 ± 1.2 abcde	91.7 ± 2.9 abcdefgh	7.6 ± 0.9 abcdefg
36	Selayer 1	276.7 ± 15.28 bcdefghijk	7.67 ± 0.6 defg	91.0 ± 4.6 abcdefgh	7.5 ± 0.4 bcdefg
37	Selayer 2	165.0 ± 13.23 lmn	10.3 ± 1.2 abcde	77.0 ± 4.6 hij	9.7 ± 1.0 abcd
38	Selayer 3	291.7 ± 7.64 bcdefgh	8.67 ± 0.6 bcdefg	95.7 ± 4.0 abcdefg	8.2 ± 0.7 abcdefg
39	Super 1	315.0 ± 0.0 abcdefg	10.7 ± 0.6 abcd	106.0 ± 1.0 ab	8.4 ± 0.5 abcdefg
40	Super 2	320.0 ± 45.8 abcdef	9.33 ± 0.6 bcdefg	87.0 ± 6.1 defghi	7.8 ± 1.6 abcdefg

Note: Shown are the mean ± standard deviation of values for each accession. The different letter indicates significant difference between the accessions ($p < 0.05$, Tukey HSD test).

Table 16. The parameters of panicle length (PL), panicle stalk length (PSL), 100 seeds weight (100SW) and total seed weight (TSW).

Accession No	Accession name	PL (cm)	PSL (cm)	100SW (g)	TSW (g)
1	Batari	57.2 ± 7.0 bc	12 ± 6.2 abcde	25.6 ± 0.6 bcdefg	57.2 ± 4.4 abc
2	Butter Ainarup 1	33.9 ± 2.4 ijklm	5.8 ± 0.7 cde	18.8 ± 2.2 defg	20.3 ± 7.7 c
3	Butter Ainarup 2	34.4 ± 4.5 ijklm	12 ± 3.7 abcde	18.1 ± 6.1 defg	33.9 ± 10.2 bc
4	Butter Bebelit 2	37.6 ± 5.3 fghijklm	9.1 ± 1.1 bcde	28.9 ± 4.5 abcdef	49.9 ± 10.1 abc
5	Butter Biara	44.3 ± 4.5 bcdefghijkl	7.4 ± 2.9 bcde	17.6 ± 1.3 defg	41.5 ± 12.3 abc
6	Butter Krek	42.3 ± 1.3 cdefghijklm	4.0 ± 0.3 e	22.8 ± 1.0 bcdefg	53.9 ± 8.0 abc
7	Butter Mean	44.1 ± 6.6 bcdefghijkl	9.6 ± 4.8 bcde	21.9 ± 0.5 cdefg	33.0 ± 12.6 bc
8	Butter Nean Reket A	29.6 ± 1.7 lm	6.9 ± 1.4 cde	15.0 ± 1.7 g	43.2 ± 6.9 abc
9	Butter Nean Reket B	41.2 ± 1.6 defghijklm	12 ± 1.9 abcde	20.7 ± 0.4 cdefg	51.2 ± 6.5 abc
10	Cantel Abrit Wonogiri	34.8 ± 1.6 ijklm	12 ± 1.8 abcde	24.9 ± 2.0 bcdefg	42.2 ± 4.5 abc
11	Coley	44.6 ± 3.3 bcdefghijkl	16 ± 0.9 abc	15.8 ± 1.8 g	36.8 ± 5.5 bc
12	Demak 1 (Gajah)	28.3 ± 2.3 m	5.9 ± 2.2 cde	24.4 ± 1.2 bcdefg	76.5 ± 9.7 ab
13	Demak 2 (Gajah)	32.4 ± 0.8 klm	8.1 ± 1.1 bcde	25.9 ± 1.1 bcdefg	72.9 ± 18.3 abc
14	Demak 3 (Gajah)	33.0 ± 2.8 jklm	6.9 ± 2.2 cde	26.7 ± 3.0 bcdefg	70.7 ± 10.6 abc
15	Demak 4 (Mejen)	31.7 ± 1.9 klm	11 ± 2.0 abcde	24.0 ± 1.0 bcdefg	72.2 ± 16.2 abc
16	Demak 5	33.6 ± 1.5 jklm	7.2 ± 1.4 cde	29.9 ± 2.4 abcd	69.8 ± 24.0 abc
17	Demak 6 (Babakan Sari)	45.2 ± 7.6 bcdefghijkl	21 ± 6.1 a	20.2 ± 1.0 cdefg	32.4 ± 4.9 bc
18	Hermada Coklat	58.0 ± 8.6 b	8.1 ± 0.4 bcde	24.0 ± 3.6 bcdefg	49.6 ± 5.4 abc
19	Kawali	30.2 ± 1.4 lm	8.3 ± 1.7 bcde	26.8 ± 7.9 bcdefg	56.6 ± 36.8 abc
20	Keler	76.7 ± 3.0 a	6.2 ± 0.9 cde	18.3 ± 2.8 defg	30.7 ± 4.0 bc
21	Kempul Putih 62R6	35.1 ± 4.1 ijklm	11 ± 3.1 abcde	26.9 ± 1.1 bcdefg	46.5 ± 7.0 abc
22	Kempul Putih 64 K6	36.3 ± 1.3 hijklm	7.5 ± 1.5 bcde	19.8 ± 1.6 cdefg	58.9 ± 16.9 abc
23	Kempul Putih 82 R10	35.2 ± 2.1 ijklm	7.3 ± 3.3 bcde	26.0 ± 2.3 bcdefg	73.7 ± 23.8 ab
24	Kolot	51.0 ± 6.0 bcdefgh	7.2 ± 2.9 cde	28.9 ± 7.9 abcdef	62.4 ± 18.0 abc
25	Lao	42.5 ± 9.0 bcdefghijklm	5.3 ± 0.9 de	30.3 ± 10.5 abcd	74.6 ± 19.1 ab
26	Lepeng	52.4 ± 0.7 bcdefg	18 ± 1.6 ab	17.0 ± 3.3 efg	44.4 ± 6.0 abc
27	Lokal Bima 1	48.7 ± 2.1 bcdefghij	5.7 ± 1.9 cde	23.8 ± 2.3 bcdefg	64.4 ± 3.4 abc
28	Lokal Bima 2	49.4 ± 1.2 bcdefghi	9.6 ± 4.1 bcde	23.7 ± 2.5 bcdefg	52.6 ± 26.2 abc
29	Lokal Bima 3	53.0 ± 3.9 bcdef	7.7 ± 2.4 bcde	21.9 ± 1.1 cdefg	45.4 ± 46.7 abc
30	14 Lokal Kaltim	38.2 ± 1.7 defghijklm	8.2 ± 1.9 bcde	40.7 ± 2.3 a	94.0 ± 13.7 a
31	Mutiara Kulonprogo L70	38.9 ± 2.3 efghijklm	5.6 ± 1.2 cde	16.7 ± 3.4 fg	41.2 ± 5.0 bc
32	Nean Reket	40.7 ± 4.8 defghijklm	12 ± 1.2 abcde	25.5 ± 9.3 bcdefg	94.2 ± 9.1 a
33	RGV	51.0 ± 7.9 bcdefgh	9.8 ± 7.5 bcde	20.6 ± 0.6 cdefg	27.1 ± 8.2 bc
34	Rio	41.1 ± 4.6 defghijklm	7.7 ± 0.8 bcde	23.2 ± 3.0 bcdefg	75.5 ± 12.7 ab
35	Rumbia (Lokal Lampung)	55.1 ± 9.2 bcd	16 ± 3.5 abcd	35.3 ± 1.7 ab	63.6 ± 19.3 abc
36	Selayer 1	46.8 ± 6.8 bcdefghijk	12 ± 10.1 abcde	28.8 ± 2.1 abcdef	41.0 ± 17.9 bc
37	Selayer 2	53.5 ± 5.2 bcde	4.8 ± 0.8 e	25.8 ± 7.7 bcdefg	59.4 ± 17.5 abc
38	Selayer 3	46.1 ± 8.1 bcdefghijk	11 ± 5.0 abcde	16.9 ± 0.3 fg	33.6 ± 22.2 bc
39	Super 1	37.2 ± 5.5 ghijklm	12 ± 3.4 abcde	31.7 ± 0.4 abc	66.9 ± 6.9 abc
40	Super 2	32.0 ± 5.3 klm	7.7 ± 1.7 bcde	29.8 ± 6.5 abcde	49.3 ± 6.9 abc

Note: Shown are the mean ± standard deviation of values for each accession. The different letter indicates significant difference between the accessions ($p < 0.05$, Tukey HSD test).

Table 17. The parameters of panicle weight (PW), fresh weight of plant biomass (FWB), dry weight of plant biomass (100SW) and sugar content of stem juice (SC).

Accession No	Accession name	PW (g)	FWB (g)	DWB (g)	SC (°Brix)
1	Batari	54.7 ± 4.1 cdef	531.9 ± 68.6 fg	186.5 ± 24 def	11.5 ± 1.0 bcdefg
2	Butter Ainarup 1	49.5 ± 5.88 f	626.6 ± 11.6 defg	217.0 ± 23 cdef	12.5 ± 3.9 abcdef
3	Butter Ainarup 2	51.8 ± 14.12 ef	684.2 ± 74.6 defg	215.6 ± 26.7 cdef	7.1 ± 1.6 cdefg
4	Butter Bebelit 2	71.5 ± 10.56 bcdef	672.5 ± 102.6 defg	247.0 ± 15.9 bcdef	12.4 ± 1.5 abcdef
5	Butter Biara	60.3 ± 13.49 cdef	528.8 ± 80.1 fg	194.0 ± 39.9 cdef	6.3 ± 2.2 efg
6	Butter Krek	76.3 ± 5.84 abcdef	733.6 ± 123.3 cdefg	285.0 ± 85.2 abcdef	12.9 ± 3.2 abcdef
7	Butter Mean	51.1 ± 14.73 ef	516.9 ± 65.8 fg	175.9 ± 4.63 def	11.7 ± 1.0 bcdefg
8	Butter Nean Reket A	67.2 ± 9.13 bcdef	940.6 ± 117.1 abcdefg	307.1 ± 34.9 abcdef	10.1 ± 3.4 bcdefg
9	Butter Nean Reket B	76.0 ± 11.43 abcdef	671.5 ± 122.7 defg	226.1 ± 39.3 cdef	14.0 ± 3.0 abcd
10	Cantel Abrit Wonogiri	71.1 ± 6.83 bcdef	981.3 ± 67.8 abcdefg	231.8 ± 26.2 bcdef	4.6 ± 1.5 g
11	Coley	59.3 ± 8.33 cdef	1269 ± 208 abc	388.0 ± 82.8 abcd	12.9 ± 2.2 abcdef
12	Demak 1 (Gajah)	116.5 ± 8.87 abcd	748.0 ± 187 cdefg	243.3 ± 48.4 bcdef	6.3 ± 0.2 efg
13	Demak 2 (Gajah)	98.8 ± 2.82 abcdef	749.5 ± 69.6 cdefg	193.5 ± 30.8 cdef	8.9 ± 1.6 bcdefg
14	Demak 3 (Gajah)	103.3 ± 9.0 abcdef	788.5 ± 84.5 cdefg	239.5 ± 37.9 bcdef	11.8 ± 1.4 bcdefg
15	Demak 4 (Mejen)	106.3 ± 19.7 abcdef	793.0 ± 134.4 cdefg	228.2 ± 51.8 bcdef	11.0 ± 0.1 bcdefg
16	Demak 5	103.7 ± 22.9 abcdef	884 ± 287 abcdefg	177.5 ± 27.9 def	7.0 ± 1.4 cdefg
17	Demak 6 (Babakan Sari)	54.6 ± 3.05 def	513.8 ± 9.03 fg	155.3 ± 1.50 ef	13.2 ± 0.8 abcdef
18	Hermada Coklat	88.9 ± 6.7 abcdef	737.0 ± 181 cdefg	227.1 ± 33.3 bcdef	8.6 ± 1.3 bcdefg
19	Kawali	81.8 ± 50.5 abcdef	675.0 ± 175 defg	231.7 ± 91.8 bcdef	15.0 ± 2.1 ab
20	Keler	102.7 ± 0.8 abcdef	1360 ± 102 a	407.9 ± 19.9 abc	11.5 ± 0.6 bcdefg
21	Kempul Putih 62R6	71.9 ± 7.7 bcdef	743.8 ± 84.7 cdefg	228.9 ± 34.5 bcdef	12.4 ± 2.4 abcdef
22	Kempul Putih 64 K6	101.5 ± 15.9 abcdef	787.6 ± 33.5 cdefg	219.1 ± 21.9 cdef	13.1 ± 0.9 abcdef
23	Kempul Putih 82 R10	111.9 ± 26.0 abcde	799.6 ± 119.5 bcdefg	254.5 ± 72.1 abcdef	10.9 ± 3.6 bcdefg
24	Kolot	99.1 ± 7.76 abcdef	1053 ± 82.9 abcdef	313.4 ± 42.6 abcdef	12.1 ± 2.4 abcdefg
25	Lao	97.9 ± 2.8 abcdef	1348 ± 522 ab	474.0 ± 229 a	10.8 ± 1.5 bcdefg
26	Lepeng	90.7 ± 19.9 abcdef	1109 ± 69 abcde	365.3 ± 23 abcde	15.4 ± 1.4 ab
27	Lokal Bima 1	78.4 ± 14.8 abcdef	861.0 ± 312 abcdefg	283.4 ± 114 abcdef	13.3 ± 3.7 abcde
28	Lokal Bima 2	79.8 ± 24.4 abcdef	653.3 ± 29.4 defg	201.1 ± 21.5 cdef	8.8 ± 3.5 bcdefg
29	Lokal Bima 3	69.5 ± 43.9 bcdef	757.9 ± 65.1 cdefg	233.0 ± 30.3 bcdef	11.9 ± 1.3 abcdefg
30	14 Lokal Kaltim	128.3 ± 11.30 ab	1265 ± 60.8 abc	447.0 ± 60.2 ab	14.0 ± 4.1 abcd
31	Mutiara Kulonprogo L70	66.1 ± 2.46 cdef	556.3 ± 27.8 fg	155.8 ± 12.5 ef	5.7 ± 1.4 fg
32	Nean Reket	134.3 ± 18.2 a	821.6 ± 167.8 abcdefg	278.6 ± 39 abcdef	9.0 ± 1.1 bcdefg
33	RGV	44.4 ± 9.5 f	914.0 ± 178 abcdefg	360.6 ± 70.2 abcde	6.6 ± 3.1 defg
34	Rio	112.3 ± 13.5 abcde	461.6 ± 41.8 g	117.3 ± 15.1 f	19.3 ± 1.6 a
35	Rumbia (Lokal Lampung)	116.7 ± 30.7 abc	812.4 ± 125.3 abcdefg	245.1 ± 54.2 bcdef	14.0 ± 1.5 abcd
36	Selayer 1	62.7 ± 19.8 cdef	611.8 ± 59.8 efg	217.0 ± 61 cdef	10.3 ± 2.0 bcdefg
37	Selayer 2	102.6 ± 25.1 abcdef	663.8 ± 126.6 defg	159.6 ± 28 ef	5.9 ± 3.7 efg
38	Selayer 3	60.0 ± 20.3 cdef	823.7 ± 71.9 abcdefg	252.4 ± 22.3 bcdef	11.4 ± 3.6 bcdefg
39	Super 1	93.6 ± 7.54 abcdef	1176.5 ± 171.4 abcd	394.7 ± 92.5 abcd	14.1 ± 1.1 abcd
40	Super 2	59.1 ± 18.8 cdef	1016 ± 469 abcdef	361.0 ± 190 abcde	14.3 ± 2.2 abc

Note: Shown are the mean ± standard deviation of values for each accession. The different letter indicates significant difference between the accessions ($p < 0.05$, Tukey HSD test).