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Exploration and identification of *Anredera cordifolia* morphological characters in the highlands and lowlands

YAYA HASANAH♥, LISA MAWARNI

Agrotechnology Program, Faculty of Agriculture, Universitas Sumatera Utara. Jl. Prof. A. Sofyan No. 3, Kampus USU Padang Bulan, Medan 20155, North Sumatra, Indonesia. Tel.: +62-61-8213236, Fax.: +62-61-8211924, ♥email: yaya@usu.ac.id

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Abstract. *Hasanah Y, Mawarni L. 2020. Exploration and identification of* Anredera cordifolia *morphological characters in the highlands and lowlands. Biodiversitas 21: 2759-2766.* Information about genetic diversity and relationships between accessions is very important in plant breeding programs, because with the availability of this information, it is easier to determine relationship between accessions that can be used as a basis for plant selection. The objective of the research was to evaluate the morphological characteristics and relationship of *binahong* or *Anredera cordifolia* (Ten.) Steenis) accessions in the lowlands and highlands. The study was conducted in Karo (highlands) and Medan (lowlands), North Sumatra, Indonesia, from May to August 2019. This research used a descriptive method. Before the survey and exploration are conducted, first a pre-survey was conducted by gathering information from key informants and other informants. The characteristic of morphological diversity *A. cordifolia* can be distinguished based on leaf color, stem shape, axillary tuber, rhizome, and the presence of flowers. The dendrogram relationship between accessions is based on a genetic similarity matrix using cluster analysis. Analysis of qualitative morphological characters revealed the existence of variability among *A. cordifolia* accessions. There is a far relationship relation between *A. cordifolia* plants in Karo and Medan with Eucludian range of 0.446 to 57.725, hence resulting in two clusters that show differences in the variation of *A. cordifolia* plants. There is a distant relationship relation with M4 and M7 accessions with a dissimilar distance of 57,725 and the closest relationship with accession K1 and K2 with a dissimilar distance of 0.446. Therefore, morphological characterization in the research is valuable to understand the variability of genetic of *A. cordifolia* accessions in the lowland and highland in North Sumatra.

Keywords: *Anredera cordifolia*, *binahong*, dendrogram, morphology, relationship

INTRODUCTION

At present, the utilization of medicinal plants in the country tends to increase along with public awareness to consume natural medicines. Medicinal plants have long been used as alternatives for the prevention and treatment of various diseases. *Binahong* (*Anredera cordifolia* (Ten.) Steenis) is one of the medicinal plants and is popular among the people in Indonesia. It is known in many countries as ornamental plant, but in Australia, South Africa, New Zealand has become an invasive species (Weber 2017). This species reproduces vegetatively, has leaf axillary tubers which play an important role in spreading species quickly (Stancic and Mihelj 2010; Kottaimuthu et al. 2011). The appearance and actual status of this species in Algeria reported by Sakhraoui et al. (2019), it is the only species that represents the Basellaceae family in Algeria.

Use of natural ingredients, either as medicine or other purposes tend to be increased, especially with the issue of back to nature as well as a prolonged crisis which resulting in decreased purchasing power against modern medicine. Traditional medicine (herbal medicine) is widely used by the middle class down especially in prevention disease preventive), healing (curative), health recovery (rehabilitative) as well as health promotion (promotive). (Syamsiah 2014).

Anredera cordifolia as a medicinal plant has many functions including anti-hyperlipidemic (Lestari et al. 2015; Sukandar et al. 2014), anti-bacterial (Amertha et al. 2012; Darsana et al. 2012; Kartika et al. 2016; Angga et al. 2016; Maharani et al. 2018; Pitaloka et al. 2018), anti-hypertension (Garmana et al. 2016), antioxidant (Djamil et al. 2012), anti-diabetes (Sukandar et al. 2016), analgesic effect (Kurniawan et al. 2014), and wound healing (Kaur et al. 2014; Sukrama et al. 2017), anti-obesity (Sukandar et al. 2016). *A. cordifolia* chemical contents are flavonoids, alkaloids, saponins, triterpenoids, quoin, sesquiterpenoids and monoterpenes. *A. cordifolia* rhizomes contain flavonoids, polyphenols, tannins, and steroids (Murni et al. 2011; Garmana et al. 2014; Souza et al. 2014).

Optimal growth and productivity of *A. cordifolia* is determined by the type of plant and the content of secondary metabolites in *A. cordifolia*. The small genetic diversity in *A. cordifolia* causes difficulties in obtaining good quality *A. cordifolia*. Therefore, efforts are needed to increase the genetic variation of *A. cordifolia* plants. One effort that can be done is by exploring *A. cordifolia* germplasm. *A. cordifolia* germplasm is collected, then characterized to identify the characteristics and potential of germplasm.

Anredera cordifolia can grow in the lowlands and highlands. Differences in growth location cause differences in growth and development of *A. cordifolia* due to differences in microclimate. Therefore, this research

activity was carried out by exploration of *A. cordifolia* in the highlands (Karo) and lowlands (Medan) of North Sumatra, Indonesia.

Anredera cordifolia's research to date has largely examined the role of *A. cordifolia* and its properties as a medicinal plant (Astuti et al. 2011; Sakti et al. 2019; Maharani et al. 2018; Sugiyarto et al. 2014; Dwitiyanti et al. 2019; Susanti 2019; Nazliniwaty et al. 2019; Leliqia et al. 2017), aquaculture research, chicken research and the growth and physiological character of *A. cordifolia* (Sukandar et al. 2014; Lubis et al. 2018; Syahputra et al. 2018; Widodo et al. 2018; Hasanah et al. 2019; Tampubolon et al. 2019; Hasibuan et al. 2020; Hasanah et al. 2020; Manurung et al. 2020), morphological study of *A. cordifolia* (Mahyuni et al. 2015); *A. cordifolia* as botanical pesticide on paddy (Yulia and Widiantini 2018); etnobotanical study of *A. cordifolia* (Mesfin et al. 2013; Nahdi et al. 2016); molecular marker of *A. cordifolia* (Royani et al. 2018); morphology and isozyme variation of *A. cordifolia* accessions from southeastern part of Central Java (Restikania et al. 2019)

Studies on the genetic diversity and identification of *A. cordifolia* accessions in the highlands and lowlands in North Sumatra have not been reported. Exploratory research is preliminary research, which forms the basis of more conclusive research in collecting data to obtain *A. cordifolia* morphological performance from various accessions. Exploration activities are tracking or exploring, searching, collecting, and researching germplasm types. The initial approach in this activity is to inventory plants and followed by characterization of morphological and agronomic characters. Therefore, this study aims to evaluate the morphological characteristics and relationship of *A. cordifolia* accessions in the lowlands and highlands.

MATERIALS AND METHODS

The research was conducted by survey method for exploration of *A. cordifolia* accessions in Karo (i.e. Simpang Empat, Berastagi, Barus Jahe) and Medan (i.e. Medan Marelan, Medan Helvetia, Medan Selayang, Medan Johor) of North Sumatra, Indonesia (Figure 1). The research was conducted in May-August 2019. A total of 13 *A. cordifolia* accessions from lowlands and highlands were used to observe morphological characters. These accessions were collected from various places in the form of living plant collections.

The materials used were *A. cordifolia* accessions found in Karo and Medan. The tools used were GPS, plastic ropes, cameras, *A. cordifolia* plant descriptor guides, stationery, calipers, hand sprayers, rulers, paper.

This research used descriptive methods in the form of direct observation techniques on objects observed in the field. Before the survey and exploration are conducted, first a pre-survey was conducted by gathering information from key informants and other informants. Key informants are community leaders, while other informants are determined based on information from key informants using the snowball sampling method.

The data source used was obtained by observing qualitative morphological characters at the location including the character of leaf (shape, color, venation), stem (shape, color), axillary tubers (shape, color), rhizome (shape, color) and flower (presence, color) using the International Plant Genetic Resources Institute (IPGRI) descriptor. Five samples were taken from each observation location. Observation of supporting data includes the condition of the environment around the plant (altitude, GPS, temperature, soil pH, light intensity, rainfall), presented in Table 1.

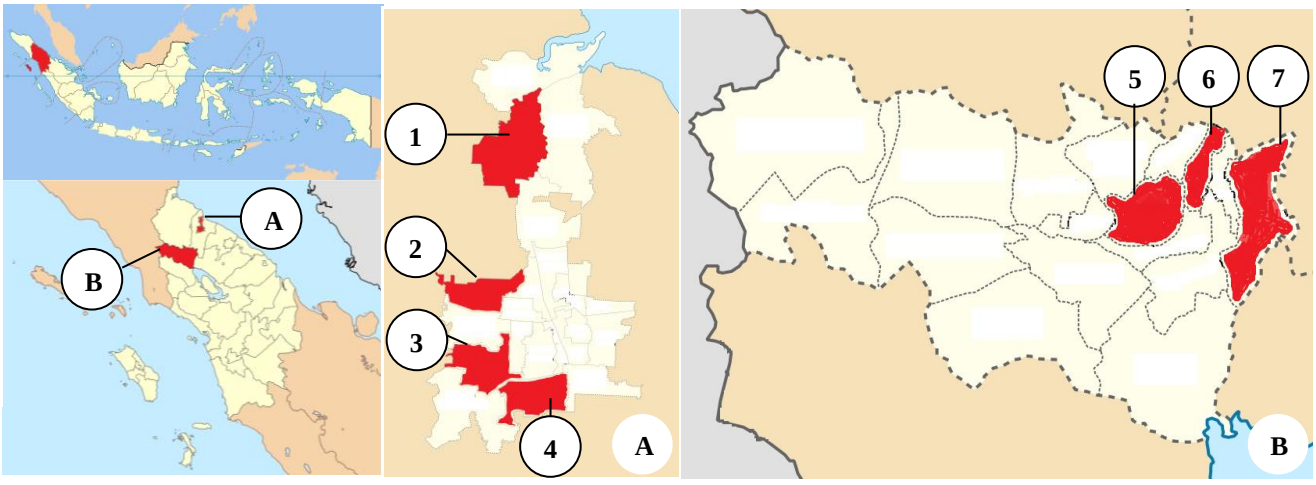

Figure 1. Schematic map research site in Medan (A) and Karo (B), North Sumatra, Indonesia as a sampling site (●): 1. Medan Marelan, 2. Medan Helvetia, 3. Medan Selayang, 4. Medan Johor, 5. Simpang Empat, 6. Berastagi, 7. Barus Jahe

RESULTS AND DISCUSSION

Anredera cordifolia morphological characters

Based on *A. cordifolia* exploration in Karo (highlands), six locations were found consisting of four locations in Barus Jahe, one location in Berastagi, and one location in Simpang Empat. Exploration results in Medan (lowland) found seven locations, namely one location in Medan Helvetia, one location in Medan Johor, two locations in Medan Marelan, and three locations on Medan Selayang.

Based on observations of *A. cordifolia* found in Karo, it was found that two *A. cordifolia* locations in Barus Jahe are wild plants (not cultivated), while two locations in Barus Jahe, one location in Berastagi and one location in Simpang Empat are cultivated plants. Meanwhile, *A. cordifolia* found in Medan has been cultivated by the community.

Environmental data around *A. cordifolia* plants in Karo and Medan are presented in Table 1. Based on these data, it can be seen that *A. cordifolia* can grow well in the lowlands (<700 m a.s.l) and highlands (> 700 m a.s.l) with a temperature range of 15-34^{o} C, with range soil pH 5.0-6.5, the average of rainfall 173-274 mm/month, light intensity 211-1338 lux. In general, the *A. cordifolia* plants were found in the shade and were not directly exposed to solar radiation, except the accession Medan 1.

Based on Table 2, it can be seen that the accessions of *A. cordifolia* in the lowlands and highlands have similarities in the shape, color, and venation of leaves, the shape and color of the stems, axillary tubers, rhizomes, and flowers. Variations in the shape of the leaves are the heart, rounded heart, and elongated heart. *A. cordifolia* leaf color found in green, dark green, and green varies, with pin venation of leaves and separated pin venation of leaves. Woody stems with reddish-green, brownish-red, and red stems color. Axillary tubers are irregularly shaped with green, brown, and brownish-green. Irregular rhizome shape with a greenish and brownish color.

All *A. cordifolia* accessions from Karo have no flower. Meanwhile, accessions from Medan, only two accessions that have white/cream flowers. This proved that the weather conditions in the highlands are not suitable for the initiation of *A. cordifolia* flowering. In the lowlands generally *A. cordifolia* will flower after being planted for 2 months, whereas in the highlands it does not have flower. This is presumable because the lowest temperature in Karo (15-16 ^{o}C) resulted in the failure of flowering initiation. Wigge (2013); Heggi and Haliday (2005); Thines et al. (2014) stated that in many plant species, warm temperature is a strong signal for flowering, and flowering to this cue appears to act through multiple signaling pathways, including the components of the photoperiod pathway. In accordance with Thakur et al. (2010) that cold temperatures induce flower abortion, pollen, and ovular infertility.

Cluster analysis

Cluster analysis is an analysis to group similar elements as research objects to become distinct and mutually exclusive clusters. The purpose of cluster analysis is to group objects based on the similarity of characteristics between the objects (Suratman et al. 2015). These objects will be classified into one or more clusters (groups) so that objects that are in one cluster will be similar to one another (Santoso 2014).

The phenotype relationship is a relationship based on the analysis of several phenotypic performances of an organism (Rahaman et al. 2019). The relationship between two individuals or two populations can be measured based on the similarity in the number of characters with the assumption that the different characters are caused by genetic makeup.

Based on the results of cluster analysis, it is obtained the proximity matrix data (Table 3), it is known that the euclidian distance of 13 *A. cordifolia* accessions in Karo and Medan is in the range of 0.446-57.725. The range proved that the coefficient of dissimilarity in the population of *A. cordifolia* accessions at all locations is broad. The great dissimilarity suggests that the variation found in the population is broad. The same thing was also found in the research of Yusran and Maemunah (2010) on the glutinous corn plant, obtained dendrogram results which showed the greater the distance formed from grouping, the smaller the diversity formed.

Based on the dendrogram (Figure 2), it can be seen that the accessions of *A. cordifolia* can be grouped into 2 clusters on a distance scale of 25, that the accessions of *A. cordifolia* in Karo (K1-K6) and Medan accessions (M1, M2, M3, M4, and M5) are all in one cluster. While cluster 2 only has one member (M7). The M7 accession was obtained from Jl. Ampera Setiabudi, Medan, where the *A. cordifolia* plant has a phenotypic different from the others because the M7 accession has brownish-colored tubers, the color of the stem is purplish-green, but some other characters are still similar.

Analysis of relationship relation based on the morphological character of *A. cordifolia* accessions on a distance scale of 23 showed the formation of 3 groups of plant relationships. The first group consists of K1, K2, K3, K4, K5, K6, M1, M4, M5, M6, the second group consists of M2 and the third group consists of M7. The grouping dendrogram analysis is based on the number of qualitative morphological characters in common. Although the *A. cordifolia* is in the same area if the environment where it grows is different it will affect the growth and development of plants expressed through the appearance of the phenotype. This is in accordance with Irawan and Purbayanti (2008) that although a cultivar originates from the same area, if the environment where it grows is different it will affect genetic diversity and also genotype originating from the same region does not always belong to the same group. The more characteristics in common, the closer the relationship.

Exploration for genetic improvement of each species originates from genetic variation that plays an important role in the Plant Improvement program (Johnson et al. 2010). In germplasm characterization in Indonesia, morphological markers have been commonly used to evaluate genetic variation between and within species, cultivars, or populations accession (Acquaah 2012; Padmini et al. 2013).

Table 1. Data supporting the environment around *Anredera cordifolia* accessions in Karo and Medan, North Sumatra, Indonesia

Accession name	Collection site	GPS	Altitude (m a.s.l)	Air temp. range (ºC)	Light intensity (lux)	Soil pH	Average rainfall (mm/month)
Karo 1	Barus Jahe, Jl. Gotong Royong	N: 03^{0}07.035' E: 098^{0}34.736'	1252	16 - 32	832	6.0	246
Karo 2	Barus Jahe	N: 03^{0}06.900' E: 098^{0}34.835'	1253	16 - 32	827	6.0	246
Karo 3	Barus Jahe	N: 3^{0}06.53' E: 098^{0}34.50'	1252	16- 32	285	6.0	246
Karo 4	Barus jahe	N: 03^{0}6'941' E: 098^{0}34'859'	1256	16 - 32	355	6.5	246
Karo 5	Berastagi, Jl. Mesjid No.12	N: 3^o.19'5578, E : 98^o.50' 17"	1400	15 - 30	792	6.5	246
Karo 6	Simpang Empat, Desa Gajah	N : 3^{o}175859' E : 98^o 465104'	1332	15 - 30	316	6.5	173
Medan 1	Medan Selayang, Jl. Dr. Mansyur No. 41 A	N: 03^{0}34.055 E: 098^0.39.038'	26	25-34	1338	5.0	274
Medan 2	Medan Johor, Jl. Aswad No.7	N: 03^{0}31.139' E: 098^0.40.018'	25	25-34	568	6.5	274
Medan 3	Medan Helvetia, Jl. Persatuan No. 4	N: 03^{0}36.692' E: 098^0.39.497'	24	24-33	312	6.0	175
Medan 4	Medan Marelan, Jl. Marelan VII Pasar 1 Tengah	N: 03^{0}41.545' E: 098^0.38.423'	6	24 - 33	792	6.0	175
Medan 5	Medan Marelan, Jl. Marelan VII	N: 03^{0}41.525' E: 098^0.38.858'	8	24-33	736	6.5	175
Medan 6	Medan Selayang, Jl. Ampera Timur Setia Budi No. 536	N: 03^{0}34.529' E: 098^0.38.215'	28	24 - 33	211	5.0	274
Medan 7	Medan Selayang, Jl. Ampera Setia Budi No. 249	N: 03^{0}34.495' E: 098^0.38.192''	34	25-34	231	6.0	274

Table 2. *Anredera cordifolia* morphological characters in Karo and Medan, North Sumatra, Indonesia

Accession name	Leaf			Stem		Axillary tubers		Rhizome		Flower	
	Shape	Color	Venation	Shape	Color	Shape	Color	Shape	Color	Presence	Color
Karo 1	Heart leaf	Green	Pinnate	Woody	Reddish green	Irregular	Green	Irregular	Brownish	Absent	-
Karo 2	Heart leaf	Green	Pinnate	Woody	Purplish green	Irregular	Green	Irregular	Brownish	Absent	-
Karo 3	Heart leaf	Green	Pinnate	Woody	Purplish green	Irregular	Green	Irregular	Brownish	Absent	-
Karo 4	Heart leaf	Green	Pinnate	Woody	Brownish green	Irregular	Green	Irregular	Brownish	Absent	-
Karo 5	Elongated heart leaf	Green	Pinnate	Woody	Reddish green	Irregular	Brownish	Irregular	Greenish	Absent	-
Karo 6	Elongated heart leaf	Green	Pinnate	Woody	Reddish green	Irregular	Green	Irregular	Greenish	Absent	-
Medan 1	Heart leaf	Dark green	Pinnate does not meet, red leaf reinforcement	Woody/ herbaceous	Red	Irregular	Brownish	Irregular	Brownish	Absent	-
Medan 2	Rounded heart leaf	Green	Pinnate does not meet	Woody	Reddish-brown	Irregular	Brownish	Irregular	Brownish	Present	Cream
Medan 3	Heart leaf	Green	Pinnate	Woody round	Reddish green	Irregular	Green	No	No	Absent	-
Medan 4	Heart leaf	Dark green	Costa	Woody round	Green	Irregular	Green	No	No	Absent	-
Medan 5	Heart leaf	Green varies	Pinnate	Woody	Reddish	Irregular	Green	No	No	Present	White
Medan 6	Heart leaf, flat periphery	Green varies	Pinnate	Woody	Brownish green	Irregular	Brownish green	No	No	Absent	-
Medan 7	Heart leaf, uneven edges	Green	Pinnate	Woody	Purplish green	Irregular	Brownish	No	No	Absent	-

Tabel 3. Proximity matrix of *Anredera cordifolia* accessions

Case	Squared Euclidean Distance												
	K1	**K2**	**K3**	**K4**	**K5**	**K6**	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**
K1	0.000	0.446	16.054	12.191	11.601	15.187	29.643	29.832	12.068	31.277	27.117	17.069	39.550
K2	0.446	0.000	15.608	10.854	12.046	15.633	27.414	26.712	12.514	32.614	28.454	15.732	39.104
K3	16.054	15.608	0.000	5.646	16.855	10.425	11.806	29.220	7.305	27.406	23.246	10.523	33.895
K4	12.191	10.854	5.646	0.000	12.992	6.562	15.668	32.192	3.442	24.434	20.275	4.877	29.141
K5	11.601	12.046	16.855	12.992	0.000	10.473	34.486	41.852	12.869	36.121	27.918	15.174	34.959
K6	15.187	15.633	10.425	6.562	10.473	0.000	21.992	53.226	6.439	23.626	21.488	12.787	36.616
M1	29.643	27.414	11.806	15.668	34.486	21.992	0.000	39.721	14.255	22.731	37.584	28.172	49.744
M2	29.832	26.712	29.220	32.192	41.852	53.226	39.721	0.000	39.200	45.218	37.015	34.374	57.725
M3	12.068	12.514	7.305	3.442	12.869	6.439	14.255	39.200	0.000	15.890	15.049	8.320	30.801
M4	31.277	32.614	27.406	24.434	36.121	23.626	22.731	45.218	15.890	0.000	14.852	36.938	54.944
M5	27.117	28.454	23.246	20.275	27.918	21.488	37.584	37.015	15.049	14.852	0.000	16.745	46.741
M6	17.069	15.732	10.523	4.877	15.174	12.787	28.172	34.374	8.320	36.938	16.745	0.000	31.323
M7	39.550	39.104	33.895	29.141	34.959	36.616	49.744	57.725	30.801	54.944	46.741	31.323	0.000

Note : This is a dissimilarity matrix. K1: Karo 1, K2: Karo 2, K3: Karo 3, K4: Karo 4, K5: Karo 5, K6: Karo 6, M1: Medan 1, M2: Medan 2, M3: Medan 3, M4: Medan 4, M5: Medan 5, M6: Medan 6, M7: Medan 7

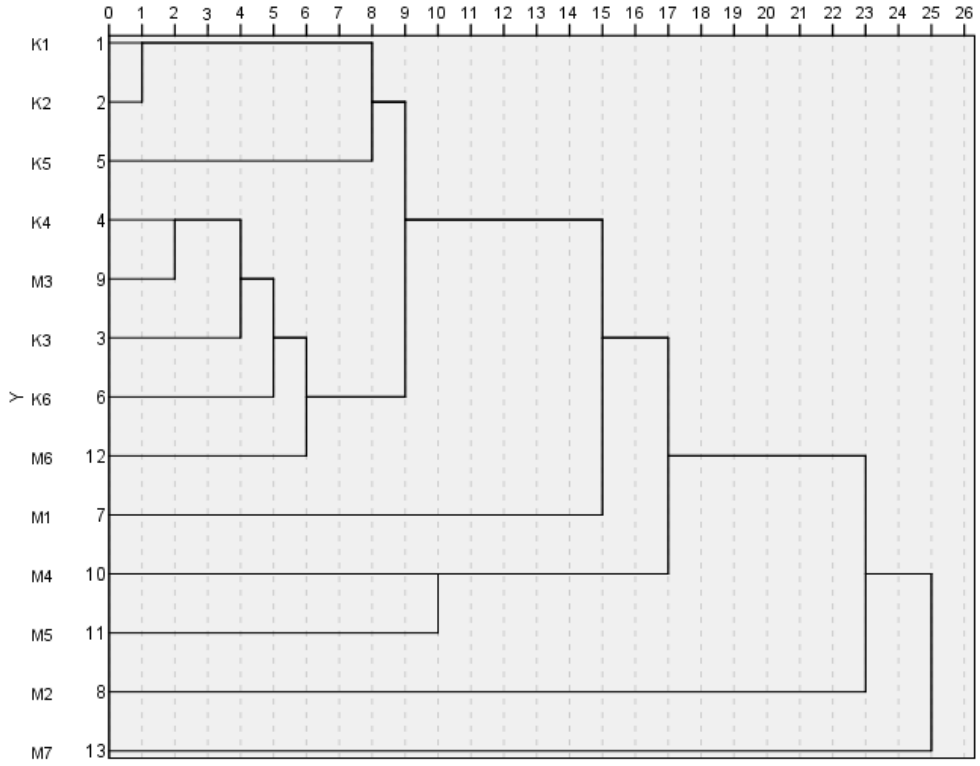

Figure 2. Dendrogram *Anredera cordifolia* grouping in Karo and Medan, North Sumatra, Indonesia

Analysis of relationship relation based on the morphological character of *A. cordifolia* accessions on a distance scale of 17 showed the formation of 4 groups of plant relationships. The first group consists of K1, K2, K3, K4, K5, K6, M1, M3, M6, the second group consists of M2, the third group consists of M4 and M5, the fourth group consists of M7. The separation of these four groups occurred because of differences in leaf color, stem shape, tuber shape, and the presence of flowers. Planting locations, in which group 1 is *A. cordifolia* accessions in the highlands namely Karo and Medan Regency, are united by the same 2 characters while the second group is *A. cordifolia* cultivated in the lowlands namely Medan. This proves that not always the adjacent geographical location is related to the same cluster diversity. Therefore, it is suspected that genetic diversity and geographic distribution have no correlation in this study. The *A. cordifolia* accession grouping does not always show similarities based on geographical origin, but may be due to genetic similarities. Genetic diversity in *A. cordifolia* is thought to be a result of abiotic and biotic factors, therefore information and *A. cordifolia* collections from various locations are germplasm collections that are very important for plant breeding (Tang et al. 2014; Restikania et al. 2019).

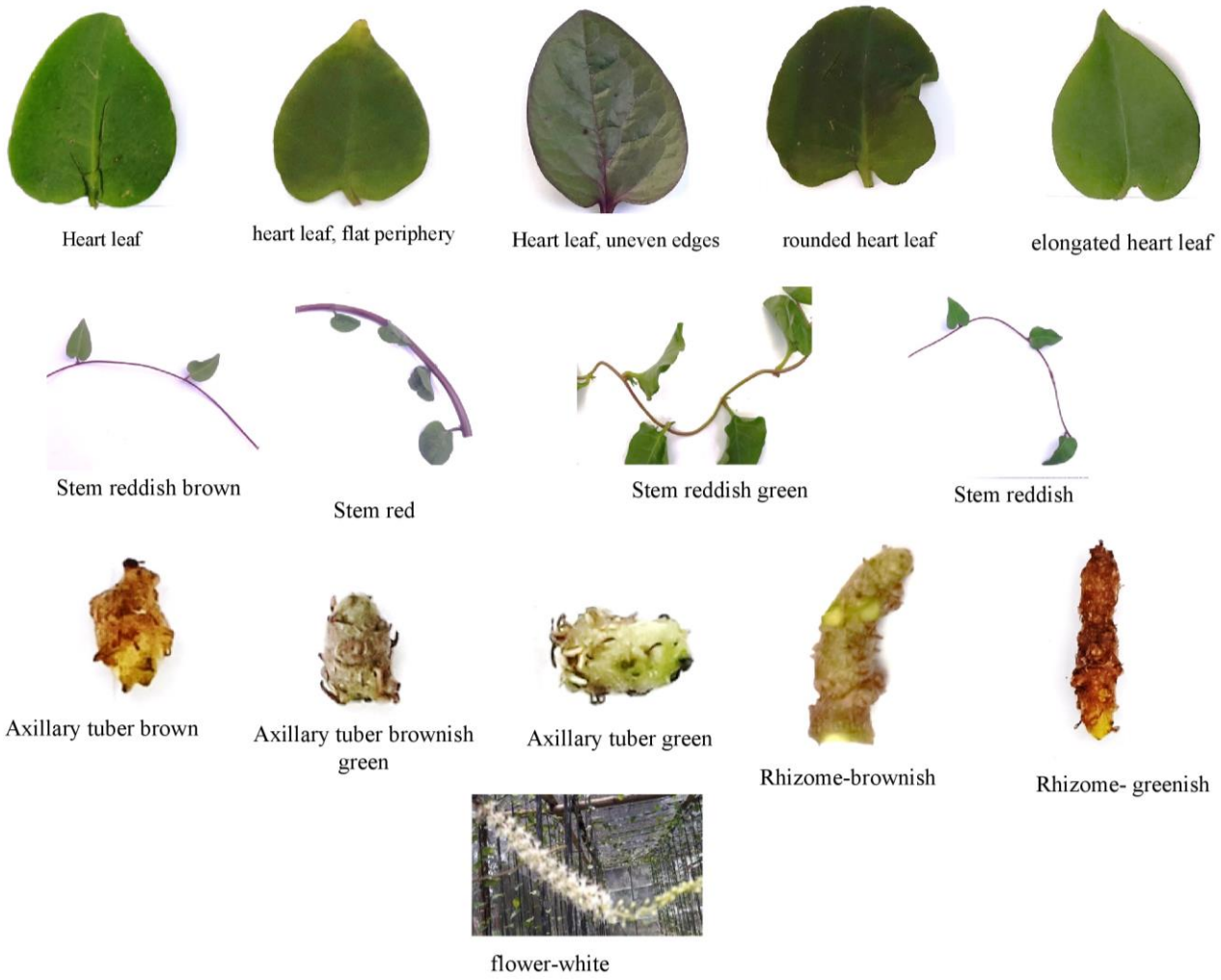

Figure 3. The phenotypic appearance differences in 13 accessions of *Anredera cordifolia* in Karo and Medan, North Sumatra, Indonesia

Previous studies (Royani et al. 2018) on the performance of 18 *A. cordifolia* accessions from various regions in Indonesia using ISSR molecular markers, showed that the dendrogram of 18 genetic accessions ranges from 0.39 to 1.00. There are two major groups obtained from 18 *A. cordifolia* accessions, the first group consisting of 17 accessions and the second group only Tanjung Bungkak accession (Denpasar, Bali).

Figure 3 showed the phenotypic appearance differences of leaf color, stem color, axillary tuber color, rhizome color, and flower color. The morphological characters had different types of each parameter observation.

It has been concluded there is a far relationship relation between *A. cordifolia* plants in Karo and Medan with eucludian range of 0.446 to 57.725, hence it produces two clusters that show differences in the variation of *A. cordifolia* plants. There is a distant relationship with M4 and M7 accessions with dissimilar distance of 57,725 and the closest relationship with accession K1 and K2 with dissimilar distance of 0.446.

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