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## Identification of a local variety of ‘uwi’ (*Dioscorea alata* Linn.) in four agro-climate regions of East-West Java - Indonesia based on tuber character

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**Abstract.** Indonesia is very well known for its genetic diversity of potential tubers plants for alternative and functional food sources. ‘Uwi’ (*Dioscorea alata* Linn.) as one of the tuber’s plants needs to get attention, so there is no genetic erosion or even extinction. Seeing the high diversity of agro-climates and the high genetic diversity of ‘uwi’ plants, it is necessary to mapping and identify the suitability of the ‘uwi’ plant in line with its agro-climate character. The study aims to identify specific local varieties and the distribution of other types with broad adaptability. The analysis using the similarity interval function on the NTSys program showed that of the 47 accessions tested at 70 % similarity level there were four groups scattered in four different agro-climates. The first group enters climate types C2, C3 and B2; the second group enters C2; the third group enters C2 and C3; all fourth enter C2, C3, D3. Found three specific accession only in type C2 and C3 and most of the ‘uwi’ plants have distribution in all types of climates, showing broad adaptability and potential to be developed without high technology. The colours, shapes, flavours, and feathers of the tubers are the main differentiators in existing diversity.

**Keywords:** Distribution, diversity, germplasm, local variety, uplands.

### 1. Introduction

Efforts to realize food self-sufficiency should not be oriented only to rice and wheat but must also be supported by other types of strategic commodities other carbohydrate sources such as tubers which are abundantly available in Indonesia. The diversity of people's food consumption will have an impact on the stability of food security, especially with the empowerment of specific commodities as a source of local food [1]. In addition, the fact shows that the quality and quantity of paddy fields continue to narrow by land conversion, and the upland and critical land area continues to increase. Currently, around 40 % of the world's agricultural land is the uplands, and in Indonesia occupying about 50 % of Indonesia's land. This condition is a potential land to support food security if appropriately managed, as well as using adequate commodities and cultivation systems. Currently, the uplands farming is dominated by field rice (*Oryza sativa* Linn.), corn (*Zea mays* Linn.), cassava (*Manihot esculenta* Crantz), and sweet potatoes (*Ipomoea batatas* Linn.). This is strongly influenced by the consumption pattern of foodstuffs in Indonesia, so that other potential crops are increasingly neglected and tend to



experience scarcity and even destruction. The real problem faced by Indonesia in relation to the primary food commodities is the very high dependence on rice, so that scarcity often occurs. Food security as a basic human need is thus very important and therefore requires intense implementation. Food security relations and sustainable agriculture development using local planning will result in multidimensional roles and impacts food security in terms of availability, access, and utilization [2].

One of the food security policies is the diversification of food consumption because food security that only depends on one type of food is very vulnerable to global environmental changes that have often occurred recently. Uwi plants (*Dioscorea alata* Linn.) have a great opportunity in food diversification programs because they are tolerant of shade and drought, so they are suitable for development on upland [3]. Food insecurity can lead to malnutrition and social instability, and food sovereignty programs are also strategically linked to the implementation of the Asean Economic Community (MEA) in late 2015.

Dioscoreaceae family tubers are a food crop with strong climate resilience and widely cultivated in India and Africa. In India, one of the primary species of tubers is the 'uwi' plant. This plant provides an excellent source of carbohydrate diet in the tropics and subtropics [4]. This condition is a potential land to support food security if appropriately managed, as well as using adequate commodities and cultivation systems. Currently, the uplands farming is dominated by field rice, corn, cassava, and sweet potatoes. This is strongly influenced by the consumption pattern of foodstuffs in Indonesia, so that other potential crops are increasingly neglected and tend to experience scarcity and even destruction. The real problem faced by Indonesia about the primary food commodities is the very high dependence on rice, so that scarcity often occurs. This scarcity did not happen because not all regions in Indonesia consumed rice and stayed with their primary food so that imports of staple rice could be eliminated or minimally reduced [2].

Indonesia has many types and varieties of potential tubers as alternative food ingredients. Indonesia has many types of plants that produce tubers that used to be consumed by our ancestors. Tubers, one of which is the 'uwi' which is produced by four different types of plants but classified in the same genus, namely *Dioscorea*. Members of the genus *Dioscorea* generally consist of climbing shrubs with heart-shaped leaves such as betel leaf, kidney, ovate, to round elongated. The genus *Dioscorea* produces tubers in the soil, but some of them also have aerial bulbs. Germplasm is the fourth natural resource other than water resources, land and air resources that are important to be conserved. In the field of agriculture, germplasm is widely studied and collected to improve agricultural products and food supply because germplasm is a source of genes that are useful for plant improvement such as genes for resistance to diseases, insects, weeds, and genes for resistance to abiotic environmental stresses. There are two methods of germplasm conservation, namely preservation, namely in situ and ex-situ. In situ conservation is a way to conserve germplasm in the community. Ex-situ preservation is a way of conservation by removing germplasm from its container, its ecosystem or biota. Indonesia's wealth in biological resources is very diverse, and there is much germplasm of native plants in the form of food crops and spice plants that are very potential to be developed and conserved [5]. The results of exploration in five regencies from the residency of Madiun (East Java) showed that 'uwi' plants have been very rarely cultivated and are prone to extinction. However, the exploration results still get the most results in Pacitan Regency (East Java), which is 44 accession [6].

Food diversification programs have not been able to succeed entirely because the community's attachment is powerful with rice consumption [7]. Rice and flour are the most common source of carbohydrates consumed by the community while, Indonesia is rich in other carbohydrate sources such as cassava, corn, sorghum (*Sorghum bicolor* Linn.), sago (*Metroxilon sagu* Rottb.), taro (*Colocasia esculenta* Linn.) and other tubers [8]. Therefore, to meet nutritional needs, people should consume other carbohydrate sources besides rice. The results of the research showed that in Nigeria the production and consumption of 'uwi' continued to increase from 1996 to 2006 with a relative increase of more than 400 %, which showed the potential of 'uwi' as a future food ingredient increasingly important [9]. Whereas to obtain high production, planting early in the season is highly recommended [10]. Indonesia as an archipelagic country that has a variety of ecosystems is very suitable if the staple

food of the population is diverse. Provision of food according to the potential of each region will significantly facilitate the community because the community can meet food needs with what is available in the area Hubeis, 2012 in [11]. Attention to the development of carbohydrate source commodities other than rice is still very lacking, even though local carbohydrate food ingredients as a companion of rice vary in number. Rice, which has dominated the community, seems to close other commodity development opportunities. This scarcity did not happen because not all regions in Indonesia consumed rice and remained with the primary food so that imports of staple rice could be eliminated or minimally reduced. The results showed that ‘uwi’ had a low GI (glycemic index) value (22.4) much lower than rice ( $> 34$ ). This value is except for the type of ‘gembili’ (*Dioscorea esculenta* (Lour.) Burkill) which has an IG value of 85 [13]. So that this food is very healthy and suitable for sufferers or people who are potentially affected by diabetes. Looking at these various benefits, it is essential that conservation efforts and development of local plant resources are of great value for future agricultural development. Production was majorly constrained by lack of capital, scarcity/high cost of seed yams, a high cost of labor and pests and diseases infestation [15]. So observation activities and collection of ‘uwi’ plants and other tubers plants are urgently needed so that there is no loss.

## 2. Materials and methods

### 2.1. Place and time

The study was conducted in November 2017–July 2018, located in the station Research of the Faculty of Agriculture, Merdeka University, Madiun, Indonesia.

### 2.2. Materials and tools

Materials and tools used in the study include seedling materials from previous explosions collected by the Faculty of the Agriculture University of Merdeka Madiun, observation equipment including calipers, standard shapes, and colours of tubers, rulers, cooking utensils and tools of organoleptic tests. The plant accession used for analysis material is in table 1.

### 2.3. Research methods

The study began with planting under controlled environmental conditions of a pot system (80 cm diameter) filled with uniform media. Observations were made on the character of the bulb, the shape of the tuber, the cooking of tubers, the number of tubers, the branching of tubers, the relationship between tubers, the outer skin color, the color of the deep skin, the surface of the skin, the color of tuber flesh, the fiber of the meat, the taste of ripe tubers, the tenderness of tubers, the weight, length, diameter, embedded tubers and roots in tubers. Figure 1 to figure 3 shows the standard shape, branching, and colour of tubers used.

### 2.4. Data analysis

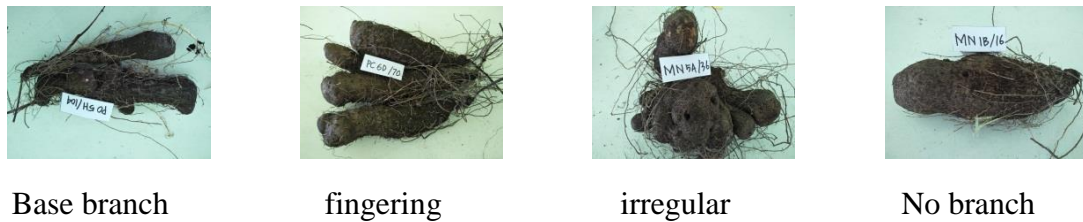
To identify the distribution of plants and traces of species suspected as local varieties, the distance similarity test was used using the application similarity interval NTSys function with the output produced in the form of a dendrogram, a graph that shows the level of similarity of plants based on the observed botanical characters. The input of plant botanical data is made by giving a value of “1” if the botanical character is fulfilled, and “0” if it is not met. In the next stage, the dendrogram used as a basis for grouping 47 ‘uwi’ accession where each group has its general characteristics.



**Figure 1.** The standard of tuber’s shape.

**Table 1.** Kinds of accession to be testing.

Number	Code	Region origin (village, subdistrict, regency)	Local name
1	MG1B	Cileng, Poncol, Magetan	Uwi Ungu
2	MG2A	Bulak, Bendo, Magetan	Uwi Berasan
3	MG6A	Pojok Sari, Sukomoro, Magetan	Uwi Ulo
4	MG7A	Jomblang, Takeran, Magetan	Uwi Ungu
5	MG7B	Jomblang Takeran, Magetan	Uwi Ungu
6	MN2D	Tawangrejo, Gemarang, Madiun	Uwi Kuning
7	MN3C	Nggempol, Kare, Madiun	Uwi Sepat
8	MN6B	Duren, Pilangkenceng, Madiun	Uwi Ungu
9	MN6C	Duren, Pilangkenceng, Madiun	Uwi Berasan
10	MN7E I	Kampungbaru, Saradan, Madiun	Uwi Kuning
11	MN7E II	Kampungbaru, Saradan, Madiun	Uwi Kuning
12	MN7G	Saradan, Kampungbaru, Madiun	Uwi Kuning
13	MN7H	Pajaran, Saradan, Madiun	Uwi Kuning
14	NG3B	Katikan, Kedunggalar, Ngawi	Uwi Putih
15	NG3C	Katikan, Kedunggalar, Ngawi	Uwi Putih
16	NG5B	Gunungrambut, Pitu, Ngawi	Uwi Senggani Putih
17	PC2E	Jeruk, Bandar, Pacitan	Uwi Ketan
18	PC2G	Tumpuk, Bandar, Pacitan	Uwi Omah
19	PC4A	Kebon Agung, Kebon Agung, Pacitan	Uwi War
20	PC4B	Kebon Agung, Kebon Agung, Pacitan	Uwi Butun
21	PC4C	Kebon Agung, Kebon Agung, Pacitan	Uwi Kuning
22	PC5A	Sidomulyo, Ngadirojo, Pacitan	Uwi Dlajar Ungu
23	PC5B	Sidomulyo, Ngadirojo, Pacitan	Uwi Beras
24	PC5C	Sidomulyo, Ngadirojo, Pacitan	Uwi Alas
25	PC6A	Ngromo, Nawangan, Pacitan	Uwi Senggani Kuning
26	PC6C	Pakisbaru, Nawangan, Pacitan	Uwi Putih
27	PC7A	Sedeng, Pacitan, Pacitan	Uwi Kuning
28	PC7F	Sedeng, Pacitan, Pacitan	Uwi Ungu
29	PC9DI	Soko, Punung, Pacitan	Uwi Beras
30	PC9DII	Soko, Punung, Pacitan	Uwi Beras
31	PC9E1	Soko, Punung, Pacitan	Uwi Dlajar
32	PC9EII	Soko, Punung, Pacitan	Uwi Beras
33	PC11A	Ngumbul, Tulakan, Pacitan	Uwi Uyah
34	PC11C	Ngumbul, Tulakan, Pacitan	Uwi Senggani Kuning
35	PO2A	Kalisat, Bungkal, Ponorogo	Uwi Senggani
36	PO5A	Cepoko, Ngrayun, Ponorogo	Uwi Beras
37	PO5B	Cepoko Ngrayun, Ponorogo	Uwi Banglit
38	PO8B	Carangrejo, Sampung, Ponorogo	Uwi Senggani Ungu
39	PO8K	Ringin Putih, Sampung, Ponorogo	Uwi Beras
40	PO8LI	Ringin Putih, Sampung, Ponorogo	Uwi Lader
41	PO8LII	Ringin Putih, Sampung, Ponorogo	Uwi Sepak
42	PO8M	Ringin Putih, Sampung, Ponorogo	Uwi Lus
43	PC9A	Kendal, Punung, Pacitan	Uwi Ulo
44	PO5F	Ringin Putih, Sampung, Ponorogo	Uwi Lus
45	MN4G	Bulu, pilangkenceng, Madiun	Uwi Putih
46	PC1A	Arjosari, Arjosari, Pacitan	Uwi Omah
47	MG1A	Cileng, Poncol, Magetan	Uwi SLuku



**Figure 2.** The standard of tuber's branch



**Figure 3.** The standard of tuber's colour.

### 3. Result and discussion

#### 3.1. Observation results

The results of qualitative observations on eighteen botanical tubers of 'uwi' characters in four agro-climate regions of ex-Madiun residency showed a high diversity based on the observed characteristics.

The dendrogram obtained shows that each 'uwi' tuber characterized by a typical tuber botanical character and has a different level of similarity. Uwi with the same variant still shows the same characteristics, so that you can group them with other root tubers that come from the more similar characteristics of different places. On the other hand, there are 'uwi' with special properties that only exist in specific areas and are suspected of being native to the agro-climate region. The benefit of this grouping, the higher the similarity value, the closer the kinship relationship is [15].

#### 3.2. Diversity analysis

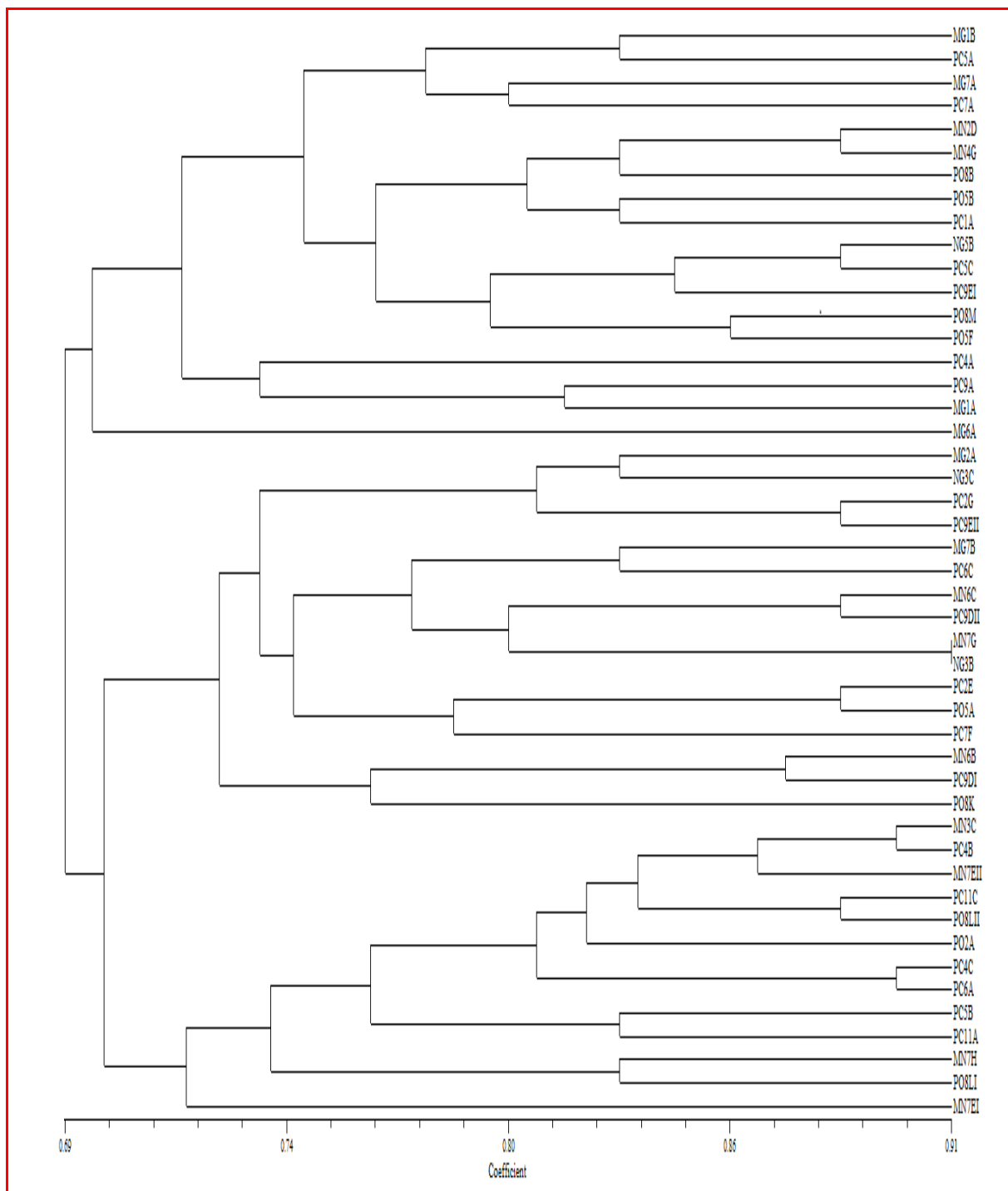
Identification of 'uwi' as the result of observations in five districts of Madiun residency was 127 accessions and after initial identification obtained 47 'uwi' plant groups were observed from various regions. Further testing of 47 of these plantations by planting in controlled environmental conditions resulted in the dendrogram as follows in figure 4.

In figure 4, it can be seen that the 70 % similarity level only obtained by four groups with different distribution. Mention that the farther the kinship relationship between the accession, the smaller the success of crosses, but the possibility of obtaining superior genotypes is more significant if crosses are successful. There is a broad distribution of three agro-climate (B2, C2, and C3) regions in the first group, which indicates that the 'uwi' species of the group have broad and adaptive adaptations to wet months > 5 mo. Widespread distribution with different distribution areas found in the 4<sup>th</sup> group (C2,

C3, and D3) indicating that members of this group are relatively suitable on wet months which are only 3 mo to 4 mo. In group 3<sup>rd</sup>, the accession was able to adapt to two agro-climate regions, namely (C2 and C3). Whereas the 2<sup>nd</sup> group consists of 1 accession (MG6A) from Magetan which is capable of adapting to the C2 agro-climate region. This condition shows that 'uwi' is mostly adaptive to 5 to 6 wet mon. C2 and C3 climate types are the types that dominate the climate in the western part of East Java (figure 5) There is one accession from Pacitan which is a specific type with a unique characteristic of light yellow meat and not tasty savoury meat. This character is not possessed by 46 other accessions so that it is considered as a type with specific characteristics. Yellow 'uwi' in the community has no economic value at all. One of the causes is relatively high of water content so that the starch content is low [15].

**Table 2.** Kind and criteria of observed parametres

NO	Parameter	NO	Parameter	NO	Parameter
1	AERIAL BULB Present/not present	8	INSIDE SKIN white	12	TUBER'S TASTE nondelicious
2	TUBERS SHAPE oval round elongated irregular		white blush yellow orange red orang red		more delicious delicious sweet delicious most delicious
3	HARVEST 6 months (7 to 8) mo (9 to 10) mo		purple old purple	13	TEXTURE low moderate high
4	TUBER'S AMOUNT 1 tuber (2 to 5) tubers > 5 tubers	9	SKIN SURFACE rough smooth	14	TUBER'S WEIGHT < 1 kg (1 to 2) kg (2 to 3) kg > 3 kg
5	TUBER'S BRANCH fingering from base irregular no branch	10	TUBER'S COLOUR white cloudy white white blush light yellow yellow old yellow yellow blush	15	TUBER'S LENGTH < 25 cm (25 to 50) cm > 50 cm
6	TUBER'S CONNECTION separate adjacent adhere on base		light purple purple old purple purple blush	16	TUBER'S DIAMETRE < 5 cm (5 to 10) cm > 10 cm
7	OUTER SKIN brown light brown old brown black	11	TUBER'S FIBRE rough smooth	17	TUBER'S DEEP shallow moderate deep
				18	TUBER'S ROOT smooth, many smooth, little crude, more crude, little

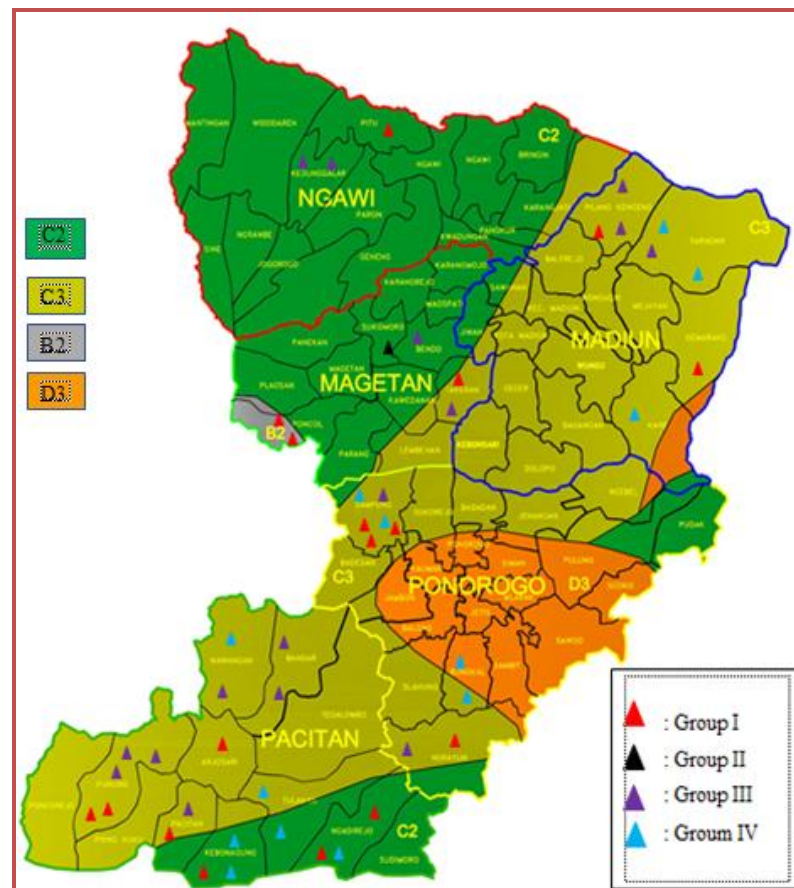


**Figure 4.** Dendrogram of 47 accession distance similiraty.

Analysis on 75 % similarity level produces 12 groups with a higher level of similarity. Of all the groups presented, there were three groups with only one member (PC4A, MG6A, and MN7E) from Pacitan, Magetan, and Madiun. This assumption is suspected to be a local variety from the region, with agro-climates of type C2 and C3 respectively, while other groups have a wider distribution. The uniqueness is in group 12 with only one, namely the accession from Pacitan Regency (PC4A), which is known as a pure white bulb that can be a local variety from the region, while other groups have an average of more than one climate regions, namely (C2 and C3). Whereas the 2<sup>nd</sup> group consists of one



accession (MG6A) from Magetan which is capable of adapting to the C2 agro-climate region. This condition shows that 'uwi' is mostly adaptive to 5 to 6 wet mon. C2 and C3 climate types are the types that dominate the climate in the western part of East Java (figure 5) There is one accession from Pacitan which is a specific type with a unique characteristic of light yellow meat and not tasty savoury meat. This character is not possessed by 46 other accessions so that it is considered as a type with specific characteristics. Yellow 'uwi' in the community has no economic value at all. One of the causes is relatively high in water content so that the starch content is low [15].



**Figure 5.** 'uwi' distribution by agro-climatic

#### 4. Conclusion

From this study resulted that *Dioscorea alata* type of 'uwi' plants in four agro-climate areas scattered in the area of ex-residency of Madiun still shows a high level of diversity based on the physical character and morphology of the tuber. The analysis on the 70 % similarity level indicates that there is one specific accession that is very different from the other, namely the accession from Magetan with unique characteristics of yellow light bulbs and less preferred taste. The analysis of the 75 % similarity level shows that there are three specific accessions that are very different from the other, namely accession from Magetan, Pacitan, and Madiun. The accession from Pacitan with unique characteristics of white bulbs blossoming with the preferred flavour, likewise, the originator of Madiun has a clean white colour with a taste that is preferred so that both of these specific accessions have the potential to be developed for food. Open opportunities for further research to identify more deeply and obtain various types of preparations for food diversification.

## References

- [1] Sibuea S M, Kardhinata E H and Syafruddin I. 2014 Identifikasi dan inventarisasi jenis tanaman umbi-umbian yang berpotensi sebagai sumber karbohidrat alternatif di Kabupaten Serdang Bedagai [Identification and inventory of tubers that have the potential as an alternative carbohydrate source in Serdang Bedagai Regency] *Jurnal Online Agroekoteknologi* **2**(4) 1408–18 [in Bahasa Indonesia]  
<https://jurnal.usu.ac.id/index.php/agroekoteknologi/article/view/8434>
- [2] Noer M 2016 Bridging food security and sustainable agriculture development through regional planning *Int. J. Adv. Sci. Eng. Inf. Technol.* **6**(3) 277–80  
[http://insightsociety.org/ojaseit/index.php/ijaseit/article/viewFile/741/pdf\\_167](http://insightsociety.org/ojaseit/index.php/ijaseit/article/viewFile/741/pdf_167)
- [3] Athira J, Sheela M N, Radhika N K, Anwar I, Kumar V and Abhilash P V 2017 Morphological characterization of greater yam (*Dioscorea alata* L.) landraces in Kerala *Journal of Root Crops* **43**(1) 3–10  
<http://isrc.in/ojs/index.php/jrc/article/view/449>
- [4] Sahusilawane A M, Kembauw E and Matulesy F 2011 Pelestarian plasma nutfah tanaman pangan secara tradisional dalam menjaga ketahanan pangandi pulau Kisar Kabupaten Maluku Barat Daya Provinsi Maluku [Traditional preservation of germplasm in maintaining food security in the islands of Kisar, Southwest Maluku District, Maluku Province] *Prosiding Seminar Nasional Pengembanagan Pulau-Pulau Kecil* 155–62 [in Bahasa Indonesia]  
<http://ejournal.unpatti.ac.id>
- [5] Wuryantoro and Arifin M 2017 Explorasi dan identifikasi tanaman umbi-umbian (ganyong, garut, ubi kayu, ubi jalar, talas dan suweg) di wilayah lahan kering kabupaten Madiun [Exploration and collaboration of tubers (canna, arrowroot, cassava, sweet potato, taro and suweg) in the dry land area of Madiun district] *Jurnal Agri-Tek.* **18**(2) 72–79 [in Bahasa Indonesia]  
<http://unmermadiun.ac.id/ejurnal/index.php/agritek/article/view/295>
- [6] Rachman 2008 Penganekaragaman konsumsi pangan Di Indonesia: Permasalahan dan implikasi untuk kebijakan dan program [Diversifying food consumption in Indonesia: Problems and implications for policies and programs] *Jurnal Analisis Kebijakan Pertanian* **6**(2) 140–54 [in Bahasa Indonesia]  
<https://www.neliti.com/publications/69111/penganekaragaman-konsumsi-pangan-di-indonesia-permasalahan-dan-implikasi-untuk-k>
- [7] Budijanto S and Yuliyanti 2012 Studi persiapan tepung sorgum (*Sorghum bicolor* L. Moench) dan aplikasinya pada pembuatan beras analog [Preparatory study of sorghum flour (*Sorghum bicolor* L. Moench) and its application in the manufacture of analog rice] *Jurnal Teknologi Pertanian* **13**(3) 177–86 [in Bahasa Indonesia]  
[https://www.researchgate.net/publication/285651587\\_Studi\\_persiapan\\_tepung\\_sorgum\\_dan\\_aplikasinya\\_pada\\_pembuatan\\_beras\\_analog](https://www.researchgate.net/publication/285651587_Studi_persiapan_tepung_sorgum_dan_aplikasinya_pada_pembuatan_beras_analog)
- [8] Regina H Y, Fu, Hidehiko K and Makoto M 2011 Research on yam production, marketing and consumption of Nupe farmers of Niger State, Central Nigeria *African Journal of Agricultura Research* **6**(23) 5301–13  
[http://www.academicjournals.org/app/webroot/article/article1380903959\\_Fu%20et%20al.pdf](http://www.academicjournals.org/app/webroot/article/article1380903959_Fu%20et%20al.pdf)
- [9] Tobih F O, Okonmoi L U and Omoloye A A 2011 Assesment of yield potensials and damage of yams in uncontroled upland yam monocrop system with varying planting dates in Oshimili Area of Delta State, Nigeria *International Journal of Agriscience* **1**(3) 178–84  
<https://www.cabdirect.org/cabdirect/abstract/20123239776>
- [10] Santoso A D, Warji, Novita D D and Tamrin 2013 Pembuatan dan uji karakteristik beras sintetis berbahan dasar tepung jagung [The production and characteristics test of synthetic rice made of maize flour] *Jurnal Teknik Pertanian Lampung* **2**(1) 27–34 [in Bahasa Indonesia]  
<https://media.neliti.com/media/publications/134571-ID-none.pdf>

- [11] Puspita Sari I, Lukitaningsih E, Rumiati and Setiawan I M 2013 Glycaemic index of uwi, gadung, and talas which were given on rat *Trad. Med. J.* **18**(3) 127–31  
<https://journal.ugm.ac.id/TradMedJ/article/view/8196>
- [12] Fatimah S 2013 Analisis morfologi dan hubungan kekerabatan sebelas jenis tanaman salak (*Salacca zalacca* (Gertner) Voss) Bangkalan [Morphological analysis and kinship relationship of eleven species of zalacca (*Salacca zalacca* (Gertner) Voss) Bangkalan] *Agrovigor* **6**(1) 1–11 [in Bahasa Indonesia]  
<http://journal.trunojoyo.ac.id/agrovigor/article/view/1460/1250>
- [13] Julisaniah N I, Sulistyowati L and Sugiharto A N 2008 Analisis kekerabatan mentimun (*Cucumis sativa* L.) menggunakan metode RAPD-PCR dan isozim [Kinship analysis of cucumber (*Cucumis sativa* L.) using the RAPD-PCR and isozyme methods] *Biodiversitas* **9**(2) 99–102 [in Bahasa Indonesia]  
<http://biodiversitas.mipa.uns.ac.id/D/D0902/D090205.pdf>
- [14] Afidin M N, Hendrawan Y and Rini Yulianingsih 2014 Analisis sifat fisik dan kimia pada pembuatan tepung umbi uwi ungu (*Discorea alata*), uwi kuning (*Discorea alata*) dan uwi putih (*Discorea alata*) [Analysis of physical and chemical in making purple yam flour (*Discorea alata*), yellow yam (*Discorea alata*) and white yam (*Discorea alata*)] *Jurnal Keteknik Pertanian Tropis* **3**(2) 297–303 [in Bahasa Indonesia]  
<http://jkptb.ub.ac.id/index.php/jkptb/article/view/234>
- [15] Omojola 2014 Cost–return analysis of upland yam production in Ekiti State, Nigeria *Adv. J. Agric. Res.* **2**(6) 99–103  
<http://fliphtml5.com/ocso/wdjl/basic>