Yield test of 13 accession groups of Yam (*Dioscorea alata* L.) on three various agroecology

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Abstract. The Yam (*Dioscorea alata* L.) as one of the varieties of the "uwi" plant has the potential to support food diversity and food security in the future. This plant is very tolerant to be planted on dry land which in Indonesia is abundant even in the world. The purpose of this study was to obtain alternative types of non-rice food from Uwi, starting with the identification of the variation and multi-location yield test to see the adaptation of each accession were obtained at various upland agro-system, Cluster analysis on plant diversity based on tuber morphological properties obtained 13 groups with 80% similarity level. While the results of adaptation tests indicate that Yam generally can adapt to various agro-ecological, but only a few accession can grow well under teak stands, especially those with large trunks and tubers. The best yield is in the upland of highlands of the Ponorogo region, followed by the lowlands of Madiun and the lowest under teak stands. However, certain types can adapt to a broad spectrum of agroecology.

1. Introduction

The serious problem faced by Indonesia in relation to the main food commodities is the dependence on rice so that crop scarcity and disruption often occur due to the vulnerability of the agricultural and ecological function. The narrowing of irrigated agricultural land is exacerbated by the deterioration of soil health, worrying about food security in the future. The global estimate of total degraded areas varies from 1 billion hectare to more than 6 billion hectare [1]. This number is prone to support population growth which currently reaches 7,626,699,925 people and is predicted to reach 10 billion in 2050 [2]. In Indonesia, land that has been heavily degraded and becomes a critical area has reached around 48.3 million hectare or 25.1% of the total area of Indonesia [3]. Director General of Food Crops Ministry of Agriculture (Ministry of Agriculture) admitted Paddy fields in 2017 decreased by 413,727 hectares compared to 2016, with details in 2016 covering 5,241,597 hectares and 2017 covering 4,827,872 hectares. Such conditions will make rice-based food security quite risky, so alternative food ingredients must be sought besides the current conventional [4]. The relationship between food security and sustainable agricultural development using local wisdom will result in a multidimensional role affecting food security in terms of availability, access and utilization [5]. The Central Statistics Agency (BPS) said that Indonesia always imported rice from 2000 to 2015 or for 15 years. Meanwhile, in 2016 to 2017 the government stopped importing rice and in 2018 Indonesia imported rice again. For 15 years, Indonesia imported 15.39 million tons. So, with the total amount of rice imported and added 500,000 tons this year, until now Indonesia has imported 15.89 million tons of rice. Thus efforts to increase food self-sufficiency become unwise if only oriented to rice and wheat. Support for other strategic commodities such as tubers, and food-producing trees such as sago, oil palm and other multipurpose trees must enter the realm of food policy.
Food stability will last if people’s consumption comes from various available sources, God’s grace is omnipotent. Food-related research must emphasize food availability, accessibility and security, and not only stimulate intensification technology to increase the production of certain commodities, especially rice. The fact shows that increasing rice productivity is very dependent on government policy facilities, one of which is credit for agriculture which has a positive impact on rice productivity. Therefore, the Government’s policy to expand access to credit markets for farmers is the key to implementing food security programs [6]. However, irrigated land areas that continue to shrink become serious threats because it is complicated to avoid. Therefore, efforts to manage resources effectively and efficiently are also the key to sustainable food security. Agriculture, food and nutrition education is also needed to understand how to manage nutrition and disease more effectively and efficiently [7]. Experiences show, this concern does not occur because not all regions in Indonesia consume rice but they have the main foods such as cassava, corn and sago. Indonesia as an archipelago with a vast variety of ecosystems, suitable for various kinds of food crops as the staple food of its population. Hubeis, 2012 in [8] shows that the provision of food in accordance with the potential of each region will significantly facilitate the community because it can meet food needs with what is available in the area. While dependence on rice causes the exploitation of irrigated land to deteriorate so quickly. This condition led to the increasingly important role of dry land as a supporter of food products, especially diversification into non-rice. Upland areas can become potential lands that support food security if appropriately managed, as well as adequate cultivation systems.

The high diversity of yams (D. alata) as one species of “uwi” (Dioscorea family) is also possible to adapt to various agro-ecological conditions. The results of research in the uplands of five districts of the Madiun Residency were obtained by 13 groups of D. alata and 6 non-alata groups [9]. The number of types of yams obtained motivated to conduct more in-depth studies. There is no single food in the world that contains all the nutrients that the body needs ideally. Therefore, to meet nutritional needs, people must consume carbohydrate sources other than rice. Indonesia has many types and potential of tubers as alternative food to substitute for rice. Indonesia has many kinds of tubers-producing plants consumed by our grandparents. From the study, it was found that yam are the primary staple food consumption, the source of income and job creation in Benue State Nigeria. There is no single food in the world that contains all the nutrients your body needs ideally. Therefore, to meet nutritional needs, people must consume carbohydrate sources other than rice. Indonesia has many types of tuber-producing plants that our grandparents consumed as a substitute for rice. From the research, it was found that uwi is the consumption of staple foods, sources of income and job creation in Benue State Nigeria [10]. The research so showing that in Nigeria the production and consumption of yam continued to increase from 1996 to 2006 with a relative increase of more than 400%, indicating that the potential yam as food for the future is increasingly important. While to get high production, planting early in the season is highly recommended [11], [12]. Even in Nigeria, yam is an essential plant as a source of nutrition, socio-culture and economic value [13]. Here, the primary production is constrained by lack of capital, high scarcity/cost of seeds, labor and pests and diseases [14]. The study results of Boutau Yam showed that the optimum harvest time was the ninth month after sowing, and gave the highest energy value in the form of carbohydrates and dry matter [15]. Research in the ex-residency of Madiun also shows that yam is the most diverse species with wide distribution [16].

Attention to the development of commodities other than rice is still very lacking, due to rice that has dominated the community as if to close opportunities for the growth of other products. As an illustration, analog rice from sweet potatoes with cassava flour and carrots [17] uwi tuber also contains a low glycemic index value. The study of the glycemic index in purple sweet potato as a food reference is 67 which fall into the moderate food category [18]. The experiment showed that uwi had a low glycemic index (22.4) much more moderate than rice (> 34). This value is except for the type of gembili (D. acuelata) which has an IG value of 85. So this food is very healthy and suitable for sufferers or people with potential for diabetes [19]. The purpose of this study was to obtain alternative types of non-rice food from Uwi, starting with the identification of the variation and multilocation yield test to see the adaptation of each accession were obtained at various upland agrosystem,
2. Material and Methods

2.1. Time and place
The experiments were carried out in three upland agro-ecologies in Madiun, 64 m above sea level altitude, upland under teak-forest stands in the Bojonegoro region, an altitude of 150 m above sea level and upland in Ponorogo district altitude 700 m above sea level. The study was conducted in the rainy season November 2016 until July 2017.

2.2. Materials
The experimental material used tubers multiplication which had begun in October 2016 from 105 samples of exploration results the previous year. Organic fertilisers and NPK chemical fertilisers are used to obtain optimal growth for plants. Basic equipment and observation equipment in the form of standard colours of leaves, stems, tuber skins, tuber meat and weighing scales are used in this study.

2.3. Research method
The experimental method using Randomized Block Design uses different locations as groups. Data were analyzed using the SPSS application to see the cluster of accession and differences between treatment and adaptation differences for each accession group.

3. Result and Discussion

3.1. Diversity of Yam accession
The results of observations of yam in the five districts of Madiun Residency were obtained 127 accessions and after being identified by planted in a controlled environment obtained 13 groups of accession based on morphological parameters of tubers. A large variety of results indicate that yams has high genetic diversity which is a potential source of germplasm to produce useful products. The results of cluster analysis using SPSS application shows in Table 1.

3.2. Yield test analysis
Yield test in three different locations were carried out in 13 groups of cluster analysis results based on tuber characteristics, the results are presented in Table 2. Types of yam incorporated in groups I, VIII, IX and XIII (C1, C8, C9 and C13) are more suitable for planting in mountainous upland and can still adapt in the lowlands or under teak stands. This type is generally characterized by a specific big stem diameter > 1 cm, so it is firm to wrap around large windings like teak trees to reach the top of the teak canopy. The types of yam incorporated in groups II, III, VI and VII, XI and XII (C2, C3, C4, C7, C11 and C12) are less tolerant to be planted under forest stands and there is no significant difference between mountains upland and lowlands. This type has a smaller stem diameter, but it have more branch. While the kinds of yam incorporated in groups IV, V and X (C4, C5 and C10) show significant differences in three different locations, and are best found in mountain upland. This type is characterized by many branches even though the stem diameter is relatively small. The studies so show that starch of purple and yellow yam grown in Jambi Province has different physical properties. Starch of purple bulb has lower swelling power but higher solubility than starch of yellow tuber [20].

Generally, this shows that the ability to adapt and produce of yam is strongly influenced by type groups. Large stem species are relatively able to adapt to the forest that stands because of their ability to wrap around teak trees to reach the light above the teak canopy. While relatively small stem species are not able to wrap around large trees. while in the open with relatively small poles of all types can adapt well, and depend on technical cultivation that still requires further study. Like in Nigeria uwi as a staple food [10], with this potential the Yam can be developed for alternative food and non-rice food diversification in the future. The Yam production and consumption in Nigeria, which continued to increase from 1996 to 2006 with a relative increase of more than 400%, indicates that the yam is potential as a food ingredient for the future. While to get high production, planting early in the season is strongly recommended [11], [12].
### Table 1. Cluster analysis results with 75 percent level of similarity.

| Cluster | Cluster Member | Specific Feature |
|---------|----------------|------------------|
| C1      | MN 6K, MN 6O, PO 8P, PO5A, PC 10C, MG 1B, NG 3B, PC 3A, PC 5A | Irregular shape, white flesh color, yellow-orange |
| C2      | MN 2B, PC 10A, MG 5C, PO 8I, MG 6A, NG3A, MG 2D, PC 2G, PC8C, MN 7E | Long-elongated shape, yellow-orange, hairy, large bulb |
| C3      | MG 6C, PO 8M, PC 9C, PO 8O, MG 1A, PC 1A | White color, oval shape, base branch |
| C4      | PC 2B, PO8L, MN 7A, NG 1A, NG 2A, PC2E | Yellow-orange color irregular shape, large tuber size |
| C5      | PC9A, PC 5B, PC 7A, MN 7G, PC 4B | Yellow-orange color irregular rounded shape |
| C6      | PC7C, MG 2B, MN 2C, NG 5A, PC5C, PC2C, PC1C, MN 1A, MN 6H | White color oval shape |
| C7      | MG 2E, MN 2D, PC8D, MN 6B, PC 6A | Yellow color irregular shapes |
| C8      | MN 6J, PC 2A, PC4A, PC 2K, PO 9B, PC6E, PC 11C, PC 2H | White-yellow color is not branched |
| C9      | PO 3A, PC 11A, MN6G, PC 6B | Color yellow-flat rounded shape |
| C10     | PC 4C, MN 6L, PC9E, MN 2A, MN 7H, MN 7F, PO 8B, MN6N, MG 5D, PO 2A, MG 6E, PC7F, MG 7A, PO5B, MN4A, MG 7B, MN 3B, PC 11B | The purple color is round-shaped elongated |
| C11     | NG 5B, PC 2J, MN 3C, MN 1B, PO9G, PC6D, PC8B, PO9H, MN 6F, MN3A, PC6C, PO7A | White color - white purple forked motifs, branch from the base |
| C12     | PO 8N, MN 3D, PC1B | Irregular yellow color, large bulb |
| C13     | PC 11D, PC 10B, MN9D, PO8K, PC8E, PO 1B, MG 2A, PC9D, PO1D | Purple-white colorcolor |

**Notes:**
1) C1-C13: Cluster 1-13
2) Code means: MN = accession observation from Madiun District; NG = accession observation from Ngawi District; PC = accession observation from Pacitan District; MG = accession observation from Magetan District; PO = accession observation from Ponorogo District

**Figure 1.** The tuber’s sample of each accession group.
Table 2. The average yield (kg) between groups of accession.

| Cluster (C) | Block / Location | Means | Estimation productivity (t ha⁻¹) |
|------------|-----------------|-------|---------------------------------|
|            | I  | II | III |                               |                               |
| C1 (9 accessions) | 1.778 A | 3.500 B | 1.072 A | 2.117 b | 15.88 |
| C2 (10 accessions) | 2.376 B | 2.290 AB | 1.400 A | 2.022 ab | 15.17 |
| C3 (6 accessions) | 1.517 B | 1.790 B | 0.550 A | 1.286 a | 9.65 |
| C4 (6 accessions) | 1.932 B | 2.850 C | 1.100 A | 1.961 ab | 14.71 |
| C5 (5 accessions) | 1.240 B | 3.300 C | 0.338 A | 1.626 a | 12.2 |
| C6 (9 accessions) | 1.800 B | 2.482 B | 0.238 A | 1.507 a | 11.3 |
| C7 (5 accessions) | 2.380 B | 1.618 B | 0.228 A | 1.409 a | 10.57 |
| C8 (8 accessions) | 1.413 A | 2.389 B | 0.931 A | 1.578 a | 11.83 |
| C9 (4 accessions) | 1.875 A | 3.277 B | 0.550 A | 1.901ab | 14.26 |
| C10 (18 accessions) | 1.772 B | 3.281 C | 0.899 A | 1.984 ab | 14.88 |
| C11 (12 accessions) | 1.649 B | 1.550 B | 0.100 A | 1.100 a | 15.88 |
| C12 (3 accessions) | 0.90 AB | 1.100 B | 1.000 A | 1.211a | 15.17 |
| C13 (9 accessions) | 1.456 A | 1.989 B | 0.782 A | 1.409 a | 9.65 |

Notes:
Cluster 1-13
The numbers followed by same capital letters in the same row show no significant in Duncan's 5% test
The numbers in the means column followed by same lowercase letters show no significant in Duncan's 5% test
Estimation planting on (1x1.5)m²

4. Conclusion
From the study, it can be concluded:
Characterization of Yam (Dioscorea alata) based on tuber morphological characters there is still quite large variations. Of the 13 variants obtained, four groups are more suitable to be planted in mountain upland and can still adapt in the lowlands and under teak stands characterized by large tuber size and stems. Five groups are less tolerant to be planted under forest stands, and there is no significant difference between dry and mountainous lowlands. There are three groups that show significant differences in three different locations and are best in mountain upland.

References
[1] H. K. Gibbs and J. M. Salmon, “Mapping the world’s degraded lands,” Appl. Geogr., vol. 57, pp. 12–21, 2015.
[2] United Nations, “World Population Prospects The 2017 Revision Key Findings and Advance Tables,” World Popul. Prospect. 2017, pp. 1–46, 2017.
[3] W. dan A. Dariah, “Degradasi Lahan di Indonesia: Kondisi Existing, Karakteristik, dan Penyertaan Definisi Mendukung Gerakan Menuju Satu Peta,” J. Sumberd. Lahan, vol. 8, no. 2, pp. 81–93, 2014.
[4] Kementerian Lingkungan Hidup dan Kehutanan Republik Indonesia, “Statistik kementrian lingkungan hidup dan kehutanan,” Pasut data infomasi Jakarta. Jakarta, pp. 1–20, 2015.
[5] M. Noer, “Bridging Food Security and Sustainable Agriculture Development through Regional Planning,” Int. J. Adv. Sci. Eng. Inf. Technol., vol. 6, no. 3, pp. 277–280, 2016.
[6] E. Wicaksono, “The Impact of Agricultural Credit on Rice Productivity,” Int. J. Adv. Sci. Eng. Inf. Technol., vol. 4, no. 5, pp. 20–23, 2014.
[7] M. Aslam and S. Rasool, “Investigating the Impact of Major Variables Influencing Food Security in Lahore, Pakistan,” Int. J. Adv. Sci. Eng. Inf. Technol., vol. 4, no. 3, pp. 19–23, 2014.
A. D. Santoso and D. D. Novita, “Pembuatan dan Uji Karakteristik Beras Sintetis Berbahan Dasar Tepung Jagung [The Production and Characteristics Test Of Synthetic Rice Made of Maize Flour],” J. Tek. Pertan. Lampung, vol. 2, no. 1, pp. 27–34, 2013.

Wuryantoro, R. M. Wardhani, and I. Rekyani, “Plasma Nutfah Tanaman Uwi, Karunia Tuhan Yang Harus Diselamatkan,” in Prosiding Seminar Hasil Penelitian Tahun 2017, 2017, pp. 1–20.

V. Nahanga V, Becvarova, “Yam Production As Pillar Of Food Security In Logo Local Government Area Of Benue State , Nigeria,” Eur. Sci. J., vol. 10, no. 31, pp. 27–42, 2014.

F. O. Tobih and L. U. Okomah, “Assessment of yield potentials and damage of yams in uncontrolled upland yam monocrop system with varying planting dates in Oshimili area of delta state , Nigeria,” Int. J. AgriScience, vol. 1, no. August, pp. 178–184, 2011.

M. N. B. Agbarevo, “An evaluation of farmers’ adoption of yam mini -sett technique in cross - river state, nigeria,” Eur. J. Res. Soc. Sci., vol. 2, no. 3, pp. 1–9, 2014.

A. G. Ironkwe and R. Asiedu, “Women farmers in seed yam production : Implication for increased productivity and sustainable yam improvement in Southeastern Nigeria,” African J. Root Tuber Crop., vol. 11, no. 1, pp. 56–64, 2014.

Omohola, “Cost – Return Analysis of Upland Yam Production in Ekiti State , Nigeria,” Adv. J. Agric. Res., vol. 2, no. 006, pp. 99–103, 2014.

N. E. E, C. Billard, D. Péro, and S. Adenet, “Physicochemical , Nutritional And Sensorial Qualities Of Boutou Yam ( Dioscorea alata ) Varieties,” J. Exp. Biol. Agric. Sci. April, vol. 3, no. 2320, 2015.

Wuryantoro, Sukar, R. M. Wardhani, and I. Rekyani, “Eksplorasi Plasma Nutfah dan Pengembangan Uwi sebagai Upaya Menunjang Program Diversifikasi Pangan Non Beras. Laporan Penelitian,” Universitas Merdeka Madiun, Madiun, pp. 1–99, 2016.

T. Anggraini, V. J. Putri, - Neswati, and - Yuliani, “Characteristics of Red Sweet Potato (Ipomea batatas) Analog Rice (SPAR) From The addition of Cassava Flour (Manihot utilissima) and Carrot (Daucus carota),” Int. J. Adv. Sci. Eng. Inf. Technol., vol. 6, no. 5, p. 723, 2016.

E. Aritonang, A. Siagian, and F. Izzati, “Mixed cooked rice with purple sweet potato is potential to be the low glycemic index food and staple food alternative,” Int. J. Adv. Sci. Eng. Inf. Technol., vol. 7, no. 2, pp. 580–586, 2017.

I. M. S. Ika Puspita Sari1, Endang Lukitaningsih2, Rumiyati2 and 1, “Glycaemic Index Of Uwi , Gadung , and Talas Which Were Given On Rat,” Tradit. Med. Journal, vol. 18, no. September, pp. 127–131, 2013.

D. F. and S. Ulyarti, Lavlinesia, “The Study of Physical Properties of Dioscorea alata ’s Starch from Jambi Province,” Int. J. Adv. Sci. Eng. Inf. Technol., vol. 6, no. 4, pp. 456–459, 2016.

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