January 2022

THE SECOND INTERNATIONAL CONFERENCE ON GENETIC RESOURCES AND BIOTECHNOLOGY: Harnessing Technology for Conservation and Sustainable Use of Genetic Resources for Food and Agriculture

Committees: The Second International Conference on Genetic Resources and Biotechnology

Cite as: AIP Conference Proceedings **2462**, 010002 (2022); https://doi.org/10.1063/12.0008934
Published Online: 19 January 2022

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AIP Conf. Proc. 2462, 010002-1–010002-3; https://doi.org/10.1063/12.0008934
Published by AIP Publishing. 978-0-7354-4172-9/$30.00

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Cite as: AIP Conference Proceedings **2462**, 010001 (2022); https://doi.org/10.1063/12.0006897
Published Online: 19 January 2022

Preface: The Second International Conference on Genetic Resources and Biotechnology

The Second International Conference on Genetic Resources and Biotechnology, which is the continuation of the first event held in 2018, focuses on topics related to advances in biotechnology to create more opportunities for effective conservation and sustainable utilization of genetic resources for food and agriculture. This year conference's theme is Harnessing Technology for Conservation and Sustainable Use of Genetic Resources for Food and Agriculture. The conference was organized by Indonesian Agency for Agricultural Research and Development (IAARD), Ministry of Agriculture, Indonesia, in collaboration with Indonesian Biotechnology Consortium and held on 24th-25th of May 2021virtually due to the pandemic of COVID-19.

The conference aims to share and exchange current scientific information and technological developments on biotechnology and their applications for conservation and sustainable use of genetic, to encourage and promote quality, efficiency, and modernization of management and utilization of genetic resources, and to facilitate national and international collaboration among participants. There are five scopes discussed in this conference. They are effective management of conservation and sustainable use of genetic resources for food and agriculture, application of genomics and molecular markers for genetic resource conservation and crop adaptation to climate change, application of innovative crop improvement techniques for conservation and sustainable use of plant genetic resources for food and agriculture, plant cell and tissue culture for conservation and effective utilization of genetic resources, and the use of microbial genetic resources as biological control agents of agricultural pests and diseases, and for soil bioremediation.

Five speakers from the United States of America, Japan, India and Indonesia were invited to discuss about their expertise and knowledge on relevant subjects in the plenary sessions. This conference was attended by more than 100 participants including 75 presenters and 44 listeners worldwide. They came from diverse governmental, private, or academic institutions and also scientific communities. The presented materials have undergone peer review processes and only qualified papers were selected. Furthermore, all papers were subjected to double blind peer-review and expected to meet the scientific criteria of significance and academic excellence to be published in a conference proceedings indexed in a well-known, reputable service.

We would like to express our sincere gratitude to our speakers, presenters and all participants for their contributions in this conference. We would also like to express our appreciation for the generosity of our sponsors that support this conference: PT CropLife, PT ITS Science Indonesia, PT Fajar Mas Murni and PT Prima Instrument Analitika. Lastly, special thanks to all committee members for their exceptional work and contributions in the conference and publication.

Chair of Organizing Committee

Dr. Toto Hadiarto

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AIP Conf. Proc. 2462, 010001-1–010001-1; https://doi.org/10.1063/12.0006897
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Location: Bogor, Indonesia
ISBN: 978-0-7354-4172-9
Editors:
I Made Tasma, Dwinita Winkan Utami, Ika Roostika, Yadi Suryadi, Chaerani, Eny Ida Riyanti, Puji Lestari, Toto Hadiarto, Reflinur, Joko Prasetyono, Fatimah, Surya Diantina, Tru Puji Priyanto, Kusumawaty Kusumanegara, Wening Enggarini, Rerenstradika Tizar Terryana and Dani Satyawan
Volume number: 2462
Published: Jan 19, 2022
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Location: Bogor, Indonesia
ISBN: 978-0-7354-4172-9
Editors:

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The diversity of morpho-agronomic characters and identification of early maturity cassava (*Manihot esculenta* Crantz.) germplasm

Cite as: AIP Conference Proceedings **2462**, 020028 (2022); https://doi.org/10.1063/5.0075658
Published Online: 19 January 2022

Tinuk Sri Wahyuni, Kartika Noerwijati and Made J. Mejaya

The Diversity of Morpho-Agronomic Characters and Identification of Early Maturity Cassava (*Manihot esculenta* Crantz.) Germplasm

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Abstract. The breeding of cassava superior varieties requires the collection of germplasm support that accommodates various gene sources and has a wide variety of characters. This research was conducted to analyze morpho-agronomic characters of 100 cassava accessions, to examine its relationship to tuber yield, and to identify accessions with early maturity and high yield potential. The field experiment was carried out at the Muneng Experimental Station of ILETRI in 2019. The characters observed included 31 characters of leaves, stems, yields, and tuber yield components at 7 and 10 MAP. The results showed that most of the characters varied widely, except for petiole length, central leaf lobe length, stem diameter, distance between leaf scar, and number of marketable tuber at 7 MAP, and weight of marketable, unmarketable, and average tuber at 7 and 10 MAP. Path analysis showed that the number of total tubers per plant and the average tuber weight at 7 MAP had a large direct effect and a positive equal effect on the total. Meanwhile, the other 11 characters had less direct effect than the indirect effect through these two important characters. Tuber yield of 100 accessions harvested at 7 MAP was equivalent to 6.8–50.6 t/ha, with average of 28.8 t/ha. Meanwhile, it was between 8.0–68.4 t/ha at 10 MAP, with average of 38.1 t/ha. With K-mean cluster analysis, eight accessions were obtained having fresh tuber yield ranged of 39.6–50.6 t/ha and 46.20–67.20 t/ha at 7 and 10 MAP, respectively. The eight selected accessions were MLG 10361, MLG 10328, MLG 10292, MLG 10371, MLG 10353, MLG 10352, MLG 10360, and MLG 10308. Accessions identified with early maturity or high yield potential need further evaluation with repeated trials and evaluation of various other advantages.

INTRODUCTION

The breeding of superior varieties of cassava (*Manihot esculenta* Crantz.) requires the collection of germplasm support that accommodates various gene sources and has a wide variety of characters. Various cassava research institutions in the world have germplasm collections. The largest collection is managed by the *Centro Internacional de Agricultura Tropical* (CIAT), reaching 5,436 accessions [1] followed by International Institute of Tropical Agriculture (IITA) with 2,544 accessions [2]. Indonesia has about 954 cassava accessions in gene bank collections [1] which the Indonesian Legumes and Tuber Crops Research Institute (ILETRI) having for 325 accessions [3]. The value of the germplasm collection does not always depend on the number of accessions, but on the extent of genetic diversity contained therein. For this reason, the main activities in managing the germplasm collection are characterization and evaluation. Characterization is carried out to obtain information on morphological and agronomic traits, while evaluation is to identify superior characters. There are 50 morphological characters of plant shoots, leaves, stems, flowers, and tubers that can be used to characterize accessions [4].

The interest of cassava farmers to keep planting it sometimes decreases because it is not profitable. The price of cassava is usually low during the main harvest. This problem can be reduced if farmers plant early varieties of cassava but have a long harvest period. Thus, farmers can harvest earlier when prices are high, or delay harvest when prices are low. The variety category is early maturity if the tuber yield reaches 35 t/ha at 7 months after

The Second International Conference on Genetic Resources and Biotechnology
AIP Conf. Proc. 2462, 020028-1–020028-11; https://doi.org/10.1063/5.0075658
Published by AIP Publishing. 978-0-7354-4172-9/$30.00

planting (MAP), and is categorized as a high yield potential if the tuber yield is more than 55 t/ha at 9 MAP or more [5].

Cassava farmers in Lampung, the largest cassava producing province in Indonesia, generally harvest the cassava plants at 9–12 MAP. However, harvesting can be accelerated from 7 MAP or postponed until 18 MAP due to the influence of prices, cash needs, availability of harvesting tools, transportation, and labor and land conditions [6]. The variety that is widely used by farmers in Lampung is UJ 5. The highest yield of UJ 5 tubers is harvested at 9–12 MAP [7]. Harvesting too early will result in low yield, but if it is delayed from the optimum age it causes woody or fibrous tubers, the starch content decreases so that the quality of the tubers decreases. Determination of the optimum harvest age has been widely carried out by researchers, and various recommendations are obtained, depending on the variety and ecology [8].

The success of assembling high yielding varieties depends on the selection of parents who have a number of superior characters that will be combined and improved in the offspring. Selection activities are more efficient if they are carried out on characters that have correlation with the seeded characters. In development of early matured cassava varieties, apart from using agronomical data, farmers (potential variety users) were also involved in the selection. Farmers also choose clones that are selected according to their preferences, so that the adoption of new varieties that are released is faster [9]. This study aimed to characterize the morpho-agronomic properties of the cassava germplasm collection, to examine its relationship to tuber yield, and to identify accessions with early maturity and high yield potential.

MATERIALS AND METHODS

Plant Material and Growth Condition

The field experiment was carried out at the Muneng Experimental Station of ILETRI in 2019. The experimental location was at a height of 10 m a.s.l., the type of soil was Alfisol, the soil texture class was clay, with a fraction of 22% clay, 38% dust, and 42% sand, the average C-organic content was 1.2%, the total N was 0.09, and the pH of the paddy field was 6.55. Rainfall averages 2,000 mm with an average number of rainy days 119 days per year, climate type E1 (Oldeman), minimum air temperature 23.5°C, maximum 34°C, and relative humidity 77% [10].

Characterization was carried out on 100 accessions of cassava germplasm, consisted of 59 accessions of breeding material, 31 local varieties, and 10 superior varieties. Each accession was planted in a single plot in the form of a single row of 10 m long, 100 cm × 50 cm spacing, 20 plants per plot, without replication. Fertilization using 600 kg/ha Phonska + 100 kg/ha urea. Urea was given twice: half a dose was given at 1 MAP and the other half at 3 MAP. Fertilizer was poured about 10–20 cm next to the plant. Irrigation and weeding were carried out in accordance with conditions in the field, while piling was carried out twice at 1 and 3 MAP.

Observations

Thirty-one of morpho-agronomic characters of cassava germplasm were observed. These characters include leaf (number, width, length, and lobe of the leaf), plant height, stem, and tuber (marketable, unmarketable, weight, and starch content) characters. Plant morphological characters refer to the method of Fukuda *et al*. [4] with modification of the observation time. Morphological characters of leaves were observed at 3 MAP. Observation of 3 sample plants, on the middle leaves. Stem morphology including distance between leaf scar and middle stem diameter was observed at 6 MAP, while plant height at 6 and 10 MAP.

Yield characters and tuber yield components were observed at 7 and 10 MAP, harvested from half of the plots (10 plants). For each harvest, observations are made by counting the number of plants harvested and collecting all the tubers produced, then counting the number of tubers and weighing the marketable tubers (>150 g/tuber) and unmarketable (<150 g/tuber). The starch content of fresh tubers was estimated using the specific gravity (X) approach [11], namely weighing 5 kg of fresh tubers in air (Wa), then weighing them in water (Ww). Specific gravity (X) was calculated using the equation:

$$X = Wa / (Wa - Ww)$$

where Wa = the weight of the tubers in the air, Ww = the weight of the tubers in the water, and starch content (SC) % = 112.1X−106.4.

Statistical Analysis

The data obtained were analyzed using simple statistics. The grouping of early maturity and high yielding accession using K-mean cluster analysis with SPSS V.19 program. Determination of early maturity was tuber yield at 7 MAP reached 35 t/ha [5]. Multivariate analysis and path analysis were used to examine correlated morphological characters and predict the direct and indirect effects of each character on tuber yield. Analysis of data was done by using the MSTAT-C and Microsoft Excel programs.

RESULTS AND DISCUSSIONS

Plant Performance

Planting was carried out on February 14, 2019, harvesting at 7 MAP was carried out on September 13, 2019, while harvesting at 10 MAP was on December 15, 2019. During the trial planting, the plants experienced a rainy season only in the first 3 months of growth. Rainfall intensity occurred in the first month, second month, and the third month were 47, 50, and 116 mm, respectively (Fig. 1), with a total of 213 mm. In the 4th to 10th months there was a dry season without rain at all. To overcome the lack of water, additional irrigation water was added. The rainfall required for one cassava growth cycle is 500–2,000 mm. For optimal growth and yield, cassava plants need 150–200 mm rainwater in the first 3 months, 250–300 mm at 4–7 MAP, and 100–150 mm before harvesting [12].

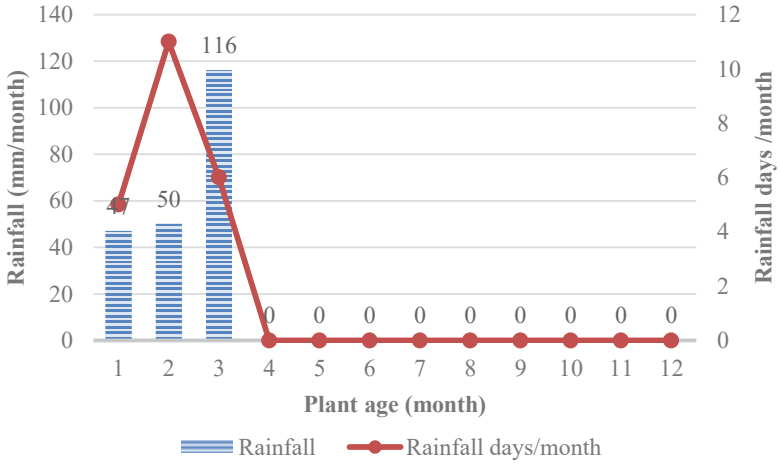

FIGURE 1. The intensity of monthly rainy and rainy days in Muneng Experimental Station of Indonesian Legumes and Tuber Crops Research Institute, 2019.

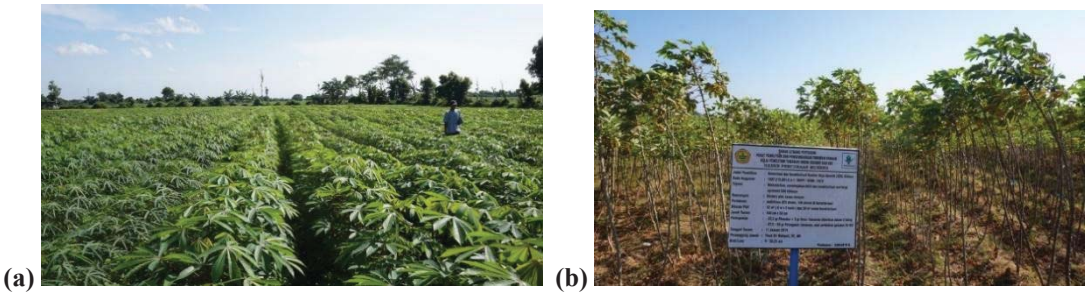

FIGURE 2. Performance of cassava plants at 2.5 months after planting (a) and 7 months after planting (b) in Muneng Experimental Station of Indonesian Legumes and Tuber Crops Research Institute, 2019.

The performance of young plants (2.5 MAP) in the rainy season and early harvest (7 MAP) in the dry season is shown in Fig. 2. Young plants grow optimally, with varying plant variability according to the characteristics of each accession. Meanwhile, the plant shows that its growing environment is dry at 7 MAP. Most of the leaves have fallen off. Remaining leaves were an average of 20% at the shoots of the stem. In the dry season, leaf loss is spurred by the attack of red mite pests. Lack of water at the beginning of growth affects the availability of element K and photosynthetic activity so that growth and plant yield are not optimum [13]. Drip irrigation during dry season increased cassava yields two times higher than that of wet season crops [14, 15].

Diversity of Morpho-Agronomic Characters

TABLE 1. The simple statistics on morpho-agronomic characters of cassava germplasm in Muneng Experimental Station of Indonesian Legumes and Tuber Crops Research Institute, 2019.

Character[a]	Minimum	Maximum	Average	SD	2SD	Variance	Criteria[b]
NLL3	5.00	9.00	7.28	1.06	2.13	1.13	*
WCLL3 (W)	13.30	24.50	18.46	2.43	4.86	5.91	**
LCLL3 (L)	1.50	6.60	4.63	1.07	2.13	1.14	*
L*W	29.88	161.70	85.88	25.57	51.15	654.04	**
L/W ratio	2.98	13.67	4.35	1.96	3.93	3.85	*
PL3	12.00	35.20	25.29	4.15	8.30	17.22	**
PL/L ratio	0.68	2.10	1.39	0.27	0.54	0.07	
PH6	81.00	206.33	136.90	26.45	52.90	699.51	**
PH10	146.00	294.33	217.25	32.94	65.88	1,085.04	**
DS6	1.23	2.23	1.67	0.22	0.45	0.05	
DBLS6	1.20	3.75	2.13	0.52	1.04	0.27	
TLN6	19.33	117.67	51.90	19.44	38.89	378.01	**
SRM6	0.00	22.56	10.35	5.78	11.56	33.43	**
NMT7	0.30	4.30	2.11	0.85	1.69	0.72	
NuMT7	0.70	9.60	5.34	1.83	3.66	3.34	*
NTT7	2.00	13.40	7.45	2.00	4.01	4.02	**
WMT7	0.19	1.88	0.80	0.37	0.74	0.14	
WuMT7	0.12	1.18	0.65	0.22	0.44	0.05	
WTT7	0.34	2.53	1.44	0.44	0.88	0.20	
AWT7	0.10	0.55	0.20	0.06	0.13	0.00	
FTY7	6.80	50.60	28.83	8.85	17.70	78.31	**
SC7	8.09	19.78	16.63	1.92	3.84	3.70	*
NMT10	0.70	7.30	2.63	1.15	2.31	1.33	*
NuMT10	1.00	10.10	5.07	1.81	3.62	3.27	*
NTT10	1.80	14.70	7.71	2.18	4.35	4.74	**
WMT10	0.27	2.61	1.29	0.56	1.12	0.31	
WuMT10	0.08	1.16	0.62	0.21	0.43	0.05	
WTT10	0.40	3.42	1.90	0.60	1.20	0.36	
AWT10	0.12	0.56	0.25	0.07	0.15	0.01	
YIELD10	8.00	68.40	38.07	12.04	24.08	144.97	**
SC10	8.62	20.30	15.79	1.91	3.82	3.64	*

[a]3, 6, 7 or 10: characters were observed at 3, 6, 7 or 10 months after planting (MAP).
SD = standard deviation, NLL = number of leaf lobe, LCLL = length of central leaf lobe, WCLL = width of central leaf lobe, PL = petiole length, PH = plant height, DS = diameter stem, DBLS = distance between leaf scar, TLN = total leaf number, SRM = score symptom of red mite attack, NMT = number of marketable tuber, NuMT = number of unmarketable tuber, NTT = number of total tuber, WMT = weight of marketable tuber, WuMT = weight of unmarketable tuber, WTT = weight of total tuber, AWT = average weight of tuber, FTY = fresh total tuber yield, SC = starch content.
[b]Not diverse: variance < SD. *Wide diversity: variance > SD. **Very wide diversity: variance > 2SD.

The plant morphological characteristics observed were some of the characteristics of accessions (clones). The morphological characteristics of the leaves at 3 MAP were observed included the number of leaf lobes (NLL), length (L) and width (W) of the central leaf lobe, L*W, L/W ratio, length of petiol (PL), and PL/L ratio. Based on the value of diversity and standard deviation, it shows that all of these variables were vary except for the PL/L ratio

(Table 1). The length of the petiole, the length and width of the central lobe and the number of lobes are related to light interception and leaf area related to photosynthesis. However, the ideal leaf area index for good growth and yield ranges from 3.0–3.5. Another ideal plant type is a short stem segment with a stem length (plant height) of about 2 m [16].

Plant heights at 6 MAP (PH6) and 10 MAP (PH10) varied widely, for PH6 ranged from 81.0–206.3 cm, with an average of 136.9 cm, while PH10 ranged from 146.0 to 294.3 cm, with an average of 217.3 cm or an increase of 58.7%. Diameter stem (DS6) and distance between leaf scar at 6 MAP (DBLS6) did not vary, for DS6 ranged from 1.23–2.23 cm, the average was 2.23 cm, while for DBLS6 1.20–3.75 cm, the average 2.13 cm. The ideal plant height is about 2 m. Usually farmers do not like clones with high biomass weight because they are considered to be wasteful of nutrients and make it difficult to maintain and harvest. Clones with larger stems diameter and height usually have a low harvest index values. A high harvest index is preferred by cassava breeders as the selection criteria. The big and heavy cassava stalks are actually not a problem because in addition to seeds and firewood, they also have other economic values, such as bioethanol as raw material [17].

The total number of leaves (TLN6) and the score symptom of red mite attack at 6 MAP (SRM6) varied widely. The TLN6 ranged from 19.33 to 117.67, the average was 51.90 strands/plant, while the SRM6 ranged from 0.00% to 22.56%, with an average of 5.78%. At 6 MAP, the plant has experienced a dry season for 3 months. Red mite pests are the main pests of cassava which cause leaf loss and even death of plants. The intensity of attacks has a positive correlation with the dry season period. The resistance of cassava plants to mite pests can be divided into two categories, through the main physical barrier in the form of lower epidermal morphological structure and palisade tissue and chemical barrier in the form of differences in flavonoid content [18].

Yield Diversity and Yield Components of Tubers

Observation of tuber yield and component yield per plant at early age (7 MAP) shows that the diversity is only obtained from the number of unmarketable tubers (NuMT7), number of total tubers (NTT7), fresh tuber yield (FTY7), and tuber starch content (SC7). The ability of all accessions to produce the number of marketable tubers (NMT7) did not vary, with an average of 2.11 tubers weighing 0.80 kg/plant. Meanwhile, the NuMT7 and the NTT7 varies, each ranging from 0.70 to 9.60 tubers, with an average of 9.60 tubers and 2.00–13.40 tubers, with an average of 7.45 tubers. The weight of marketable tubers (WMT7), unmarketable tubers (WuMT7), the weight of total tuber (WTT7), and the average weight of the tubers (AWT7) also do not vary. At the early harvest, WTT7 ranged from 0.34 to 2.53 kg, with an average of 1.44 kg, or equivalent to a very wide range of fresh tuber yield (FTY7) between 6.80–50.60 t/ha, with an average of 28.83 t/ha. Diversity was also found in the tuber starch content (SC7), ranging from 8.09–19.78%, with an average of 16.63% (Table 1).

The trend criteria for the diversity of yield variables and yield components harvested at 10 MAP were similarly with yield harvested at 7 MAP. The only difference was the number of marketable tubers (NMT), at 7 MAP was not vary and varied widely at 10 MAP. The increased yield components were the number of marketable tubers (NMT10; 2.11 to 2.63), the number of total tuber (NTT10; 7.45 to 7.71), the average weight of tuber (AWT10; 0.20 kg to 0.25 kg), the weight of marketable tuber (WMT10; 0.80 kg to 1.29 kg), and weight of total tuber (WTT10; 1.44 kg to 1.90 kg). The declining yield components were unmarketable tubers, the number (NuMT10) decreased from 5.34 to 5.07 tubers, while the weight (WuMT10) was from 0.65 kg to 0.62 kg, and starch content (SC10) from 16.63% to 15.79% (Table 1). If the yield of tubers per plant (spacing of 1.0 m × 0.5 m) is equalized to the yield of tubers per hectare, then at 7 MAP, the yield of tubers is 28.83 t/ha, while at 10 MAP 38.07 t/ha.

The increase in yield and yield components is due to the accumulation of photosynthate into the tubers, the tubers that were originally small (unmarketable) at 7 MAP will turn out to be marketable at 10 MAP, so that the number of small tubers decrease while the large tubers increase. The decrease in starch content occurred due to pests and environmental conditions. The starch content of tubers depends on the accumulation of starch resulting from the concurrent effect of a strong stem transport capacity characterized by a higher SFR (stem flow rate), high starch synthesis, and starch degradation in low tubers, as well as high sugar transporter gene expression in the stem [19].

Identification of Early Maturity and High Yield Potential Accessions

The frequency distribution of tuber yields produced by 100 accessions at 7 and 10 MAP is presented in Fig. 3. At 7 MAP, there were 43 accessions that produced tubers ranging from 25.1–35.0 t/ha, 34 accessions yielded 15.1–25.0 t/ha, and there were 21 accessions produced tubers of more than 35.0 t/ha. Accession was identified as early

maturity if produces tubers of more than 35.0 t/ha at 7 MAP [5]. At 10 MAP, 47 accessions produced tubers ranging from 35.1–55.0 t/ha, and as many as 7 accessions produced tubers of more than 55.0 t/ha which were identified as high yield potential [5]. Several research results regarding the delay when harvesting various tuber crops obtained three patterns of yield change, namely increasing, constant, and decreasing. Not all of the accessions identified as early maturity had an increase in tuber yield in line with the increasing age of the plant. It may be due to the effectiveness on photosynthesis processing occurred is different for each genotype. The consumers prefer early age varieties of cassava and high yield potential.

The clustering of 100 accessions based on FTY7 and FTY10 into five clusters were appropriate. The criteria for each cluster were high, rather high, medium, rather low, and low (Table 2). The final cluster center obtained with the criteria is presented in Table 3. Based on the F-test, the average FTY7 and FTY 10 were significantly different between one group and another (Table 3**)**. Accessions with criteria high tuber yield in FTY7 and FTY10 were in cluster 4. Eight accessions were obtained in cluster 4, consisted of 4 high yielding varieties (UK1 Agritan, Litbang UK2, Malang 4, and Malang 1), 3 breeding clones, and 1 local variety. The eight accessions with high FTY7 and FTY10, respectively, were MLG 10361 (50.6 and 53.60 t/ha), MLG 10328 (50.0–53.60 t/ha), MLG 10292 (44.4–67.20 t/ha), MLG 10371 (43.8–46.20 t/ha), MLG 10353 (43.6–57.60 t/ha), MLG 10352 (43.2–54.20 t/ha), MLG 10360 (39.6–48.20 t/ha), and MLG 10308 (39.4–61.00 t/ha). Accessions identified with early age or high yield potential need further evaluation with repeated trials and evaluation of various other advantages.

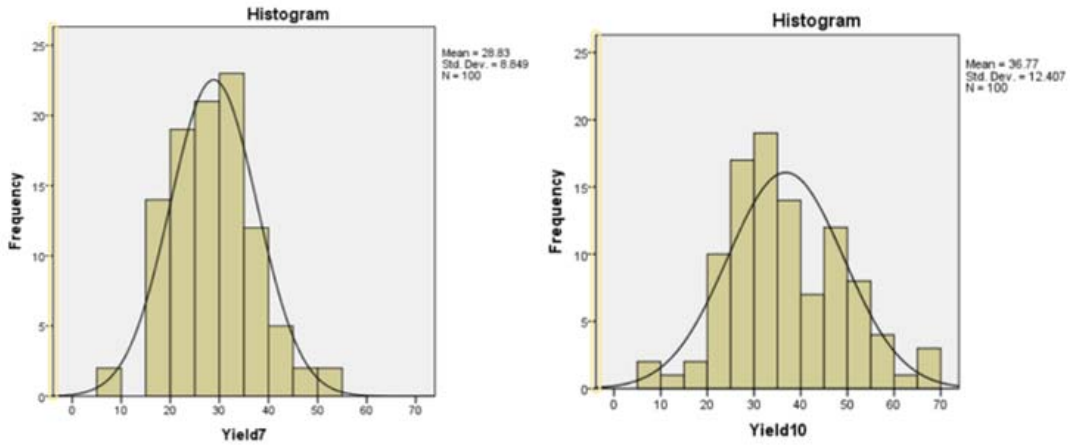

FIGURE 3. The frequency distribution of fresh tuber yield at 7 and 10 months after planting in Muneng Experimental Station of Indonesian Legumes and Tuber Crops Research Institute, 2019.

TABLE 2. The final cluster centers and criteria of fresh tuber yields (FTY) characters at 7 and 10 MAP.

Character	Cluster				
	1	**2**	**3**	**4**	**5**
Z-score (FTY7)	0.15527 Medium	1.02006 Rather high	-1.21062 Low	1.75147 High	-0.27415 Rather low
Z-score (FTY10)	1.20629 Rather high	0.09320 Medium	-1.10702 Low	1.39876 High	-0.33609 Rather low

MAP = months after planting, FTY7 = plant harvested at 7 MAP, FTY10 = plant harvested at 10 MAP.

TABLE 3. Anova K-mean cluster of fresh tuber yields (FTY) character at 7 and 10 MAP.

Character	Cluster		Error		F	Sig.
	Mean square	**df**	**Mean square**	**df**		
Z-score (FTY7)	20.202	4	0.1910	95	105.493	0.000
Z-score (FTY10)	18.788	4	0.0251	95	74.846	0.000

MAP = months after planting, FTY7 = plant harvested at 7 MAP, FTY10 = plant harvested at 10 MAP.

TABLE 4. Cluster average of fresh tuber yield (FTY) characters at 7 and 10 MAP and cluster membership.

Cluster	Average yield (t/ha)		Number of accessions in each cluster	Cluster membership (registration number – MLGs)
	FTY7	FTY10		
1	30.20	51.74	19	10150, 10290, 10295, 10300, 10307, 10310, 10316, 10329, 10332, 10335, 10337, 10338, 10348, 10349, 10354, 10358, 10359, 10378, and 10383
2	37.85	37.93	19	10282, 10285, 10288, 10289, 10291, 10298, 10302, 10305, 10318, 10319, 10320, 10323, 10325, 10327, 10346, 10350, 10357, 10362, and 10373
3	18.11	23.03	23	10255, 10284, 10315, 10321, 10322, 10324, 10326, 10331, 10333, 10336, 10339, 10342, 10345, 10347, 10363, 10364, 10367, 10368, 10369, 10370, 10376, 10379, and 10384
4	44.33	54.13	8	10292, 10308, 10328, 10352, 10353, 10360, 10361, and 10371
5	26.4	32.6	31	10247, 10283, 10287, 10301, 10304, 10306, 10311, 10312, 10313, 10314, 10317, 10330, 10334, 10340, 10341, 10343, 10344, 10351, 10355, 10356, 10365, 10366, 10372, 10374, 10375, 10377, 10380, 10381, 10382, 10385, and 10386

MAP = months after planting, FTY7 = plant harvested at 7 MAP, FTY10 = plant harvested at 10 MAP.

Correlation between Morpho-Agronomic Characters

A total of 16 X characters were selected for multivariate analysis because their correlation to tuber yield (Y) was relatively large compared to other characters that were not selected or considered important for breeding purposes. Multiple regression analysis between observed characters with tuber yields harvested at 7 MAP to identify early age accessions and at 10 MAP to identify accessions with high yield potential, the correlation matrix is shown in Table 5.

The character of fresh tuber yield at 7 MAP (FTY7) were positively correlated with plant height at 6 MAP (PH6), stem diameter (DS6), width of central leaf lobe (W), L*W, total of leaves number (TLN6), number of total tubers at 7 MAP (NTT7), average of tuber weight at 7 MAP (AWT7), number of total tubers at 10 MAP (NTT10), average of tuber weight at 10 MAP (AWT10), and fresh tuber yield at 10 MAP (FTY10). The intensity of red mite attack at 6 MAP (SRM6) had a negative correlation with the FTY7, but not with the FTY10. Some of the same X characters also correlated with the yield of tubers at 10 MAP (FTY10). Meanwhile, the result of previous study showed that plant height, number of tubers, stover weight, and harvest index were correlated with yield, while stem diameter and leaf lobe were not correlated [20].

Among food crops as carbohydrate sources, such as rice, corn and sweet potatoes, the life cycle of cassava is the longest (10–12 months). Therefore, plant breeding also takes the longest time. The yield potential can be increased through the improvement of other characters that have an immediate effect in line with the magnitude of the correlation. Selection can be done without having to wait for the harvest so that the process is faster. With the path analysis, it can be seen that the relative role of each character X on the Y result can be measured from the magnitude of the direct effect and the indirect effect [21].

Table 5 also shows a correlation between variable X. Plant height at 6 MAP (PH6) correlates with stem diameter (DS6), length of distance between leaf scar (DBLS6), number of leaf lobes (NLL6), total of leaves number (TLN6), and score of symptom red mite attack at 6 MAP (SRM6). Stem diameter (DS6) has a positive correlation with the average weight of tubers at 7 MAP (AWT7) and 10 MAP (AWT10). There are many more correlations between other X characters. One of the assumptions that must be fulfilled in multiple correlation analysis is that the X characters analyzed must be independent from one another or there is no co-linearity. In this study, this assumption cannot be fulfilled, because the characters X are correlated with each other. Therefore, to study the relationship between the various characters X and the yield (Y), the analysis was continued with path analysis.

TABLE 5. Correlation matrix of morpho-agronomic characters, yields, and yield components of early maturity tubers (7 months after planting) and optimal (10 months after planting) in Muneng Experimental Station of Indonesian Legumes and Tuber Crops Research Institute, 2019.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1	1.000															
2	**0.238**	1.000														
3	0.052	0.158	1.000													
4	0.138	**0.549**	**0.907**	1.000												
5	**0.214**	**0.279**	0.041	0.138	1.000											
6	0.190	**0.257**	**0.327**	**0.393**	**0.273**	1.000										
7	0.136	0.133	-0.087	-0.011	**0.642**	**0.204**	1.000									
8	0.027	0.140	0.034	0.070	**0.309**	**0.248**	0.091	1.000								
9	-0.141	-0.185	-0.252	**-0.289**	**-0.320**	**-0.287**	-0.159	**-0.375**	1.000							
10	-0.098	-0.102	0.096	0.016	0.198	-0.113	0.196	0.055	-0.016	1.000						
11	-0.149	-0.211	0.008	-0.100	0.081	-0.115	0.116	0.137	0.042	**0.668**	1.000					
12	0.170	0.137	0.162	0.183	0.107	**0.237**	-0.020	**0.445**	-0.188	**-0.361**	-0.130	1.000				
13	0.056	**0.265**	0.173	**0.260**	0.117	**0.350**	-0.011	**0.396**	**-0.233**	**-0.214**	**-0.346**	**0.674**	1.000			
14	-0.008	-0.015	0.135	0.085	0.058	-0.103	-0.088	0.112	-0.050	0.199	0.173	-0.053	-0.123	1.000		
15	-0.058	0.030	0.154	0.119	-0.016	-0.115	-0.097	0.059	-0.033	0.164	**0.218**	-0.071	-0.174	**0.818**	1.000	
16	0.112	0.075	**0.234**	**0.203**	**0.294**	0.139	0.175	**0.353**	**-0.246**	**0.585**	**0.407**	**0.466**	**0.430**	0.095	0.028	1.000
17	-0.108	0.042	0.18	0.158	0.172	**0.233**	0.101	**0.466**	-0.174	**0.391**	**0.587**	**0.461**	**0.524**	0.097	0.096	**0.708**

Numbers in bold are significant correlation.
Numbers (3, 6, 7 or 10) following trait codes indicate that the characters were observed at 3, 6, 7 or 10 months after planting .
1 = NLL3, **2** = LCLL3 (L), **3** = WCLL3 (W), **4** = L*W, **5** = PH6, **6** = DS6, **7** = DBLS6, **8** = TLN6, **9** = SRM6, **10** = NTT7, **11** = NTT10, **12** = AWT7, **13** = AWT10, **14** = SC7, **15** = SC10, **16** = FTY7, **17** = FTY10

The direct and indirect effects of path analysis of the 11 selected X variables on the yield of tubers harvested at early (FTY7) and optimal (FTY10) are presented in Tables 6 and 7. For the FTY7 it shows that the character of the number of tubers at 7 MAP (NTT7) and the average weight of tubers at 7 MAP (AWT7) are characters that have a positive direct effect equivalent to the value of the correlation coefficient (Table 6). The conclusions are the same for the yields at 10 MAP (FTY10), the characters that have a direct effect are the number of total tubers at 10 MAP (NTT10) and the average of weight tuber at 10 MAP (AWT10) (Table 7). The FTY7 has a small effect on the FTY10, and *vice versa*.

Path analysis was also carried out by several researchers [22–24]. There is a research result which states that the character which has a direct effect on tuber yield is the tuber diameter or leaf area index. In this study, the length of the central leaf lobe (L), the width of the central leaf lobe (W), L*W, plant height at 6 MAP (PH6), and the distance between leaf scar (DBLS) each had a negative or small direct effect. The real correlation of these variables to tuber yields is through indirect influence on other variables and is greater than the direct effect. The five X characters above each have an indirect effect through the NTT7 or the AWT7. Characters that play an indirect role must be considered simultaneously in the selection [21].

The broadleaf cassava varieties are preferred by farmers because they are believed to have high tuber yields. To assemble broadleaf varieties, although the selection to select broadleaf clones can be done at 3 MAP, the character of the number and the high average weight of tubers harvested at 7 or 10 MAP should be considered. Thus, the selection process to obtain cassava clones with broad leaves and high yield potential could not be accelerated by simply selecting clones with broad leaves. In Nigeria, the largest cassava producing country in the world, farmers prefer varieties with high yields with lots of large tubers, early maturity, and can be delayed harvest with good conditions for up to 2 years and tolerant of barren land, livestock, do not need irrigation and drought-tolerant [25].

TABLE 6. Path analysis of quantitative characters (Xi) to the fresh tuber yield character at 7 MAP (Y-early) of 100 cassava accessions in Muneng Experimental Station of Indonesian Legumes and Tuber Crops Research Institute, 2019.

Character[a]	Direct and indirect effect of variables Xi to Y											rXi.Y
	PH6	DS	W	L*W	TLN	SRM	NTT7	AWT7	NTT10	AWT10	FTY10	(FTY7)
PH6	0.022	0.004	-0.002	0.005	-0.036	0.031	0.179	0.077	-0.002	0.018	-0.002	0.294
DS6	0.006	0.016	-0.017	0.013	-0.029	0.028	-0.102	0.171	0.002	0.053	-0.003	0.139
W	0.001	0.005	-0.051	0.031	-0.004	0.025	0.087	0.117	0.000	0.026	-0.002	0.234
L*W	0.003	0.006	-0.047	0.034	-0.008	0.028	0.014	0.132	0.002	0.039	-0.002	0.203
TLN6	0.007	0.004	-0.002	0.002	-0.118	0.036	0.050	0.322	-0.003	0.060	-0.005	0.353
SRM6	-0.007	-0.005	0.013	-0.010	0.044	-0.097	-0.014	-0.136	-0.001	-0.035	0.002	-0.246
NTT7	0.004	-0.002	-0.005	0.001	-0.006	0.002	0.903	-0.261	-0.013	-0.032	-0.004	0.585
AWT7	0.002	0.004	-0.008	0.006	-0.053	0.018	-0.326	0.723	0.003	0.102	-0.005	0.466
NTT10	0.002	-0.002	0.000	-0.003	-0.016	-0.004	0.603	-0.093	-0.020	-0.052	-0.007	0.407
AWT10	0.003	0.006	-0.009	0.009	-0.047	0.023	-0.193	0.487	0.007	0.151	-0.006	0.430
FTY10	0.004	0.004	-0.009	0.005	-0.055	0.017	0.353	0.333	-0.012	0.079	-0.011	0.708
Residual effect		**0.317**										

Numbers in diagonal are a direct effect.
[a]6, 7 or 10: characters were observed at 6, 7 or 10 months after planting (MAP).
PH = plant height, DS = diameter stem, L = length of central leaf lobe, W = width of central leaf lobe, TLN = total leaf number, SRM = score symptom of red mite attack, NTT = number of total tuber, AWT = average weight of tuber, SC = starch content, FTY = fresh total tuber yield.

TABLE 7. Path analysis some quantitative characters (Xi) to the fresh tuber yield character at 10 MAP (Y-optimal) of 100 cassava accessions in Muneng Experimental Station of Indonesian Legumes and Tuber Crops Research Institute, 2019.

Character[a]	Direct and indirect effect of variables Xi to Y											rXi.Y
	PH6	DS6	W	L*W	TLN6	SRM6	NTT7	AWT7	FTY7	NTT10	AWT10	(FTY10)
PH6	-0.010	0.012	0.000	0.002	0.005	0.001	-0.002	0.002	-0.002	0.071	0.092	0.172
DS6	-0.003	0.042	0.003	0.004	0.004	0.001	0.001	0.005	-0.001	-0.101	0.275	0.233
W	0.000	0.014	0.010	0.010	0.001	0.001	-0.001	0.004	-0.001	0.007	0.136	0.180
L*W	-0.001	0.017	0.009	0.011	0.001	0.001	0.000	0.004	-0.001	-0.087	0.204	0.158
TLN6	-0.003	0.011	0.000	0.001	0.018	0.001	-0.001	0.010	-0.002	0.120	0.311	0.466
SRM6	0.003	-0.012	-0.003	-0.003	-0.007	-0.003	0.000	-0.004	0.001	0.037	-0.183	-0.174
NTT7	-0.002	-0.005	0.001	0.000	0.001	0.000	-0.009	-0.008	-0.003	0.584	-0.168	0.391
AWT7	-0.001	0.010	0.002	0.002	0.008	0.001	0.003	0.022	-0.003	-0.113	0.530	0.461
FTY7	-0.003	0.006	0.002	0.002	0.006	0.001	-0.005	0.010	-0.006	0.356	0.338	0.708
NTT10	-0.001	-0.005	0.000	-0.001	0.002	0.000	-0.006	-0.003	-0.002	0.875	-0.272	0.587
AWT10	-0.001	0.015	0.002	0.003	0.007	0.001	0.002	0.015	-0.002	-0.303	0.786	0.524
Residual effect		**0.224**										

Numbers in diagonal are a direct effect.
[a]6, 7 or 10: characters were observed at 6, 7 or 10 months after planting (MAP).
PH = plant height, DS = diameter stem, L = length of central leaf lobe, W = width of central leaf lobe, TLN = total leaf number, SRM = score symptom of red mite attack, NTT = number of total tuber, AWT = average weight of tuber, SC = starch content, FTY = fresh total tuber yield.

CONCLUSION

Most of the characters varied widely or very widely, except petiole length with central leaf lobe length, stem diameter, distance between leaf scar, and number of marketable root at 7 MAP, and weight of marketable, unmarketable, and average tuber at 7 and 10 MAP. Path analysis involving 11 characters showed that the total

number of tubers per plant and the average tuber weight at 7 MAP had a large direct effect and a positive equal effect on the total. Meanwhile, the other 11 characters had less direct effect than the indirect effect through these two important characters. Thus, indirect selection to improve other characteristics must simultaneously consider the total number of tubers and the average tuber weight in order to obtain high yields. Tuber yield of 100 accessions at 7 MAP was equivalent to 6.8–50.6 t/ha, with an average of 28.8 t/ha, while at 10 MAP it was between 8.0–68.4 t/ha, with an average of 38.1 t/ha. With K-mean cluster analysis, eight accessions were obtained having fresh tuber yield ranged of 39.6–50.6 t/ha and 46.20–67.20 t/ha at 7 and 10 MAP, respectively. The eight selected accessions were MLG 10361, MLG 10328, MLG 10292, MLG 10371, MLG 10353, MLG 10352, MLG 10360, and MLG 10308. Accessions identified with early planting age or high yield potential need further evaluation with repeated trials and evaluation of various other advantages.

ACKNOWLEDGMENTS

Appreciations were conveyed to the Ministry of Agriculture through the Agency for Agricultural Research and Development (IAARD) which had facilitated these research activities.

REFERENCES

1. R. Howeler, N. B. Lutaladio and G. Thomas, *Save and Grow: Cassava, a Guide to Sustainable Production Intensification* (Food and Agriculture Organization of the United Nations, Rome, 2013), 142 pp.
2. R. Bhattacharjee, D. Dumet, P. Ilona, F. Soyode and J. Franco, Plant Genet. Res. **10(2)**, 119–127 (2012).
3. ILETRI, "Hasil utama penelitian tanaman aneka kacang dan umbi" in *Laporan Tahunan 2019* (Indonesian Legumes and Tuber Crops Research Institute, Malang, 2020), 28 pp.
4. W. M. G. Fukuda, C. L. Guevara, R. Kawuki and M. E. Ferguson, *Selected Morphological and Agronomic Descriptors for the Characterization of Cassava* (International Institute of Tropical Agriculture, Ibadan, Nigeria), 19 pp.
5. Suwandi, *Prosedur Operasional Standar Penilaian Varietas dalam Rangka Pelepasan Varietas Tanaman Pangan* (Direktorat Jenderal Tanaman Pangan, Kementerian Pertanian, Republik Indonesia, Jakarta, 2019), 136 pp.
6. E. Sagala and Suwarto, Bul. Agrohorti **5(3)**, 400–409 (2017).
7. P. Puspitorini, D. Pitaloka and T. Kurniastuti, J. Viabel Pertan. **10(1)**, 63–70 (2016).
8. K. Oriola and A. Raji, ISDE **4(9)**, 15–23 (2013).
9. J. Kamau, R. Melis, M. Laing, J. Derera, P. Shanahan and E. C. K Ngugi, J. Plant Breed. Crop Sci. **3(3)**, 44–52 (2011).
10. ILETRI, *http://balitkabi.litbang.pertanian. go.id/?p=12315* (2017).
11. K. Kawano, W. M. G. Fukuda and U. Cenpukdee, Crop Sci. **27**, 69–87 (1987).
12. J. Wargiono, A. Hasanuddin dan Suyamto, *Teknologi Produksi Ubikayu Mendukung Industri Bioethanol* (Center for Food Crops Research and Development, Bogor, 2006), 42 pp.
13. D. O. Wasonga, J. Kleemola, L. Alakukku and P. S. A. Mäkelä, Agron. **10(3)**, 321 (2020).
14. L. F. M. Pereira, S. Zanetti and M. de Almeida Silva, Acta Physiol. Plant. **40**, 13 (2018).
15. A. Pholtanee and M. Srisutham, Indian J. Agric. Res. **52(5)**, 554–559 (2018).
16. V. Lebot, "Tropical root and tuber crops: cassava, sweet potato, yams, aroids" in *Crop Production Science in Horticulture Series: 17* (CABI, Wallingford, 2009), 413 pp.
17. A. Anushya, M. Swathika, S. Sivamani and N. Sivakumar, "Bioprocessing of cassava stem to bioethanol using soaking in aqueous ammonia pretreatment," in *Bioprocessing for Biomolecules Production*, edited by G. Molina, V. Gupta, B. Singh and N. Gathergood (John Wiley & Sons, Inc., Hoboken, 2019), pp. 429–441.
18. Y. Yang, X. Luo, W. Wei, Z. Fan, T. Huang and X. Pan, Sci. Rep. **10**, 14197 (2020).
19. Y. Z. Li, J. Y. Zhao, S. M. Wu, X. W. Fan, X. L. Luo and B. S. Chen, Sci. Rep. **6,** 19823 (2016).
20. N. Zuraida, Bul. Plasma Nutfah **16(1)**, 49–56 (2010).
21. R. K. Singh and B. D. Chaudhary, *Biometrical Methods in Quantitative Genetic Analysis* (Kalyani Publishing, New Delhi, 1979), 304 pp.
22. O. O. Aina, A. G. O. Dixon and E. A. Akinrinde, J. Biol. Sci. **7(5)**, 759–764 (2007).
23. H. F. Ojulong, M. T. Labuschagne, L. Herselman and M. Fregene, Crop Breed. App. Biotechnol. **10**, 191–196 (2010).

24. T. Mulualem and Y. Dagne, J. Plant Sci. **1(3)**, 33–38 (2013).
25. J. Bentley, A. Olanrewaju, T. Madu, O. Olaosebikan, T. Abdoulaye, T. Wossen, V. Manyong, P. Kulakow, B. Ayedun, M. Ojide, G. Girma, I. Rabbi, G. Asumugha and M. Tokula, "Cassava farmers' preferences for varieties and seed dissemination system in Nigeria: gender and regional perspectives," in *IITA Monograph* (International Institute of Tropical Agriculture, Ibadan, 2017), p. 90.