Advances in Biological Sciences Research, volume 14
Proceedings of the 3rd KOBI Congress, International and National Conferences (KOBICINC 2020)

Yield Potential and Morphological Characters of Promising Sweetpotato Clones Rich in Anthocyanin and High Dry Matter Content

F.C. Indriani[1,*] J. Restuono[1] W. Rahajeng[1] M.J. Mejaya[1]

[1]*Indonesian Legumes and Tuber Crops Research Institute (ILETRI) Malang, East Java. Indonesia*
[*]*Corresponding author. Email: febria_cahya@yahoo.co.id*

ABSTRACT
The contribution of sweetpotato to the national economy is quite large with increasing export volume. Sweetpotato frozen were exported mainly to Malaysia, Japan, Korea and Singapore. The role of superior varieties is quite large in increasing the production of sweetpotato. Purple sweetpotato which is rich in anthocyanins is very useful for increasing body health in Covid 19 Pandemic. The objective of this research was to obtain the information of yield potential and morphological characteristics of promising sweetpotato clones with rich in anthocyanin and high dry matter content. The research was carried out in Magetan district, East Java province at dry season II in 2019. The 13 promising sweetpotato clones of purple fleshed along with two check varieties were arranged in randomized block design (RBD) with three-replications. A few promising clones of sweetpotato selected had been high yield potential, rich in anthocyanin and high dry matter content from adaptation trial. The results showed that five clones (MSU 10001 32, MSU 10003-06, MSU 10003-07, MSU 10010-43 and MSU 10018-40) had higher yield potential (> 30 t / ha) and high dry matter (> 30%) compared to check varieties (Antin 2 and Antin 3). These five clones have good quality, uniformity of shape and size with dark purple which rich in anthocyanin. These clones are prospective to be proposed as new purple fleshed variety with high dry matter content.

Keywords: *potential yield, purple fleshed, sweetpotato*

1. INTRODUCTION

Sweetpotato is a potential commodity to be used as an alternative carbohydrate source especially on purple sweetpotatoes. Purple sweetpotatoes are rich in anthocyanins that may function as antioxidants and can increase endurance in the Covid 19 pandemic. Sweetpotato plants are relatively adaptable to various environments, so it is a great prospect of being developed in various agroecologies in Indonesia.

The main nutritional component of sweetpotato is carbohydrate which functions as energy, besides that sweetpotato is rich in vitamins, minerals and fiber [1]. Sweetpotato with orange tuber flesh contains β-carotene, while purple sweetpotato contains anthocyanin. The purple-fleshed sweetpotatoes contain higher level of anthocyanins compared to white, yellow, and orange-fleshed one, and the contents differ depending on the varieties [2]. Purple sweetpotato which is rich in anthocyanins has high commercial value, the role as a functional food for health and a stable natural coloring agent. The function of anthocyanins namely as antioxidants, anti-hypertension, prevention of liver disorders [2]. In Japan, purple sweetpotato is widely developed as a natural coloring agent in various foods, antitoxin, prevents constipation, and helps absorb fat in the blood. It can also block the appearance of cancer cells and suitable for consumption by coronary heart sufferers [3].

The increase of population is one of the factors enhancement demand for sweetpotato, so it must be balanced with increase of productivity which can be done by using superior varieties. Efforts can be made by creating new superior varieties that have better characters than the existing varieties. The availability of superior varieties of sweetpotato which is not only high in productivity but also has good tuber quality, with a variety of nutrients will increase the selling value of this commodity. Foods that are beneficial to health are increasingly needed by consumers, anthocyanin content, wide adaptation and suitable for processing into various food products are needed. This will accelerate its spread, use it at the industrial level and increase its consumption as a healthy food. Availability of raw materials with nutritional content encourages the development of agro-industry, added value to processed sweetpotato products can increase the selling value. Fulfilling the needs of the community for products with adequate nutritional quality will directly support food security. The objective of this research was to obtain the information of yield potential and morphological characteristics of promising sweetpotato clones with rich in anthocyanin and high dry matter content.

2. MATERIALS AND METHODS

Research on the adaptation test of anthocyanin-rich sweetpotato clones with high dry matter content was conducted in Sambirobyong Village, Sidorejo District, Magetan Regency, East Java Province during dry season II, 20. The 15 clones of sweetpotato including the check varieties (Antin 2 and Antin 3) were evaluated using a randomized block design (RBD), repeated three times. Each clone was planted on a plot measuring 5 m x 5 m with a plant spacing of 100 cm x 25 cm. The research was carried out starting with land cultivation and made longitudinal mounds according to the width of the land, the distance between the center of one ridge and the center of the other ridges was 1 m. Shoot cuttings were planted at a slight angle at the top of the mound, with 2-3 nodes sinking into the soil.

Fertilizer was applied at a dose of 300 kg of Phonska compound fertilizer and manure at a dose of 2 t/ha. Phonska fertilizer was given 2 times, namely when the plants were one week old with a dose of one-third of the fertilizer and the rest was given at the age of 1.5 months after planting. Weeding was done depending on the growth of weeds, around the age of 4, 7 and 10 weeks after planting. Mound reduction was carried out when the plants were 1.0-month-old together with the first weeding and followed by supplementary fertilizers. Reversal of the stems was done when the plants were 6, 9, and 12 weeks after planting, while increasing the mounds was done at 2 months after planting together with the second weeding and supplemental fertilizers. Tuber yield were harvested at the age of 4-4.5 months after planting.

The observations included: tuber number and weight/plot, harvest index, high dry matter production, stunt weight, tuber dry matter, skin color and tuber flesh, tuber length and diameter, anthocyanin (visual), tuber shape score, tuber shape and size uniformity score, cracking tubers. The criteria for tuber size were: small = <100 g/tuber, medium = 100-200 g/tuber, and large > 200 g/tuber. Analysis of variance per location or combination of each observed character was calculated based on a randomized block design. The tested clones were differentiated based on the 5% LSD test.

3. RESULT AND DISCUSSION

3.1. Agronomy Performance

The results of the analysis of variance showed that the genotype affected the number and weight of large tubers, tuber production, harvest index, and tuber dry matter as shown in Table 1.

The average number of large tubers ranged from 81.33 to 173.0 tubers, while the average weight of large tubers ranged from 32.73 to 49.44 kg. There were nine clones that had the number and weight of large tubers higher than the two check varieties. This shows that the promising clones tested have high yield potential as well. The yield potential of this adaptation test ranged from 28.40 - 40.35 t/ha with an average of 33.18 t/ha. Of the 13 clones tested, there were 10 clones had a potential yield above > 30 t/ha and higher than the two check varieties Antin 2 (29.27 t/ha) and Antin 3 (28.70 t/ha) as showed in Table 2. Yield potential is influenced by genetic and environmental factors, by which sweetpotato is very sensitive to environmental changes. The variation of sweetpotato yields in various environments indicates an interaction between the genotype and the environment which reflects the adaptability of the genotype [4].

The harvest index showed a range of 40.27 - 67.40% with an average of 56.77%, the highest harvest index was the MSU clone 10003-07 and the lowest was the RIS 10043-02 clone. The harvest index also had a wide variability among sweetpotato genotypes and high broad sense heritability [5]. A high HI value indicates a greater distribution of assimilates to the tubers, while a low HI indicates a greater distribution of assimilates to the upper part of the plant [6].

Table 1. Analysis of variance of adaptation tests of sweetpotato clones with high levels of anthocyanin and dry matter. Magetan, East Java, 2019

Characters	Mean Squares			CV (%)
	Block	Genotype	Error	
Number of large tubers	164.29^{ns}	2,25489**	532.19	20.44
Number of intermediate tubers	3,830.07**	856.47 ^{ns}	425.38	28.33
Number of small tubers	79.02 ^{ns}	629.46 ^{ns}	382.52	39.56
Weight of large tubers	25.54 ^{ns}	359.41**	85.04	20.36
Weight of intermediate tubers	241.42**	53.50 ^{ns}	26.64	28.29
Weight of small tubers	1.79 ^{ns}	14.07 ^{ns}	8.57	39.19
Tuber production	14.53^{tn}	50.66*	19.12	13.18
Harvest index	20.54 ^{ns}	165.75**	33.28	10.16
Tuber dry matter	28.04*	40.43**	6.18	7.23
Tuber dry matter productivity	4.94 ^{ns}	6.06 ^{ns}	3.43	16.29

Note: * = significantly different at the 0.05 probability level
** = significantly different at the 0.01 probability level
ns = not significantly different at the 0.05 probability level

Table 2. Average of agronomic characters of the anthocyanin-rich sweetpotato clones adaptation test with high dry matter content in Magetan district, East Java, in dry season II 2019

Clones and Varieties	Number of Tubers			Tuber Weight (Kg)			Yield Potential (t/ha)	Harvest Index (%)	Tuber Dry Matter (%)	Tuber Dry Matter Productivity (t/ha)
	Large	Medium	Small	Large	Medium	Small				
RIS 10043-02	92.33^{def}	77.00	40.67	36.97^{def}	19.27	6.17	28.49^{c}	40.27^{g}	36.13^{abc}	10.35
RIS 10053-01	92.67^{def}	57.00	27.33	37.20^{def}	14.30	4.17	28.70^{c}	51.18^{f}	37.80^{ab}	10.86
RIS 10051-01	100.00^{def}	73.00	55.33	40.17^{def}	18.30	8.33	31.10^{bc}	50.57^{f}	31.13^{ef}	9.67
MSU 10001-32	112.33^{cdef}	57.33	50.67	45.17^{cdef}	14.40	7.67	34.49^{abc}	63.20^{abcd}	36.63^{abc}	12.61
MSU 10001-15	147.00^{abc}	44.67	26.33	59.00^{abc}	11.17	4.00	38.77^{a}	64.81^{abc}	26.77^{g}	10.37
MSU 10002-05	91.67^{def}	73.00	36.67	36.93^{def}	18.30	5.57	31.13^{bc}	52.98^{ef}	37.40^{ab}	11.62
MSU 10003-06	173.00^{a}	49.33	37.00	69.33^{a}	12.33	5.63	38.21^{ab}	57.56^{bcdef}	34.63^{bcde}	13.24
MSU 10003-07	129.00^{bcd}	104.67	70.00	51.67^{bcd}	26.17	10.57	37.65^{ab}	67.40^{a}	31.73^{def}	11.96
MSU 10008-35	124.00^{bcde}	86.67	68.33	49.67^{bcde}	21.73	10.27	34.97^{abc}	54.41^{def}	36.93^{ab}	12.94
MSU 10010-43	120.00^{bcde}	92.00	65.00	48.13^{bcdef}	23.07	9.83	34.49^{abc}	59.99^{abcdef}	35.77^{abcd}	12.37
MSU 10010-50	81.33^{f}	76.33	57.33	32.73^{f}	19.10	8.67	31.00^{bc}	52.57^{ef}	39.67^{a}	12.30
MSU 10018-40	152.33^{ab}	93.33	67.67	61.00^{ab}	23.33	10.17	40.35^{a}	66.94^{ab}	32.63^{cdef}	13.17
MSU 10021-26	98.67^{def}	62.67	51.00	39.63^{def}	15.73	7.67	28.40^{c}	50.84^{f}	37.83^{ab}	10.78
Antin 2	92.33^{def}	68.33	46.33	37.00^{def}	17.20	7.00	29.27^{bc}	57.08^{cdef}	30.23^{fg}	9.50
Antin 3	86.67^{ef}	76.67	42.00	34.93^{ef}	19.27	6.33	28.70^{c}	61.82^{abcde}	30.43^{fg}	8.87
CV	20.44	28.33	39.56	20.36	28.29	39.19	13.18	10.16	7.23	16.29
LSD 5%	38.58	ns	Ns	15.42	Ns	ns	7.31	9.65	4.16	Ns
Min.	81.33	44.67	26.33	32.73	11.17	4.00	28.40	40.27	26.77	8.87
Max.	173.00	104.67	70.00	69.33	26.17	10.57	40.35	67.40	39.67	13.24
Average	112.88	72.80	49.44	45.30	18.24	7.47	33.18	56.77	34.38	11.37

Note: ns = not significantly different at the 0.05 probability level

The promising clones tested generally had higher dry matter content than the check varieties Antin 2 and Antin 3 which had dry matter of about 30%. Dry matter content is one of the selection criteria because it can be used as an indicator of tuber quality. The range of dry matter for tubers was 26.77 - 39.67%. High dry matter is needed for the flour industry, so that the breeding activity to develop a purple sweetpotato variety with high yield potential and high dry matter is needed. The test results showed that there were nine clones of sweetpotato with purple tuber flesh had higher yield potential and dry matter compared to the check varieties Antin 2 and Antin 3. These clones were potential to be proposed as candidates for new purple sweetpotato varieties with high yield potential (> 30 t/ha) with high dry matter content (30%) as shown in Table 2.

3.2. Tuber Performance

Tuber performance is one of the selection criteria because consumers will choose a tuber that looks good and has a uniform tuber shape and size as well as skin color and tuber flesh. Of the 15 clones and varieties tested, the average tuber quality, tuber shape, shape uniformity, and size uniformity had an average score of 4.5, 4.4, 4.6, and 4.3, respectively which means it is quite good performance. From the observation of the tuber shape score, there were four clones gave an average score of 5.0, which means that these clones (MSU 10001-15, MSU 10003-07, MSU 10018-40, and MSU 10021-26) had good tuber shape (Table 3). The shape of the tubers is very important as a consideration when selecting by which the shape of the tubers that most consumers are interested in namely: oval-shaped with a flat surface (not grooved) and smooth.

Cracking is also a parameter of sweetpotato selection, causing the tuber looks less good, the price is lower than the tubers that are not cracked. Cracking can be caused by nematodes, genetics, or too long at the field due to late harvest period. The tested promising clones had an average score of 5.0, which means the tubers were not cracked, this indicated that the quality of tuber morphology was good. The skin color of the tubers is mostly red (R) with a brightness level of 5 (slightly dark)

Table 3. Tuber morphological characteristics of anthocyanin-rich sweetpotato clones with high dry matter content, Magetan, East Java

No.	Clones/Variety	Tuber		Uniformity		Cracking	Tuber Color	
		Quality	Shape	Shape	Size		Skin	Flesh
1	RIS 10043-02	4,0	4,5	5,0	4,0	5,0	R6	P7
2	RIS 10053-01	3,5	3,5	4,0	4,0	5,0	R7	P7
3	RIS 10051-01	5,0	4,0	5,0	5,0	5,0	R5	P7
4	MSU 10001-32	4,5	4,0	4,5	4,5	5,0	R7	P7
5	MSU 10001-15	5,0	5,0	4,0	4,0	5,0	R6	P6
6	MSU 10002-05	4,0	4,0	4,5	4,0	5,0	R7	P7
7	MSU 10003-06	4,5	4,5	4,5	4,0	5,0	R6	P6
8	MSU 10003-07	5,0	5,0	5,0	5,0	5,0	R7	P6
9	MSU 10008-35	5,0	4,0	5,0	4,5	5,0	R6	P7
10	MSU 10010-43	4,5	4,5	5,0	4,0	5,0	R7	P6
11	MSU 10010-50	4,0	4,0	4,0	4,0	5,0	R7	P6
12	MSU 10018-40	5,0	5,0	5,0	4,5	5,0	R6	P6
13	MSU 10021-26	5,0	5,0	5,0	4,5	5,0	R7	P7
14	Antin 2	4,5	4,5	4,0	4,0	5,0	R6	P6
15	Antin 3	4,5	4,5	4,5	4,0	5,0	R7	P7
	Average	4,5	4,4	4,6	4,3	5,0		

Note:
a. Tuber quality and Tuber shape: :5 = very good, 4 = good, 3 = moderately good, 2 = bad, 1 = very bad.
b. Uniformity of shape and size: 5 = very homogen, 4 = homogen, 3 = moderately homogen, 2 = not homogen, 1 = least homogen.
c. Cracking: 1 = > 75% crack, 2 = 51-75% cracks, 3 = 26-50% cracks, 4 = 11-25% cracks and 5 = no cracks.
d. Tuber skin colour and flesh colour: R = red, P = purple; 1 = very pale, 2 = slightly pale, 3 = pale, 4 = bright, 5 = slightly dark, 6 = dark, 7 = very dark [7].

and 7 (very dark). Of the 15 clones and varieties tested, there was one clone, namely RIS 10051-01 which had a slightly dark red skin color (R5) and 6 clones (including the check variety Antin 2) which had dark red skin color (R6) and there were 8 clones (including the check variety Antin 3) which had a very dark red skin color (R7). The color of the tuber flesh was generally dark purple (score 6) and very dark (score 7). Of the 15 clones and varieties tested there were 7 clones (including the check variety Antin 2) had dark purple tuber flesh color (P6) and 8 clones (including the check variety Antin 3) had very dark purple tuber flesh color (P7). Visually, tubers with very dark purple flesh color correlated with anthocyanin content, meaning that the darker the purple color, the higher the anthocyanin content. According to [2], the color of anthocyanin in purple sweetpotato is strongly influenced by the pH of the solution, namely red (acid pH), purple (neutral pH), and blue (alkaline pH). According to [8], the appearance of anthocyanin content in sweetpotatoes is controlled by more than one gene pair, the genes controlling anthocyanin are not dominant, and are present in the cell nucleus.

4. CONCLUSION

There were five clones (MSU 10001-32, MSU 10003-06, MSU 10003 -07, MSU 10010-43 and MSU 10018-40) had higher yield potential (> 30 t / ha) and dry matter (> 30%) compared to the check varieties Antin 2 and Antin 3. In addition, these clones had the tuber characteristics of good quality, uniformity of shape and size, with dark purple tuber flesh color which reflected high levels of anthocyanins. These clones had the opportunity to be released as new superior varieties with the advantages of having high yield potential, high dry matter and rich in anthocyanins.

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