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Vamas 1, a new early root bulking, high-yielding, high-starch content cassava variety

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Abstract. A good variety of cassava is important factor in increasing the productivity. If the productivity of cassava is increase, the competitiveness of cassava will increase. Vamas 1 is new variety released 2020 by Indonesian Government. Based on multi-location trial during 2015-2018 in 8 location in Lampung, the fresh tuber yield in 7 months of Vamas 1 was 25% higher that UJ3, equal to IDR 64,600,00,-/ha if the price of cassava IDR 1000,-/kg and 15% higher than UJ5, equal to IDR 6,460,000,-/ha. Starch yield of Vamas 1 was 39% higher than UJ3, equal to IDR 16,056,000,-/ha and 23% higher than UJ5, equal to 10,736,000,-/ha. Plant height of Vamas 1 was lower than UJ5. Starch content of Vamas 1 was higher than UJ3 and UJ5. Vamas 1 was shown moderately resistant against mite insect under artificial screening which is similar to UJ3 and UJ5. Vamas 1 has shown moderately resistant to cassava root rot desease under artificial screening, while the checks showed the susceptible. HCN content of fresh tuber of Vamas 1 was 19.68 ppm less than UJ3 (48.9 ppm) and UJ5 (40.56 ppm) as checks.

1 Introduction

Cooked cassava, fried cassava, fried cassava chips, and fermented cassava are some of human food product made from the fresh cassava tuber. These product needs sweet cassava. Sorbitol, fructose, and glucose are some of industry product made from tapioca starch. Tapioca starch can use bitter and sweet cassava. Many type of foods are made from cassava flour as a partial or complite replacement for these ingredients. such as cakes and cookies. Cassava leaves, cassava tuber, cassava chip, and cassava pulp are some kind of feeds. These all product made from cassava have economic value. The harvest area of cassava in Indonesia 2020 was 701615 ha with production 18.3 million ton [1]. If the price of cassava is 1,000 IDR/kg, the value of cassava will be IDR 18,300 billion. This value will increase if the processing product like cassava starch, cassava cracker, and other processing product are included in determining the value.

Tapioca starch is important product made from the fresh tuber. The export price FOB Bangkok of the tapioca starch fluctuate from year to year. During 2018-2021, the export price was 445 – 497 USD. The highest export price is in 2018 and the lowest one was in 2020 [2]. Within a year, the export price of tapioca starch also fluctuate. The export price

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of tapioca starch affected the regional price including in Indonesia. Tapioca starch export prices have impacted prices in regions including Indonesia. As the price of tapioca starch fluctuates, so does the price of raw cassava tubers. Though, the price of cassava tuber fluctuate from year to year and whin a year, cassava farmer still plant the cassava till now. The harvest area in Indonesia 2020 was 701,165 ha [1].

Lampung is central of cassava in Indonesia, most of them are dry acid area. Acidic soils are soils that have a pH below 5.5 year-round. They are associated with various toxicities (aluminum), deficiencies (molybdenum), and other crop-limiting conditions. Many of the acidic soils belong to the subgroups of acrysoils, alisoils, podsoils, and dystric sub-groups of other soils. [3]. Most farmers in Lampung want the early root bulking variety. In this area, farmer plant the cassava any time during the year. UJ3 (Rayong 60) and UJ5 (Kassart 50) are the existing varieties in Lampung. Most farmers want new varieties that are better than existing ones. Utilization of released varieties is an important factor in determining the productivity of cassava plantations

2 Breeding methods

Vamas 1 has code OMR 51-20-5 / PC 4. It was selected from population from open pollination done 2008 with female parent CMR44-29-12. Selections were carried out as follows: single plant selection, single row selection, single plot selection, preliminary yield test, advanced yield test and multi-location test. OMR 51-20-5 was a selected clone with higher raw tuber yield, starch yield and starch content than the existing cultivar (UJ5) during single row selection and a single plot selection [4,5]. During 2012-2013, the entry was evaluated in the advanced yield test. The starch yield of OMR 51-20-5 was the highest and significantly higher than the existing UJ5 cultivar during the advanced yield test [6].

3 Performance characteristics

3.1 Varietal descriptor

Table 1. Morphological comparation of Vamas 1 to UJ3 and UJ5

No.	Characteristics	Vamas 1	UJ3	UJ5
1.	Color of young leaf (Un-opened completely)	brownish green	light brown	brown
2.	Mature leaf color	green	green	green
3.	Color of young stem	light green	yellowish light green	light green
4.	color of mature stem	brownish gray	gray	gray
5.	color of upper part of petiole	reddish green	Reddish and yellowish green	reddish green
6.	color of under part of petiole	light green	light green	reddish green
7.	the color of periderm of tuber	cream	cream	cream
8.	The color of cortex	cream	cream	cream
9.	Color of root parenchyma	white	white	white

Vamas 1, cassava variety with absence of branch generally in normal condition. Color of young leaf (Un-opened completely) is light green and mature leaf color is green (Table 1). Color of young stem is light green and color of mature stem is brownish gray. Color of upper part of petiole reddish green and color of under part of petiole is light green. The color of periderm of tuber and cortex is cream. Color of root parenchyma is white.

3.2 The fresh tuber yield and plant height

Fresh tuber yield is an important trait for farmers as it is taken into account when choosing cultivar. Fresh tubers are affected by genetic factors and interactions between genetic and environment [7, 8]. The fresh tuber yield determine the starch yield. There was no correlation between raw tuber yield and starch content at 9 months [9]. Multiple genes control the fresh tuber yield. Sixteen genes predicted to encode proteins potentially associated with root yield have been identified [10]. Vamas 1 with mean fresh tuber yield of 32.42 t ha^{-1} in seven months significantly out-yielded all the check varieties UJ3 and UJ5, 25% and 15%, respectively higher than check (Table 2). This increased value corresponds to USD 745/ha and USD 482/ha. It showed a potential fresh tuber yield of 40.5 t ha^{-1} in seven months [7].

The environment of cassava plant is so various and climate factor is unpredictable from year to year. Yield stability of fresh tuber is an important feature for farmers when choosing varieties. Many method to determine the yield stability, one of them is ASV (AMMI stability value) [11]. The genotype with low value of ASV is more stable than genotype with high value of ASV. Vamas 1 has ASV value lower than UJ5 (Table 2.) [7], so Vamas 1 is more stable than UJ5. The key environmental factors influencing the yield stability of promising cassava genotypes based on tuber yield during the 7- month cropping period were top-soil N and P_2O_5 content [7].

Table 2. Yield Performance and plat height of Vamas 1 yield trials (2015-2018)

Item	Year of testing	Number of trial	Vamas 1	Check varieties	
				UJ3 (Rayong 60)	UJ5 (Kassart 50)
7 months average tuber yield t ha^{-1}	2015-2018	8	32.42	25.96	28.24
Plant height (cm)	2015-2018	8	252	278	307
%increase of fresh tuber yield over checks	2015-2018	8	-	25	15
% decrease of plant height over checks	2015-2018	8	-	9	18
Yield potential of fresh tuber yield (highest yield harvested at multi-locations trial) t ha^{-1}	2015-2018	8	43.61	34.86	41.86
AMMI Stability Value	2015-2018	8	2.093	1.769	2.191

Ideal plant height of cassava is moderate plant height. There are some factors as consideration for ideal plant height. First, farmer plant the cassava using cuttings, so plant with high plant height produce more cuttings than plant with low plant height. Second, cassava with high plant height have more chance to be lodging than cassava with low plant height. Plant height of cassava is affected by genetic factor and interaction between genetics and environments [12]. Plant height in 4 months positively correlated to starch yield in 9 month [13]. Plant height in 9 months negatively correlated to tuber yield and starch yield [9]. Vamas 1 with mean of plant height of 252 cm in seven months is significantly shorter than all the check varieties UJ3 and UJ5, 9% and 18%, respectively shorter than checks (Table 1) [14]. Probability of root lodging of the high plant are higher than the short plant. Usually, the short plant have high harvest index. Vamas 1 / OMR 51-20-5 had harvest index higher than that of UJ5 [6]. Nutrition removal from soil of plant with high harvest index is less than that of plant with low harvest index.

3.3 The starch yield

Starch yield is an important attribute for tapioca industry owners. There was positive correlation between starch yield and starch content in nine months [9]. Starch is affected by genetic factor and interaction between genetics and environments [15, 16, 17]. Vamas 1 with mean of starch yield of 7.21 t ha^{-1} in seven months is significantly out-yielded all the check varieties UJ3 and UJ5, 34% and 23%, respectively higher than check (Table 3), it was significantly higher (34%) than the existing cultivar (UJ3). If tapioca starch cost USD 485 per ton, this incremental value equates to USD 970 per hectare, significantly higher (23%) than the existing cultivar (UJ5). This incremental value equates to 650 USD per hectare. It shows a potential starch yield of 10.06 t ha^{-1} in seven months and relatively stable performance across the environments in acid area [15].

Table 3. Yield Performance of Vamas 1 in Yield Trials (2015-2018)

Item	**Year of testing**	**Number of trial**	**Vamas 1**	**Check varieties**	
				UJ3 (Rayong 60)	**UJ5 (Kassart 50)**
Mean of starch yield in 7 months) t ha^{-1}	2015-2018	8	7.21	5.21	5.87
% increase of starch yield over checks	2015-2018	8	-	34	23
Yield potential of starch yield (highest yield harvested at multi-locations trial) t ha^{-1}	2015-2018	8	10.06	7.36	8.78

3.4 Resistance to mite and root rot diseases.

Mite *(Tetranychus bimaculatus)* is important insect, especially during dry season because population of mite during dry season is higher than in rainy season. The mite attach can reduce the yield range by 15-73 %, depending on the variety, 15 % for susceptible variety and 73 % for resistance variety [18]. Vamas 1 is shown moderately resistant against mite insect under artificial screening which is similar to the checks (Table 4). Expression of cassava green mite density and cassava green mite leaf damage were controled by additive and non-additive genes [19]. There were 35 single-nucleotide polymorphism (SNPs) that were significantly associated with cassava green mite severity, leaf pubescence, leaf retention, stay green, shoot tip compactness, and shoot tip size [20]. They may indicate pleiotropy or the presence of closely related genes that regulate those traits. Root rot is the diseases for cassava. A Few pathogens cause root rot, one of them is *Fusarium* spp. It is mentioned as dry root rot [21]. This pathogen is as a soil microbe. There were 8 and 22 SNPs associated with to the severity of dry root rot in the pulp and peel, respectively [22]. Cassava root rot (CRR) diseases are controlled by low-impact loci, and key SNPs can be used to identify putative genes that control these traits [21]. Vamas 1 has shown moderately resistant under artificial screening, while the checks showed the susceptible (Table 4) [14].

Table 4. Evaluation of Vamas 1 / OMR 51-20-5 along with checks for mite insect and root rot diseases

Insect and diseases	Vamas 1	Check varieties	
		UJ3 (Rayong 60)	UJ5 (Kassart 50)
Mite ((*Tetranychus bimaculatus)*	Moderately resistant	Moderately resistant	Moderately resistant
Root diseases cause by fusarium spp.	Moderately resistant	Susceptible	Susceptible

3.5 Quality attributes

Cassava with high HCN content is considered bitter is mainly consumed as flour, starch, glucose. Cassava with low HCN content (less than 100 ppm in fresh roots) is known as sweet cassava and can be consumed cooked or processed [22]. However, there is another report that cassava with HCN content < 50 ppm in fresh roots is called sweet cassava, while cassava with HCN concentration ≥50 ppm in fresh root is called as bitter cassava [23]. I is also reported that the maximum cyanogenetic potential for human consumption is 50 ppm for fresh root [24]. Cyanogenic potential is the potential amount of HCN that can be released. Multiple genes control HCN content. Two major loci were identified that encode ATPase and MATE proteins, and contribute up to 7 and 30% to root HCN concentratios, respectively [25]. Five new QTI affecting cyanogenic potential were successfully identified from 4 linkage groups. The discovery of these QTL may prove to be useful markers to aiding in cassava breeding and the study of genes that influence traits [26]. Mean of HCN content of fresh tuber of Vamas 1 / OMR 51-20-5 was 19.68 ppm less than UJ3 (48.9 ppm) and UJ5 (40.56 ppm) as checks (Table 5) [14]. Therefore, Vamas 1 may used as raw material for boiled cassava, fied cassava, fried cassava chips, and fermented cassava.

The starch content of cassava tubers is an important feature for farmers and traders when choosing varieties. This parameter is important in determining the starch yield and conversion value of fresh tuber to ethanol. Cassava tuber with high starch content have higher price than the cassava tuber with low starch content of cassava tuber. Cassava tuber with high starch content is more efficient in processing of fresh tuber into cassava starch. Starch content tuber is affected by genetic factor and interaction between genetics and environments [12]. In general, starch content of tuber will increase if the growing period of plant increase till certain growing period. There was positive correlation between starch content of tuber with rain fall during growing period 6-9 months, however the correlation will be negative, if rain fall happen during 1 or two months before harvesting [27]. There was no correlation between tuber starch content and the fresh tuber yield, whereas tuber starch content was positively correlated with starch yield [9]. Multiple genes control starch content of tuber. Genes predicted to encode for glycosyl hydrolases, uridine 5’-diphospho-(UDP)-glucuronosyl transferases and UDP-glucosyl transferases were found among the 44 genes located within the region containing the QTL controlling starch content [10]. Among 44 genes Mean of starch content of fresh tuber based gravity system of OMR 51-20-5 was 22.14% in seven months, significantly out-yielded all the check varieties UJ3 and UJ5, 11% and 7%, respectively higher than checks. Mean of starch content of fresh tuber based dry basis of OMR 51-20-5 was 83.65% in seven months, out-yielded all the check varieties UJ3 and UJ5, 10% and 11%, respectively higher than checks (Table 5.). Farmers and businessman prefer the high starch content of tuber. Tuber with a high starch content are priced higher than those with a low starch conten.

Table 5. Quality attributes of Vamas 1

Item	Vamas 1	Check varieties	
		UJ3 (Rayong 60)	UJ5 (Kassart 50)
Mean of starch content*	22.14	19.88	20.68
Mean of starch content**	83.65	76.06	75.04
% increase of starch content over checks	-	11	7
HCN content of fresh tuber	19.68	48.9	40.56

*: based on gravity system
**: dry basis

4 Conclusions

1. Vamas 1 is potential to be developed in cassava area for increasing cassava planting area and productivity to support availability of cassava as raw material of industry and to develop and maitain competitive industries
2. The productivity of Vamas 1 15-25% higher than the existing varieties (UJ3 and UJ5). This increasing value are equal to USD 482-745/ha. pact recognition.

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