Genetics variances of three elite cassava clones under different environment of fertilizer types

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Abstract. It is very important to evaluate traits of cassava clones, especially early harvest cassava clones under different environments of fertilizer types. Until now, study of genetics variance in early harvest cassava is still very rare. Accordingly, the objective of this study was to evaluate the genetics parameter of early harvest cassava clones under different fertilizer types. Treatments were arranged by factorial design (3x4) in completely randomized block design with two reps. The first factor was three cassava clones as Soponyono, local Waxy (early harvest clone), and UJ5 (conventional clone). The second factor was four fertilizer types as inorganic fertilizer of KCl, organic fertilizer of K, cow manure, modified EM (bio fertilizer). The organic fertilizer of K was from cassava fresh stem that was finely small chipping as source of K. Observations of variables were carried out when the plants were 6 months old after planting. The observed variables were plant height, number of green leaves, total number of leaves, stem weight, fresh leaf weight, number of roots, number of storage root, storage root weight. The result was storage root number and storage root weight showed negative genetic variation. It means that storage root traits were influenced by environment as fertilizer types.
Keywords: early harvest, K-organic, storage root, traits

1 Introduction

Genetic variation is the basic capital in plant breeding. In the future, the increase in cassava yield is very important to achieve the balance between demand and supply. Until now, the demand of cassava yield in form of tapioca seemed to be higher than the supply. It means that the tapioca production needs to be improve to minimize the tapioca yield gap. One of the main efforts to increase cassava yield was to select high yielding cassava clones at early harvest age. There are several cassava clones that can be harvested early with high production and starch content [1]. The important characters to select the high yielding cassava clones was to create the genetic variation. The achievement of high yielding cassava clones was based on the genetic variation resulted to easily select to the best performance [2]. The best performance would be affected by environment especially fertilizer. Recently, the price

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of fertilizer was expensive and very rare in the market sale. Therefore, the use of organic fertilizer is highly recommended in this situation.

In one population, if the genetic variation is large enough, then the heritability is assumed to be quite high. Heritability is a comparison between the amount of genetic variation and the amount of phenotypic variation of a character. However, heritability estimates alone do not provide an idea of the expected gains in the next generation but must be considered by estimating genetic progress and changes in the mean values between generations [3,4]. Fresh weight of root had a high heritability value (78.39%) and high genetic advance (26.27%) [5]. It means root fresh weight is controlled mostly by genetic variance.

Moreover, there was variation in starch content due to clone [6]. High heritability value in a broad sense and the high genetic advance in character means that the character is under control of the influence of additive genes which indicates that selection in germplasm should lead to a rapid increase in the trait [5,7]. Additionally, stated that fresh weight of root and plant height had high heritability value as 31% and 62%, respectively [8]. Therefore, the objective of this study was to evaluate genetic variation and genetic advance of three cassava clones. Local Waxy clone has high amylopectin content and promising to be early harvest clone, UJ5 clone produce high starch and commonly planted by farmers, then Soponyono is promising to be early harvest clone with low starch content [5,9]. The alternative fertilizer to be promisingly applied in cassava was organic fertilizer. Yet, the genetic variation of some cassava clones might be influenced by organic fertilizer as environment condition. Unfortunately, the information regarding the genetic variance of cassava clones under different environments especially organic fertilizer was limited.

2 Materials and methods

2.1 Location and time

This study was conducted on the village of Gadingrejo, Pesawaran, Lampung Indonesia with the soil type of podzolic red yellow pH around 4.6. After applying 2-ton dolomite ha-1, the pH increased to 7,1. The planting time started on middle of March 2020 until September 2020.

2.2 Trial design

The treatment was arranged by factorial (3x4) in completely randomized block design with two reps. First factor was three cassava clones as local Waxy, Soponyono, and UJ5. the second factor was four fertilizer types as inorganic fertilizer of KCl, organic fertilizer of K (grated cassava stem), cow manure, modified EM (bio fertilizer). Organic K fertilizer comes from finely chopped fresh cassava stems as a source of K applied at 40 tons ha-1. Cow manure was applied as much as 20 tons ha-1. Biofertilizer in the form of EM4 with a concentration of 2% which was applied by spraying with a volume of 150 ml per m2. The inorganic fertilizer treatment was 200 kg urea ha-1 (45% N), 100 kg KCl ha-1 (60% K2O) and 100 kg SP-36 ha-1 (30% P2O5). The base fertilizer for other fertilization treatments was 100 kg urea ha-1 (45% N), 50 kg KCl ha-1 (60% K2O) and 50 kg SP-36 ha-1 (36% P2O5). The application of fertilizer was twice, first, TSP was fully applied one month after planting (MAP) in the field together with half of urea and KCl. The second fertilizer was applied at 3 MAP by half dosage of urea and KCl.

2.3 Statistical analysis

Data were analysed in Analysis of variance and Least Significant Difference by Statistic Analysis System. After assumptions of normality and variance homogeneity were fulfilled, data was continued to be analysis of variance. Since there was a significant difference among treatment means, least significant difference (LSD) was performed by 5% level of significant difference. Estimation of genetic parameters includes estimating genetic variance (σ2g), phenotype variance (σ2p) [10]. The estimated value of heritability in the broad sense (h2) based on the formula according to Fehr [11].

Observations of variables were carried out when the plants were 6 months old after planting (MAP). The observed variables were plant height, number of green leaves, total number of leaves, stem weight, fresh leaf weight, number of roots, number of storage root, storage root weight. The observed variables were plant height, number of green leaves, total number of leaves, stem weight, fresh leaf weight, number of roots, number of storage root, storage root weight.ight, number of roots, number of storage root, storage root weight.

3 Results and discussion

The results of the research showed that the genetic variation in the cassava production variables, namely number of storage root, fresh storage root weight and storage root diameter had negative values and had positive phenotypic variation values, especially for the character of weight (Table 1). This could happen if individuals in a population, the diversity that appears was homogeneous or uniform and the phenotypic diversity was more influenced by environmental factors.

The visible characters or phenotypic diversity were the result of interactions between genetic and environmental factors [12]. Variance estimates that have a negative value were considered to have a value of zero [13]. Apart from that, according to Aryana [14], in conditions of narrow genetic diversity, it shows that the individuals in the population have homozygous loci for all the observed characters. Several researchers also found that genetic diversity was negative due to the large environmental influence on population [15–17].

Table 1. Estimation of genetic variation, phenotypic variation and heritability of 3 cassava clones at 6 months after planting.

Variables	σ_g^2	σ_p^2	h^2
Plant height	254.25	311.60	0.82
Number of leaves	-33.84	2,493,450.41	0.00
Total number of leaves	658.42	685.46	0.96
Stem weight	-121.36	777.66	-0.16
Leaf weight	2,039.97	2,250.66	0.91
Number of roots	-22.17	2.66	-8.34
Number of storage roots	-7.61	1.97	-3.86
Fresh storage root weight	-52,781.50	112,178.91	-0.47

The large environmental influence on production characteristics could be seen in the Least significant difference test which shows significant differences between clones, types of fertilizer and their interactions. The presence of negative genetic diversity in production variables, this was suspected to be due to the absence of genetic diversity in cassava clones

harvested at 6 months of age. The UJ5 clone had also been used as a comparison to detect early harvested cassava clones where the average value of fresh storage root weight was slightly below that of superior early harvested clones and the starch content was no different at 7-month-old harvest [1]. Soponyono and Local waxy clones could be categorized as early harvested cassava clones.

Table 2. The means of observed variables from 4 types of fertilizer at 6 MAP.

Variables	Chemical	Cow Manure	Grated Cassava Stem	Biofertilizer	LSD 5%
Plant height	139.25 ^{b}	153.58 ^{ab}	148.42 ^{ab}	156.42 ^{a}	14.47
Leaf weight	98.83 ^{ab}	119.83 ^{a}	80.25 ^{b}	97.00 ^{ab}	32.05
Number of roots	19.17 ^{b}	25.42 ^{a}	21.50 ^{ab}	23.75 ^{ab}	5.60
Fresh storage root weight	1638.80 ^{a}	1285.40 ^{ab}	1405.90 ^{ab}	1078.30 ^{b}	434.02

The highest value of the fresh storage root weight variable among the types of fertilizer provided was achieved with chemical fertilizer (KCl) which was not significantly different from organic fertilizer (grated cassava stem) and cow manure (Table 2). This shows that the use of grated cassava stem or cow manure as an alternative and could substitute chemical fertilizer. Providing optimum potassium fertilizer could increase cassava fresh storage root weight [18,19]. Laboratory test results for K2O levels in grated cassava stems were 1.01% [20]. Cow manure had a K2O content of 0.4-0.56% [21]. The highest value of clone interaction with fertilizer type was achieved by Soponyono clone with the fertilizer type for the variable of number of storage roots and storage root weight (Table 4). This shows that Soponyono clone was responsive to the application of cow manure or inorganic fertilizers (Table 2). As with another research, cassava was responsive to the application of chemical fertilizers or cow manure in increasing storage root fresh and dry weights, percentage of total starch and amylose content [18].

Table 3. The mean of observed vegetative variables from 3 cassava clones at 6 MAP.

Variables	UJ5	BW2	Soponyono	LSD 5%
Stem length	159.94 ^{a}	152.69 ^{a}	135.63 ^{b}	12.53
Total number of leaves	64.88 ^{b}	65.38 ^{b}	97.19 ^{a}	11.81
Leaf weight	128.00 ^{a}	62.25 ^{b}	106.69 ^{a}	27.75

Table 4. The means of observed variables of 4 cassava clones at 6 months after planting.

Clones	Fertilizers	NL	TNL	LW	NR	NSR	FSRW
Soponyono	CF	42.25 ^{ab}	98.50 ^{a}	121.00 ^{abc}	20.75 ^{bc}	14.8 ^{abc}	2099.0 ^{a}
	CM	51.75 ^{ab}	101.25 ^{a}	127.00 ^{ab}	29.00 ^{ab}	18.8 ^{a}	2180.0 ^{a}
	GCS	37.75 ^{b}	101.25 ^{a}	78.25 ^{bcd}	20.50 ^{bc}	13.3 ^{abcd}	1626.8 ^{ab}
	BF	41.75 ^{ab}	87.75 ^{ab}	100,50 ^{abc}	14.50 ^{c}	7.8 ^{d}	595.3 ^{c}
Local Waxy	CF	32.75 ^{b}	61.25 ^{cd}	43.75 ^{d}	16.50 ^{c}	9.0 ^{cd}	1193.0 ^{bc}
	CM	59.00 ^{a}	68.25 ^{bcd}	97.25 ^{abcd}	27.50 ^{ab}	12.8 ^{abcd}	990.8 ^{bc}
	GCS	49.25 ^{ab}	65.00 ^{bcd}	65.75 ^{cd}	16.25 ^{c}	10.5 ^{bcd}	1060.5 ^{bc}
	BF	35.50 ^{b}	67.00 ^{bcd}	42.25 ^{d}	33.50 ^{a}	14.8 ^{abc}	1664.0 ^{ab}

UJ5	CF	49.25 ab	57.50 d	131.75 ab	20.25 bc	12.0 abcd	1624.3 ab
	CM	41.25 ab	58.00 cd	135.25 a	19.75 bc	8.8 cd	685.5 c
	GCS	41.75 ab	81.25 abc	96.75 abcd	27.75 ab	17.0 ab	1530.5 ab
	BF	45.50 ab	62.75 cd	148.25 a	23.25 bc	16.0 ab	975.8 bc

Note: [1] CF: Chemical Fertilizer; CM: Cow Manure; GCS: Grated Cassava Stem and BF: Biofertilizer
[2] NL: Number of Leaves; TNL: Total Number of Leaves; LW: Leaf Weight; NR: Number of Roots; NSR: Number os Storage Roots and FSRW: Fresh Storage Root Weight
[3] Numbers followed by the same letter are not significantly different at the LSD level of 5%

Heritability is the proportion of genetic factors shown by a certain quantity to environmental factors and describes the ability of the genotype to inherit traits [13]. Heritability for the production variable from this study has a negative value (Table 1). The results of the analysis of character variations with negative heritability values are considered to have no diversity or a value of 0 [22]. Negative heritability estimation values were also found in the another research [22,23]. The heritability estimation value in this study is negative and can be considered zero or in the low category. A low heritability value indicates that the appearance of a character/trait is more influenced by environmental factors than genetic factors [24,25]. The environmental factor that influences heritability in this case is the type of fertilizer. The low heritability estimation value indicates the ineffectiveness of selection for the cassava clones studied due to the large influence of the environment, in this case the various types of fertilizer treated.

Different results in the estimation value of genetic variation in vegetative variables, namely the total number of leaves, stem length, leaf weight and which had positive values. The positive genetic variation value also had a high heritability value in the range of 82-96% (Table 1). This shows that the effectiveness of selection on the characters total number of leaves, stem length, leaf weight, was getting better for the three clones studied. Selection will be effective if the population had wide genetic diversity and high heritability [26]. High heritability means that phenotypic appearance was more influenced by genetics than environmental influences. Selection for characters with wide diversity and high heritability would result in selection progress or an increase in the mean value after selection. The LSD test on the vegetative variables was significantly different between clones, type of fertilizer and their interactions. High heritability for vegetative variables can be concluded that selection can be carried out among the clonal. The highest value of vegetative variables for the total number of leaves was achieved by the Soponyono clone, but for the variables of stem length, and leaf weight the highest value was achieved by the UJ5 clone (Table 3). This can be concluded that the UJ5 clone has better vegetative genetic characteristics than the Soponyono and Waxy clones.

Conclusion

The presence of negative genetic diversity in production variables, this was suspected to be due to the absence of genetic diversity in cassava clones harvested at 6 months of age. Soponyono and Local waxy clones could be categorized as early harvested cassava clones.

The highest value of the fresh storage root weight variable among the types of fertilizer provided was achieved with chemical fertilizer (KCl) which was not significantly different from organic fertilizer (grated cassava stem) and cow manure. Grated cassava stems or cow manure could be used as an alternative and replace chemical fertilizers.

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Author contributions

Kukuh Setiawan assisted in conducting the experiments, Muhammad Syamsoel Hadi and Muhammad Kamal performed the statistical analysis. Sungkono assisted in data visualization. Eko Pramono wrote the manuscript. Ardian designed and conducted all of the experiments and wrote the manuscript. All authors have read and approved of the final manuscript.

Conflict of interest

The authors declare that they hold no competing interests.

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