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Heretability and Correlation of Vegetative and Generative Character on Genotypes of Jatropha (*Jatropha curcas* Linn.)

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Abstract

This study was aimed to obtain information of heritability predictive value and correlations of vegetative and generative characters on six genotypes of *J. curcas*. The characters of plant height, leaf number, leaf width, number of primary and secondary branches, number of fruit bunches, number of fruits per plant, seed's and 100 seeds' dry weight showed high predictive value of heritability. Characters related to positive correlation and high heritability values (leaf width, number of primary branches, number of secondary branches, number of fruit bunches, number of fruits per plant) are able to be used as criteria for selection of *J. curcas* plant.

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Keywords: Correlation;heritability;*Jatropha curcas* Linn.

1. Introduction

Jatropha curcas L., which is also known as *physic nut,* included as the family of *Euphorbiaceae.* This plant is supposedly to have come from Mexico or central America and have been introduced to Africa and Asia. In present time, *J. curcas* is widely cultivated in most of the tropical countries [1,2] including Indonesia. *J. curcas* produces seed that contains high oil content and can be used as bio-diesel [3]. The advantage of *J. curcas* as an energy source such as; the utilization of this energy source will not compete with other food needs as they occur in plants producing other bio-fuels, the utilization is not only limited to biofuel producer, but also for lubricats, soaps,

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insecticides industry, fungicides and molluscicide, as well as drugs for anti-tumor [4].

Breeding activities for *J. curcas* in Indonesia began in 2006 [5]. Today's primary need is obtaining high yielding of *J. curcas* especially for high production potential [6]. However, up to now, information on *J. curcas*'s cultivation techniques, which is based on the research results is still very limited. The provision of quality seed in large scale has become one of many obstacles in *J. curcas* cultivation development. To overcome these issues, the effort that must be done is improving the plant materials through plant breeding activities. Improvement of *J. curcas*'s plant material, which is a plant the annual cross-pollinated plant can be done through population improvement and hybrid assembling. The activities of *J. curcas* plant improvement have been conducted by the Indonesia's Center for Plantation's Research and Development through mass selection activity for genotypes which were collected from various regions in Indonesia. The result of plant selection material have higher levels of production than the average population [7], however up to present time, the resulted plant material is considered not be able to provide benefits for farmers. This has become one of the problems that led to farmers are less interested in developing *J. curcas.*

In *J. curcas* breeding program, high production requires basic population which related to high genetic diversity, especially in characters related to plant production ability. Until now, studies and information on plant genotypic diversity of *J. curcas* still limited. Therefore, it needs to carry out some further evaluation related to genotypic studies toward some genotypes which are going to be used as parent in crossing.. Besides genetic diversity, the necessary information needed is heritability of generative character and correlations between characters [8]. Heritability value is one of method to estimate how strong a character is affected by genetic and environmental factors. The high heritability value shows that genetic factor has major roles compared to its environmental factors [9].

Information about correlation between characters is also necessary to simplify the selection process. Correlation is a method used to determine the strong relationship between the quantitative characters [10]. The properties that can be used as selection criteria include; the real correlated characters and other characters. Correlation that occurs between characters with the final result is influenced by all segregating genes or various environmental factors that control the diverse of its correlated factors [11]. Estimating genetic parameters for various *J. curcas* plant characters had been done [2,12-15]. With the information of correlation between characters, especially between characters that can be earlier evaluated with characters included in resulted components, it is expected to shorten the time of selection for the selection can be done without waiting crop production period.

The objective of this research was to obtain information about heritability predictive value and correlation of vegetative and generative characters of some genotypes *J. curcas*. The obtained information is expected to be useful as a basis for selection of high yield *J. curcas* breeding programs.

2. Material and method

This research was done in experiment plantation sites located in Kedung Pengaron village, Kejayan District, Pasuruan - East Java. The research was done by simple randomized group design, by four replications. Planting material used was four *J. curcas* genotypes from crossing number 5 (HS49 × SP34), number 6 (HS49 × SM35), number 7 (HS49 × IP1A), number 18 (SP16 × SM35) and two comparison plants from the Ministry of Agriculture which were IP3A, IP3P [16]. Vegetative characters observed include plant height, number of leaves, number of leaves indentations, leaf width, number of primary branches, number of secondary branches, stem diameter and canopy diameter. While the observed generative character include the number of fruit bunches, number of fruits per plant, seeds' dry weight per plant and 100 seeds' dry weight at the second harvest.

Data analysis was conducted using analysis of variance and covariance, followed by using t test. Genetic variability was known through calculation of genetic variance and its standard of deviance. Heritability value was estimated by using formula: $h^2 = \sigma^2 g / \sigma^2 p$ (h^2= heritability, $\sigma^2 g$ = genotype variance, $\sigma^2 p$ = phenotype variance). Then, the heritability value is classified by [17], which is high if $h^2 > 0.50$, moderate if $0.20 \geq h^2 \leq 0.50$, and low if $h^2 < 0.20$.

3. Results and discussions

3.1. Value correlation between J. curcas vegetative and generative characters

The correlation analysis result of the vegetative and generative character (Table 1) showed that the plant's height growth correlated negatively to the number of leaves. This may be implied that the increasing in any of the plant's characters is not followed by increasing in other characters. Furthermore, plants' height character showed no correlation with some generative characters.

The number of leaves showed a positive correlation to the leaf width, number of primary branches, number of secondary branches and number of fruits per plant. Plant branching is the location where leaves and fruits grow, so if the number of secondary branch increased, it will be followed by the increasing of the number of leaves. Leave is an important part in the process of plant photosynthesis, so that the photosynthesis results can be utilized by generative character such as the number of fruit per plant.

Table 1. Analysis of vegetative and generative character correlation of *Jatropha curcas*

	PH	NL	TIL	LA	PB	SB	SD	CD	NFB	NFP	SDW	DW100
PH (rg)	1	-0.00079**	0.78**	-0.101**	-0.97ns	-0,50*	-0.14**	0.82**	-0.65 ns	-0.68 ns	-0.64 ns	-0.61ns
(rp)	1	-0.037**	0.31ns	-0.058**	-0.46*	-0.36**	-0.14**	0.30ns	-0.48*	-0.49*	-0.49*	-0.30**
NL (rg)		1	-0.13**	0.85**	0.53**	0.94**	-0.11**	-0.07**	0.43 ns	0.55*	0.33 ns	-0.48**
(rp)		1	-0.34**	0.86**	0.33ns	0.80**	0.02ns	0.50*	0.43*	0.47*	0.37 ns	-0.34**
TIL (rg)			1	-0.20**	-0.59*	-0.56*	0.85**	0.86**	-0.86 ns	-0.85 ns	-0.77 ns	-0.36**
(rp)			1	-0.40**	-0.21**	-0.35**	-0.08**	0.006ns	-0.57 ns	-0.58 ns	-0.55 ns	-0.30**
LA (rg)				1	0.77**	0.96**	0.57**	-0.24**	0.68**	0.82**	0.59**	-0.37**
(rp)				1	0,43*	0.77**	0.21ns	-0.30ns	0.53**	0.58**	0.47*	-0.21**
PB (rg)					1	0.98**	0.77**	-0.46**	0.71*	0.82**	0.57*	-0.11**
(rp)					1	0.64**	0.28ns	-0.05**	0.36 ns	0.41*	0.35 ns	-0.23**
SB (rg)						1	0.43 ns	-0.56 ns	0.56**	0.64**	0.45*	-0.45**
(rp)						1	0.35 ns	0.32 ns	0.54**	0.60**	0.49*	-0.25**
SD (rg)							1	-0.27**	0.70**	0.67**	0.78**	0.43*
(rp)							1	-0.24**	0.49*	0.48*	0.50*	0.06ns
CD (rg)								1	-0.99 ns	-0.98 ns	-0.87 ns	-0.98ns
(rp)								1	-0.43*	-0.33**	-0.46*	-0.69ns
NFB (rg)									1	0.98 **	0.98**	0.71*
(rp)									1	0.98**	0.98**	0.47*
NFP(rg)										1	0.97**	0.62*
(rp)										1	0.97**	0,39 ns
SDW(rg)											1	0.82**
(rp)											1	0.51*
DW100(rg)												1
(rp)												1

PH : Plant high
NL : Number of Leaves
TIL : Total indentation leaf
LA : Leaf Area
PB : Primary branch
SB : Secondary branch
SD : Stem diameter
CD : Canopy diameter
NFB : Number of fruit bunch
NFP : Number of fruit per plant
SDW : Seed dry weight
DW 100 : Dry weight of 100 seeds
(rg) : genotype varians
(rp) : phenotype varians
*/** : significant
(-) : negative
ns : non significant

Information about correlation between characters is urgently needed to simplify the selection process. In *J. curcas* plant, which is an annual plant, evaluation of the genetic material must be conducted during some times in a minimum one-year production period so that the data obtained more accurate. With the existing correlation information between the characters, especially the existing correlation between the characters that can be evaluated earlier with characters including in result components, it is expected to shorten the time of selection because the selection can be done without waiting the crops' production [8].

The analysis result showed the number of primary branches and number of secondary branches correlated positively with generative characters which are the number of fruits' bunches, number of fruits per plant and fruit's dry weight per plant (Table 1). This is in line to [18] that more number of branches produce, more flower bunches will be generated, as well as the establishment of branches and fruit bunches will be more evenly distributed. This result is consistent with the evaluation of 60 genotypes of *J. curcas* which shows the correlation between the characters of vegetative to generative character [19] the existing consistency in evaluated characters in this study with the results of previous study showed that these characters is the character that is much more influenced by genetic factors than environmental factors. The correlated vegetative character to generative character can be considered to be used in the selection process of high yielding *J. curcas* plant. By utilizing the vegetative characters in the selection process, the activities of plant selection are expected to be done earlier.

Correlation test results demonstrate a correlation between the character of the leaf width toward the generative characters (number of fruit bunches, number of fruits and seeds' dry weight of per plant). This is presumably because the plants that have wider leaf width will have wider surface area in receiving sunlight and absorption of CO_2 by leaves, so photosynthesis will increase and can increase seeds' dry weight. The increasing in photosynthesis will significantly provide higher photosynthate supply against the increasing of *J. curcas* plant seeds' production [20].

Stem diameter was positively correlated to the number of fruit bunches, number of fruits per plant and seed's dry weight. Mariam [21] stated that plant's diameter is indirectly able to increase the number of *J. curcas* plants flowers bunches. The research of Jatropha heretability [8] showed that the width of the canopy is a vegetative characters which positively correlated with generative character which are the number of flower bunches and the number of flower bunches and and yield components of fruit number per plant. Yet, canopy diameter in this study did not show any correlation with number of bunches, number of fruits and fruit's dry weight per plant.

In general, generative character from number of fruit bunches and number of fruits per plant was positively correlated with the seed's dry weight per plant and 100 seeds' weight. These two characters showed their consistency as a character in early selection on *J. curcas* plant. Hartati [10] stated that the number of flowers bunches character, number of fruit bunches and number of fruits per plant can be considered as a selection criteria of *J. curcas*. In addition, from the results of Das et al. [12] also stated that the character of the number of flowers bunches and number of fruits per plant is effective characters used in plant improvement programs to improve *J. curcas* plants outcomes.

3.3. Heritability

Heritability value of a character shows how big the characters are influenced by genetic or environmental factors. High heritability value indicates more genetic factors play a role in controlling a character than environmental factors [9]. In this research, heritability analysis is done by using the heritability formula in the broad meaning. The result of analysis showed that heritability values vary for each observed character s (Table 2). The criteria for heritability values were then classified according to [17, 22], which are; high if $h^2 > 12.50$ %, moderate if $0.20\ \% \geq h^2 \leq 0.50$ %, and low if $h^2 < 0.20$ %. The result of the heritability predictive value analysis of each character is showed in Table 3.

A character has a broad genetic variability if its genetic variance value is greater than twice its standard deviation values. Plant height ($h^2 = 0.61$), number of leaves ($h^2 = 0.52$), leaf width ($h^2 = 0, 71$), primary branch ($h^2 = 0.51$), secondary branch ($h^2 = 0.70$), number of fruit bunches ($h^2 = 0.60$), number of fruits per plant ($h^2 = 0.55$), seed's dry weight ($h^2 = 0.63$), and 100 seeds' weight ($h^2 = 0.53$) deliver high heritability values. It can be implied that on the character stated, genetic factors has greater influences than environmental influences.

Other characters which were tested and posed a moderate heritability value is stem diameter ($h^2 = 0.27$) and canopy diameter ($h^2 = 0.25$) whereas the low heritability value is on the character of the number of leaves indentation ($h^2 = 0.02$). Poespodarsono [22] argues that the higher the heritability value of a character, the greater

genetic influence than the environment. While Amzeri [23] stated that the high heritability value of a character can provide criteria in which the selection process for these characters can be done at the early generation.

Table 2. Heritability predictive value

Charakters	$\sigma^2 g$	$\sigma^2 p$	h^2	Criteria
Plant high	15.19	24.89	0.61	High
Number of Leaves	370.34	699.14	0.52	High
Total indentation leaf	0.0003	0,013	0.02	Low
Leaf Area	10 051 192	14 091 982	0.71	High
Primary branch	0.46	0.89	0.51	High
Secondary branch	8.39	11.93	0.70	High
Stem diameter	0.037	0.135	0.27	Medium
Canopy diameter	10.50	41.17	0.25	Medium
Number of fruit bunch	30.43	49.99	0.60	High
Number of fruit per plant	389.21	704.47	0.55	High
Seed dry weight	2 162.93	3 398.96	0.63	High
Dry weight of 100 seeds	10.02	18.77	0.53	High

$\sigma^2 g$: phenotype variance $\sigma^2 p$: genotype variance h^2 : heretability

Heritability value also determines the level of progress of selection. The higher heritability value of a character, the greater progress can be achieved through selection on the character [24]. Generative character shown by the character of the amount of fruit bunches per plant, the number of fruit per plant, seed's dry weight and 100 seeds'dry weight have high heritability values (Table 2). The high heritability value in the broad meaning indicates that this character is more influenced by genetic factors rather than environmental factors.

Based on [25] criteria, the character of flowering, number of flowers' bunches, number of fruits' bunches and numbers of fruits have a broad genetic diversity. These four characters are good enough to be utilized in the selection process to select high yielding genotypes of *J. curcas*. Number of flowers bunches per plant and the numbers of fruit per plant are quite effective character used in plant improvement programs for improving results as reported [23].

Although some generative characters posse high genetic diversity value and good enough to be used in the selection process, the presence of vegetative characters that can be used as selection criteria will contribute more benefits, as it can speed up the time for selection. Based on the correlation values in this research, vegetative characters which show consistency correlated positively to the generative character and result component which are leaf width, number of primary branches, number of secondary branches, and stem diameter, however the stem diameter has a moderate heritability value in the broad sense, so it is less suitable if used as selection criteria.

Mohapotra and Panda [26] conducted research in India on 20 genotypes *of Jatropha* which have different morphologies and reported a correlation between the width of branches and number of flowers bunches per plant with the number of fruits. Thus, in addition to the number of flower bunches per plant, number of fruits bunches per plant and number of fruits per plant, character of total number of branches are good enough to be utilized in the selection *J. curcas.* Some other researchers also recommend using the character of fruit number in the selection program. The use of fruit number per plant characters as selection criteria is easy to be performed for the size of the *J.curcas* fruit is the relatively large so that it is easier to be observed.

3.3. *Cross analysis.*

The result of cross analysis on 100 seeds' dry weight (Table 3) showed that the character which have e high value of the direct influence to the 100 seeds' dry weight was the number of bunches per plant (7.324), number of fruits per plant (5.289), and the number of leaves (5.070). If we observe the results of heritability predictive value calculations, these three characters also showed high heritability values.

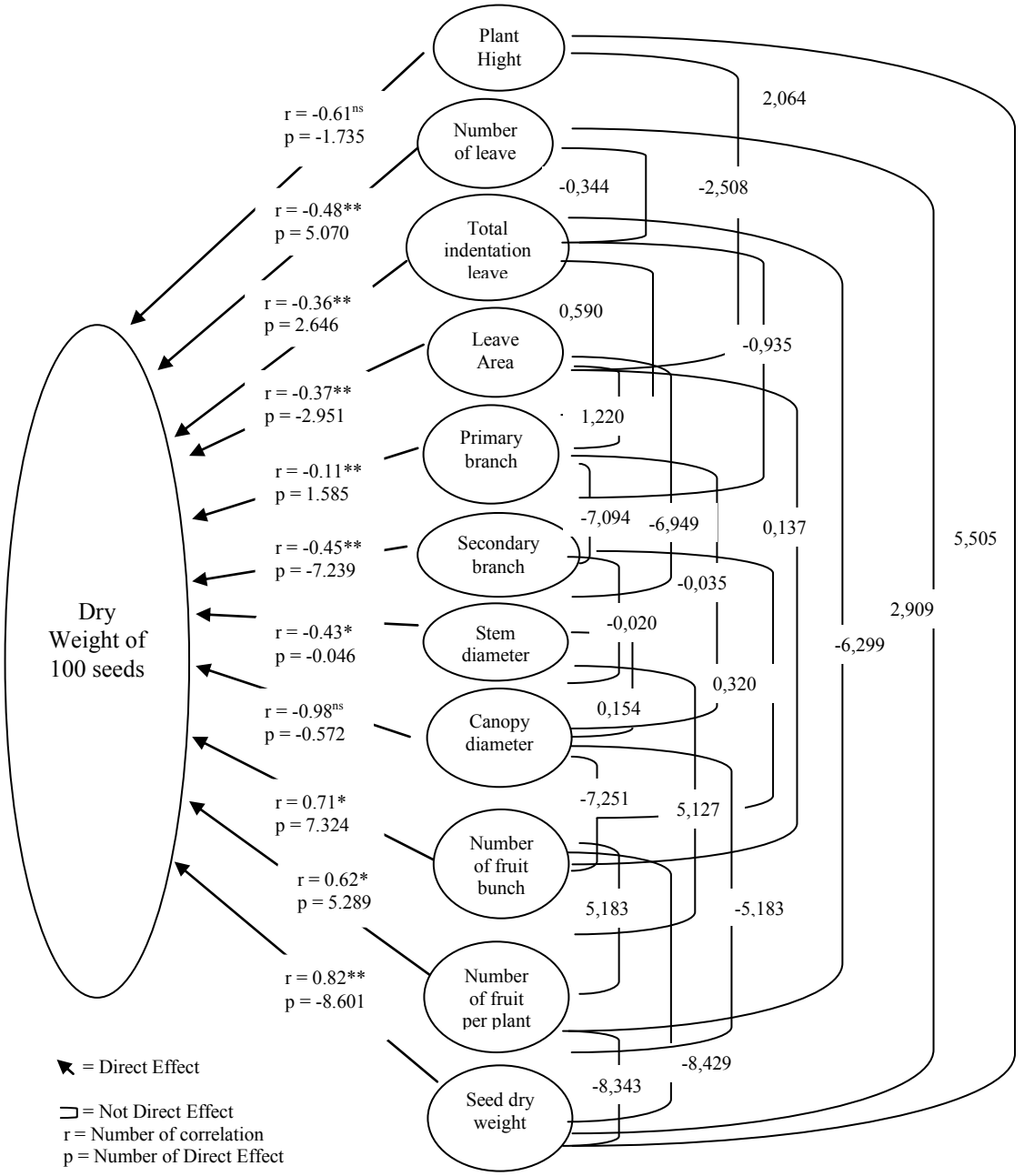

Figure 1. Cross analysis on vegetative and generative character of the 100 seeds' dry weight per plant

Table 3. Cross analysis on vegetative and generative character of the 100 seeds' dry weight per plant.

Independent Variable	Directly	Not Directly										Total
		PH	NL	TIL	LA	PB	SB	SD	CD	NFB	NFP	SDW	
PH	-1.735		-0.004	2.064	0.298	-1.537	3.619	0.006	-0.469	-4.761	-3.596	5.505	-0.610
NL	5.070	0.001		-0.344	-2.508	0.840	-6.805	0.005	0.040	3.150	2.909	-2.838	-0.480
TIL	2.646	-1.353	-0.659		0.590	-0.935	4.054	-0.039	-0.492	-6.299	-4.496	6.623	-0.360
LA	-2.951	0.175	4.310	-0.529		1.220	-6.949	-0.026	0.137	4.981	4.337	-5.075	-0.370
PB	1.585	1.683	2.687	-1.561	-2.272		-7.094	-0.035	0.263	5.200	4.337	-4.903	-0.110
SB	-7.239	0.867	4.766	-1.482	-2.833	1.553		-0.020	0.320	4.102	3.385	-3.871	-0.450
SD	-0.046	0.243	-0.558	2.249	-1.682	1.220	-3.113		0.154	5.127	3.544	-6.709	0.430
CD	-0.572	-1.422	-0.355	2.275	0.708	-0.729	4.054	0.012		-7.251	-5.183	7.483	-0.980
NFB	7.324	1.128	2.180	-2.275	-2.006	1.125	-4.054	-0.032	0.566		5.183	-8.429	0.710
NFP	5.289	1.180	2.789	-2.249	-2.420	1.300	-4.633	-0.031	0.561	7.178		-8.343	0.620
SDW	-8.601	1.110	1.673	-2.037	-1.741	0.903	-3.257	-0.036	0.498	7.178	5.130		0.820

PH : Plant high
NL : Number of Leaves
TIL : Total indentation leaf
LA : Leaf Area
PB : Primary branch
SB : Secondary branch
SD : Stem diameter
CD : Canopy diameter
NFB : Number of fruit bunch
NFP : Number of fruit per plant
SDW: Seed dry weight
DW 100: Dry weight of 100 seeds

The high direct connection of those three characters to the 100 seeds' dry weight showed that the character of the number of fruit bunches per plant, number of fruits per plant and numbers of leaves are important characters which determine 100 seeds dry weight of plant *J. curcas.*

4.Conclusion

Characters that related to high heritability values were plant height, number of leaves, leaf width, number of primary branches, number of secondary branches, number of fruit bunches per plant, number of fruits per plant, seeds' dry weight per plant and 100 seeds' weight. Characters that posse positive correlation and high heritability values (leaves width, number of primary branches, number of secondary branches, number of fruit bunches and number of fruit per plant) can be utilized as selection criteria for *J. curcas* plant.

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