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Estimation of Genetic Parameters, Correlation, and Genetic Relationship of Tomatoes Genotype in Lowland

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Abstract

The cultivation of tomato in lowland experience many obstacles, such as low produvtivity. One effort to increase tomato productivity in lowland is through selection of tomato genotype for high yield and yield component in lowland. This study aims to determine the variability based on genetic information, heritability and correlation of characters as well as the yield components of tomato genotypes relationship patterns in the lowlands. A Randomized Complete Block Design was used to characterization base on best genotype of yield component character, genetic variability, broad sense heribility and correlation to yield. Genotype of tomato tested had diverse characteristics. Best genotypes based on the yield character is IPB T1, based on the number of fruit per plant is IPBT30, based on the fruit length and day to flowering is IPB T74, based on the fruit diameter is IPB T73 and fruit thickness is IPBT60. Wide genetic diversity has a high heritability. Number of fruit per plant, fruit length, fruit diameter, and fruit thickness has a wide genetic diversity and high heritability. Yield characters has a narrow genetic diversity and heritability is low. Characters that have a direct impact on the yield are the fruit diameter. Based on the cluster analysis, tomato genotypes are grouped into five groups. Group I consists of seven genotypes (IPBT1, IPBT58, IPBT60, IPBT64, IPBT78, IPBT80 and IPBT82), group II consists of one genotype (IPBT74), group III consists of three genotypes (IPB T13, IPB T73 and IPB T86), group IV consists of five genotypes (IPBT3, IPBT33, IPBT43, IPBT53, and IPBT3) which is characterized by fruit thickness, fruit length and days to flowering, and group V consists of one genotype (IPBT30).

Keywords: cluster analysis, genetic variability, heritability, lowland

A. Introduction

Tomato is one of the vegetables that have priority to be developed in Indonesia. Tomato as a vegetable commodities market has a bright prospect. Tomatoes have many uses, both as a vegetable and as raw material for the food and beverage industry. The market potential tomatoes can also be seen in terms of price that is affordable by all segments of society, thus opening up greater opportunities to the market uptake.

When viewed from the average production, it turns out tomatoes in Indonesia is still low, at 6.3 ton/ha compared with countries Taiwan and India were respectively 21 ton/ha and 9.5 ton/ha. The low productions of tomatoes in Indonesia likely due to the varieties grown are not suited to the environmental conditions. Most tomato varieties is only suitable grown in the highlands, but often occurs planting tomatoes regardless of environmental conditions, so that the yield and quality of the fruit produced is very low. Tomato ability to produce fruit is highly dependent on the interaction between plant growth and environmental conditions (Wijayani & Widodo, 2005).

In Indonesia, tomato cultivated in the highlands (60%) and in the lowlands (40%) (Purwati, 2007). The average yield of tomato cultivation in the lowlands are generally around 6.0 ton/ha, whereas in the highlands reached 26.6 ton/ha. Shifting the tomato planting area to the lowlands is causing downside risks to the quality and fruit production. High temperatures not only affect the time of fruit ripening, but also on the growth rate in tomato fruit (Adams, Cocksshull & Cave, 2001). The increase in temperature of 2 – 4$_o$C of the optimum temperature reported to influence the development of gametes and inhibit the formation of fruit resulting in lower production of tomatoes (Peet *et al.*, 1997; Sato *et al.,* 2001; Firon *et al.*, 2006).

The low production in the lowlands is partly due to the limited varieties of potentially high yield (Purnamaningsih, 2008; Purwati, 1997). Therefore, the use of high yielding varieties of tomatoes that are adaptive lowland is seen as an effective way to solve the problems on tomatoes grown in lowland.

The first step that must be done in the activities of plant breeding for resistant varieties is the formation of a population base with high variability (Poespodarsono, 1988). High genetic diversity is crucial to establish a successful breeding of improved varieties (Mangundidjojo, 2003). The genotypes that have been collected was then characterized, analyzed the diversity and relationships are to facilitate the activity of plant breeding. In addition, please also known heritability characters that will be targeted selection (Pinaria *et al*., 1995). In this study, estimation of genetic variability, heritability and genotype grouping character based production components to determine the selection criteria. The objective of this research was to determine genetic variability base on genetic information, heritability, correlation and genetic relationship of tomoto genotype at lowland.

B. Methodology

The experiment was conducted in March 2012 - August 2012 at the IPB Research Field, Leuwikopo Bogor (250 m above sea level). The type soil is latosol. The study was conducted using Randomized Complete Block Design with three replication. Each experimental unit consisted of 20 plants. Plant material used were consisted of 17 tomato genotypes collection of Plant Breeding Laboratory of Agricultural Department IPB, namely IPBT1, IPBT3, IPBT13, IPBT30, IPBT33, IPBT43, IPBT53, IPBT58, IPBT60, IPBT63, IPBT64, IPBT73, IPBT74, IPBT78, IPBT80, T82IPB, IPBT86.

Cultivation techniques used are standard in tomato cultivation techniques. Tomato seeds germinated the seedling tray containing sterile growing media until age 4 Weeks After Planting. After giving the manure and basic, beds covered with black plastic mulch silver. Spraying pesticides, insecticides and fungicides is done according to recommended dosage. Characters are observed is the number of fruits per plant (fruit), fruit weight per plant (g), fruit length (mm), fruit diameter (mm), fruit thickness (mm), day to flowering (HST), and hardness of fruit.

C. Result and Discussion

Tests on some genotypes showed a marked influence on the character of the amount of fruit production, fruit length, fruit diameter (Table 2). The number of fruits per plant genotypes best in IPBT3 (104.24) and vary with other genotypes except IPB T30, T33 IPB, IPB T33 and T53 IPB. The number of fruits per plant genotype lowest in IPBT74 is 18.92. Best production on the genotype IPB T1 (1696.4 g per plant) and the lowest in genotype IPB T74 (669.4 g per plant). Production IPB T1, IPB T3, IPB T13, IPB T33, IPB T43, IPB T58, IPB T60, IPB T63, IPB T64, IPB

T73, IPB T78, IPB T80, IPB T80, IPB T82 and IPB T86 better than IPB T30 IPB T53, T74 IPB. The fruit length of the best fruit in the IPB T74 genotype (52.22 mm) and the shortest at IPB T30 genotype (27.19 mm). IPBT58, T60IPB, IPBT74, IPBT78, IPBT80 and IPBT82 have the best fruit length compared to other genotypes. The fruit diameter of the largest is IPBT73 and different from other genotypes except IPB T1, IPBT60, and IPB T86, whereas the diameter of the smallest fruit in IPBT30 genotype (27.69 mm).

Table 2. Average of characters of tomato production

Genotype	Number of Fruit (fruit/plant)	Fruit weight (g per plant)	Fruit Length (mm)	Fruit Diameter (mm)
IPB T1	43.46 bc	1696.4 a	41.01 cd	48.18 ab
IPB T13	50.25 bc	1470.6 ab	39.94 cd	43.57bcd
IPB T30	126.29 a	914.6 bc	27.19 e	27.69 f
IPB T33	128.82 a	1171.6abc	29.04 e	31.51 f
IPB T43	48.64 bc	1023.2abc	37.7 d	37.67 de
IPB T53	113.33 a	916.0 bc	28.90 e	30.16 f
IPB T58	31.80 bc	995.0abc	49.00 ab	40.03cde
IPB T60	32.86 bc	1041.5abc	45.94abc	45.85abc
IPB T63	54.33 b	1194.0abc	39.10 cd	37.55 e
IPB T64	45.68 bc	1083.5abc	45.02bcd	41.81cde
IPB T73	53.87 b	1420.4 ab	27.67 e	51.46 a
IPB T74	18.92 c	669.4 c	52.22 a	38.73 de
IPB T78	31.29 bc	1015.1abc	51.31 ab	42.12cde
IPB T80	37.28 bc	1217.2abc	45.78abc	45.24 bc
IPB T82	47.04 bc	1271.6abc	46.20abc	40.02cde
IPB T86	63.38 b	1484.1 ab	27.35 e	48.62 ab

Description: Figures followed by the same letters in the same column are not significantly different at DMRT 0.05

Table 3. Average of production of component of tomato germplasm

Genotype	Fruit Thick (mm)	Days to Flowering (HST)	Fruit Hardness
IPB T1	4.55 def	32.0 ab	1.58abcde
IPB T3	4.40 ef	27.6 c	1.69abcde
IPB T13	4.81cde	29.3 bc	1.31 cde
IPB T30	3.59 fg	27.6 c	0.93 e
IPB T33	3.66 fg	30.6 bc	1.19 ed
IPB T43	4.24 efg	30.6 bc	0.96 e
IPB T53	3.38 g	31.3 abc	1.55abcde
IPB T58	5.67 bc	32.0 ab	2.10 abc
IPB T60	5.51 bc	33.3 ab	2.18 a
IPB T63	4.9 cde	30.6 bc	1.83 abcd
IPB T64	6.28 ab	30.6 bc	1.71abcde
IPB T73	4.08 efg	27.6 c	1.47abcde
IPB T74	5.40bcd	35.0 a	2.12 ab
IPB T78	5.51 bc	30.6 bc	1.34 bcde
IPB T80	6.68 a	30.6 bc	1.23 de
IPB T82	5.96 ab	31.0 bc	1.40abcde
IPB T86	4.22 efg	29.3 bc	1.52 bcd

Description: Figures followed by the same letters in the same column are not significantly different at DMRT 0.05

Table 3 shows that the character of thick fruit, days to flowering, fruit hardness and water content fruit real effect on genotype was observed. The range of values observed thickness of the fruit is 3:38 mm - 6.68 mm. Genotype best for fruit character is IPB T80 thickness (6.68 mm), IPB T64 (6:28 mm) and IPB T82 (5.96 mm). While the genotype with the smallest

thickness of the fruit is IPB T53 (3:38 mm), IPB T30 (3:59 mm), IPB T33 (3.66 mm), IPB T43 (4:24 mm), IPB T73 (4:08 mm) and IPB T86 (4:22 mm). Genotypes with a faster flowering date is IPB T74 (35 HST) and the longest flowering date on IPB IPB T30 and T73 respectively 27.6 HST. Violence is best fruit IPB T60 (2.18) and genotype with the thinnest thickness of the meat is IPB T30 (0.93), while for the water content of the highest fruit on IPB T1 (89.95%) and the lowest in the IPB T60 (4.93%).

Selection is the basis of all plant improvements to get new varieties. Genetic variability plays a very important because the higher the genetic variability the greater the chance of getting a source of genes for the character to be repaired. Table 4 presents the coefficient of genetic variability of some character of tomato yield component. The coefficient of genetic variability (CGV) ranges between 1:47% to 55.17%. CGD highest value on characters number of fruits per plant. Based on the classification Pinnaria *et al*. (1995) shows that the characters have a broad genetic variability is the number of fruit per plant, fruit length, fruit diameter, and thickness of the flesh of the fruit, while a character with low genetic variability is the fruit weight per plant, days to flowering, and fruit hardness.

Extensive genetic variability is a condition of the course of the selection process effective because it will provide more flexibility in the process of selecting a genotype. Extensive genetic variability showed a genetic influence is more dominant compared to environmental influences. Characters with low genetic variability tends to be influenced by environmental factors, a quantitative controlled by many genes (Martono, 2009).

Table 4. The coefficient of genetic variability, genetic variability predictive value and heritability

Characters	CGV	σ_2 G	$2\,\sigma\,\sigma^2{}_G$		h^2_{bs}	
			Value	Criteria	Value	Criteria
Number of fruits per plant	55.17	1120.41	811.09	Large	79.84	High
Fruit weight per plant	11.62	18083.37	48302.57	Narrow	11:56	Low
Fruit length	22:48	77.27	55.12	Large	82.85	High
Fruit diameter	17:04	44.42	31.82	Large	81.99	High
Fruit thickness	2:33	0.87	0.64	Large	76.90	High
Day of flowering	5:03	2.37	2.61	Narrow	35.59	moderate
Fruit hardness	18.80	0.08	0.10	Narrow	33.27	moderate

Description: CGD: Coefficient of Genetic Variability, σ_2 G: Genetic variance, $\sigma\,\sigma_{2\,G}$: standard deviation of genetic variance, h_{2bs} : Broad sense heritability.

The heritability estimates ranged characters were observed between 11:56% to 82.85% (Table 4). The heritability estimates a character you need to know to predict whether the character is more influenced by environmental or genetic factors. High heritability indicates that genetic factors influence the phenotype is greater compared to environmental influences. High heritability values that play a role in improving the effectiveness of selection (Syukur *et al*., 2010).

Characters that have a heritability in the broad sense that higher is the number of fruit per plant, fruit length, fruit diameter, and thickness of the fruit. While the characters have a low heritability is the production of fruits per plant. Program Selection of a character less effective when estimating the heritability is low. In this study, the production of fruits per plant cannot be used as selection criteria because it has a low heritability.

Table 5. Correlation of the observed phenotypic characters

Characters	FN	FL	FD	FT	DF	FH	Prod
FN	1.00	-0.634**	-0.529**	-0.601**	-0.365**	-0.308*	0.189
FL		1.00	0.358*	0.784**	0.477**	0.184	-0.0005
FD			1.00	0.446**	0.067	-0.035	0.523**
FT				1.00	0.255	0.112	0.052
DF					1.00	0.435**	-0.257
FH						1.00	-0.262
Prod							1.00

Note: * = significantly correlated to the level of 5%. ** = Highly significant correlation at level 1%. NF = number of fruits per plant (fruit per plant), Prod = Production, weight per plant (g per plant), FL =Fruit Length (mm), FD = fruit diameter (mm), FT = Thickness of fruit (mm), DF = day to flowering (DAT), FH = fruit hardness.

On tomato plants, fruit weight per plant, the main character is expected to be high. Inheritance of these characters is complex and may involve a number of other characters. Therefore, the selection of which is aimed at improvement of production need to consider the other characters. Results of correlation analysis shows that the characters positively and significantly correlated with yield (fruit weight per plant) are the fruit diameter (Table 5). Character number of fruit, and thick fruit was positively correlated but not significant. While the character of fruit length, days to flowering and fruit hardness negatively correlated and not significant. Determination of characters that can be used as effective selection criteria can be seen from the correlation with the yield (weight per plant). In addition, the information of genetic variability and heritability also determine the selection criteria. Based on these three things, characters that can be used as selection criteria in this study is the fruit diameter.

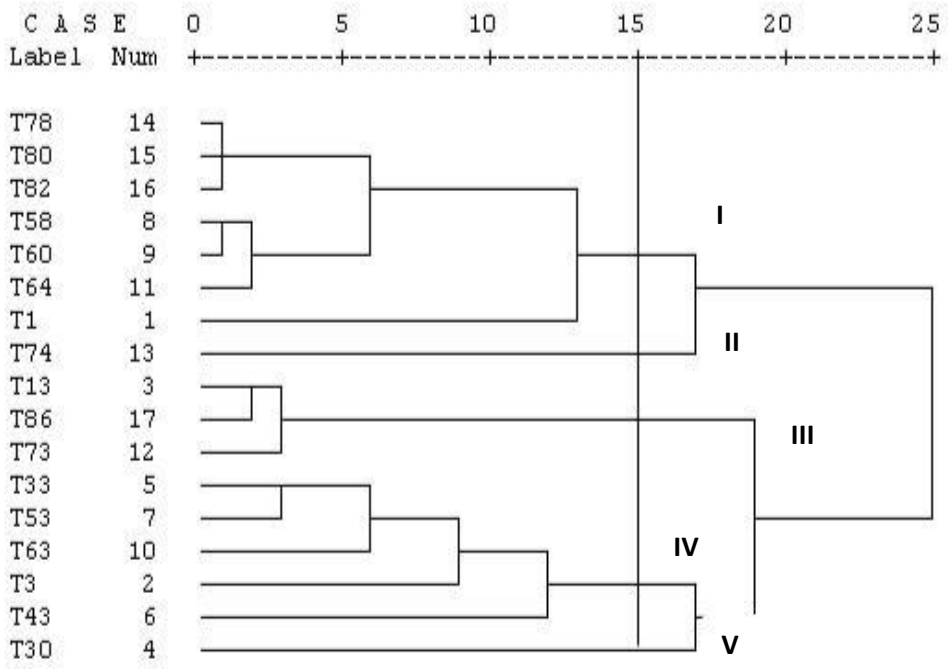

Figure 1. Dendogram tomato based character of production and component production.

Relationship patterns more accurately done by grouping based on relationships between genotypes were analyzed. Analysis conducted clump aims to group data (observations) into several classes, so that members in the class is more homogeneous (similar) compared to members in another class. Grouping criteria are based on a similarity measure (Djuraidah, 1991). Santoso (2004) states that one technique is a technique of grouping hierarchy, which start two or more objects by grouping the closest similarity, so as to form a sort of tree where there is a clear level between objects of the most similar to least like.

Cluster analysis performed on 17 genotypes of tomato with 8 characters produces Dendogram as in Figure 1. At 85% similarity level, 17 tomato genotypes were grouped into five cluster. Group I consists of seven genotypes (IPB T1, IPB T58, IPB T60, IPB T64, IPB T78, IPB T80 and IPB T82), group II consists of one genotype (IPB T74), group III consists of three genotypes (IPB T13, IPB IPB T73 and T86), group IV consists of five genotypes (IPB T3, T33 IPB, IPB T43, T53 IPB and IPB T3), and group V consists of one genotype (IPB T30).

Principal component analysis was conducted to determine traits or characters that distinguish individual genotypes by cluster analysis just knowing grouping based on a particular character, but cannot know with certainty distinguishing these groupings. The results of principal component analysis based on the character of yield and yiled components presented in the scatter diagram indicates that no genotype group based on the character of fruit weight per plant, and number of fruits (Figure 2). Genotype IPB T3, T33 IPB IPB T30 and T53 IPB clustered based on the character of fruit hardness, fruit length and days to flowering. This approach is based on the analysis grouping clump in group IV consisting of IPB IPB T3, T33 IPB and IPB T53. While genotype IPB T1, IPB T13, IPB T43, IPB T58, IPB T60, IPB T63, IPB T64, IPB T73, IPB T74, IPBT78, IPB T80, IPB T82, IPB T86 clustered based on fruit diameter and thickness of the fruit on principal component analysis.

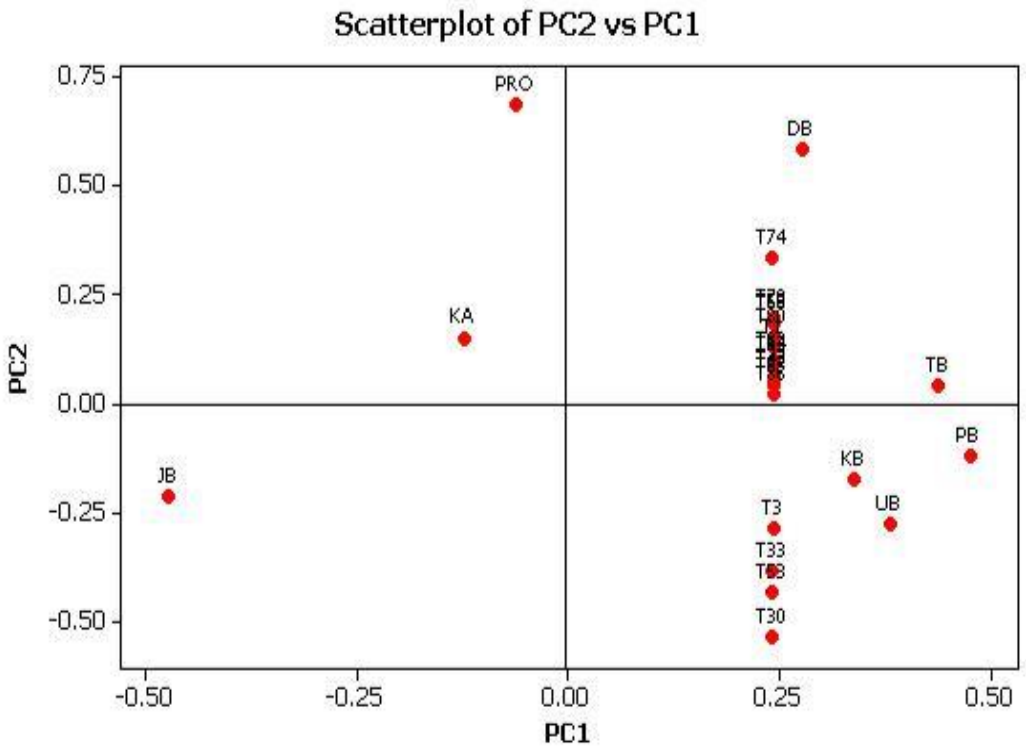

Figure 2. Diagram scatter of tomato based character of production and component production.

D. Conclusion

Genotype tomato plants tested had diverse characteristics. Best genotypes based on the character of yield (fruit weight per plant) is IPB T1, based on the number of fruit per plant is IPB T30, based on the character fruit length and day to flowering is IPB T74, based on the fruit diameter is IPB T73 and fruit thickness is T60. Wide genetic variability has a high heritability. Character number of fruit per plant, fruit length, fruit diameter and fruit thickness has a wide genetic variability and high heritability rate. Characters production has a narrow genetic variability and low heritability. Characters that have a direct impact on the fruit weight per plant are the fruit diameter.

Based on the cluster analysis, tomato genotypes are grouped into five groups. Group I consists of seven genotypes (IPBT1, IPBT58, IPBT60, IPBT64, IPBT78, IPBT80 and IPBT82), group II consists of one genotype (IPBT74), group III consists of three genotypes (IPB T13, IPB T73 and IPB T86), group IV consists of five genotypes (IPBT3, IPBT33, IPBT43, IPBT53, and IPBT3) which is characterized by fruit thickness, fruit length and days to flowering, and group V consists of one genotype (IPBT30).

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