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EVALUATION OF COWPEA CULTIVARS FROM SOUTHWEST MALUKU - INDONESIA UNDER DIFFERENT ENVIRONMENTSBASED ON MORPHOLOGICAL CHARACTERS

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SUMMARY

Cowpea is one of the crops that have a lot of potential to be utilized as raw food resource in the Southwest Maluku district. The objective of this study was to evaluate local cowpea cultivars from Southwest Maluku under different locations based on morphological characters. The research was conducted in Ambon and Bogor using randomized complete block design (RCBD) with three replications. As many as seven local cultivars and three cultivars from ILETRI were evaluated. Observations were conducted on 18 morphological characters. The results showed that morphological characters were significantly affected by cultivars on each location. In general: KM3, KM4, and KM6 cultivars have the highest value in some morphology characters. Correlation analysis showed a significant correlation between the number of nodes with number of leaves followed by seed number plant^{-1} with seed weight plant^{-1} and loci number pod^{-1} with seed number pod^{-1}. Principal component analysis showed that there were nine principal components and clustering in two clusters. The local cultivars have the highest genetic potential in this study and could be selected as plant materials in future plant breeding program.

Key words: Different environments, local cowpea, Southwest Maluku, morphological characters

Key findings: Cowpea cultivar KM3 was the best genotype at both locations i.e., Ambon and Bogor, Indonesia. It also showed similar stability in some characters and almost equal with cultivars from ILETRI in these locations.

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INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) is one of the African crops. In the area of its origin, it rank second after peanut as an important legume group (Timko *et al*., 2007). In Indonesia, it is well adopted by farmers in some areas but is rarely cultivated in places, such as in the Maluku area. In Maluku, the germplasm of cowpea is found in two districts namely: Southwest Maluku and Southeast West Maluku. Southwest Maluku district has a number of very diverse cultivars compared with Southeast West Maluku (Hetharie *et al*., 2013).

On the other hand, the purpose of germplasm conservation to find superior cultivars for plant breeding program in this area must be expanded. To achieve this, there are series of activities needed which consists of collection and characterization, evaluation/selection, expansion of genetic diversity, evaluation and testing, cultivar release and propagation (Syukur *et al*., 2015). The characterizations can be observed on qualitative and quantitative traits while evaluation must be conducted on important traits, such asproductivity potential. The genotype that has the highest productivity potentialcan be used inparental crosses in new cultivar development (Hapsari *et al*., 2015). In addition, the testing of local cultivars can be developed to obtain a superior cultivar with highest productivity and well adapted to different locations. According to Shiringani and Shimelis (2011), differences in the environments are being used to determine adaptability and stability of a cultivar. Therefore, specific cultivar recommendationscould be made based on these results.

Recently, Africa did a study about the evaluation of performance of cowpea genotypes with different ecology zone (Agyeman *et al*., 2014). It is very important to know the effect of soil and climate factors on growth of new cultivars especially the yield component. Growth and yield components can be increased by the evaluation of all cultivars indifferent agro-ecological zone. A good performing cultivar can be developed as a superior cultivar. Akande (2007) mentioned that plant production can be affected by location, year, date of planting, climate factors, and the interaction between cultivar and its traits. In Indonesia, the development of cowpea research on this level has never been carried out. It is becauseIndonesia has a wide differences in agroecology zone such as temperature, rainfall, relative humidity, soil factors, etc. Thus, a comprehensive study is needed to obtain superior cultivars, especially as alternative food resources. The objectives of this study are to evaluate local cowpea cultivars from Southwest Maluku under different locations based on morphological characters.

MATERIALS AND METHODS

The study was conducted at two locations namely: Ambon (latitude 03° 42 S, longitude 128° 05 E, 20 m asl) from December 2017 to March 2018 and Bogor (latitude 06° 33 S,

longitude 106° 43 E, 193 m asl) from January to April 2018. A randomized complete block design with three replications was used. Seven local cultivars from Kisar Island, Southwest Maluku district consists of KM1, KM3, KM4, KM6, KM7, KM8, KM9 and three cultivars from Indonesia Legumes and Tuber Research Institute (ILETRI), Malang i.e., KT1, KT2, and KT7 were used as references.

The experimental unit was a 1 m x 1.5 m plot with plant spacing of 40 cm between rows and 20 cm between plants within the rows. Three kg manure plot^{-1} (20 tons/ha^{-1}) of fertilizers were applied before the planting date. To measure seed quality, they were sowed on seeding tank as many as 150 seeds per cultivar for 1 week. After that, each seedling was planted in the plot. Morphological characters observed were growth characters and yield components. Growth characters including number of branches (NB), number of nodes (NN), and number of leaves (NL), were calculated six weeks after planting (WAP) whereas plant height (PH) and dry weight (DW) were measured after harvesting. Yield components such as flowering day (FD) were observed when 50% of the plant flowered. Pod number plant^{-1} (PNP), loci number pod^{-1} (LNPd), pod length (PL), seed number plant^{-1} (SNP) and seed number pod^{-1} (SNPd), seed weight plant^{-1} (SWP) and seed weight pod^{-1} (SWPd), 100 grain weight (HGW), seed length(SL), seed width (SW), seed thickness(ST), and potential yield (P) were measured after harvesting.

Statistical analysis

To analyse the effect of cultivars on growth characters and yield components on each location, ANOVA was used with Duncan Multiple Range Test (DMRT) at 5% significant levels. While Pearson correlation analysis was performed based on growth and yield components using the software SPSS version 16.0. In addition, principal components analysis (PCA) was studied based on correlated data on PAST version 3.0.

RESULTS

Evaluation of local cowpeafrom Ambon

Different cultivars gave significant effect to growth characters and yield components except for dry weight and yield potential (P <0.05). The results showed that all local cultivars had significant differences on growth characters (P <0.05) (Table 1). The cultivar with highest plant height was KM3 but it had the lowest number of branches. On the other hand, KM4 had the lowest plant height but had the highest number of branches. The highest number of nodes and number of leaves was KM6 with dry weight was the lowest than other cultivars. On the other hand, KM8 had the lowest number of nodes and number of leaves but it had the highest dry weight after harvesting. For the flowering day, KM3 had the earliest flowering day while KM8 cultivar had the latest. In general, local cultivars have growth characters better than cultivars from ILETRI but their flowering days were longer.

The results showed that yield components on pods and seeds were significantly different between each cultivar (P <0.05). The highest pod number plant^{-1} was KM4 with the lowest pod length and loci number

Table 1. The average growth characters of local cowpea from Ambon.

Cultivars	PH (cm)	NB (branch)	NN (node)	NL (blade)	DW (g)	FD (day)
KM1	326a	5.06a	11.2a	33.6a	32.34ab	74.67ef
KM3	373.33a	4.28a	12.33a	36.98a	35.56a	56.67b
KM4	308.33a	5.11a	14.18a	42.55a	21.68ab	69de
KM6	340.67a	4.33a	14.2a	42.61a	15.63ab	61bc
KM7	352a	4.67a	13.36a	40.08a	25.51ab	65.33cd
KM8	368.33a	4.39a	11.09a	33.28a	38.36a	77.67f
KM9	361.67a	4.39a	12.13a	36.39a	35.71a	58.67bc
KT1	161.67b	2.78b	6.43b	19.28b	10.46b	49a
KT2	180.33b	2.17b	4.63b	13.89b	16.16ab	54.67ab
KT7	187.67b	2.72b	6.4b	19.22b	17.86ab	56b
Mean	296	3.99	10.59	31.79	24.93	62.27

Different letters in the same column show significant differences (α=0.05). PH: plant height; NB: number of branches; NN: number of nodes; NL: number of leaves; DW: dry weight plant; FD: flowering day.

pod^{-1}. Besides pod characters, seed on each cultivar had differences in number, weight, and size. KM3 had the highest seed number and weight plant^{-1}.It also had the highest yield potential in ton/ha^{-1}. While the highest seed number and weight pod^{-1} was KM9 (Table 2). The highest average for 100 grain weight was KM4 and it also had the highest seed thickness. On the other hand, KM3 had the highest length and width of the seed (Figure1). Local cultivars have yield components lower than cultivars from ILETRI.

Correlation between characters and principal component analysis from Ambon

Correlation analysis showed that there were significant correlations between some growth characters and yield components (Table 3). The number of nodes was positively correlated to the number of leaves on growth characters with a correlation coefficient of 0.99. On yield components, there was a significant positive correlation between seed number plant^{-1} and seed weight plant^{-1}(r = 0.98). A positive correlation was also observed between plant height and seed length (r = 0.45).

Based on the significant correlation of characters, PCA was used to reduce characters in clustering of cultivars. From 18 characters, they were reduced to nine principal components with percentage of variance as big as 57.28% on the first main component and 21.87% on the second main component. Based on morphology characters, cluster analysis using K-Means showed that cowpea cultivars were clustered in two groups (Figure 2). Cluster I consisted of local cultivars separated from cultivars from ILETRI on cluster II.

In general, Figure 1 showed that cultivars from ILETRI were grouped based on yield component characters i.e. number of pods plant^{-1}, loci number pod^{-1}, pod length, seed number plant^{-1}, and seed number pod^{-1}, seed weight plant^{-1} and seed weight pod^{-1}, seed width, and potential yield. On the other hand, the local cultivars were classified based on growth component and some yield components including plant height, number of branches, number

Table 2. The average yield component of local cowpea from Ambon.

Cultivars	PNP	LNP	PL (cm)	SNP	SNPd	SWPd (g)	SWP (g)	HGW (g)	P (ton/ha)
KM1	3.3c	12.7a-c	13.1c-e	41.67c	12.67a-c	1.17bc	3.79d	11.56cd	0.38d
KM3	5.79bc	12.32bc	13.98b-d	66.19c	11.55c	1.11bc	6.53b-d	14.24a-c	0.75b-d
KM4	5.93bc	10.25d	11.84e	34.89c	7.76d	0.92c	4.17cd	15.73a	0.3d
KM6	3.43c	13.35a-c	13.5c-e	44.4c	12.86a-c	1.11bc	3.82d	10.28d	0.75b-d
KM7	3c	12.49a-c	12.63de	36.41c	12.12a-c	1.09bc	3.42d	11.44cd	0.25d
KM8	4.51bc	12.7a-c	14.96a-c	53.3c	11.93bc	1.08bc	4.8cd	12.46b-d	0.53cd
KM9	3.94bc	12.7a-c	13.37c-e	52.55c	12.94a-c	1.24a-c	5.05cd	13.14a-d	0.51cd
KT1	10.85a	14.28a	16.44a	149.06a	13.79ab	1.42ab	15.51a	11.89cd	1.51a
KT2	6.03bc	12.03c	15.6ab	71.3bc	11.79c	1.56a	9.32bc	14.73ab	1.14a-c
KT7	8.21ab	13.91ab	14.07b-d	116.56ab	13.91a	1.37ab	11.21ab	11.12d	1.37ab
Mean	5.5	12.67	13.95	66.63	12.13	1.21	6.76	12.66	0.75

Different letters in the same column show significant differences (α=0.05). PNP: pod number plant^{-1}; LNP: loci number pod^{-1}; PL: pod length; SNP: seed number plant^{-1}; SNPd: seed number pod^{-1}; SWPd: seed weight pod^{-1}; SWP: seed weight plant^{-1}; HGW: 100-grain weight;P: yield potential.

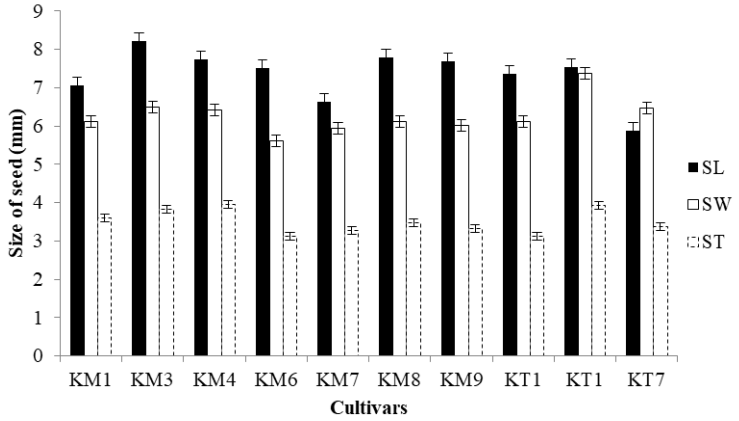

Figure 1. Size of seed cowpea varieties from Ambon. SL:seed of length; SW: width of seed; ST: seed thickness.

Table 3. Correlation between characters of local cowpea from Ambon.

	PH	NB	NN	NL	DW	FD	PNP	LNP	PL	SNP	SNPd	SWPd	SWP	HGW	SL	SW	ST
NB	0.71**																
NN	0.76**	0.87**															
NL	0.76**	0.86**	0.99**														
DW	0.57**	0.4*	0.33	0.34													
FD	0.51**	0.65**	0.47**	0.48**	0.44*												
PNP	-0.5**	-0.44*	-0.47**	-0.49**	-0.23	-0.52**											
LNP	-0.38*	-0.25	-0.28	-0.29	-0.29	-0.33	0.19										
PL	-0.37*	-0.43*	-0.51**	-0.52**	-0.29	-0.39*	0.44*	0.56**									
SNP	-0.57**	-0.51**	-0.57**	-0.59**	-0.27	-0.61**	0.89**	0.49**	0.6**								
SNPd	-0.31	-0.29	-0.34	-0.35	-0.12	-0.35	0.17	0.91**	0.53**	0.48**							
SWPd	-0.44*	-0.43*	-0.55**	-0.56**	-0.29	-0.52**	0.36*	0.43*	0.69**	0.53**	0.53**						
SWP	-0.61**	-0.55**	-0.63**	-0.64**	-0.32	-0.64**	0.90**	0.4*	0.65**	0.98**	0.4*	0.64**					
HGW	0.13	0.02	-0.02	-0.02	0.09	-0.04	0.24	-0.58**	0.01	-0.04	-0.59**	0.09	0.1				
SL	0.45*	0.27	0.27	0.26	0.17	0.12	-0.14	-0.36	0.11	-0.28	-0.41*	-0.04	-0.19	0.59**			
SW	-0.39*	-0.45*	-0.52**	-0.51**	-0.15	-0.25	0.21	-0.23	0.31	0.13	-0.21	0.5**	0.29	0.6**	0.16		
ST	0.1	0.03	0.02	0.03	0.04	0.15	-0.09	-0.59**	-0.14	-0.29	-0.62**	0.01	-0.16	0.72**	0.38*	0.71**	
P	-0.47**	-0.61**	-0.62**	-0.62**	-0.26	-0.63**	0.71**	0.34	0.55**	0.81**	0.4*	0.62**	0.84**	0.01	-0.18	0.26	-0.18

**: significant at 1% level significance; *: significant at 5% level significance.

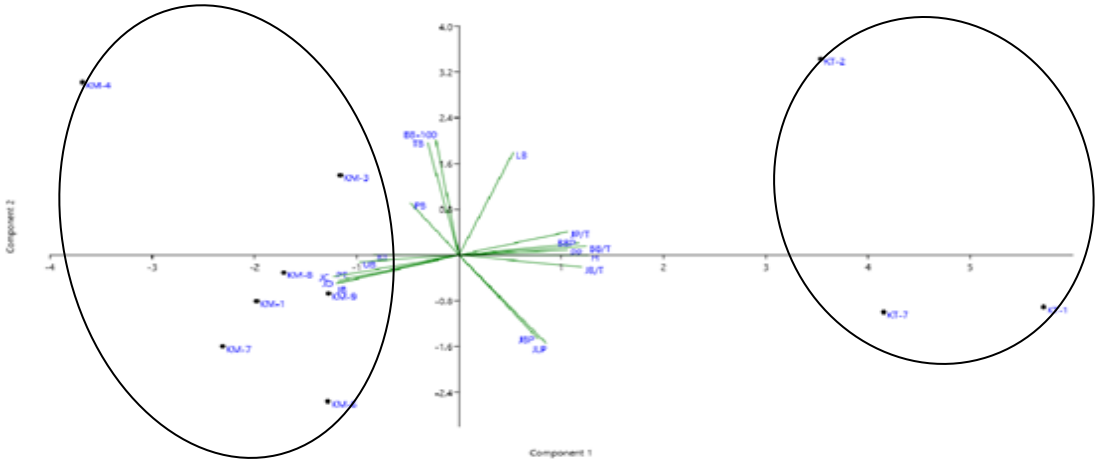

Figure 2. Cluster analysis based on morphological characters of local cowpea from Ambon using clustering K-Mean.

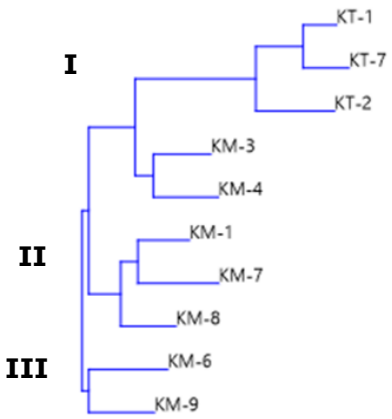

Figure 3. Cluster analysis based on morphological characters of local cowpea from Ambon using neighbor-joining.

Table 4. The average growth characters of local cowpea from Bogor.

Cultivars	PH (m)	NB (branch)	NN (node)	NL (blade)	DW (g)	FD
KM1	332.33a	3.03bc	6.5a	20.22a	55.32a	62.33c
KM3	274.67b	3.5b	6.45a	19.89a	29.21bc	57b
KM4	277.33b	3.27b	6.39a	19.33a	31.29a-c	69.33d
KM6	264.67b	3.22b	6.33a	18.67ab	26.12bc	61.67c
KM7	303.33ab	3.03bc	5.89ab	17.78ab	25.67bc	71.67de
KM8	303.33ab	2.39bc	5.5ab	16.33ab	50.77ab	74.33e
KM9	301ab	1.5c	3.89b	11.56b	49.58ab	70de
KT1	181c	6.77a	6.26a	18.28ab	20.66c	45a
KT2	183.67c	7a	5.89ab	16.72ab	30.89a-c	45a
KT7	182.33c	6.28a	7a	20.22a	23.31c	47a
Mean	260.37	3.99	6.01	17.9	34.28	0.33

Different letters in the same column show significant differences (α=0.05).PH: plant height; NB: number of branches; NN: number of nodes; NL: number of leaves; DW: dry weight plant; FD: flowering day.

of nodes, number of leaves, dry weight, flowering day, 100-grain weight, seed length, seed thickness.

In addition, clustering on PCA also can be used with neighbor-joining on Jaccard similarity matrix. The results of the cluster using this analysis showed that there were three clusters. Cluster I consisted of cultivars from ILETRI, KM3, and KM4. Cluster II consisted of KM1, KM7, and KM8 while KM6 and KM9 cultivars were grouped in cluster III (Figure 3). Cultivars from ILETRI were grouped together with KM3 and KM4 based on yield components shown in Figure 1. This means that KM3 and KM4 have a relationship with cultivars from ILETRI.

Evaluation of local cowpeafrom Bogor

Similar to Ambon, morphology characters were significantly affected by cultivars except on the number of nodes and number of leaves (P <0.05). The differences of significance on each cultivar were represented in Table 4. KM1 had the highest plant

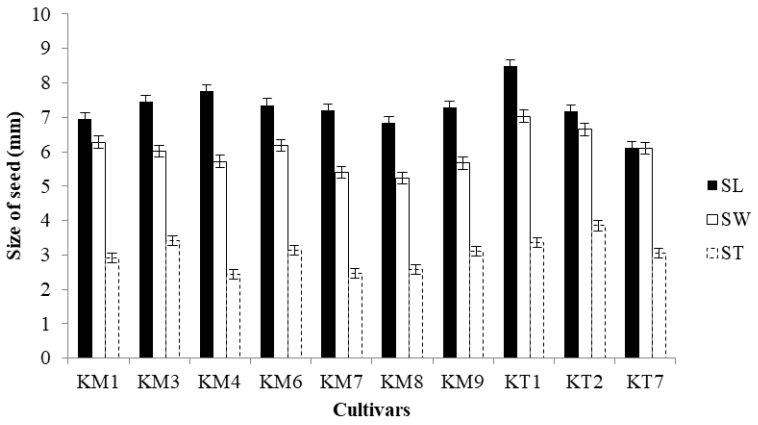

Figure 4. Size of seed cowpea varieties of local cowpea from Bogor. SL:seed of length; SW: width of seed; ST: seed of thickness.

height, number of nodes, number of leaves, and dry weight. The highest number of branches was KM3 and lowest on KM9. In the flowering day, KM3 cultivar was the earliest similar to Ambon. Cultivars from ILETRI had flowering day faster than local cultivars but the growth characters were low.

Yield components also showed differences between each cultivar (Table 5). The highest pod number plant^{-1} and the lowest loci number pod^{-1} was KM6. KM4 had the longest pod and the shortest was KM9 but it had the most loci number pod^{-1}. In the seed characters, KM3 had the highest seed number plant^{-1}, seed weight pod^{-1}, 100 grain weight, and yield of potential. The highest seed number pod^{-1} was KM9 and the lowest was KM6 but it had the most seed weight plant^{-1}. In addition, KM4 had the highest of length seed while the highest of width seed was KM1 and the highest seed thickness was KM3 (Figure 4).

Correlation between characters and principal component analysis from Bogor

In general, there was a significant correlation between some characters (Table 6). The number of nodes was positively correlated to the number of leaves on growth character. On yield components, the significant positive correlation between loci number pod^{-1} and seed number pod^{-1} (r = 0.98) was also observed between seed number plant^{-1} with seed weight plant^{-1}. Besides on growth character and yield components, there was positive correlation between the number of branches with pod number plant^{-1}, seed number plant^{-1}, seed weight plant^{-1}, and yield potential, respectively.

The result of PCA showed that the percentage of variance on the first component was 57.68% and the second component as big as 16.52%.

Table 5. The average yield component of local cowpea from Bogor.

Cultivars	PNP	LNP	PL (cm)	SNP	SNPd	SWPd (g)	SWP (g)	HGW (g)	P (ton/ha)
KM1	2.1c	13.33c	14.25bc	27.97b	13.33cd	1bc	2.22c	10.72b	0.27c
KM3	2.86c	13.89bc	16.06ac	39.65b	13.89b-d	1.23b	3.54c	13.36a	0.4bc
KM4	1.65c	14.04bc	16.91ab	20.84b	14.08b-d	0.95bc	1.51c	13.14a	0.17c
KM6	2.94c	12.96c	14.93a-c	38.24b	12.96d	1.2b	3.55c	10.98b	0.34bc
KM7	1.09c	13.29c	14.27bc	14.52b	13.29cd	0.55c	0.59c	5.66d	0.02c
KM8	1.85c	14.54ab	16.32ab	26.87b	14.54a-c	0.9bc	1.67c	11.23b	0.15c
KM9	1.47c	14.79ab	13.26c	21.58b	14.79ab	1.02bc	1.55c	7.67c	0.11c
KT1	5.3b	14.61ab	16.7ab	110.24a	14.8ab	1.32b	9.52b	13.54a	0.74b
KT2	7.33a	15.63a	17.44a	137.17a	15.54a	1.81a	15.38a	13.91a	1.28a
KT7	7.54a	14.74ab	14.28bc	111.57a	14.66a-c	1.27b	9.74b	10.36b	1.28a
Mean	3.42	14.18	15.44	54.87	14.18	1.12	4.93	11.06	0.48

Different letters in the same column show significant differences (α=0.05). PNP: pod number plant^{-1}; LNP: loci number pod^{-1}; PL: pod length; SNP: seed number plant^{-1}; SNPd: seed number pod^{-1}; SWPd: seed weight pod^{-1}; SWP: seed weight plant^{-1}; HGW: 100 grain weight;P: yield potential.

Table 6. Correlation between characters of local cowpea from Bogor.

	PH	NB	NN	NL	DW	FD	PNP	LNP	PL	SNP	SNPd	SWPd	SWP	HGW	SL	SW	ST
NB	-0.84**																
NN	-0.33	0.48**															
NL	-0.23	0.38*	0.98**														
DW	0.66**	-0.42*	-0.27	-0.23													
FD	0.83**	-0.86**	-0.32	-0.24	0.44*												
PNP	-0.89**	0.83**	0.23	0.14	-0.51**	-0.85**											
LNP	-0.52**	0.39*	-0.18	-0.23	-0.11	-0.4*	0.49**										
PL	-0.32	0.36*	0.11	0.08	-0.15	-0.24	0.21	0.44*									
SNP	-0.91**	0.86**	0.19	0.1	-0.48**	-0.88**	0.96**	0.58**	0.32								
SNPd	-0.52**	0.36*	-0.21	-0.26	-0.12	-0.39*	0.48**	0.98**	0.47**	0.58**							
SWPd	-0.61**	0.54**	0.06	0.01	-0.36*	-0.68**	0.65**	0.59**	0.47**	0.67**	0.55**						
SWP	-0.87**	0.82**	0.15	0.06	-0.46*	-0.85**	0.94**	0.58**	0.37*	0.98**	0.58**	0.74**					
HGW	-0.39*	0.42**	0.13	0.09	-0.16	-0.52**	0.41*	0.22	0.49**	0.45*	0.23	0.49**	0.46**				
SL	-0.09	0.05	-0.04	-0.01	-0.19	-0.02	-0.16	-0.03	0.26	-0.02	0.01	0.07	-0.03	0.26			
SW	-0.63**	0.64**	0.39*	0.35	-0.36*	-0.72**	0.57**	0.19	0.21	0.64**	0.20	0.52**	0.62**	0.39*	0.42*		
ST	-0.57**	0.49**	0.08	0.03	-0.29	-0.68**	0.58**	0.40*	0.19	0.64**	0.37*	0.69**	0.68**	0.36	0.22	0.71**	
P	-0.83**	0.83**	0.23	0.15	-0.44*	-0.83**	0.97**	0.51**	0.22	0.91**	0.47**	0.72**	0.91**	0.4*	-0.17	0.55**	0.56**

**: significant at 1% level significance; *: significant at 5% level significance.

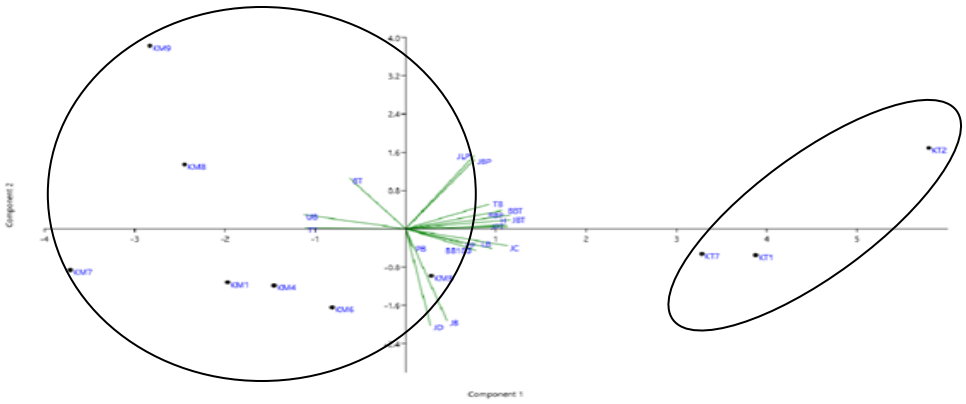

Figure 5. Cluster analysis based on morphological characters of local cowpea from Bogor using clustering K-Means.

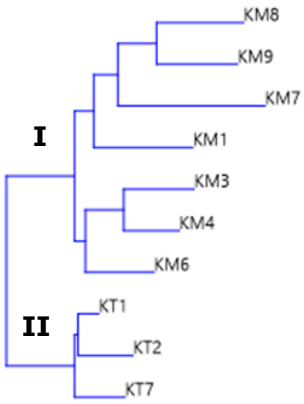

Figure 6. Cluster analysis based on morphological characters of local cowpea from Bogor using neighbor joining.

Analysis clustering using K-Means showed that Bogor had two clusters. Cultivars from ILETRI were grouped in cluster I and the local cultivars in cluster II (Figure 5). KM3 was located in the same quadrant as KT1 and KT7. Unlike Ambon, clustering in Bogor showed that local cultivars were grouped only based on plant height, dry weight, and flowering day. On the other hand, cultivars from ILETRI were classified based on all yield components, number of nodes, and number of leaves. Furthermore, cluster analysis using neighbor-joining showed the same results just like clustering with K-Means which consisted of two clusters (Figure 6).

DISCUSSION

Evaluation of local cultivars is one of the phases of plant breeding. It is done to obtain superior cultivars with high productivity as well as adaptive to different environmental conditions. The significant results from cultivars on growth characters and yield components for this location implied the important role of improvement of local cultivars. To identify the highest

and sustainable productivity of genotypes is needed in multi-location evaluation under different agro-ecologies. It can show the consistency of a genotype performance in different environments (Ezeaku *et al*., 2012). On the other hand, Baiyeri *et al.* (2008) also explained that the reproduction of a crop is mostly determined by the interaction of the genotype to its environment. Therefore, plant height, number of branches, number of nodes, and number of leaves are measured in this study to show that genotype can affect productivity. Plant height, number of nodes, and number of leaves on local cultivars in Ambon were highest than Bogor. Hayatu and Mukhtar (2010) also mentioned the plants grown in limited water conditions tend to grow higher in an effort to obtain nutrients around the growing environment. It was shown that Ambon has averaged the highest of temperature and the lowest of rainfall.

Khan *et al*., (2010) reported that the plant that has the widest canopy can affect photosynthesis and also indirectly affect productivity. In addition, Agyemen *et al*. (2014) mentioned that branches with most production of leaves and with erect growth habit to reflect the highest light interception and photo-assimilates can increase productivity. This case is showed in KM4 on Ambon and KM1 on Bogor. Therefore, this study showed that local cultivar with the lowest plant height can have a high yield component. Similarly, Hetharie *et al*. (2013) reported that the highest production component that supported the lowest plant height are important traits. These could cause a cowpea with lush canopy will be difficult to maintain, inefficient in light absorption, and have a convoluted growth. In addition, dry weight of the plant is used to describe the highest assimilation product. At these two locations, KM8 had different dry weight even though both are highest. So that, the differences in location could affect growth and biomass like as the rainfall as explained by Berchie *et al*. (2012).

The flowering day is very important in influencing the productivity of a plant (Manggoel and Oguru, 2011). In this study, local cultivars have the longest flowering day than cultivars from ILETRI. On these two locations, KM3 had the longest flowering day and was consistent. Ehlers and Hall (1997) explained that the difference of the flowering day on cowpea was associated with genetic inheritance.

Better growth characters could result to good yield component. The number of seeds per pod is an important character in yield component contributes in determining productivity. Many seeds in pods are influenced by environmental factors and cultivars. This shows that the cultivar that has the highest number of pods do not necessarily have a large number of seeds. In addition, these are also caused by the time of accumulation of assimilates in seeds and genetic differences of each cultivar. In this study, KM3, KM4, and KM6 had the highest yield component in the form of number of pods per plant, number of loci per pod, pod length, number of seeds per plant, the weight of seeds per plant, and 100-grain weight on each location. The size of seeds also determines yield component. According to Ezeaku *et al*. (2015), the size of seed is inherited and less influenced by environmental factors. Similar to flowering day, KM3

performed consistently on a number of seeds per plant, 100-grain weight, and size of a seed on these two locations. In addition, KM3 has the highest significant difference on a number and weight of seed on each location. Therefore, it is an adaptive cultivar. This is in line with Shiringani and Shimelis (2011); Kaya and Ozer (2014) who explained that a genotype is considered more adaptive and stable if it has the highest seed yield on different environments.

The yield potential of cowpea can reach to 1.5 up to 2 ton ha^{-1} and depends on the cultivar, location, planting season, and cultivate of technology (Kasno *et al*., 1991). In this study, yield potential from local cultivars was very low when compared with cultivars from ILETRI. KM3 showed the stability of yield on these two locations with the highest on Ambon. Therefore, it can be seen that location affects production of cowpea along with water availability, temperature, light, etc. Ezeaku *et al*. (2015) reported that local cultivars have significantly the lowest of yield component and yield when compared with superior cultivars. It was also supported by Singh *et al*. (2002) who showed that using a superior cultivar with result to a realization of 4 ton ha^{-1}. In general, the local cultivars have better growth characters, have long flowering day, and the lowest yield component when compared with cultivars from ILETRI. Local cultivars have not been utilized as food resources. But they are able to produce the highest fresh and dry feeds.

Correlation analysis is very important in plant breeding program to improve the new cultivar. The positive correlation between growth characters, yield components, and interaction in each location or between locations showed that each character is used as the indicator in selected important traits for a specific purpose (Ibrahim *et al*., 2013). The significant correlation is caused by the association of source-sink on the plant. It is influenced by genetics and environment. de Souza *et al*., (2007) explained that each component that correlates with the product indirectly can be selected. One of these characters is the length of the main stem and it is positively correlated with the number of pods and the number of seeds per plant so that the stem length can be used as an indirect selection character in increasing cowpea production. In this study, they are correlated between plant height and seed length, number of branches and size of the seed, number of the pod, number and weight of seed per plant, and yield potential.

Correlation analysis with PCA can be used as a tool to identify the number of cultivars to be selected and used in the breeding program (Johnson, 1998). In cowpea, identification of accessions is being conducted based on effective characters such as flowering day, number of flowers per plant, number of pod per plant, and yield (Ishiyaku *et al*., 2005; Omoigui *et al*., 2006). According to Shiringani and Shimelis (2011), significant differences in yield between evaluated genotypes show which specific genotype is adaptive. Similarly, Kaya and Ozer (2014) explained that a genotype is considered more adaptive or stable if it has the highest average of yield on different environments (location and year). In this study, KM3 has been adaptive and stable on these two locations. The effective characters found in KM3 were faster flowering

day, the highest number of seeds per plant, 100-grain weight, size of seed, and yield potential. On the other hand, on these two locations, KM4 in Ambon and KM6 in Bogor have the highest number of the pod but the lowest number of loci, pod length, number and weight of seed.

CONCLUSION

Evaluation of morphological charactersare significantly affected by the cultivars on each location. Some of the highest characters were obtained by KM3, KM4, and KM6 cultivars. KM3 showed to be adaptive, stable and consistent on these characters. Aside from that, there are correlations between growth characters, yield components and clustering. Based on these characters are two clusters on each location. The local cultivars have good genetic potential that could further be developed in plant breeding.

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