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Morphological Characterization of 10 Chili Pepper Genotipes in Low Altitude Land

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ABSTRACT

Development of high yielding and superior cultivars requires information on characteristic of germplasm will be used. Ten curly -type chili pepper genotypes was grown in a completely randomized design with three replication in a low altitude land to determine their morphological characters and to evaluate genetic relationship among them based on their morphological similarities. The study was conducted in September 2015 until January 2016 in Medan Baru Experimental Station of Faculty of Agriculture, 15 m above sea level. Observation was conducted on both quantitative and qualitative characters. The results showed that there were not significantly diferent (α=5%) for plant habitus, leaf shape, leaf tip, leaf edge, leaf shape and seed shape. Whereas for quantitative variables of stem diameter, number of fruits per plants and fruit length were significantly different, while for the other variables were not. Cluster analysis with phylogenetic trees in 58% similarity coefficient resulted that the genotypes grouped in to six groups. Group I consisted of genotype Local Payakumbuh and Ferosa, group II Mario, group III was genotype Laris, group IV consisted of genotype Kopay and Romario, group V KH and Local Curup, and group VI included genotype Bogota and Sempurna. The Kopay and Romario genotypes have the closest relationship level of 73%, while Local Payakumbuh and Local Curup have the farrest relationship with the coefficient of 35%. From the results of the study it can be concluded that Local Payakumbuh and Local Curup genotypes can be used as parents with the highest probability to have high transgresive segregation or highest hybrid vigor..

INTRODUCTION

Chili pepper (*Capsicum annuum* L.) is the most widely cultivated so that developing many new cultivars is highly prospective. This seasoning vegetable has a favorable economic outlook, because increasing demand of household needs, food industry and pharmaceuticals in harmony with the increase of population. Chili pepper fruit is consumed either in the form of fresh fruit or dry form and it is also needed as a raw material for chili sauce, various spices, oleoresin, dyes and drugs (analgesics). In addition to the spicy substances, chili pepper also contains provitamin A, vit C, potassium, phosphorus and calcium (Guil-Guerrero *et al*., 2006). Genetic improvement to elevate chili pepper production is still the most priority of chili pepper breeding programs.

Genetic resources can be found in the form of wild relatives, landraces, mutants, or commercial

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varieties (Syukur *et al*., 2012). It can be obtained by introduction, hybridization or mutations. Once the genetic collection was accessible, phenotypic characterization is imperative for their efficient use in efforts of breeding programs to improve crop production (Terzopoulos and Bebeli, 2010). Characterization can be carried out based on guidelines descriptors for capsicum established by the International Plant Genetic Resources Institute (IPGRI, 1995). Any plant breeding programs to improve plant characteristics suit human needs is basically utilizing the genetic potential in interactions with environments (Gepts, 2006; Syukur *et al*., 2012).

The effect of interactions between genetic and environmental factors on plants will directly reduce genetic contributions in the final appearance of plants (Furbank *et al*., 2015) (Govindaraj *et al*., 2015). Morphological characters in plants can be either qualitative or quantitative characters. Qualitative characters are manifestation of phenotypes that differ sharply from one to another which can be categorized qualitatively to form groups. They are controlled by a few genes. Meanwhile the quantitative characters are controlled by many genes. The later is usually influenced by environments. Information on the inheritance patterns of each character is important in determining plant breeding strategies (Syukur *et al*., 2012).

Study on genetic diversity and its prospective usage to support future breeding programs have been conducted on many plants, such as in rice (Thomas *et al*., 2017), maize (Peiffer *et al*., 2013; Abdel-Ghani *et al*., 2013), wheat (Lopes *et al*., 2015), tomato (Aflitos *et al*., 2014), cucumber (Qi *et al*., 2013), and mustard (Singh *et al*., 2016). The objective of this study was to do morphological characterization and to determine genetic relationship of ten chili pepper genotypes. The information will be useful to select the most prospective parents to develop superior varieties.

MATERIALS AND METHODS

This research was conducted in Medan Baru experimental station of Faculty of Agriculture, the University of Bengkulu at Muara Bangkahulu Sub-District, Bengkulu City, with the elevation of 15 m above sea level, in September 2015 - January 2016. The experiment was arranged in a Completely Randomized Design (CRD) with a single factor of 10 curly-type chili pepper genotypes and three replications. The genotypes used were ‘Local Payakumbuh (LPK)’, ‘Ferosa’, ‘Laris’, ‘Kopay’, ‘Romario’, ‘Keriting Hitam’, ‘Local Curup (L Curup)’, ‘Bogota’, ‘Sempurna’ and ‘Mario’. The total number of experimental units was 30 units each of which comprised or three plants.

Prior to seeding, the seeds were soaked in warm water, then were germinated in moisted tissue paper for five days. The germinated seeds were then transplanted onto 72-celled seedling trays containing a soil-manure (1:1 v/v) mix media. Seedling maintenance including watering, fertilizer application, and pest and diseases control was conducted as needed.

Seedlings of 35-days old were transplanting into the polybags of 40 cm in diameter containing 10 kg mix media of soil : manure (9:1 w/w), single plant per polybag. All plants were set 50 cm apart. The plants were watered daily to provide optimum soil moisture. Urea fertilizer application was conducted twice at transplanting and four weeks after transplanting, at the rate of 200 kg.ha^{-1}. Phorpor and potassium fertilizer in the form of SP36 and KCl were applied at transplanting in the rate of 300 and 100 kg.ha^{-1}, respectively. Plant maintenance comprising of watering, staking, pest and disease controlling was conducted with a standard maintenance of commercial chili pepper growers. Harvesting was performed when the fruit was physiologically ripen indicated by at least 75% of the fruit turn to red color.

Observation was carried out on qualitative variables and quantitative variables. The former was on plant habitus, stem color, leaf shape, leaf tip, leaf edge, leaf color, petal color, sepal color, pistil head color, stamen color, young fruit color, ripe fruit color, fruit shape, seed color, seed shape, and fruit surface texture. The later included plant height, dichotomous branch height, number of branches, leaf length, leaf width, leaf greenery, fresh weight, plant dry weight, canopy width, age to flowering, fruit diameter, fruit weight, harvest age, fruit shelf life , and weights of 100 seeds.

Qualitative data obtained were analyzed descriptively. The quantitative data was variance analyzed with ANOVA at $\alpha = 5\%$. Mean comparison was performed with Duncan's Multiple Range Test (DMRT). Genetic relationship was accessed with UPGMA (Unweighted Pair Group Method with Arithmetic Mean) cluster analysis using NTSYS program. The results of the analysis was presented in the form of a dendogram with the distance of the correlation coefficient in the form of a percentage of similarity. The greater the percentage value the closer the relative between accessions.

RESULTS AND DISCUSSION

The experiment was carried out during the dry season, so that rainfall was relatively low. At the beginning of the experiment, the plants experienced drought condition with the rainfall intensity of 80 mm, with only four rainy days during the first month. Eventhough the average temperature was still supportive which was 25.7°C, these condition hampered growth and yield most plants. Watering was applied twice a day in the morning and in the evening with deep well water. However, the ground water used for irrigation was already contaminated with salt due to sea water intrusion. This was indicated by the salty taste and its high electric conductivity of 17.36 ms which was far higher compared to that of fresh water, 0.03 ms. The intrusion is happening when seawater enters the porous soil and contaminates the ground water so that the ground water turns into salt water (Putranto and Kusuma, 2009).

Low rainfall at the beginning of planting and salinity stress was probably to cause chili plants to show poor growth. Sumarni and Muharram (2005) explain that low rainfall inhibits the growth and development of chili plants due to lack of water, and conversely, too high rainfall causes root decay so the plants become stunted and die.

Qualitative Variables

Qualitative variables observed in this study include: plant habitus, stem color, leaf shape, leaf tip, leaf edge, leaf color, flower petals, flower crown color, pistil head color, stamen color, young fruit color, ripe fruit color , fruit shape, seed color, seed shape, and fruit skin surface. The qualitative nature of a plant is controlled by a simple gene (one or two genes) and less influenced by environmental factors such as climate, rainfall, and the duration of the solar irradiation (Syukur *et al*., 2012). The results showed uniformity in plant habitus, leaf shape, leaf tip, leaf edge, fruit shape and seed shape of 10 chili genotypes, which have compact plant habitus, lanceolate leaf, tapered leaf tip, flat leaf edge, elongated fruit shape and flat-shaped seeds.

The color of the stem of the chili plant was only greenish purple and green. The purple color on the stem of chili plants is caused by anthocyanin substances found in the stem and stem nodes, where anthocyanin in some cases can be used as an indicator of genetic differences (Rubatzsky and Yamaguchi, 1999). Leaf color in 10 chili genotypes was observed visually and compared using the Munsel Color Chart. Almost all of the 10 chili genotypes possesses dark green leaves, except Romario and Mario which have purple and green leaves. The color of the leaves of chili plants was divided into 6 gradation green according to the color groups found in the color chart, namely light green, dark green to purplish (Sofiari and Kirana, 2009).

The flower petals of the 10 chili genotypes are green, dark green to purplish green (Table 1). Whereas for flower crown color almost shows uniformity that is white in Local Payakumbuh, Ferosa, Laris, Kopay, Keriting Hitam, Local Curup, Bogota and Sempurna genotypes, whereas Romario and Mario genotypes are purple with white base color. According to (Kaharjanti, 2008), the crown color of chili flowers varies, i.e. white, greenish white, purplish white to deep purple. The color of the pistil head of the tested genotype is yellow, while genotype Kopay and 'Keriting Hitam' is white. The color of the pistil head of chili plants was generally yellowish white (Simanjuntak, 2013). The color of the stamens Local Payakumbuh, Ferosa, Laris, Romario, Bogota, Sempurna and Mario were white, while that of Kopay is light yellow, Local Curup Black and Keriting Hitam were light yellow.

Young fruit color of Local Payakumbuh, Ferosa, Romario, Local Curup, Bogota, Sempurna, Mario were dark green, that of Laris and Kopay were green, while that of Keriting Hitam was black. The results of the Simanjuntak (2013) study showed that the color of young chili fruits varied from light green, green, dark green, purple, and black. The color of ripen fruit of chili plants ranges from red, bright red ad dark red. The color of ripen fruit of Laris, Kopay, Bogota and Mario genotypes were bright red, while that of Local Payakumbuh, Ferosa, Romario, Keriting Hitam, Local Curup and Sempurna were dark red. The green color of the chili is related to the chlorophyll content, the red color is related to the percentage of carotenoids, and the purple color is related to anthocyanin. In the ripen fruits, chlorophyll has disappeared (decomposed) and only yellow and red color are visible (Rubatzsky and Yamaguchi, 1999).

Regarding to the fruit skin surface texture of 10 genotypes observed, all genotype have to curly surface textur, except Ferosa whish has smooth texture (Table 2). Light yellow seed color was found in the genotype Local Payakumbuh, Ferosa, Bogota, Sempurna and Mario, while brownish yellow color was in Laris, Kopay, Romario, Keriting Hitam and Local Curup genotypes. Brownish (straw) yellow was the common color of chili seeds (Kusandriani, 1996).

Quantitative Character

Genotype has a significant effect on stem diameter, number of fruits and fruit length. While plant height, dichotomous branch height, dichotomous branch number, leaf length, leaf width, leaf greenery, canopy width, flowering age, fruit diameter, fruit weight, harvest age, fruit shelf life, 100 seeds weight, fresh weight and dry weight were not affected by genotypes (Table 3). This result was

Table 1. Stem color, leaf color, petal color, sepal color, pistil color, stamen color, young fruit color of 10 curly chili pepper genotypes

Genotype	Stem color	Leaf color	Petal color	Sepal color	Pistil color
LPK	green, purple strips	dark green	dark green	white	yellow
Ferosa	green, purple strips	dark green	dark green	white	yellow
Laris	green, purple strips	dark green	green	white	yellow
Kopay	green, purple strips	dark green	dark green	white	white
Romario	green, purple strips	dark green	dark green	white	yellow
KH	green, purple strips	purple	Purplish green	purple	white
L. Curup	green, purple strips	dark green	green	white	yellow
Bogota	green, purple strips	dark green	green	white	yellow
Sempurna	green	dark green	green	white	yellow
Mario	green	green	green	White purple	yellow

Table 2. Stamen color, young fruit color, ripe fruit color, seed color, fruit surface texture of the fruit of 10 chili pepper genotypes

.Genotype	Stamen color	Young fruit color	Ripe fruit color	Seed color	Fruit surface texture
LPK	white	dark green	dark red	white	curly
Ferosa	white	dark green	dark red	white	smooth
Laris	white	green	bright red	yellow	curly
Kopay	light yellow	green	bright red	yellow	curly
Romario	white	dark green	dark red	yellow	curly
KH	yellow	purple	dark red	yellow	curly
L. Curup	yellow	dark green	dark red	yellow	curly
Bogota	white	dark green	bright red	white	curly
Sempurna	white	dark green	dark red	white	curly
Mario	white	dark green	bright red	white	curly

not in agreement with the finding of (Qosim *et al.,* 2014) that growth and yield components were signigicantly affected by genotypes.

The coefficient of variation value (CV) in this study varies between 8.01% - 18, 96%, with the lowest value of 100 seeds and the highest value found in plant fresh weight (Table 3). High CV value indicated high experimental error due to environment or human error (Gomez *et al*., 1984). Coefficient of variation also indicates the level of accuracy of an experiment (Palaniswamy, 2005). Genotype factor showed significantly different effect which illustrate at least there were a pair of genotypes showed different measurement.

Mean comparison on the stem diameter showed that genotype Local Payakumbuh and Local Curup showed bigger stem than other genotype, eventhough they were not significantly different from genotype Ferosa, Romario, Bogota and Mario (Table 4). The different of stem diameter among genotype was due to genetic factor manifested in a response to environment condition. Stem diameter determines the strength to support plant canopy. The larger the stem diameter of the plant, the stronger the ability of a plant to be able to support the branches and fruit of the plant (Silva *et al*., 2016). This variables can also be use as an indicator of plant vegetative growth. Plant growth is strongly influenced by environmental factors such as light and temperature, where these factors play an important role in the production and transportation of nutrient (Jones, 2013).

Table 3. Summary of F-calculated values and CV results of analysis of variance on 10 genotypes of curly chili pepper in a low altitude land

No	Character observed	F calc.	CV (%)
1	Plant height	1.03 ns	11.37
2	Stem diameter	3.47*	10.99
3	Height of branch	1.32 ns	11.51
4	Number of branch	1.16 ns	11.70
5	Panjang daun	0.48 ns	18.18
6	Leaf widht	0.84 ns	16.79
7	Leaf greenish	2.02 ns	13.88
8	Plant dry weight	1.10 ns	16.27
9	Plant fresh weight	0.49 ns	18.96
10	Canopy widht	1.15 ns	12.58
11	Age to flowering	2.10 ns	10.40
12	Number of fruit	2.48*	13.45
13	Fruit length	2.84*	14.92
14	Fruit diameter	2.06 ns	17.73
15	Fruit weight	1.91 ns	15.88
16	Age to harvest	0.48 ns	10.17
17	Fruit shelf life	0.90 ns	10.97
18	Weight of 100 seeds	1.99 ns	8.01

Note : * = significant different at α= 5%, ns= not significant different

Table 4. DMRT results on 10 chili pepper genotype grown on low altitude land

Genotype	Stem diameter (mm)		Number of fruit		Fruit length (cm)	
L. Payakumbuh	8.94	a	32.1	abc	12.9	a
Ferosa	7.51	ab	42.7	a	9.2	bc
Laris	6.50	b	39.8	ab	9.6	bc
Kopay	6.45	b	18.4	c	11.8	ab
Romario	7.74	ab	37.2	ab	8.9	bc
Keriting Hitam	6.69	b	24.8	bc	8.7	c
Lokal Curup	8.81	a	41.5	ab	8.9	bc
Bogota	7.55	ab	25.9	abc	11.5	abc
Sempurna	6.87	b	35.1	ab	9.4	bc
Mario	7.67	ab	32.4	abc	10.0	bc

Mean comparion on the number of fruits showed that Ferosa was the genotype with the higherst number of fruit, and Local Curup was in the second rank. The number of fruit is a yield component which highly determine the yield of chili pepper. The higher the number of fruits per plant, the higher the total fruit weight per plant. In addition, the number of fruits per plant is also influenced by the number of flowers formed until pollination occurs (Do Rêgo *et al*., 2011).

Fruit length of chili pepper is determined by genetic. Local Payakumbuh was the genotype bearing the longest fruit which reach as long as 12.9 cm, followed by Kopay and Bogota. However, environment may influence the expression of genetic factor so that similar genotype may produce different fruit legth in different environment (Syukur *et al*., 2012).

Cluster analysis

The height of curly red chili plants tested can be divided into three groups. The first group which had an average plant height of 52.3 cm to 56 cm, were the Keriting Hitam, Local Curup and Bogota. The second group with an average of 59.3 to 63.1, were Ferosa, Laris, Kopay, Romario, Sempurna and Mario. The third group which had an average height of 68 cm was Local Payakumbuh.

Plants in each group of genotypes observed were included in the compact plant habitus group. The growth of plant height from 10 genotypes of curly red chili was not highly different in each genotype.

In this experiment, the stem diameter was divided into three groups. The first group had stem diameters of 6.4 cm to 6.8 cm, namely in the Kopay, Romario, Keriting Hitam, Local Curup, Bogota and Sempurna the second group had a stem diameter of 7.5 mm to 8.3 mm, namely in Ferosa and Laris, while for the third group stem diameter was 8.7 mm to 8.9 mm, namely in Local Payakumbuh.

The dichotomous branch height in 10 genotypes of curly red chili was able to group into three classes, the first class had a dichotomous branch height average of 24.9 cm to 27.4 cm, namely in Ferosa, Laris, Kopay and Mario, the second group had a high dichotomous branch average 28.1 cm to 30.6 cm, namely Local Payakumbuh, Keriting Hitam and Local Curup, whereas for the third group the dichotomous branches had an average height of 31.5 cm to 32.4 cm, namely in the Bogota genotype and Sempurna. The higher the dichotomous branch of a plant, the greater the likelihood that chili fruits will be prevented from attack because the chili fruit was further away from the ground so that it can reduce the splash of water from the soil which is the source of fungal infection.

The number of branches could be divided into three groups, the first group had an average number of branches of 138 to 178, i.e. Laris, Kopay, Bogota and Sempurna genotypes, the second group had an average of 188 to 228 namely in the Romario genotype, Keriting Hitam, Local Curup and Mario, and the third group had an average number of branches of 232 to 259, namely Local Payakumbuh and Ferosa. The number of branches correlates with the number of fruits because the more dichotomous branches in the chili plant, the more fruit the plant produces.

The length of the leaves could be clustered into three groups, the first which has an average leaf length of 46.1 mm to 48.6 mm, namely Kopay, Romario, Keriting Hitam, Sempurna and Mario, the second has an average of 50.8 mm to 52.8 mm which is in Local genotypes Payakumbuh, Ferosa, Laris and L Curup, and the third group had the highest average leaf length of 53.5 mm in the Bogota genotypee. The leaf width of 10 chili genotypes tested showed no significant difference in analysis of variance. In this experiment, the width of the leaves could be grouped into three groups. The first group had a leaf width of 47 mm to 49 mm in the Kopay, Romario, Sempurna and Mario genotypes, the second group had a mean leaf width of 49.5 mm to 51.5 mm, namely in Ferosa, Laris, Keriting Hitam and Local Curup, and the third group that had an average of 52.2 mm to 53.0 mm in the Local Payakumbuh and Bogota. The leaf length and leaf width determine leaf area related to photosynthesis. The greater the leaf area, the greater the photosynthate produced from photosynthesis. The greenness of the leaves is related to the amount of chlorophyll in the leaves. The greater the amount of chlorophyll in the leaves, the better the photosynthesis process in plants, the more green the leaves of plants. The 10 tested genotypes of chili were divided into three groups. The first group had a leaf greenness average of 40.9 to 47.5 in the Romario genotype, Keriting Hitam, Local Curup and Sempurna, the second group was 48.6 to 55.2 in Kopay and Bogota, while the third group had average 55.5 to 60.0, namely Local Payakumbuh, Ferosa, Laris and Mario.

The width of the canopy in a plant is usually used to determine plant spacing that is closely related to the efficiency of land use and sunlight in the process of photosynthesis. The width of the canopy will affect the efficiency of determining the plant population per hectare (Gardner *et al*., 2017). The wider the plant canopy, the more branching will be the place where the flowers emerge (Kusandriani, 1996). In this experiment, there were three groups of canopy widths in each genotype, the first group had an average canopy width of 27.3 cm to 36.6 cm in the Keriting Hitam, Local Curup, and Bogota genotypes. The second group averages 38 to 47.3 cm in the Laris, Kopay, Romario and Sempurna genotypes. And the third group in the Local Payakumbuh, Ferosa and Mario genotypes with canopy widths average 53 cm to 55.3 cm.

Age to flowering of chilli pepper plants affects the length of harvesting life in a plant. Slow flower blooms are influenced by the intensity of sunlight, daily temperature and plant genotypes. In this experiment, age to flowering was nos significantly different among genotype. Age to flowering could be divided into three groups. The first group was 27.3 days to 29 days, namely the Keriting Hitam, Local Curup, Bogota and Sempurna, the second group which was of 30.3 days to 32.3 days, they were Kopay, Romario and Mario, and the third group which was of 33 days or higher, was of Laris genotype.

The number of fruits could be grouped into three groups. The first group had an average number of fruits per plant i.e. fruit number of 19.3 to 27.6 consisted of the Bogota and Sempurna genotypes, the second group had an average number of fruits of 33 to 40.6 was Local Payahkumbuh, Ferosa, Local Curup, and Mario genotypes. The third group averages 41.3 to 43.3 inluded Laris, Kopay and Romario genotypes. However, overall the number of fruits is considered a little because basically the number of fruit plants can reach 200 fruits in one plant, the low number of fruits is caused by a lack of supply of nitrogen that can be transferred to fruit formation (Dermawan, 2006). The low number of fruits can also be caused by the large number of flowers that fall out due to rainfall that is too high during the generative phase. According to Sumarni and Muharram (2005) the rain that is too high can cause the flowers to fall and the fruit to rot. The difference in the number of fruits in each genotype tends to be caused by interactions between genotypes and the environment.

In this study the fruit length was grouped into three groups. The first group with an average fruit length of 9.1 cm to 10.3 cm, which consisted of genotypes Ferosa, Laris, Kopay, Romario and Keriting Hitam. The second group averaged 10.9 cm to 12.1 cm, which included Local Curup, Bogota, Sempurna and Mario genotypes. The third group with an average of 12.9 cm which was the Local Payakumbuh.

Fruit diameter could be classified into three classes. The first class with an average of 4.44 mm to 4.99 mm, namely the Laris genotype, Local Curup, Bogota and Sempurna. The second group averaged 5.11 mm to 5.78 mm in the local genotype Payakumbuh, Ferosa and Mario. The third group averaged 5.80 mm to 6.82 mm in the Kopay, Romario and Keriting Hitam genotypes. The difference in fruit diameter is because of the genetic factor so that morphologically the size and shape of the fruit will also be different.

The fruit weight of 10 curly chili genotypes ranged from 46.1 g to 112.5 g. Fruit weight was grouped into three groups, namely the first group with an average of 46.1 g to 57.9 g, namely in the Bogota and Sempurna genotypes, the second group with an average of 70.5 g to 87.3 g namely Local Payakumbuh, Kopay, Romario, Keriting Hitam and Local Curup, and the third group with an average of 99.8 g to 112.5 g, namely genotypes Ferosa, Laris and Mario. The yield is a resultant of the number of fruits and weight per fruit. Weight per fruit is determined by fruit length, fruit diameter, number of seeds, seed weight and fruit flesh (Do Rêgo *et al*., 2011).

The weight of 100 seeds from the research results showed no significant difference, from the results of this study genotype Bogota had the lowest seed weight of 0.66 g while Ferosa and Laris have the highest average fruit weight of 1.23 g. The weight of 100 seeds could be arranged into three groups, i.e. the first group with an average of 0.66 g to 0.73 g consisted of Local Curup, Bogota and Sempurna, the second group (0.83 g to 0.96 g) included Local Payakumbuh, Romario and Keriting Hitam, and the third group (1.06 g to 1.23 g) comprised of Ferosa, Laris and Mario genotypes.

Age to harvest is influenced by genetics and environment, where genetic background greatly affects the length of harvesting of plants. In additon, age to harvest is also related to age flowering in plants. The results of the study showed that Ferosa had the shortest age to harvesting age, while Bogota was the longest age to harvest ing age. The average harvest age of the 10 chili genotypes could be grouped into three groups, the first group that had an average harvest age of 83 days to 87 days after transplanting, they were Ferosa and Laris genotypes, the second group which had an average of 89 days to 92 days, they were Kopay, Romario, Keriting Hitam, Local Curup, Sempurna and Mario, while the third group which had age to harvest of 93 days to 94 days, included Local Payakumbuh and Bogota genotypes.

Fruit shelf life was limited by fruit respiration during the storage. One of the advantages of chili pepper is they have relatively long shelf life (Syukur *et al*., 2012). From the results of the study it was noticeable that Kopay, Romario, Black and Local Curls Curup the fruit's shelf life longer than the other genotypes. The fruit's shelf life is influenced by genetics and condition during harvesting. Acording to the observed fruit shelf life, the genotypes used could be group into three group. The first group with fruit shelf life of 10 to 11 days consisted of Sempurna and Mario; the second group with 11 to 12 days, were Ferosa and Laris genotypes; and the third group with shelf life longer than 12 days were Local Payakumbuh, Kopay, Romario, Keriting Hitam, and Local Curup.

Based on the fresh weight of the plants in this study, genotypes could be sorted into three groups. The first group with the weight of 83.5 to 90.6 g consisted of Ferosa and Sempurna; the second group with 96.8 g to 108.2 g included Kopay genotype, Romario, Keriting Hitam and Local Curup; and the third group with fresh weight of 111.9 g to 120.7 g consisted of Local Payahkumbuh genotype, Laris, Bogota and Mario. Based on plant dry weight, the genotypes could be classed into three classes. The first group with plant dry weight of 26.6 g to 31.5 g consisted of genotypes Ferosa, Kopay, Romario, Keriting Hitam and Sempurna; the second group (32.9 to 34.8 g) covered Laris, Local Curup, Bogota and Mario; and the third group (42 g or higher) comprised of Local Payakumbuh.

The similarity of the characters in the chili genotype tested can show closeness in the relationship between these genotypes. Grouping analysis of 10 curly red chili genotypes in low altitude land produced dendrograms with similarity coefficients ranging from 58% to 73% (Figure 1). Similarity analysis based on qualitative and quantitative character among genotypes is a basis for Cluster Analysis to construct a phylogenetic tree. At the 58% similarity coefficient, the genotypes could be grouped into six groups. The group I has white seeds, medium to high plants, dichotomous branches low to moderate, many dichotomous branches, wide canopies, quite early maturing flowers, quite a large number of fruits, large fruits, high fruit weights, harvested to early maturity , and has a long shelf life, which consists of Local Payahkumbuh and Ferosa genotypes. Group II characterized by white seeds, medium plant height, low dichotomous branches, moderate dichotomous branches, wide canopies, medium age to flowering, medium fruit numbers, medium fruit diameter, early age to harvest with low shelf life, covered only Mario genotype. Group III which has yellow seeds, low plants, low dichotomous branches, medium number of branches, narrow canopies, age to flowering, large number of fruits, small fruit diameter, medium fruit weight, early age to harvesting age with long shelf life, comprised of only Laris genotype. Group IV which have yellow colored seeds, medium to high plant height, low dichotomous branches, many dichotomous branches, wide canopies, early maturity, large number of fruits, large fruit diameter, medium fruit weight, early maturity and long shelf life, included Kopay and Romario genotypes. Group V which have yellow seeds, short plants, medium dichotomous branches, moderate dichotomous branches, narrow canopies, early flowering, medium fruit, small to large fruit, medium fruit weight, medium to deep harvest, have long fruit storage consisted of Keriting Hitam and Local Curup genotype. Group VI has white seeds, short to medium plants, high dichotomous branches, a small number of branches, a narrow to moderate canopy, early flowering, small number of fruits, small fruit diameter, low fruit weight, moderate to late harvesting, short shelf life, included Bogota and Sempurna.

Based on the results of cluster analysis, it can be seen that Kopay and Romario have a high level of similarity, because it has a similarity coefficient value of 73%. Overall, Kopay and Romario have similarities to the qualitative and quantitative variables observed, except for the color of the pistil, stamen color, young fruit color, greenness of the leaves, and the weight of 100 seeds. So that it can be seen that with a high degree of similarity the genetic variation possessed by Kopay and Romario is very narrow, but to cross the potential success is very high because it has almost the same morphological properties. Genotypes that are in the same group have close genetic relationship so that they cannot be used as parents material as they will not produce significant genetic improvement in further generation (Hartati and Darsana, 2015).

Based on the results of cluster analysis the coefficient values of 0.35 to 0.73 were obtained by two large groups and six small subgroups. The first group consisted of Local Payahkumbuh genotypes, Ferosa, Mario, and Laris. While the second group consisted of Kopay, Romario, Keriting Hitam, Local Curup, Bogota and Sempurna genotypes. The first group was divided into three small subgroups consisting of 1a: Local Payakumbuh and Ferosa, 1b: Mario, 1c: Laris. The second group is divided into three small subgroups, namely 2a: Kopay and Romario genotypes, 2b: Keriting Hitam and Local Curup, and 3c: consisting of Bogota and Sempurna genotypes. Parental chosen from different major group will be prospective to be crossed. A cross of parents which have distant genetic relationship is potential to have hybrid vigor or transgressive segregation in the next generation (Herison *et al*., 2017).

CONCLUSIONS

Based on 58% similarity level, 10 genotypes of curly red chili can be grouped into six groups. The first group consisted of Local Payakumbuh and Ferosa, the second group Mario, the third group Laris, the fourth group consisted of Kopay and Romario, the fifth group consisted of Keriting Hitam and Local Curup, and the sixth group consisted of Bogota and Sempurna. Local Payakumbuh and Lokal Curup have the least similarity level of 35% so that they were recommended as parental in further breeding program.

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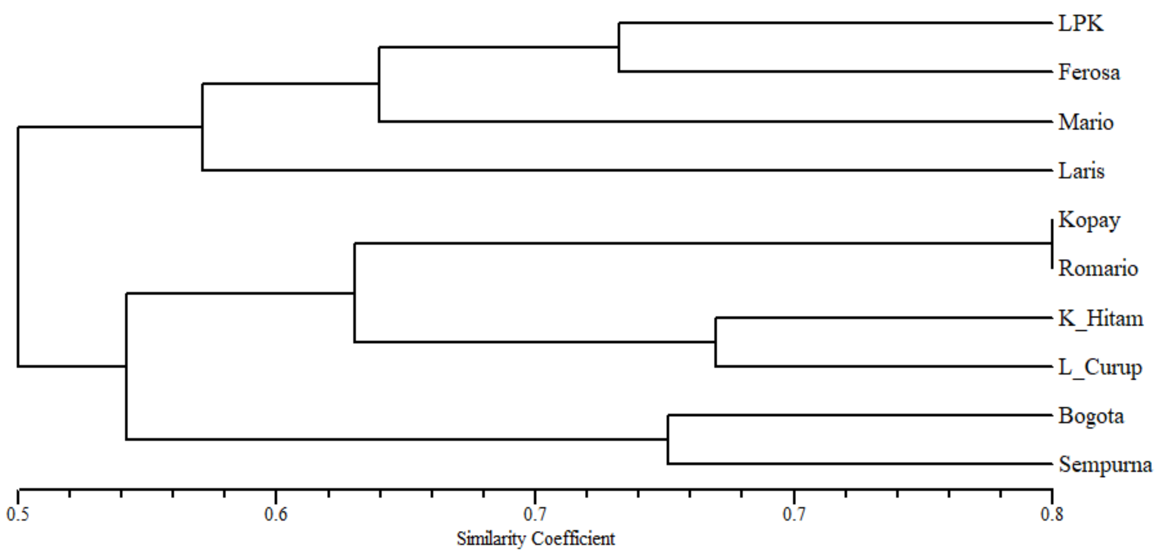

Figure 1. Dendrogram based on the similarity of qualitative and quantitative characters of 10 curly chili pepper genotypes in low altitude land

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