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Diversity of capsaicin content, quantitative, and yield components in chili (*Capsicum annuum*) genotypes and their F1 hybrid

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Abstract. *Sahid ZD, Syukur M, Maharijaya A. 2020. Genetic diversity of capsaicin content, quantitative, and yield component in chili (Capsicum annuum) and their F1 hybrid. Biodiversitas 21: 2251-2257.* Chili (*Capsicum annuum* L.) is one of the horticultural plants that have many benefits. The benefit of chili was determined by pungency level of its fruit. Pungency level of the chili is due to the capsaicin content in fruit. Information about the genetic diversity of capsaicin is still rarely available. The aims of this study were to obtain diversity information on quantitative, yield component, and capsaicin content, and to analyze the correlation among chili genotypes based on their morphological characters. This study used Randomized Complete Block Design with three replications. The genetic material used in this study consisted of 21 genotypes consisting of 6 genotypes of chili elders and 15 hybrid F1 genotypes resulting from their crossing. Six genotypes of the chili parents are C5, F6074, F9160291, Yuni, Bara, and Giant. 15 hybrid F1 genotypes used in this study are C5 x Bara, C5 x F6074, C5 x Yuni, C5 x Giant, C5 x F9160291, Bara x F6074, Bara x Yuni, Bara x Giant, Bara x F9160291, F6074 x Yuni, F6074 x Giant, F6074 x F9160291, Yuni x Giant, Yuni x F9160291, and Giant x F9160291. The observation was made on the variables of quantitative, yield, and capsaicin components on chili. The results showed that the highest capsaicin content only was found in Bara x F9160291. The results of scatterplot analysis showed that the highest capsaicin and yield component was found in BaraxF6074 and C5 x Yuni genotype. The results of cluster analysis showed that chili was clustered into three color groups. The character of capsaicin content is negatively correlated and very different from fruit weight, fruit diameter, fruit length, thick fruit flesh, total amount of fruit per plant, and fruit weight per plant.

Keywords**:** *Capsicum annuum*, capsaicin content, high-performance liquid chromatography, yield components

INTRODUCTION

Chili (*Capsicum annuum* L.) has many benefits because it has many phytochemical contents i.e phenols, flavonoids, and capsaicinoids (Krzyzanowska et al. 2010). Chemical content that regulates the spiciness level of chili is capsaicin (Puvača 2018). Capsaicin in chili is used as a spicy enhancer in food (Pugliese et al. 2013; Materska 2014), a prevention drug for cardiovascular disease, cancer, and neurological disorders (Shetty 2004), and as a self-protective spray for women (Lingga 2012). Capsaicin is a group of compounds responsible for the spicy flavor of chili (Simonovska et al. 2016). In general, fresh chili fruit has 0.1-1.0% capsaicin content. Capsaicin can be found in chili pods i.e seeds, skin, placenta, and flesh. Capsaicin processing on chili can increase the selling value of chili plants so that the welfare of the community increases (Saing and Reni 2018).

The spicy nature of chili is the role of a single dominant gene located on chromosome 2 (Guzman et al. 2011). The capsaicin content in *Capsicum chinense* is controlled by the Pun1 gene (Stewart et al. 2007). The Pun1 gene encodes putative acyltransferase (Stewart et al. 2005). The types of gene action involved in capsaicin inheritance can be epistasis, over dominant and complementary dominant gene actions (Naresh et al. 2016; Sarpras et al. 2016). This is because the action of genes is influenced by environmental conditions (Reyes et al. 2011) i.e stress conditions (Annor and Apraku 2016), drought conditions (Esfahlani et al. 2018), low light (Emami et al. 2018), high temperature (Kandel et al. 2017) and pest and disease disorders (Lekshmi and Celine 2017) at the time of chili development.

Addition of plant genetic diversity can be done with plant breeding activities (Orobiyi et al. 2013). One of the plant breeding activities that can increase genetic diversity is by artificial crossing (Istiqlal et al. 2018). Various studies on capsaicin from crosses were carried out at interspecific crosses (Yarnes et al. 2013; Lee et al. 2016; Zhu et al. 2019). In this study crosses in the same species (*Capsicum annuum*) were used.

The potential productivity of chili plants in Indonesia can reach more than 20 tons ha^{-1} (Syukur et al. 2010). Indonesian chili (*Capsicum annuum* L.) cultivar which has the highest productivity is Tanjung 2 cultivar. Increased production of chili plants can be influenced by fruit length, fruit weight, fruit diameter, fruit weight per plant, and total amount of fruit per plant. The Genetics and Plant Breeding Laboratory, Department of Agronomy and Horticulture, IPB University has a total of 21 chili genotypes consisting of 6 genotypes of chili elders and 15 hybrid F1 genotypes. Six genotypes of the chili parents were C5 (Syukur et al.

2017), F6074, F9160291, Yuni, Bara, and Giant (Yunandra et al. 2018). This collection is used to study its diversity which is evaluated based on morphology, capsaicin, and its production. The aims of this study were to obtain diversity information on quantitative, yield component, and capsaicin content, and to analyze the correlation among chili genotypes based on their morphological characters.

MATERIALS AND METHODS

Study area and genetic material

This research was conducted at the IPB University Experimental Field, Dramaga Subdistrict, Bogor, West Java, Indonesia. Analysis of capsaicin was carried out in the Laboratory on Indonesian Center for Agriculture Postharvest Research and Development, Bogor, West Java. The genetic material used in this study consisted of 21 genotypes consisting of 6 genotypes of chili elders and 15 hybrid F1 genotypes resulting from their crossing. Six genotypes of the chili parents were C5, F6074, F9160291, Yuni, Bara, and Giant. Fifteen hybrid F1 genotypes used in this study are C5 x Bara, C5 x F6074, C5 x Yuni, C5 x Giant, C5 x F9160291, Bara x F6074, Bara x Yuni, Bara x Giant, Bara x F9160291, F6074 x Yuni, F6074 x Giant, F6074 x F9160291, Yuni x Giant, Yuni x F9160291, and Giant x F9160291. This genetic material was a collection of Genetics and Plant Breeding Laboratory, IPB University. The design used was a Randomized Complete Block Design (RCBD) with three replications in each replication consisted of 20 plants per genotype.

Morphological characterization

The experimental activity begins with seeding activities. Fertilization is done after the seedlings are 2 weeks after seedling using NPK 15:15:15 fertilizer (10 g L^{-1} water). Planting is done after the chili seeds are 30 days after sowing or plant height of about 15 cm and the number of leaves is 8. Beds measuring 1 × 5 m with a distance between beds 50 cm. The beds are covered with silver black plastic mulch and a planting hole is made with a distance of 50 x 50 cm. Maintenance activities are carried out, i.e watering in the morning and evening, fertilizing is done once a week using NPK fertilizer 15:15:15 (10 g L^{-1} water) as much as 250 mL per plant, spraying pesticides once every 2 weeks using a fungicide made from active Mankozeb (2 g L^{-1}) and insecticide with active ingredients Prefonofos (2 mL L^{-1}). Harvesting is done when the chili has reached a level of maturity of 75% or at the age of 70 days after planting which is carried out every week for 8 weeks.

Observation on these variables refers to the Descriptor of Capsicum International Plant Genetic Resources Institute (IPGRI 1995). Observations were made on non-yield and yield component characters, including plant height, dichotomous height, leaf height, leaf width, stem diameter, header width, fruit length, fruit stalk length, fruit diameter, thick fruit flesh, fruit weight, fruit weight per plant, total amount of fruit per plant and capsaicin content.

Capsaicin analysis

Sample preparation

Capsaicin analysis in this research using modified HPLC method (Tilahun et al. 2013). The initial step in the analysis of capsaicin is drying the sample of chili using an oven at 50ºC for 2 x 24 hours. The next step is to measure the water content at 59ºC then crushed the chilies until smooth. Chili powder weighed 0.5 g^{-1} g and put it into a 50 mL volume test tube. Add 5 mL of Aceton p.a then shake hands and use ultrasonic for 5 minutes at room temperature. The test tube was closed using alufo and heated using a water bath for 8 hours at 80ºC. The next step is to cool in the refrigerator overnight at 4ºC. The sample was then filtered with Whatman 41 filter paper into a test tube scale and taken 30 mL then ultrasonic for 20 minutes. After that, a part of the solution is taken using a 0.45-micron Syringe Filter and put in a 1.5 mL vial bottle for HPLC. In this study, we used 2 samples per genotype.

HPLC condition

HPLC Detector DAD UV-VIS with C18 column (4.6 mm×150 mm, 4 μm). The C18 column was used for effectively partition and quantification of capsaicinoids (Othman et al. 2011). Temperature column used in this research is 30ºC and 4ºC sample temperature with 250 mm with 276-280 nm wv. Fluorescence 1.5 mL min^{-1} and injection volume 20 micron. Mobile phase: Acetonitrile : Phosphate Acid 0.1% (40 : 60).

Capsaicinoids quantitation

The major capsaicinoids in peppers, capsaicin, and dihydrocapsaicin, were determined by comparison to external reference standards injected under the same conditions (Schmidt et al. 2017). Their identification was based on the retention times measured under identical HPLC conditions while their quantitative determination in the different peppers samples was carried out using the peak areas. The ratio between these capsaicinoids was calculated by dividing capsaicin and dihydrocapsaicin contents to the total capsaicinoids. The capsaicinoid concentrations in samples are expressed as μg g^{-1} pepper.

Scoville heat unit conversions

Capsaicin contents were converted to Scoville Heat Units (SHU) by multiplying the pepper dry weight capsaicin content in g of capsaicin per g of pepper by the coefficient of the heat value for capsaicin; which from literature is 1.6 × 107 (Todd et al. 1977).

Data analysis

Data analysis was performed using ANOVA, Cluster Analysis, and Corr. Analysis. ANOVA is performed according to a general linear model (GLM), using the SAS v software package. 9.0 and least significant mean comparisons by Tukey's Studentized Range Test (HSD test) were used. Cluster analysis and Correlation analysis was performed with the PB-STAT software package using the Pearson correlation test. Analysis of Capsaicin was carried out by analyzing the result of extraction of chili fruit using HPLC so the quantitative data of capsaicin content were obtained.

RESULTS AND DISCUSSION

The middle values of each genotype based on capsaicin content were described in Table 1. The high capsaicin content of chili is found in the Bara x F9160291 genotype. The highest content was obtained from the crossing of spicy chili elders (Bara and F9160291). Bara genotype was the highest elders that have capsaicin content. The lowest elders that have capsaicin content was found in Giant genotype. The middle values of each genotype based on yield components were described in Table 2. Table 2 explains that the highest middle value in fruit weight character per plant (703.070 g) was obtained in the C5 x F6074 genotype, and highest number of fruit (197.287) was obtained in the Bara x F9160291 genotype. Ritonga et al. (2017) reported that the character of the largest number of fruit per plant was shown by the genotype of the results of the crossing.

C5 x Giant genotype had the highest middle value based on fruit weight character (13.077 g), fruit diameter (19.017 mm), and thick fruit flesh (1.637 mm). Daryanto et al. (2010) also reported that there is positive correlation between fruit weight, fruit diameter, and fruit flesh thickness. The highest middle value of fruit length was obtained in the Yuni genotype. In this research explains that the high fruit weight per plant is not always influenced by fruit diameter, fruit stalk length, thick fruit flesh, and fruit length. Fruit weight per plant could also be high, if the total amount of fruit per plant and fruit weight was high. Nasution and Respatijarti (2019) also reported that chili yield components influenced by several characters such as fruit length, fruit diameter, total number of fruits per plant, and weight per fruit.

The middle values of each genotype based on non-yield characters (plant height, dichotomous height, stem diameter, leaf height, leaf width, and header width) were described in Table 3. Table 3 explains that the highest middle value in dichotomous height (25.843 cm) and header width (75.073 cm) were obtained in the Bara x Yuni genotype. Chili genotypes that have header width and dichotomous height that are too high are likely to be easier to fall due to wind (Grinberg et al. 2005). However, short dichotomous causes chili to come in contact with mulch or soil and is prone to direct exposure to rainwater which can cause disease in fruit (Rommahdi et al. 2015). The highest middle value based on leaf character (leaf height and leaf width) was obtained in the F6074 x Giant with value of 8.36 and 3.68 centimeters. This explains that high leaf heights indicate high leaf width. C5 genotype had the highest middle value based on plant height (70.387 cm) and stem diameter (10.3 mm). This explains that the high plant weight was influenced by stem diameter. Suntoyo et al. (2015) also reported that the large diameter of the stems gives an advantage to vegetative and generative growth, because the plants become more sturdy and do not easily fall.

The results of Pearson correlation analysis of the 21 genotypes presented in Fruit weight per plant was positively correlated and very significantly different from fruit length, fruit stalk length, fruit diameter, thick fruit flesh, and fruit weight but has a negative correlation and significantly different from total amount of fruit per plant and capsaicin content. Ritonga et al. (2018) also reported in his research that fruit weight has positive correlation and significantly different from fruit number per plant.

The character of capsaicin content was negatively correlated and very different from fruit weight, fruit diameter, fruit length, thick fruit flesh, total amount of fruit per plant, and fruit weight per plant. This result shows that the character of the capsaicin content with fruit weight, fruit diameter, fruit length, thick fruit flesh, total amount fruit per plant, and fruit weight per plant also has an opposite close relationship. The character of capsaicin content was not significantly with fruit stalk length. This result shows that the character of capsaicin content is not influenced by fruit stalks. Kumar et al. (2003) also reported in his research that capsaicin content has positive and different with total amount fruit per plant, and negatively associated with fruit weight, fruit diameter, and fruit length.

The positive correlation highly significant and also occur between the characters fruit diameter with fruit weight, but a negative correlation highly significant and occurs between the character capsaicin content with fruit weight. The character of fruit weight has a negative correlation and very significantly with the character capsaicin content and fruit. This explained is the character of the weight of the fruit has a close relationship that is opposite to the capsaicin content in chili.

Table 1. Middle value of 21 genotypes based on capsaicin contents in chili

Genotypes	Capsaicin
Bara	58130.80 [b]
Bara x F_{6074}	51541.60 [d]
Bara x $F_{9160291}$	78992.60 [a]
Bara x Giant	41935.90 [gh]
Bara x Yuni	55075.10 [c]
C5	19784.10 [l]
C5 x Bara	31714.00 [j]
C5 x F_{6074}	16933.60 [m]
C5 x $F_{9160291}$	43984.50 [fg]
C5 x Giant	17833.20 [lm]
C5 x Yuni	40216.90 [hi]
F_{6074}	25868.60 [k]
F_{6074} x $F_{9160291}$	47067.30 [e]
F_{6074} x Giant	16627.50 [m]
F_{6074} x Yuni	51907.70 [d]
$F_{9160291}$	45453.00 [ef]
Giant	12298.30 [n]
Giant x $F_{9160291}$	38317.50 [i]
Giant x Yuni	45575.90 [ef]
Yuni	39787.50 [hi]
Yuni x $F_{9160291}$	51741.70 [d]

Note: Numbers followed by the same letter in the same column were not significantly different according to HSD 5% level

Information on the relationship among genotypes can be observed on dendrogram (Figure 1). It showed that the grouping of 21 chili genotypes was divided into three main groups and the division of this group divides on a scale of ± 0,3. This result showed that the grouping of 21 chili genotypes is the same as the grouping of okra genotypes (Yora et al. 2018). Group I consists only of Giant genotypes. Group II consisted of Bara, F9160291, Bara x F9160291, Bara x F6074, F6074 x F9160291, C5 x Bara, F6074, F6074 x Yuni, Bara x Giant, Bara x Yuni, C5 x F9160291, Yuni x F9160291, Yuni, Giant x F9160291, C5 x Yuni, Giant x Yuni. Group III consisted of C5, C5 x F6074, C5 x Giant, F6074 x Giant genotypes.

Table 2. Middle value of 21 genotypes based on yield components in chili

Genotypes	FL	FSL	FD	TFF	FW	TFP	FWP
Bara	2.650 ^{j}	2.600 ^{cdef}	7.230 ^{ghi}	0.647 ^{g}	0.933 ^{i}	178.027 ^{b}	165.840 ^{gh}
Bara x F_{6074}	6.750 ^{efg}	3.103 ^{bcde}	9.097 ^{fgh}	0.940 ^{cdefg}	3.150 ^{fgh}	110.767 ^{d}	349.110 ^{cdef}
Bara x $F_{9160291}$	3.247 ^{ij}	2.767 ^{cdef}	7.237 ^{ghi}	0.850 ^{defg}	1.067 ^{hi}	197.287 ^{a}	210.480 ^{fgh}
Bara x Giant	6.133 ^{fghi}	3.417 ^{abcde}	10.340 ^{ef}	1.017 ^{cdef}	3.093 ^{fghi}	81.890 ^{gh}	253.210 ^{fgh}
Bara x Yuni	7.760 ^{defg}	3.363 ^{abcde}	6.047 ^{i}	0.720 ^{fg}	2.200 ^{ghi}	101.303 ^{e}	222.840 ^{fgh}
C5	7.760 ^{defg}	3.357 ^{abcde}	14.890 ^{bc}	1.253 ^{bc}	8.297 ^{bc}	62.343 ^{k}	517.120 ^{b}
C5 x Bara	5.963 ^{fghi}	3.303 ^{abcde}	11.390 ^{def}	1.053 ^{cde}	3.747 ^{efg}	85.223 ^{g}	320.770 ^{def}
C5 x F_{6074}	9.577 ^{bcde}	3.333 ^{abcde}	13.873 ^{bcd}	1.407 ^{ab}	8.943 ^{b}	78.747 ^{hi}	703.070 ^{a}
C5 x $F_{9160291}$	5.710 ^{ghi}	3.180 ^{bcde}	10.137 ^{efg}	0.977 ^{cdef}	3.247 ^{efgh}	92.687 ^{f}	301.030 ^{defg}
C5 x Giant	9.563 ^{bcde}	3.590 ^{abcd}	19.017 ^{a}	1.637 ^{a}	13.077 ^{a}	32.600 ^{m}	424.700 ^{bcd}
C5 x Yuni	12.120 ^{ab}	4.387 ^{a}	9.840 ^{fg}	1.053 ^{cde}	6.493 ^{cd}	73.057 ^{ij}	476.540 ^{bc}
F_{6074}	8.810 ^{cdef}	2.923 ^{bcdef}	10.197 ^{efg}	0.920 ^{defg}	5.380 ^{de}	81.857 ^{gh}	440.290 ^{bcd}
F_{6074} x $F_{9160291}$	6.630 ^{fg}	2.420 ^{def}	9.383 ^{fg}	0.867 ^{defg}	2.853 ^{ghi}	105.833 ^{de}	301.970 ^{defg}
F_{6074} x Giant	9.883 ^{bcd}	3.563 ^{abcd}	14.470 ^{bc}	1.247 ^{bc}	9.767 ^{b}	40.710 ^{l}	399.360 ^{bcde}
F_{6074} x Yuni	6.973 ^{efg}	2.697 ^{cdef}	9.843 ^{fg}	1.090 ^{bcd}	3.453 ^{efg}	69.647 ^{j}	239.940 ^{fgh}
$F_{9160291}$	3.547 ^{hij}	2.450 ^{def}	6.133 ^{hi}	0.807 ^{defg}	0.930 ^{i}	181.437 ^{b}	169.140 ^{gh}
Giant	6.310 ^{fgh}	1.793 ^{f}	16.733 ^{ab}	0.893 ^{defg}	9.057 ^{b}	16.000 ^{n}	144.800 ^{h}
Giant x $F_{9160291}$	5.380 ^{ghij}	2.337 ^{ef}	13.150 ^{cde}	1.243 ^{bc}	3.937 ^{efg}	82.400 ^{gh}	324.000 ^{def}
Giant x Yuni	11.407 ^{abc}	3.987 ^{ab}	9.477 ^{fg}	0.987 ^{cdef}	5.067 ^{def}	46.233 ^{l}	234.260 ^{fgh}
Yuni	13.200 ^{a}	3.680 ^{abc}	5.947 ^{i}	0.747 ^{efg}	2.827 ^{ghi}	84.110 ^{gh}	237.040 ^{fgh}
Yuni x $F_{9160291}$	7.893 ^{defg}	2.833 ^{bcdef}	7.303 ^{ghi}	0.863 ^{defg}	2.157 ^{ghi}	126.707 ^{c}	273.190 ^{efgh}

Note: Numbers followed by the same letter in the same column were not significantly different according to HSD, 5% level, FL: fruit length, FSL: fruit stalk length, FD: fruit diameter, TFF: thick fruit flesh, FW: fruit weight, TFP= total amount of fruit per plant, FWP: fruit weight per plant.

Table 3. Middle value of 21 genotypes based on non-yield components in chili

Genotypes	PH	DH	SD	LH	LW	HW
Bara	43.407 ^{defg}	20.923 ^{bcdef}	6.330 ^{d}	4.787 ^{b}	2.067 ^{cd}	51.033 ^{cde}
Bara x F_{6074}	52.533 ^{bcdef}	21.867 ^{abcde}	7.630 ^{bcd}	5.970 ^{ab}	2.343 ^{bcd}	67.000 ^{abc}
Bara x $F_{9160291}$	48.663 ^{cdefg}	21.133 ^{bcdef}	7.910 ^{bcd}	5.343 ^{b}	2.173 ^{cd}	62.403 ^{abcd}
Bara x Giant	42.393 ^{efg}	18.617 ^{efg}	6.893 ^{cd}	5.527 ^{b}	2.460 ^{bcd}	53.813 ^{bcde}
Bara x Yuni	63.847 ^{ab}	25.843 ^{a}	9.040 ^{ab}	5.343 ^{b}	2.000 ^{d}	75.073 ^{a}
C5	70.387 ^{a}	20.147 ^{cdef}	10.300 ^{a}	5.893 ^{ab}	2.290 ^{cd}	57.807 ^{abcd}
C5 x Bara	52.167 ^{bcdef}	22.207 ^{abcde}	8.170 ^{bcd}	6.170 ^{ab}	2.523 ^{bcd}	62.457 ^{abcd}
C5 x F_{6074}	55.700 ^{bcde}	20.623 ^{cdef}	8.083 ^{bcd}	6.187 ^{ab}	2.397 ^{bcd}	58.883 ^{abcd}
C5 x $F_{9160291}$	49.920 ^{bcdef}	20.367 ^{cdef}	8.987 ^{ab}	5.007 ^{b}	2.013 ^{cd}	59.553 ^{abcd}
C5 x Giant	42.833 ^{efg}	19.467 ^{cdefg}	7.317 ^{bcd}	6.470 ^{ab}	3.000 ^{abc}	46.180 ^{de}
C5 x Yuni	57.230 ^{abcd}	20.460 ^{cdef}	9.130 ^{ab}	7.160 ^{ab}	2.753 ^{abcd}	58.843 ^{abcd}
F_{6074}	53.307 ^{bcdef}	23.250 ^{abcd}	7.793 ^{bcd}	6.650 ^{ab}	2.320 ^{bcd}	61.430 ^{abcd}
F_{6074} x $F_{9160291}$	50.033 ^{bcdef}	25.733 ^{a}	7.713 ^{bcd}	5.783 ^{ab}	2.353 ^{bcd}	62.433 ^{abcd}
F_{6074} x Giant	46.543 ^{cdefg}	22.320 ^{abcde}	6.363 ^{d}	8.360 ^{a}	3.680 ^{a}	46.603 ^{de}
F_{6074} x Yuni	58.770 ^{abc}	25.350 ^{ab}	7.903 ^{bcd}	6.293 ^{ab}	2.327 ^{bcd}	70.040 ^{ab}
$F_{9160291}$	41.090 ^{fg}	19.120 ^{defg}	7.960 ^{bcd}	5.020 ^{b}	1.907 ^{d}	54.823 ^{bcd}
Giant	47.333 ^{cdefg}	16.667 ^{fg}	7.403 ^{bcd}	5.197 ^{b}	3.300 ^{ab}	61.333 ^{abcd}
Giant x $F_{9160291}$	34.657 ^{g}	15.510 ^{g}	6.823 ^{cd}	5.747 ^{b}	2.627 ^{bcd}	46.550 ^{de}
Giant x Yuni	41.137 ^{fg}	20.210 ^{cdef}	6.303 ^{d}	5.507 ^{b}	2.430 ^{bcd}	36.267 ^{e}
Yuni	55.377 ^{bcdef}	21.340 ^{abcde}	8.573 ^{abc}	6.517 ^{ab}	2.090 ^{cd}	53.370 ^{bcde}
Yuni x $F_{9160291}$	58.017 ^{abc}	24.000 ^{abc}	9.107 ^{ab}	5.707 ^{b}	2.053 ^{cd}	70.337 ^{ab}

Note: Numbers followed by the same letter in the same column were not significantly different according to HSD, 5% level, PH: plant height, DH: dichotomous height, SD: stem diameter, LH: leaf height, LW: leaf width, HW: header width.

Table 4. Correlation analysis of yield components and capsaicin for 21 genotypes of chili

Character	FL	FSL	FD	TFF	FW	TFP	FWP	CAPS
FL	1.00	0.65324**	0.16942	0.28009*	0.48762**	-0.6136**	0.44469**	-0.4097**
FSL		1.00	-0.0029	0.22634	0.22682*	-0.2527*	0.35722**	-0.0905
FD			1.00	0.79782**	0.89137**	-0.7068**	0.48546**	-0.7875**
TFF				1.00	0.77564**	-0.5406**	0.68347**	-0.5928**
FW					1.00	-0.7662**	0.61511**	-0.8356**
TFP						1.00	-0.3382**	0.76944**
FWP							1.00	-0.5326**
CAPS								1.00

Note: ** very significantly correlation at level α 1%,* significantly correlation at level α 5%, FL: fruit length, FSL: fruit stalk length, FD: fruit diameter, TFF: thick fruit flesh, FW: fruit weight, TFP: total amount of fruit per plant, FWP: fruit weight per plant, CAPS: capsaicin

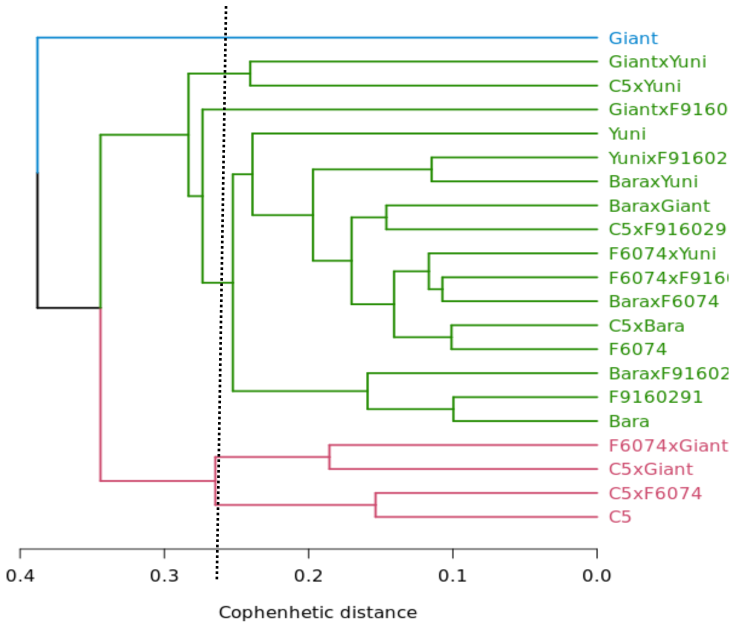

Figure 1. Dendrogram of 21 chili genotypes

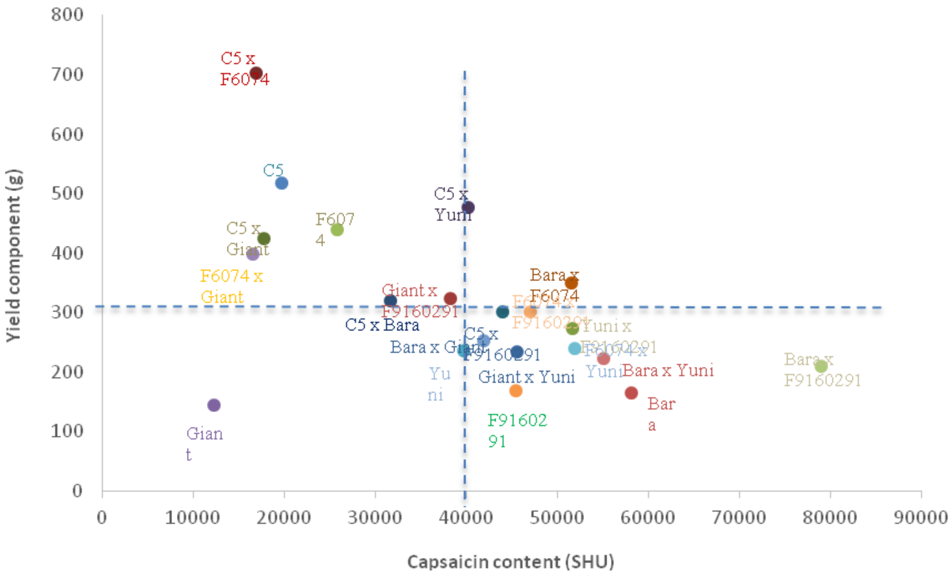

Figure 2. Scatterplot of 21 chili genotypes

Information about scatterplot analysis can be observed on Figure 2. Ritonga et al. (2019) reported that tomato genotypes had different selection responses. The expected results in this study through the selection process is to produce chili with high productivity and high capsaicin content (Ganefianti et al. 2019). Selection activities in plant breeding programs are needed to produce superior varieties from various aspects. The results of scatterplot analysis showed that the highest capsaicin and yield component was found in Bara x F6074 and C5 x Yuni genotype.

In conclusion, based on the results of the analysis carried out on 21 chili genotypes showed that the chili fruit which has the best capsaicin content was genotype Bara x F9160291. The cluster analysis showed that chili was clustered into three color groups. The character of capsaicin content is negatively correlated and very different from fruit weight, fruit diameter, fruit length, thick fruit flesh, total amount of fruit per plant, and fruit weight per plant. The character of total amount of fruit per plant and capsaicin content greatly influences the determination of the selection process. Accordingly, the characters can be used as a selection character so as to produced a high yield chili and contains capsaicin. The results of scatterplot analysis showed that the highest capsaicin and yield component was found in Bara x F6074 and C5 x Yuni genotype. Further research is needed to use the F2 hybrid genotype C5 x Yuni and Bara x F074 to produce chili plants with high productivity and high capsaicin content.

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