Diversity and genetic parameter of chili pepper (*Capsicum annuum*) based on yield component in three location

TRI WAHONO DYAH AYU SAYEKTI¹*, MUHAMAD SYUKUR²**, SRI HENDRUSTUTI HIDAYAT³, AWANG MAHARIJAYA⁴

¹Plant Breeding and Biotechnology Graduate Program, Department of Agronomy and Horticulture, Faculty of Agriculture, Institut Pertanian Bogor, Jl. Meranti, Kampus IPB Darmaga, Bogor 16680, West Java, Indonesia. Tel.: +62-251-8629354, Fax.: +62-251-8629352, *email: dyah_sayekti@apps.ipb.ac.id
²Department of Agronomy and Horticulture, Faculty of Agriculture, Institut Pertanian Bogor, Jl. Meranti, Kampus IPB Darmaga, Bogor 16680, West Java, Indonesia. Tel.: +62-251-8629354, Fax.: +62-251-8629352, **email: muhsyukur@apps.ipb.ac.id
³Department of Plant Protection, Faculty of Agriculture, Institut Pertanian Bogor, Jl. Meranti, Kampus IPB Darmaga, Bogor 16680, West Java, Indonesia

Abstract. Sayekti TWDA, Syukur M, Hidayat SH, Maharijaya A. 2021. Diversity and genetic parameter of chili pepper (*Capsicum annuum*) based on yield component in three locations. Biodiversitas 22: 823-829. With the increase in the use of chili, it is necessary to develop these commodities through plant breeding activities. Phenotypes are not only determined by genetics, but also by environmental factors and the GxE interactions, so all the factors need to be considered. The aims of this study were to evaluate the variability of ten elite breeding lines and three commercial varieties of chili pepper (*Capsicum annuum* L.) across three different environments. This experiment was conducted in three environments namely Bogor, Kolaka, and Palembang, from January until July 2019. Thirteen genotypes consisting of ten elite lines and three commercial chili pepper were used. This experiment was arranged in a randomized complete block design (RCBD) with three replications for each environment. To determine the effect of environment, Combined Analysis of Variance was carried out for all environments using PBSTAT-GE. The environment used in this experiment was lowland that varies between each other. The genotype with the fastest harvesting age relative in three environments was F7-145293-19-8-3-113-1. The highest number of fruits per plant was observed in genotype F9-1601291-9-4-3-2-1-1-1 with 261 fruits per plant. The highest yield was observed in genotype F7-145174-9-7-1-5-3. From the clustering analysis, this population was grouped into five clusters. The heritability values for the 12 observed traits ranged between 22.68-69.97%, classified into high and moderate criteria.

Keywords: Chili pepper, cluster analysis, genetic parameter, heritability, yield components

INTRODUCTION

Since the demand for chili for consumption and industrial purposes is increasing, chili research becoming important as well. Among several types of chili pepper that are commonly consumed, such as sweet pepper and chili pepper, the most commonly consumed fresh is the chili pepper. The increase in the use of chili for fresh consumption reaches 10.87% each year. Total use of chili pepper reaching 1,925 million tons per year. In order to provide people’s needs for chilies, it is necessary to develop these commodities through plant breeding activities. The objectives of plant breeding include improving the quantity and quality of yields, post-harvest resistance, pest and disease resistance, and tolerance to abiotic stress in sub-optimal environments (Wattimena 2011). Plant breeding activities are important to assemble new high-yielding varieties that potential to produce biomass and distribute to the harvested part (Syukur et al. 2015). According to Syukur et al. (2010), the potential productivity of chili pepper (*Capsicum annuum* L.) in Indonesia can reach more than 20 tons ha⁻¹. The use of elite lines was an important step in determining the amount of production at harvest time (Nsabiyera et al. 2012).

To get the genotype that well growing and has a potential yield, the breeder needs to consider the genetic potential of the genotype to be developed. Besides genetic potential, the environment also needs to be considered because the phenotype of the plant not only determined by genetics, but also by environmental factors and the interaction between genetic and environmental (Roy 2000). This interaction makes breeding activities more complicated. If the interaction of Genetic x Environment (GXE) was not significant, all genotypes can perform stably in each environment (Cabra et al. 2017). However, if this GXE interaction was significant, then there will be differences in plant performance in certain environments (Hu et al. 2013) thus making it difficult for breeders to provide suitable genotype recommendations. It is necessary to study this phenomenon so that it can be used as a basis to recommend the genotypes that are suitable for each environment on purpose to increase productivity. The development of site-specific superior genotypes can be directed to obtain environment-specific varieties, while varieties that are superior in all environments can be released into varieties that are widely adapted (Ganeffiani et al. 2009).

From the previous study, some elite lines or genotypes of chili pepper with a high yield potential have been found. These lines are expected to be widely used for consumption and industrial purpose. To get these purposes, it necessary to study the performance of each line at various locations,
as well as to see the effect of factors on the yield component. The objective of this experiment is to evaluate the character variability of ten elite lines and three commercial varieties of chili pepper in three different environments.

MATERIALS AND METHODS

Study area and genetic material
This experiment was conducted in three environments. First set (set one) was conducted at Tajur PKHT-LPPM IPB University Experimental Field (250 m asl), Bogor, West Java, Indonesia. Second set (set two) at Universitas Sembilan Belas November Kolaka Experimental Field (38 m asl), Kolaka, Southeast Sulawesi. Third set (set three) was conducted at Universitas IBA (8 m asl), Palembang, South Sumatra.

Thirteen genotypes consisting of ten elite lines and three commercial chili pepper were used. This experiment was arranged in a randomized complete block design (RCBD) with three replications for each set. The plot that used was a soil bed with 6 m x 1 m soil in size.

Procedures
Seed of thirteen genotypes of chili pepper was sown in the seedling tray for 5 weeks, then transplanted on the soil beds with a spacing 50 cm x 50 cm (24 plants per plot). The seedling that transplanted was a well-growth seedling with green leaves and not affected by pest or disease. The soil beds were covered by black-silver plastic mulch. Watering is done every day to ensure that plants are not affected by drought. Fertilizer was applied every week since seedling phase using NPK (16-16-16) (250 mL per plant) and foliar fertilizer. The concentration of fertilizer that used was 10 g L\(^{-1}\) for NPK 16-16-16 and 5 g L\(^{-1}\) for foliar fertilizer. Pest and disease management were done using recommended pesticide when needed. Weeding was scheduled for every two weeks after transplanting. Harvesting was done when 75% of plant population already has ripe fruit. The ripe fruit marked by 80% of the fruit has been red. Harvesting was scheduled every week for eight weeks.

Table 1. F-Ratios used to test effects for randomized complete blocks experiments combined over location

| Sources of variation | Mean square | Expected mean squares (fixed model) |
|----------------------|-------------|------------------------------------|
| Location (l)         | M1          | \(\sigma^2_{e} + \sigma^2_{RL(l)} + \sigma_l^2\) |
| Block (Location) (r) | M2          | \(\sigma^2_{e} + \sigma^2_{RL(l)}\) |
| Treatment (T)        | M3          | \(\sigma^2_{e} + \sigma_l^2 + \sigma_T^2\) |
| Location x treatment | M4          | \(\sigma^2_{e} + \sigma_l^2 + \sigma_T^2\) |
| Pooler error         | M5          | \(\sigma^2_{e}\) |

Note: \(\sigma^2_{e}\): environment variance; \(\sigma^2_{L}\): location x treatment variance; \(\sigma^2_{T}\): treatment variance; \(\sigma^2_{l}\): location variance; \(\sigma^2_{RL(l)}\): block variance

Results and discussion

Variability of 13 chili pepper
The coefficient of variation (C.V) of this experiment was less than 20% for almost all characters indicating the precision in the data recorded. From the result of Combined Analysis of Variance, it can be seen that genotype, environment, and the GxE interaction have a significant effect in the observed characters. This result indicates that the productivity of chili pepper was affected by genotype, environment, and their interactions. Environment, in this study, was the biggest contributor to yield variability, then genotype and GxE interaction effect (Table 2). These cases indicate that the response to crop yield depends on the environmental conditions.

Days to harvest ranged from 67-95 days after planting (DAP) in Bogor, 69-92 DAP in Kolaka, and 83-94 DAP in Palembang (Table 3). The genotype with the fastest harvesting age in Bogor was F7-145293-19-8-3-113-1 (67 DAP) and this genotype tends to reach harvest early at all three locations. Whereas at Kolaka and Palembang locations, genotypes F9-145291-115-8-1-1-1, F7-145291-10-7-1-1-1-2, and other genotypes had an early harvest age; however, were not significantly different from each other.

The yield components comprised of fruit length, fruit weight, number of fruits per plant, and yield per plant. Genotype F7-160291-4-13-9-8-1 displayed the best fruit length across all environments, which had 5.30 cm fruit length (Table 4), and significant differences were observed for fruit length across environments. The Chili pepper grown in Bogor was significantly longer than in other environments and environmental and climate factors may have caused this. Different results were obtained for fruit weight and significant differences between environments were also observed but chilies are grown in Bogor conversely had a lower weight than other environments. Highest fruit weight was observed in Bara with an average fruit weight of 2.20 g per fruit (Table 5).
Table 2. Estimation of mean square for different characters of 13 chili pepper under combined analysis of variance

| Source      | df | Fruit length Mean square | Fruit diameter Mean square | Fruit weight Mean square | Number of fruits per plant Mean square | Fruit yield per plant Mean square | Days to flowering Mean square | Days to harvest Mean square |
|-------------|----|--------------------------|----------------------------|--------------------------|----------------------------------------|-----------------------------------|-------------------------------|------------------------------|
| Environment | 2  | 12.423**                 | 0.781**                   | 0.813**                  | 307160.2**                             | 40981.0**                        | 1701.13**                    | 2101.64**                   |
| Rep(Env)    | 6  | 0.036**                  | 0.011**                   | 0.000**                  | 456.6**                                | 3362.0**                         | 9.77**                       | 51.35**                     |
| Genotype    | 12 | 1.726**                  | 0.094**                   | 1.183**                  | 11829.7**                              | 21636.0**                        | 16.13**                      | 152.82**                    |
| GxE         | 24 | 0.893**                  | 0.036**                   | 0.499**                  | 23885.5**                              | 21709.0**                        | 16.13**                      | 152.82**                    |
| Error       | 72 | 0.063**                  | 0.063**                   | 0.019**                  | 400.6**                                | 712.9**                          | 11.00                        | 5.43                        |
| CV (%)      |    | 5.84                     | 10.46                     | 8.70                     | 11.61                                  | 11.00                            | 5.43                         | 5.02                        |

Note: CV: Coefficient of Variance; Rep: Replication; Env: Environment; GxE: Genotype x Environment; ** significant at level of 1%; * significant at level 5%; ns: not significant

Table 3. Days to Harvest of 13 chili pepper genotypes across different locations

| Genotype | Bogor | Kolaka | Palembang | Mean to Harvest (DAP) |
|----------|-------|--------|-----------|-----------------------|
| Bara     | F8-145291-10-7-1-1-1-2 | 74.00e | 70.77ef | 96.33a | 80.37 |
| Batari   | F9-160291-9-4-3-2-1-1-1 | 95.00a | 69.97f | 88.67abc | 84.54 |
| Genie    | F9-160291-3-12-5-4-5-1-1 | 88.00b | 73.13def | 98.33a | 86.49 |
| Mean     | F9-160291-115-8-1-1-1 | 88.00b | 69.93f | 87.00abc | 81.64 |
| Bara     | F9-160291-3-12-5-1-1-2 | 74.33d | 73.70def | 96.33a | 81.46 |
| Batari   | F8-145291-14-10-10-4-9-1-1 | 81.00c | 81.50bc | 98.33a | 86.94 |
| Genie    | F7-145291-14-9-3-3-12-1 | 74.00e | 73.27def | 81.00c | 76.09 |
| Mean     | F7-160291-4-3-1-1-8-1-1 | 74.00e | 76.43cde | 94.33ab | 81.59 |
| Bara     | F7-145174-9-7-1-5-3 | 74.00e | 83.60b | 96.33a | 84.64 |
| Batari   | F7-145293-19-8-3-3-113-1 | 67.00f | 77.53cd | 83.00bc | 75.84 |
| Genie    | F4-145291-10-7-1-1-1-2 | 81.00c | 76.46cde | 90.67abc | 82.71 |
| Mean     | F4-145291-9-4-3-2-1-1-1 | 81.00c | 74.97def | 83.00bc | 79.66 |

Note: Number followed by the same letter in the same column were not significantly different to DMRT 5% level; Number followed by the same capital letter in the same row were not significantly different to HSD 5% level

Figure 1. Dendrogram generated by hierarchical cluster analysis showing the relationships among the characterized chili pepper genotypes using 12 quantitative traits
For the number of fruits per plant, the results indicated that there was a large variation between locations (Table 6). Some genotypes have an increase or decrease in the number of fruits per plant when grown in different environments. However, several genotypes were observed to be quite stable across three environments, namely Bara and several subclusters (Figure 1). The coefficient of similarity is 0.82. The genotypes were grouped into two major clusters and several subclusters (Figure 1). Partitioning clusters at a similarity coefficient of 0.62 for ease of interpretation generated five different clusters. Cluster I contained six genotypes, including five elite lines and one commercial variety (Batari), with similarity coefficient ranging from 0.637-0.866 (Dissimilarity ranging from 0.134-0.363). Cluster II consisted of two genotypes namely F9-160291-3-12-5-4-5-1-1 and F7-145291-14-9-3-12-1 with coefficient of similarity of 0.71. Cluster III contained two genotypes namely Bara and F7-145174-9-7-1-5-3 with coefficient of similarity of 0.82. The fourth cluster consisted of two genotypes, Genie and F9-145291-115-8-1-1-1 with coefficient of similarity of 0.74, and the fifth cluster consisted of single genotype F8-145291-14-10-10-4-9-1.

Table 4. Mean fruit length of 13 genotypes of chili pepper evaluated across different environments

| Genotype            | Bogor    | Kolaka    | Palembang | Mean  |
|---------------------|----------|-----------|-----------|-------|
|                     | ---------|-----------|-----------|-------|
| F7-145291-10-7-1-1-1-2 | 4.85d    | 3.84efgh  | 3.28d     | 3.99f |
| F9-160291-9-4-3-2-1-1-1-1 | 4.88d    | 3.50h     | 3.33d     | 3.91f |
| F9-160291-3-12-5-4-5-1-1 | 6.80a    | 3.85efgh  | 3.28d     | 4.64bc|
| F9-145291-115-8-1-1-1 | 5.17cd   | 4.60c     | 4.25b     | 4.67b |
| F9-160291-3-12-5-51-1-1-2 | 4.90d    | 4.14de    | 3.79bc    | 4.27ed|
| F8-145291-14-10-10-4-9-1 | 5.12cd   | 3.77fgh   | 3.39d     | 4.09ef|
| F7-145291-14-9-3-12-1 | 5.35bc   | 4.68c     | 4.06bc    | 4.70b |
| F7-160291-4-13-9-8-1 | 5.66b    | 5.44a     | 4.80a     | 5.30a |
| F7-145174-9-7-1-5-3  | 4.80d    | 4.21d     | 4.22b     | 4.41cd|
| F7-145293-19-8-3-113-1 | 4.10e    | 3.56gh    | 3.48cd    | 3.71g |
| Bara                | 4.08e    | 5.07b     | 3.69bc    | 4.28ed|
| Batari              | 4.02e    | 4.01defg  | 3.74bc    | 3.92fg|
| Genie               | 4.09e    | 3.89defg  | 4.04bc    | 4.01f |
| Mean                | 4.91A    | 4.19B     | 3.79C     |       |

Note: Number followed by the same letter in the same column were not significantly different to DMRT 5% level; Number followed by the same capital letter in the same row were not significantly different to HSD 5% level.

Table 5. Fruit weight of 13 genotypes of chili pepper in different location

| Genotype            | Bogor    | Kolaka    | Palembang | Mean  |
|---------------------|----------|-----------|-----------|-------|
|                     | ---------|-----------|-----------|-------|
| F7-145291-10-7-1-1-1-2 | 1.47c    | 1.30gh    | 1.25fg    | 1.34fg|
| F9-160291-9-4-3-2-1-1-1-1 | 1.29cde  | 1.13h     | 1.13g     | 1.18h |
| F9-160291-3-12-5-4-5-1-1 | 2.75a    | 1.59ef    | 1.67cde   | 1.99bc|
| F9-145291-115-8-1-1-1 | 1.75b    | 1.94cd    | 1.95c     | 1.88cd|
| F9-160291-3-12-5-51-1-1-2 | 1.28de   | 1.29gh    | 1.27fg    | 1.28gh|
| F8-145291-14-10-10-4-9-1 | 1.39cd   | 1.50fg    | 1.45ef    | 1.45ef|
| F7-145291-14-9-3-12-1 | 1.74b    | 1.79de    | 1.76cd    | 1.76d |
| F7-160291-4-13-9-8-1 | 1.40f    | 1.69defg  | 1.75cd    | 1.49e |
| F7-145174-9-7-1-5-3  | 1.37cd   | 2.30b     | 2.43b     | 2.03b |
| F7-145293-19-8-3-113-1 | 1.22defg | 1.30gh    | 1.30fg    | 1.27h |
| Bara                | 1.12ef   | 2.91a     | 2.85a     | 2.20a |
| Batari              | 1.09f    | 1.23gh    | 1.30fg    | 1.21h |
| Genie               | 1.097f   | 2.11      | 1.47defg  | 1.55e |
| Mean                | 1.43B    | 1.69A     | 1.66A     |       |

Note: Number followed by the same letter in the same column were not significantly different to DMRT 5% level; Number followed by the same capital letter in the same row were not significantly different to HSD 5% level.
The heritability values for the 12 observed traits ranged between 22.68-69.97% and were classified into several criteria. The properties of plant height, leaf length, days to flowering, fruit length, fruit diameter, and fruit weight have high heritability. Whereas stem diameter, leaf width, days to harvest, number of fruits per plant, and fruit yield have moderate heritability. Criteria of heritability were determined based on Whirer (1979) as high (> 50%), moderate (20-50%), and low (<20%) (Table 8).

**Discussion**

The environment used in this experiment was lowland with elevations ranging between Palembang (8 m asl), Kolaka (38 m asl), and Bogor (250 m asl), and climatic conditions varied between these environments. Bogor has a temperature ranging from 25.97-27.05 °C with 86.5% humidity and rainfall varied from 297.10-679.60 mm per month. Kolaka temperature ranges from 26.9-28.60 °C with humidity of 83.45% and the rainfall ranging from 45.00-263.9 mm per month. Palembang city temperature ranges from 27.01-28.28 °C with a humidity of 84.24% and rainfall ranging from 80.70-119.70 mm per month.

The harvest age of plants grown in Bogor was significantly shorter than those grown in Kolaka and Palembang (Table 3). According to (Pimenta et al 2016) environmental factors are known to greatly influence the expression of quantitative traits. However, in some cases, environmental factors affect the qualitative characters and their respective phenotypes. This shows that the dominant factors that control these characters. This information can be found simply through the heritability value (h²) of the target trait. The heritability value itself is a comparison between the values of variety of genotypes and their respective phenotypes. This shows that the heritability value is an estimator of how big the role of genetics plays in the expression of observed phenotypic characters. High heritability value indicates that the trait is more influenced by genetic factors than environmental factors.

One of the important information that needs to be known before carrying out further breeding and selection is related to the inheritance pattern of the targeted traits and the dominant factors that control these characters. This information can be found simply through the heritability value (h²) of the target trait. The heritability value itself is a comparison between the values of variety of genotypes and their respective phenotypes. This shows that the heritability value is an estimator of how big the role of genetics plays in the expression of observed phenotypic characters. High heritability value indicates that the trait is more influenced by genetic factors than environmental factors.

**Table 6. Number of fruits per plant of 13 genotypes of chili pepper evaluated across different locations**

| Genotype          | Bogor  | Kolaka | Palembang | Mean  |
|-------------------|--------|--------|-----------|-------|
| F7-145291-10-7-1-1-1-2 | 227.90de | 77.48gha | 85.39ea | 130.26gh |
| F9-160291-9-4-3-2-1-1-1 | 652.70a | 67.36hha | 63.80ea | 261.29a  |
| F9-160291-3-12-5-4-5-1-1 | 208.57e | 94.80efa | 213.83ab | 172.40cde |
| F9-145291-115-8-1-1-1 | 319.97b | 115.91eda | 158.12cd | 198.00b   |
| F9-160291-3-12-5-5-1-1-2 | 294.67bc | 76.90gha | 90.56eca | 154.04ef  |
| F8-145291-14-10-1-9-1 | 198.74e | 89.27fga | 65.97eaa | 117.99h   |
| F7-145291-14-9-9-1-2-1 | 206.87e | 106.81dea | 241.05a | 184.91b    |
| F7-160291-4-13-9-8-1 | 201.17e | 100.92def | 153.24c | 151.77ef  |
| F7-145174-9-7-1-5-3 | 257.63cd | 137.63bba | 180.20bc | 191.82bc   |
| F7-145293-19-8-3-113-1 | 284.63bc | 77.70gha | 75.80ea | 146.06fg  |
| Bara              | 199.23e | 174.07aaa | 134.31da | 169.21de  |
| Batari            | 259.47cd | 73.69gha | 248.30aa | 193.82b   |
| Genie             | 221.97de | 125.87bca | 155.75cd | 167.86de  |
| Mean              | 271.81A | 101.42C | 143.57B |       |

Note: Number followed by the same letter in the same column were not significantly different to DMRT 5% level; Number followed by the same capital letter in the same row were not significantly different to HSD 5% level.
Table 7. Fruit yield per plant of 13 chili peppers evaluated across different locations

| Genotype | Bogor | Kolaka | Palembang | Mean |
|----------|-------|--------|-----------|------|
| F7-145291-10-7-1-1-1-2 | 256.49c | 153.03c | 125.63c | 178.38h |
| F9-160291-9-4-3-2-1-1-1 | 378.60a | 197.13cd | 71.48d | 215.74fg |
| F9-160291-3-12-5-4-5-1-1 | 364.50ab | 233.87ab | 310.41b | 302.92ab |
| F9-145291-115-8-1-1-1 | 342.08ab | 225.97abc | 281.88b | 283.31bc |
| F9-160291-3-12-5-5-1-1-1-2 | 314.76b | 219.33abc | 123.77c | 219.29fg |
| F8-145291-14-10-10-4-9-1 | 210.82cde | 206.87bcd | 101.43cd | 173.04h |
| F7-145291-14-9-3-12-1 | 325.18ab | 208.80bcd | 400.36a | 311.45a |
| F7-160291-4-13-9-8-1 | 201.01cde | 188.50cd | 258.72b | 216.08fg |
| F7-145174-9-7-1-5-3 | 317.20ab | 186.44d | 431.75a | 311.80a |
| F7-145293-19-8-3-113-1 | 237.16cd | 243.63a | 100.03cd | 193.61gh |
| Bara | 172.40e | 227.83ab | 391.12a | 263.78cd |
| Batari | 235.96cd | 220.13abc | 304.97b | 253.69de |
| Genie | 192.37de | 198.73cd | 303.80b | 231.63ef |
| Mean | 272.96A | 208.48C | 246.56B | |

Note: Number followed by the same letter in the same column were not significantly different to DMRT 5% level; Number followed by the same capital letter in the same row were not significantly different to HSD 5% level

Table 8. Estimation of genetic parameters of 13 chili pepper genotype

| Character | σ²e | σ²GXE | σ²G | σ²p | h²bs (%) |
|-----------|-----|-------|-----|------|---------|
| Plant height (cm) | 13.800 | 25.667 | 16.000 | 26.089 | 61.329 |
| Dichotomous height (cm) | 8.518 | 7.478 | 7.323 | 10.762 | 68.044 |
| Stem diameter (cm) | 0.006 | 0.014 | 0.003 | 0.008 | 35.876 |
| Leaf width (cm) | 0.550 | 0.250 | 0.042 | 0.187 | 22.683 |
| Leaf length (cm) | 2.335 | 0.881 | 0.590 | 1.143 | 51.628 |
| Day to flowering (days) | 3.480 | 4.217 | 2.290 | 4.082 | 56.097 |
| Day to harvest (days) | 17.080 | 45.247 | 12.223 | 29.203 | 41.856 |
| Fruit length (cm) | 0.063 | 0.277 | 0.185 | 0.284 | 65.060 |
| Fruit diameter (mm) | 0.009 | 0.009 | 0.009 | 0.013 | 70.334 |
| Fruit weight (g) | 0.019 | 0.160 | 0.129 | 0.185 | 69.974 |
| Number of fruit per plant | 400.576 | 7828.293 | 1269.789 | 3923.728 | 32.362 |
| Fruit yield per plant (g) | 712.850 | 6998.717 | 2324.794 | 4736.906 | 49.078 |

Note: σ²e: genetic variance; σ²GXE: genetic x environment variance; σ²G: environment variance; σ²p: phenotypic variance; h²bs: broad-sense heritability

Selection will be effective if the additive effects are sufficiently higher than the environmental effect, seen from the high genetic coefficient of variation and also high heritability. From the work of Shabanimofrad et al. (2013), high genetic variation and heritability alone provide no indication of the amount of genetic improvement that would result from selection. The information combined from both of these two parameters is more powerful. In this study, all the traits had moderate (stem diameter, leaf width, day to harvest, number of fruits per plant, and fruit yield per plant) to high (plant height, dichotomous height, leaf length, day to flowering, fruit length and diameter, and fruit weight). From the study done by Belay et al. (2020) dan Rosmaina et al. (2016) this high heritability indicating that the traits were more influenced by genetic factors. Generally, characters like fruit length, fruit diameter, and fruit weight with high genetic variation and heritability should be considered as reliable selection criteria for yield improvement in chili pepper. This result is in agreement with the work of Usman et al. (2014) that study for heat tolerance chili pepper cultivar.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the Indonesia Directorate General of Higher Education (DIKTI) for financial support (under PMDSU Research Grant financial year 2020 No. 200/SP2H/PMDSU/DRPM/2020). The author also would thank all parties who helped in data collection and work on this research.

REFERENCES

Belay F, Abate B, Tsehayu Y. 2020. Genetic variability and characters association of hot pepper (Capsicum annuum L.) genotypes tested under irrigation in Northern Ethiopia. Agric Sci 2 (1): 289-303.
Cabrall NSS, Medeiros AM, Neves LG, Sudre CP, Pimenta S, Coelho VI, Serafim ME, Rodrigues R. 2017. Genotype × environment interaction on experimental hybrids of chili pepper. Genet Mol Res 16 (2). DOI: 10.4238/gmr16029551.

Ganeffianti DW, Suryati D, Hasamuddin. 2009. Stability analysis of six chili pepper populations using additive main effect multiplicative interaction. (AMMI) Agrosia 12 (2): 147-154.

Hu X, Yan S, Shen K. 2013. Heterogeneity of error variance and influence on genotype comparison in multi-location trials. Field Crops Res 149: 322-328. DOI: 10.1016/j.fcr.2013.05.011.

IPGRI, AVRDC, CATIE. 1995. Descriptors for Capsicum (Capsicum spp.). International Plant Genetic Resources Institute, Rome, Italy; the Asian Vegetable Research and Development Center, Taipei, Taiwan, and the Centro Agronómico Tropical de Investigación y Enseñanza, Turrialba, Costa Rica.

Kandel M, Ghimire S, Menezes D, Neder DG, Melo RA, Araujo ALR, Maranhão P, Purwoko BS, Khumaida N. 2011. Bioteknologi dalam Pemuliaan Tanaman. Pendahuluan. IPGRI, AVRDC, CATIE. Bogor.

Madu EA, Uguru MI. 2006. Inter-relation of growth and disease expression in pepper using principal component analysis (PCA). Afr J Biotechnol 5 (11): 1054-1057.

McIntosh MS. 1983. Analysis of combined experiments. Agronomy J 75: 153-155.

Nsabiyera V, Logose M, Ochwo-Ssemakula M, Sseruwagi P, Gibson P, Ojewo C. 2012. Morphological characterization of local and exotic hot pepper (Capsicum annuum L.) collections in Uganda. Bioremed Bioavail 7 (1): 22-32.

Pimenta S, Menezes D, Neder DG, Melo RA, Araujo ALR, Maranhão EAA. 2016. Adaptability and stability of pepper hybrids under conventional and organic production systems. Hortic Bras 34: 168-174. DOI: 10.1590/S0102-053620160000100004

Rosmaina S, Hasrol FY, Jufriyanti, Zulfahmi. 2016. Estimation of variability, heritability and genetic advance among local chili pepper genotypes cultivated in peatlands. Bulgarian J Agric Sci 22 (3): 431-436.

Roy D. 2000. Plant Breeding, Analysis and Exploitation of Variation. Narosa Publishing House, New Delhi.

Shahbanimofrad M, Rafii MY, Wahab PEM, Biabani AR, Latif MA. 2013. Phenotypic, genotypic, and genetic divergence found in 48 newly collected Malaysian accessions of (Jatropha curcas L.). Ind Crops Prod 42 (1): 543-551. DOI: 10.1016/j.indcrop.2012.06.023

Sharma VK, Senwal CS, Uniyal SP. 2010. Genetic variability and character association analysis in bell pepper (Capsicum annuum L.). J Hortic For 2 (3): 58-65.

Syukur M, Sujiprihati S, Yuniani S. 2015. Teknik Pemuliaan Tanaman. Penebar Swadaya. Bogor.

Syukur M, Sujiprihati S, Yuniani R, Kusumah DA. 2010. Evaluasi daya hasil cabai hibrida dan daya adaptasinya di empat lokasi dalam dua tahun. Jurnal Agronomi Indonesia 38 (1): 43-51.

Thul ST, Lal RK, Shasan N, Darokar MP, Gupta AK, Gupta MM, Verma RK, Kajha SPS. 2009. Estimation of phenotypic divergence in a collection of Capsicum species for yield-related traits. Euphytica 168: 189-196. DOI: 10.1007/s10681-009-9882-y

Usman MG, Rafii MY, Ismaill MR, Malek MA, Latif MA. 2014. Heritability and genetic advance among chili pepper genotypes for fruit and pod yield and morphophysiological characteristics. ScientificWorldJournal. 2014: 308042. DOI: 10.1155/2014/308042

Votava Baral JB, Bosland PW. 2005. Genetic diversity of chile (Capsicum annuum var annuum L.) landraces from Northern New Mexico, Colorado, and Mexico. Econ Bot 59: 8-17. DOI: 10.1663/0013-0001(2005)059[0008:GDOCC2.0.CO;2

Wattimena GA, Nurhajati AM, Wiendi NM, Parwito A, Efendi D, Purwoko BS, Khumaidi N. 2011. Bioteknologi dalam Pemuliaan Tanaman. Pendahuluan. IPB Press, Bogor.

Whitler KS. 1979. Breeding of Cross-pollinated Crops. In: Knight. R. (Ed). A Course Manual in Plant Breeding. Australian Vide Chancellor’s Committee, Brisbane.

Wubs AM, Hevelink E, Marcelis LFM, Hemenik L. 2011. Quantifying abortion rates of reproductive organs and effects of contributing factors using time to event analysis. Funct Plant Biol 38 (5): 431-440. DOI: 10.1071/FP10249.