



Estimation of Genetic Parameters, Genetic Variability, and Heritability Values of 10 Curly Chili Genotypes (*Capsicum annuum* L.)

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Abstract

Curly red chili is one of the high-value horticultural commodities and plays an important role in meeting food needs. Unpredictable weather conditions can cause declines in crop yield. One effort to increase chili productivity is the use of superior varieties with high yield potential. This study aimed to estimate genetic parameters, genotypic and phenotypic coefficients of variation, and heritability values in 10 tested genotypes, as well as to identify genotypes with high yield potential. The study used a field experiment in a Randomized Complete Block Design (RCBD) with one factor, namely genotype: 379380-42-1-15, 379380-12-16-18, 379381-23-9, 379381-28-3, 379380-49-8-8, 379380-12-16-15, Pesona, Neno Tavi, Cmk Tavi, and Laris. The data were analyzed using analysis of variance followed by Duncan's Multiple Range Test (DMRT) at the 5% level, as well as genotypic coefficient of variation and heritability analyses. The results showed varying levels of variability in all growth and yield variables. Moderate genotypic coefficients of variation were observed for flowering time, fruit weight, number of fruits per plant, and fruit weight per plant. High phenotypic coefficients of variation were observed for number of fruits per plant and fruit weight per plant. High heritability values were obtained for flowering time, plant height, dichotomous height, canopy width, fruit weight, fruit diameter, fruit length, and fruit stalk length.

Keywords: *Curly Chili, Genotype, Genetic Variability, Heritability*

INTRODUCTION

Curly chili (*Capsicum annuum* L.) is a horticultural commodity widely cultivated in Indonesia, with continuously increasing market demand. This commodity contributed 7.94% of total national vegetable production in 2023. In addition to its high economic value, chili is also a source of vitamins and bioactive compounds. However, curly chili productivity at the farmer level remains fluctuating due to limited availability of superior varieties that are adaptive and have high yield potential.

In 2024, chili oversupply caused farm level prices to decline sharply, resulting in losses for producers ([National Food Agency, 2024](#)). Curly chili production in the Special Region of Yogyakarta in 2026 was 451,717 kw, with a harvested area of 98,651 ha (BPS, 2026). Fluctuations in curly red chili prices in traditional markets in Yogyakarta from early to mid-2026 were dynamic, ranging from IDR 32,000 to IDR 42,500 per kg. Fluctuations in price and curly chili production due to erratic rainfall can disrupt the productivity and harvest yield of curly chili farmers.

The use of genotypes as breeding materials can shorten the process of developing early-maturing, high yielding, and disease resistant chili. Various superior traits may be accumulated in a single individual. The use of *Capsicum annuum* as breeding material is important because (1) it has diverse plant, leaf, and fruit forms, as well as variation in flowering time, and (2) it has been cultivated throughout the year in various regions of Indonesia, making it more readily accepted by the market.

On the other hand, seasonal supply shortages can cause consumer prices to increase sharply.

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This problem is exacerbated by the vulnerability of curly chili plants to changes in rainy and dry season patterns, which can lead to pest and disease attacks, particularly in varieties that are not adapted to local environmental conditions ([Center for Agricultural Data and Information Systems, 2023](#)). Continuous demand for chili throughout the year makes increasing productivity an important aspect of developing this commodity.

Chili productivity is influenced by interactions between genetic and environmental factors. Genetic differences among genotypes can result in variation in growth, flowering, yield components, and plant yield traits. Such variability is a basic resource in plant breeding because the success of selection is strongly determined by the presence of genetic variation in the population used.

Selection for agronomic traits should not be based solely on phenotypic values but should also consider the contribution of genetic factors to the phenotype. One parameter that can be used to assess this contribution is heritability. Heritability describes the proportion of phenotypic variation attributable to genetic variation within a particular population and environment. High heritability indicates that phenotypic variation in a trait is relatively strongly influenced by genetic factors, so selection for that trait has the potential to produce greater genetic progress.

In addition to heritability, the genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) can be used to describe the degree of variation in a trait. The comparison between GCV and PCV provides an indication of the extent to which environmental factors influence the expression of a trait. Traits with high GCV and high heritability are generally more effective as selection criteria.

Estimating genetic parameters in various curly chili genotypes is important for identifying traits with high genetic variability and selection potential. Therefore, this study was conducted to estimate genetic parameters, genetic variability, phenotypic variability, and heritability in 10 curly chili genotypes.

This study aimed to: (1) obtain qualitative and quantitative characteristics of several curly chili genotypes, (2) determine genotypic and phenotypic coefficients of variation, (3) estimate heritability values for several quantitative traits, and (4) identify curly chili genotypes with potential as candidate hybrid varieties.

LITERATURE REVIEW

Chili is an important horticultural commodity belonging to the Solanaceae family. The genus *Capsicum* originated in the Americas and exhibits extensive morphological and genetic diversity. This genus includes various cultivated chili types such as red chili, cayenne pepper, and curly chili. The pungency of chili is caused by its capsaicin content, making it useful for fresh consumption, seasoning, and industrial raw materials ([Rohcahyani et al., 2022](#)).

Curly chili (*Capsicum annuum*) has high morphological diversity in vegetative and generative traits, including plant, leaf, flower, fruit, and seed characteristics. Flower and fruit morphology can distinguish genotypes; *C. annuum* fruits vary in shape and may change from green to red (Nisa & Ambarwati, 2022; [Wijaya et al., 2020](#)).

Efforts to increase curly chili productivity include developing new superior varieties with high yield, disease resistance, and environmental adaptability ([Mareza et al., 2021](#)). Chili growth and development are influenced by genetic and environmental factors. Environmental factors that determine successful chili growth include temperature, light intensity, water availability, humidity, soil conditions, nutrients, and altitude. Genotype $\times$ environment interactions can cause differences in the expression of growth and yield traits among genotypes.

Variation in a plant trait can originate from genetic variation and environmental effects. The Genotypic Coefficient of Variation (GCV) describes the magnitude of variation originating from

the genetic component, whereas the Phenotypic Coefficient of Variation (PCV) describes the total variation expressed in the phenotype, which is a combination of genetic and environmental effects.

Broad-sense heritability is the proportion of phenotypic variation that can be attributed to genetic variation within a particular population and environment. High heritability indicates that phenotypic variation in a trait is relatively more closely associated with genetic differences than with environmental effects. Therefore, selection based on such traits tends to be more effective. Conversely, low heritability indicates a relatively large environmental contribution, making selection based on individual phenotypes less effective ([Sravanthi et al., 2025](#)).

Studies of various *C. annuum* genotypes have shown extensive variation in qualitative and quantitative traits. Evaluation of 39 chili genotypes showed broad genetic variability in flowering time, age at first harvest, number of fruits per plant, fruit diameter, fruit length, fruit stalk length, and fruit weight. Flowering time, fruit diameter, fruit length, and fruit weight also showed high heritability and therefore have potential as selection traits ([Almunawar et al., 2025](#)). [Nadia et al. \(2025\)](#) reported Bangka 2 as superior for several growth and fruit traits in a coastal field, with high heritability for plant height, stem diameter, flowering time, dichotomous height, fruit length, and fruit diameter, supporting further breeding evaluation.

In chili breeding programs, genotype selection based on specific traits is very important for improving yield and quality. A study evaluating several M2 curly chili genotypes found high genetic variability, heritability, and genetic advance for fruit weight per plant, ascorbic acid content, fruit diameter, and number of secondary branches ([Rakasiwi et al., 2026](#)).

MATERIALS AND METHODS

The study was conducted from April to July 2026 at the Experimental Farm of the Faculty of Agriculture, UPN Veteran Yogyakarta, Wedomartani, at an altitude of 191 m above sea level, on Regosol soil. The curly chili genotypes used were 379380-42-1-15, 379380-12-16-18, 379381-23-9, 379381-28-3, 379380-49-8-8, 379380-12-16-15, and the varieties Pesona, Neno Tavi, Cmk Tavi, and Laris. Other materials included manure, rice husk charcoal, sand, dolomite lime, M21, humic acid, Furadan, AB Mix Platinum solution, NPK fertilizer, urea, KCl, fungicide, and insecticide.

The study used a field experiment in a Randomized Complete Block Design with one factor, namely genotype treatment, consisting of 7 candidate hybrid genotypes and 3 check varieties: 379380-42-1-15, 379380-12-16-18, 379381-23-9, 379381-28-3, 379380-49-8-8, 379380-12-16-15, and Pesona, Neno Tavi, Cmk Tavi, and Laris. The experiment used 3 replications, resulting in 30 experimental units. Each experimental unit consisted of 20 plants, with 5 sample plants.

The research activities included seedling preparation, land preparation, planting, replanting, maintenance, shoot pruning, staking, fertilization, pest and disease control, harvesting, and observation. The observed parameters were flowering time, harvest age, plant height, dichotomous height, stem diameter, leaf length, leaf width, fruit weight, fruit diameter, fruit length, fruit stalk length, fruit flesh thickness, number of fruits per plant, and fruit weight per plant.

Data analysis was performed using analysis of variance on quantitative morphological traits, followed by Duncan's Multiple Range Test (DMRT) at the 5% level. Genetic parameters were estimated based on genotypic variance, phenotypic variance, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), and broad-sense heritability, which were calculated according to [Nabila et al. \(2025\)](#).

FINDINGS AND DISCUSSION

The results of this study consisted of data obtained from field observations. The data were analyzed using analysis of variance and further tested using Duncan's Multiple Range Test at the 5% level. The results of the analysis of quantitative traits of curly chili are presented in Table 1.

Table 1. Analysis of variance results for quantitative traits of curly chili

Trait	Significance
Flowering time (DAP)	33.9 *
Harvest age (DAP)	79.73 *
Plant height (cm)	75.04 *
Dichotomous height (cm)	29.34 *
Stem diameter (mm)	11.65 *
Canopy width (cm)	76.16 *
Leaf length (cm)	7.95 *
Leaf width (cm)	2.77 *
Fruit weight (g)	5.94 *
Fruit diameter (mm)	8.92 *
Fruit length (cm)	15.06 *
Fruit stalk length (cm)	4.32 *
Fruit flesh thickness (mm)	1.26 ns
Number of fruits per plant (fruit)	85.6 *
Fruit weight per plant (fruit)	366.06 ns

Note: Population mean values followed by (*) indicate a significant difference, while (tn) indicates no significant difference at the 5% level.

Table 1 shows that genotype treatment had a significant effect on flowering time, harvest age, plant height, dichotomous height, stem diameter, canopy width, leaf length, leaf width, fruit weight, fruit diameter, fruit length, fruit stalk length, and number of fruits per plant. This indicates considerable genetic variation in these traits, which can potentially be used as a basis for selection in plant breeding programs. In contrast, genotype treatment had no significant effect on fruit flesh thickness and fruit weight per plant. These two traits showed relatively uniform phenotypic expression among the genotypes tested.

The significant differences observed in most traits indicate that the ten genotypes tested had different growth responses and morphological characteristics. These differences may reflect genetic differences among genotypes, although phenotypic expression remained influenced by environmental conditions. The phenotype expressed by a plant is the result of interaction between genotype and environment. These results are consistent with [Prihaningsih *et al.* \(2023\)](#), who reported variation in qualitative and quantitative morphological traits among several chili varieties. Similar findings were reported in 39 chili genotypes, which showed significant differences in several generative traits, yield components, and yield ([Al Munawar *et al.*, 2025](#)).

The results of the qualitative trait analysis, followed by the GCV, PCV, and heritability values, are presented in Table 2.

Table 2. Genetic parameters of quantitative traits of curly chili genotypes

Trait	GCV		PCV		Heritability	
	12.5	Moderat		Moderat		
Flowering time (DAP)	1	e	13.44	e	86.62	High
						Moderat
Harvest age (DAP)	2.74	Low	4.77	Low	33.03	e
		Moderat		Moderat		
Plant height (cm)	12.6	e	14.02	e	80.85	High
Dichotomous height (cm)	9.32	Low	11.43	Moderat	66.57	High

Trait	GCV		PCV		Heritability	
				e		
Stem diameter (mm)	7.52	Low	11.14	Moderate	45.49	Moderate
Canopy width (cm)	8.34	Low	10.73	Moderate	60.45	High
Leaf length (cm)	6.73	Low	11.72	Moderate	32.96	Moderate
Leaf width (cm)	9.02	Low	13.74	Moderate	43.15	Moderate
Fruit weight (g)	15.2	Moderate	16.77	Moderate	82.32	High
Fruit diameter (mm)	2	e	9.56	Low	71.08	High
Fruit length (cm)	8.06	Low	10.56	Moderate	87.94	High
Fruit stalk length (cm)	9.9	Low	9.16	Low	74.45	High
Fruit flesh thickness (mm)	7.9	Low	14.16	Moderate	19.92	Low
Number of fruits per plant (fruit)	6.32	Moderate	24.22	High	35.14	Moderate
Fruit weight per plant (fruit)	14.3	Moderate	26.06	High	30.46	Moderate
	6	e				
	8	e				

Note: GCV: Genotypic Coefficient of Variation; PCV: Phenotypic Coefficient of Variation

Table 2 shows that PCV values were generally higher than GCV values for the traits observed. This condition indicates that trait expression was determined not only by genetic factors but was also influenced by the environment. Similar results were reported by [Saisupriya et al. \(2022\)](#) in 35 *Capsicum annuum* genotypes in India, in which the PCV was higher than the genotypic coefficient of variation for all traits observed. The study also found substantial variation in plant height, fruit length and diameter, number of fruits per plant, fruit weight, and fruit yield per plant. This similar pattern supports the present finding that the difference between GCV and PCV indicates an environmental contribution to the expression of quantitative traits in chili.

In this study, the number of fruits per plant and fruit weight per plant showed relatively higher PCV than GCV. This indicates that phenotypic variation in yield traits did not entirely reflect genetic variation. This finding is consistent with [Almunawar et al. \(2025\)](#), who reported that phenotypic variability in yield traits could be greater than genotypic variability in 39 chili genotypes. Therefore, direct selection based on the number of fruits per plant or fruit weight per plant within a single environment should be conducted cautiously.

[Hulagannavar et al. \(2024\)](#) reported high genetic variability in number of fruits per plant, fruit weight, and fruit yield among 17 traits evaluated in *C. annuum* genotypes in India. High heritability accompanied by genetic advance in several yield traits indicates that these traits have potential for use in selection. Thus, the present results reinforce the importance of distinguishing genetic and phenotypic variation when determining traits to be used as selection criteria.

High heritability values were obtained for flowering time, plant height, dichotomous height, canopy width, fruit weight, fruit diameter, fruit length, and fruit stalk length, indicating that these traits were relatively more influenced by genetic factors and therefore have potential as selection criteria in breeding programs. High heritability indicates that the observed variation in these traits was substantially associated with genetic factors. This is consistent with [Nadia et al. \(2025\)](#), who

evaluated several chili genotypes and found that high heritability was more strongly influenced by genetic factors than environmental factors, making selection for these traits more effective.

An international study by Saisupriya *et al.* (2022) reported high heritability for flowering time, fruit length, fruit diameter, number of fruits per plant, fruit weight, and fruit yield in *C. annuum* genotypes, along with high genetic advance, indicating potential for improvement through direct selection. These results are consistent with the present study, particularly for fruit length, which showed high heritability of 87.94%, and fruit weight, which showed 82.32%.

The findings of this study can also be compared with those of Sushmitha *et al.* (2024), who evaluated 12 chili genotypes in two contrasting environments in India and found significant differences among genotypes and locations. Plant height, fruit width, fruit length, flowering time, maturity age, and yield showed high GCV and PCV, as well as significant heritability and genetic advance. One genotype, Arka Meghana, showed superior performance in both environments. These results indicate that yield and yield-related traits in chili have substantial genetic potential, but evaluation across more than one environment remains important to confirm genotype performance stability.

High heritability for fruit weight, fruit diameter, and fruit length indicates that these fruit traits have relatively large genetic components. Therefore, these traits can be considered in selecting chili genotypes with fruit characteristics that meet target market requirements.

CONCLUSIONS AND FUTURE RESEARCH

Conclusions

1. Phenotypic and genetic variation was observed in growth, flowering, fruit morphology, and yield component traits among the 10 curly chili genotypes tested.
2. Moderate Genotypic Coefficients of Variation (GCV) were obtained for flowering time, plant height, fruit weight, number of fruits per plant, and fruit weight per plant, whereas most other traits had low GCV. PCV values were generally higher than GCV values.
3. High heritability values were obtained for flowering time, plant height, dichotomous height, canopy width, fruit weight, fruit diameter, fruit length, and fruit stalk length. These traits have potential as selection criteria because the proportion of genetic variation relative to phenotypic variation was relatively high under the conditions of this study.

Future Research

This study was limited by the number of genotypes, evaluation at one location, and one growing season. Nevertheless, the results can be used by breeders as a basis for selecting genotypes for further testing, particularly based on flowering time, fruit weight, fruit length, and other traits showing high heritability.

Further research is recommended to evaluate selected genotypes across several locations and growing seasons to determine their stability and adaptability, accompanied by assessment of pest and disease resistance and fruit quality according to target market requirements.

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